Southern Sydney's urban koalas: community research and education at Campbelltown

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ABSTRACT

We compiled an extensive database of koala sightings from the community. The records of koala sightings which met conditions for reliability were used in conjunction with vegetation mapping by the NSW National Parks and Wildlife in the Georges River catchment to produce relative exploitation (RE), or preference, indices. Shale/Sandstone Transition Forest with a high sandstone influence had the highest RE value (RE>1 indicates preference), indicating that it was highly preferred, followed by Upper Georges River Sandstone Woodland, and Western Gully Forest, with Riparian Scrub being marginally preferred. Shale/Sandstone Transition Forest with a low sandstone influence had an RE value of 0.92 (RE<1 indicates avoidance), but this low value is most likely because heavily impacted vegetation with <10% crown cover was included. Shale/Sandstone Transition Forest thus appears to be the vegetation type that koalas within the Georges River catchment most prefer.

Ward (2002) investigated differences between female koalas that could access vegetation, of various types, growing on shale substrates, and females with access only to vegetation growing on sandstone substrates, and found that the females with access to the shale substrate vegetation were heavier, in better condition, and had a higher fertility rate than females on sandstone substrates only. Vegetation growing on shale substrates has been extensively cleared, and the important Shale/Sandstone Transition Forest, represents only 3.7% of the extant vegetation in the Georges River catchment. Most of this vegetation is sandstone-derived, with the high and low categories of sandstone influence having, respectively, 58.1% and 77.6% of remaining vegetation classified as less than 10% crown cover. The clearing associated with urban areas, therefore, impact upon the koala population. As this population has been estimated to consist of only 90 to 200 individuals (Ward 2002), conserving vegetation on shale substrates and habitat links to other populations are high priorities. The listing of Shale/Sandstone Transition Forest and O'Hares Creek Shale Forest as Endangered Ecological Communities under the *Threatened Species Conservation Act 1995* will support koala conservation in the Campbelltown area, but impacts such as altered fire regimes, mortalities from vehicles and dogs, weeds, and other impacts from urban areas must also be managed.

Key words: Koala, community reports, conservation, soil fertility, postal survey, community survey

Introduction

Koalas, *Phascolarctos cinereus* (Goldfuss 1817), are classified as Vulnerable in New South Wales (*Threatened Species Conservation Act 1995*) and are economically important, worth an estimated $1.1 billion per year to the Australian economy (Hundloe and Hamilton 1997). That the koala is also clearly valued within Australian society is demonstrated by groups such as the Australian Koala Foundation (AKF) and the Port Macquarie Koala Hospital (Starr *et al.* 1990) which specifically focus on research, conservation, or welfare, of koalas.

Koalas are present in the southern Sydney region (Ward and Close 1998). The population is of low density, estimated to be 0.1 animals per ha within suitable habitat in the Wedderburn region (Close 1993). Furthermore, the population size in the Campbelltown region is low; Ward (2002) crudely estimated there were between 90 and 200 koalas in the region from two separate calculations using home range size and population density, but with both calculations depending on an estimate of habitat area used by breeding female koalas. Moreover, it appears that koala densities in the Sydney region have been historically low, as the first sighting of a koala was not reported until 1798, ten years after white settlement (Martin and Handasyde 1999), and there are few records prior to 1980 in the Australian Museum and NSW National Parks and Wildlife Service databases.

The presence of koalas in the Campbelltown region became widely known after a housing development at Wedderburn was approved in 1986, arousing significant public opposition (Dobson 1990). An independent study of the development proposal by CSIRO found that the development would not result in the direct loss of prime koala foods trees or habitat, but that there could be significant impacts from dogs, bushfires, fragmentation of habitat, and affects on water and nutrient flows (Cork *et al.* 1988). The protests continued and the development was ultimately abandoned. Since then, Campbelltown City Council has had a Comprehensive Koala Plan of Management (CKPoM) prepared by the Australian Koala Foundation (Callaghan *et al.* 1998), but council has not yet adopted the plan.

Pp 44 - 54 in *Urban Wildlife: more than meets the eye,* edited by Daniel Lunney and Shelley Burgin 2004. Royal Zoological Society of New South Wales, Mosman, NSW.

Given the continuing development pressure in the region, we sought to investigate the distribution of the local koala population. However, the low population density, the large study area (Fig. 1) and the steep sandstone gullies restricted the use of traditional survey methods. Fortunately, the koala is well known and easily recognised and the community was engaged to report koala sightings. This method of survey has been used in a number of studies (Campbell *et al.* 1979; Reed *et al.* 1990; Smith and Smith 1990; Close 1993; Patterson 1996; Lunney *et al.* 1996, 1997, 1998, 2000; Callaghan *et al.* 1998; Ward and Close 1998; Harris 1999; Curtin *et al.* 2002; Ward 2002).

Campbelltown is well situated for a community survey with bushland extending along the eastern edge of Campbelltown's suburbs for a distance of 25 km. A population of over 143 000 resides in the Campbelltown Local Government Area, with approximately 350 000

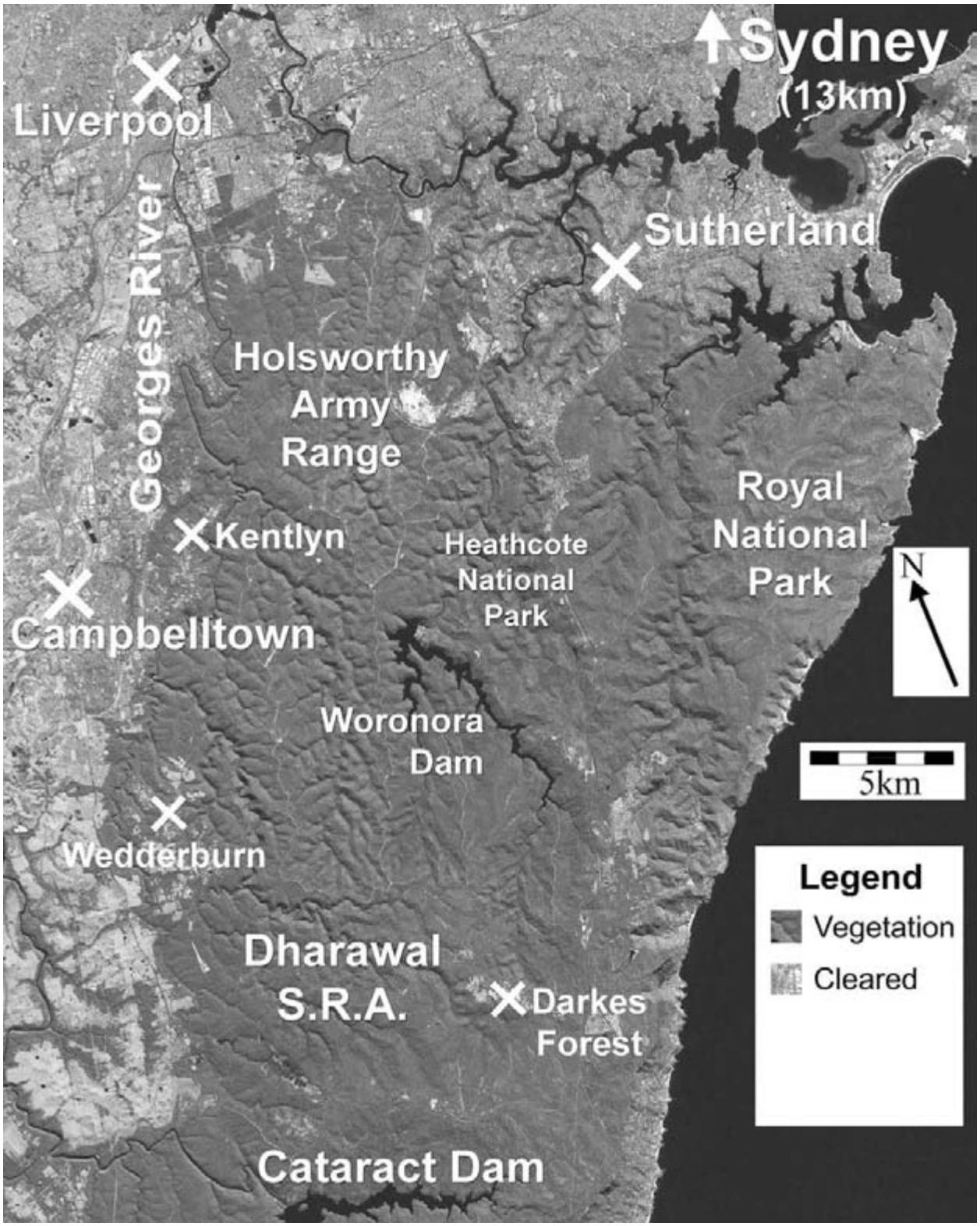

Figure 1. Satellite image with major landmarks within the study region.

in the total study area (the region shown in Fig. 1), which includes part of the Bankstown, Campbelltown, Hurstville, Kogarah, Liverpool, Rockdale, Sutherland, Wollondilly and Wollongong local government areas (Australian Bureau of Statistics 2000).

Community sightings can provide current and historical information for a large area (Smith and Smith 1990; Ward 2002). However, we expected that areas with relatively little human access would be poorly surveyed. Access to the Holsworthy Army Range, and the Woronora and Cataract Dam catchments is restricted. While unauthorised use of water catchment along fire trails is relatively common (pers. obs.), fencing and the presence of unexploded ordinance deter most people from illegally entering the Army Range. Rugged terrain also prevents public access to much of the Heathcote National Park and Dharawal State Recreation Area. Furthermore, as adult female koalas are sighted less often than males within the area because of behavioural differences (Ward 2002), there is also a sexual bias in the animals detected.

Community reports also vary in their reliability. For example, several identifications made from moving vehicles of koala corpses were erroneous (Ward 2002). However, with appropriate data handling it is possible to remove these, and other dubious reports, thereby improving the reliability of the remaining data (Ward 2002).

Organising the community response requires wide promotion of the survey's aims. Extensive publicity was undertaken in our study, using a variety of media. Education about our research and basic koala biology was an intrinsic part of this publicity. The koala was also used as a flagship species to advertise other species and to promote ecological concepts by covering such topics in our column in the *Macarthur Advertiser*, when talking to the public, or during presentations to community groups. We emphasise the value of this publicity in our ability to locate animals for the study. Without the reports of sightings from the community we would have been unable to locate sufficient animals for our study because of the low density of the koala population in the Campbelltown area.

Soils

There are two main soil types in the study region: Sydney Sandstone and the more fertile Wianamatta Shales. Several authors suggested that soil fertility is an important determinant of habitat quality for koalas (Cork *et al.* 1990; Cork and Braithwaite 1996).

Ward (2002), using 1:100 000 geology maps to define regions where vegetation on shale substrates occurred, investigated the effect that access to this type of vegetation had upon adult female koalas. He found that females with access to vegetation on shale substrates were, on average, 0.92 kg heavier, in better condition, and raised a higher percentage of young to independence. Although all statistical tests were significant at $p<0.05$, the results should be used with caution due to small sample sizes (data came from 9-10 females with access to shale substrate vegetation, and from 4-6 females with access to only sandstone substrate vegetation). The findings are, however, consistent with the results of Phillips and Callaghan (2000) who found that Grey gum *Eucalyptus punctata,* and Blue-leaved stringybark *E. agglomerata*, were most preferred in the Campbelltown local government area, but only when growing on shale substrates.

This picture is further complicated, however, by the clearing that has occurred since European settlement and the transition between shale and sandstone substrates. Vegetation on shale substrates has been heavily cleared, initially for farming (Benson and Howell 1990), and later for housing (see Fig. 2 for distribution of Wianamatta Shale substrates). Hence, Shale/Sandstone Transition Forest and O'Hares Creek Shale Forest are now recognised as Endangered Ecological Communities under the *Threatened Species Conservation Act 1995*. Remnant Shale/Sandstone Transition Forest occurs along Campbelltown's eastern fringes from Long Point to Wedderburn, and the vegetation is influenced by the size, and extent, of lenses of shale substrate (NSW National Parks and Wildlife Service 2000). The association between improved weight, condition, and fertility was observed by Ward (2002) in female koalas with access to vegetation on shale substrates. That is, these females could access vegetation growing on shale substrates, but their home ranges would have also included vegetation growing on sandstone substrates, so it is likely that vegetation on any shale lens will provide some benefit to female koalas.

Thus vegetation on shale substrates containing preferred koala food trees appears vital to koalas in the Campbelltown area. However, this vegetation has been heavily cleared, initially for farming (Benson and Howell 1990), and later for housing. What little vegetation on shale substrates that now remains lies close to urban areas (Fig. 1, 2), the exception being the small amount of vegetation in the Darkes Forest area (Keith 1994). If the koala population is indeed limited by the extent of vegetation on the more fertile shale substrates, the impacts of urban areas upon the koala population will be significant, despite extensive remnant vegetation on sandstone substrates within the Holsworthy Army Range, Royal and Heathcote National Parks, and Woronora and Cataract Dams.

There is pressure in the Campbelltown region for clearing of vegetation on shale substrates for housing, road development and firebreaks. Other urban impacts are injuries and deaths caused by cars, trains, dogs and arson. Arson also affects remnant vegetation as do off-road vehicles, weeds, nutrient-laden stormwater runoff, and rubbish from gardens, houses and streets.

To test if koalas exhibited a preference for certain types of vegetation we used a relative exploitation (RE) index, which has been used to investigate koala tree preferences (White and Kunst 1990). This index compares proportional usage, the number of reports of koala sightings in a vegetation type, with the proportional availability of that vegetation type, the area of vegetation. For this index a $RE>1$ indicates over exploitation of that vegetation type, and a $RE<1$ indicates under exploitation.

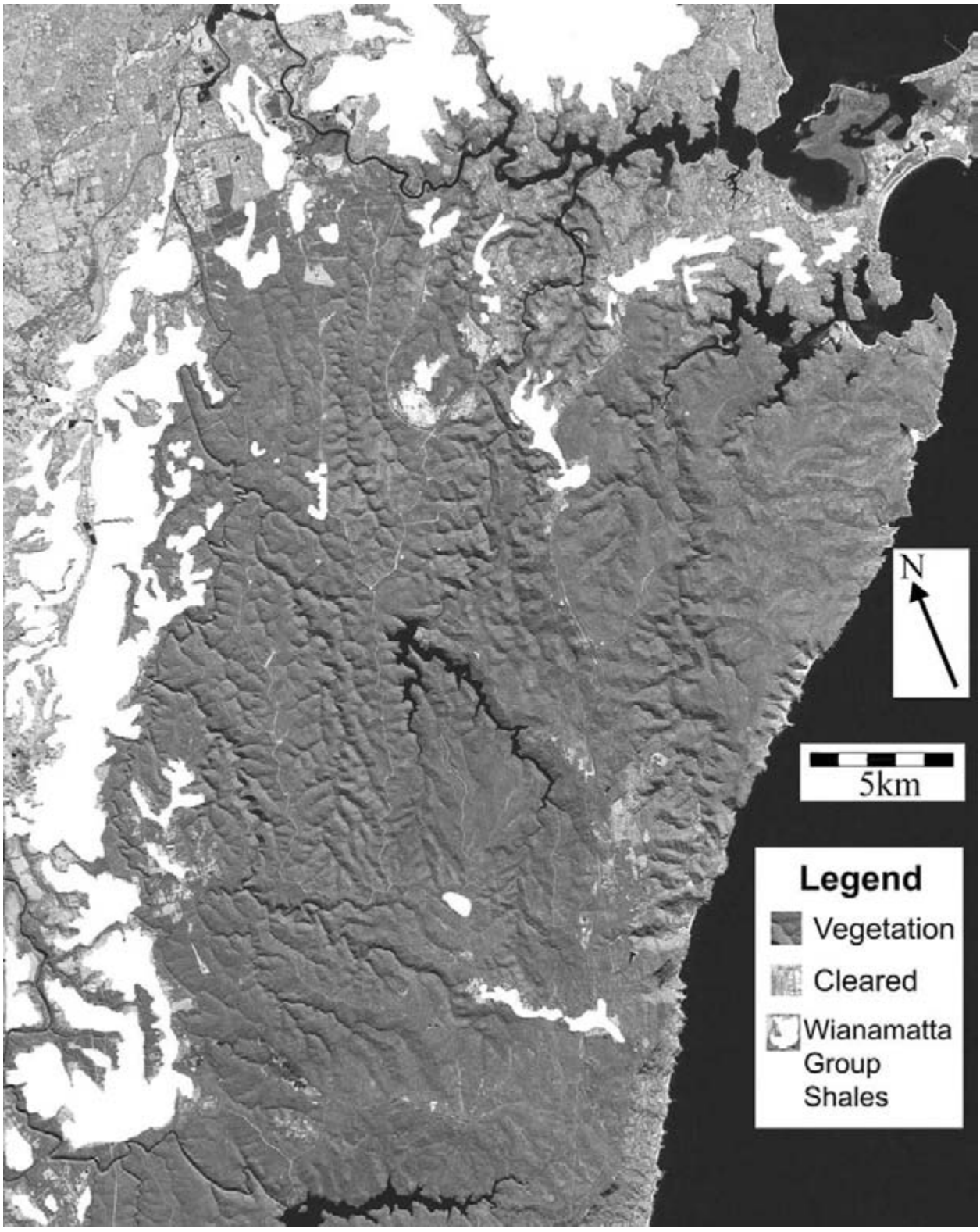

Figure 2. Satellite image with Wianamatta group shales superimposed. Shale areas are derived from 1:100000 Geology sheets: Wollongong and Port Hacking 1985, Penrith 1991, and Sydney 1983; Department of Mineral Resources.

Methods

Publicity used to elicit koala reports from the community included the following: a weekly newspaper column published in *The Macarthur Advertiser* from October 1995; Mac's Koala Club, a promotional club run by the same newspaper with 1200 members in 2002; stories in other newspapers and radio and television interviews; school and community talks and displays; setting up a 24h telephone hotline (02-99629996), that the public uses to report sightings, with messages being sent out to two pagers; erection by Campbelltown City Council of road-signs with a koala image above the pager hotline number; a call-number for listeners to hear a taped koala bellow; and a 19 minute video designed for local schools.

In addition, 25,925 postal surveys were distributed in October-November 1999 to selected suburbs in the Sutherland region (Fig. 3). The survey forms requested reports of koala sightings and other wildlife (Ward 2002).

Details of koala sightings on walks conducted by the National Parks Association were also collated. These walks were primarily conducted from 1986 to 1990 in the Wedderburn area to document the presence of koalas in response to the proposed development of housing at Wedderburn. Sightings of non-radiocollared animals by university staff, students, and volunteers were also recorded; most were incidental sightings while tracking other animals in Wedderburn and Kentlyn. Sightings by the Australian Army and Sydney Water Board were also collated.

A series of "filters" was used to eliminate those sightings considered to be of dubious quality. Reports that were removed from the data set included incorrect identifications, hoaxes, unreliable and multiple reports. Unreliable reports were those where the location of a sighting could not be established to within 1 km, or where a dead koala was reported, but the corpse was not checked by the reporter to confirm its identity. Multiple reports were those where similar reports were received from the same region within seven days of the first report. The aim was to reduce the effect of a few animals being seen and reported by many people. All data gathered were entered in a database which allowed retrieval using any of the attributes of the data (Ward 2002).

The filtered koala sighting data were combined with vegetation mapping for the Georges River catchment (Fig. 4, NSW National Parks and Wildlife Service 2000) in *ArcView*, a geographic information system (GIS) program. The area of vegetation remaining and the number of koala sightings within that vegetation type were used to produce relative exploitation (RE) indices. The RE formulae was adapted from a tree preference index used White and Kunst (1990), and for each vegetation type (i) the RE index was:

$$RE_i = \frac{(\text{Number of koala sightings in vegetation type i} \ / \sum \text{koala sightings})}{(\text{Area of vegetation type i} \ / \sum \text{vegetation area})}$$

Results

A total of 732 reports of koala sightings were recorded for the study region. After the filters were applied, 570 (77.9%) remained (Table 1). Together, the community and the postal survey sources accounted for 75% of the unfiltered reports, with only 81.8% and 55%, respectively, retained in the filtered reports.

For the distribution of sightings, most occurred immediately to the east of Campbelltown, and appeared to be concentrated close to remnant vegetation on shale substrates (Figs 2, 5). Other reports arose from the Sutherland region and scattered throughout the rest of the study region (Fig. 5).

Of the filtered reports, 68 (11.9%) were of female koalas with young. Most of these reports were in the Campbelltown region, with eleven scattered through the eastern part of the study region (Fig. 6).

Koalas, for both filtered sightings and sightings of females with young, showed over exploitation (preference) for four vegetation types within the Georges River catchment, and Shale/Sandstone Transition Forest with a high sandstone influence had the highest RE value (Table 2). Upper Georges River Sandstone Woodland and Western Gully Forest vegetation also showed considerable over exploitation (RE>2), while Riparian Scrub was marginally over-exploited. Shale/Sandstone Transition Forest with a low sandstone influence had only five koala sightings and was marginally under-exploited, but had a RE of zero for female koalas with young (Table 2). Sandstone Ridgetop Woodland, the most abundant type of vegetation, was also slightly under-exploited.

Discussion

Breeding areas in the study area (Fig. 1) occur to the east of Campbelltown, with most of the sightings coming from this region. It must be recognised, however, that the sources of reports of koala sightings were biased in the areas covered. The National Parks Association and University sightings were heavily biased towards areas where fieldwork occurred in the Campbelltown suburbs of Kentlyn and Wedderburn. Publicity to encourage

Table 1. Number of reports of koala sightings by source (NPA = National Parks Association, UWS = sightings by University of Western Sydney staff, students and volunteers of animals without radiocollars, Postal Survey = reports received from the postal survey in the Sutherland region in 1999). Filtered reports exclude reports defined as: false alarms, hoaxes, unreliable and multiple reports. * - Percentage of total number of reports in brackets, ** - Percentage of number of filtered reports in brackets.

Data Source	Number of Reports of Koala Sightings	Number of Filtered Reports*	Number of Reports of females with young**
Army / Water Board	11	10 (90.9%)	0 (0.0%)
Community	379	310 (81.8%)	27 (8.7%)
NPA	75	68 (90.7%)	15 (22.1%)
Postal Survey	169	93 (55.0%)	11 (11.8%)
UWS	98	89 (90.8%)	15 (17.0%)
Total	732	570 (77.9%)	68 (11.9%)

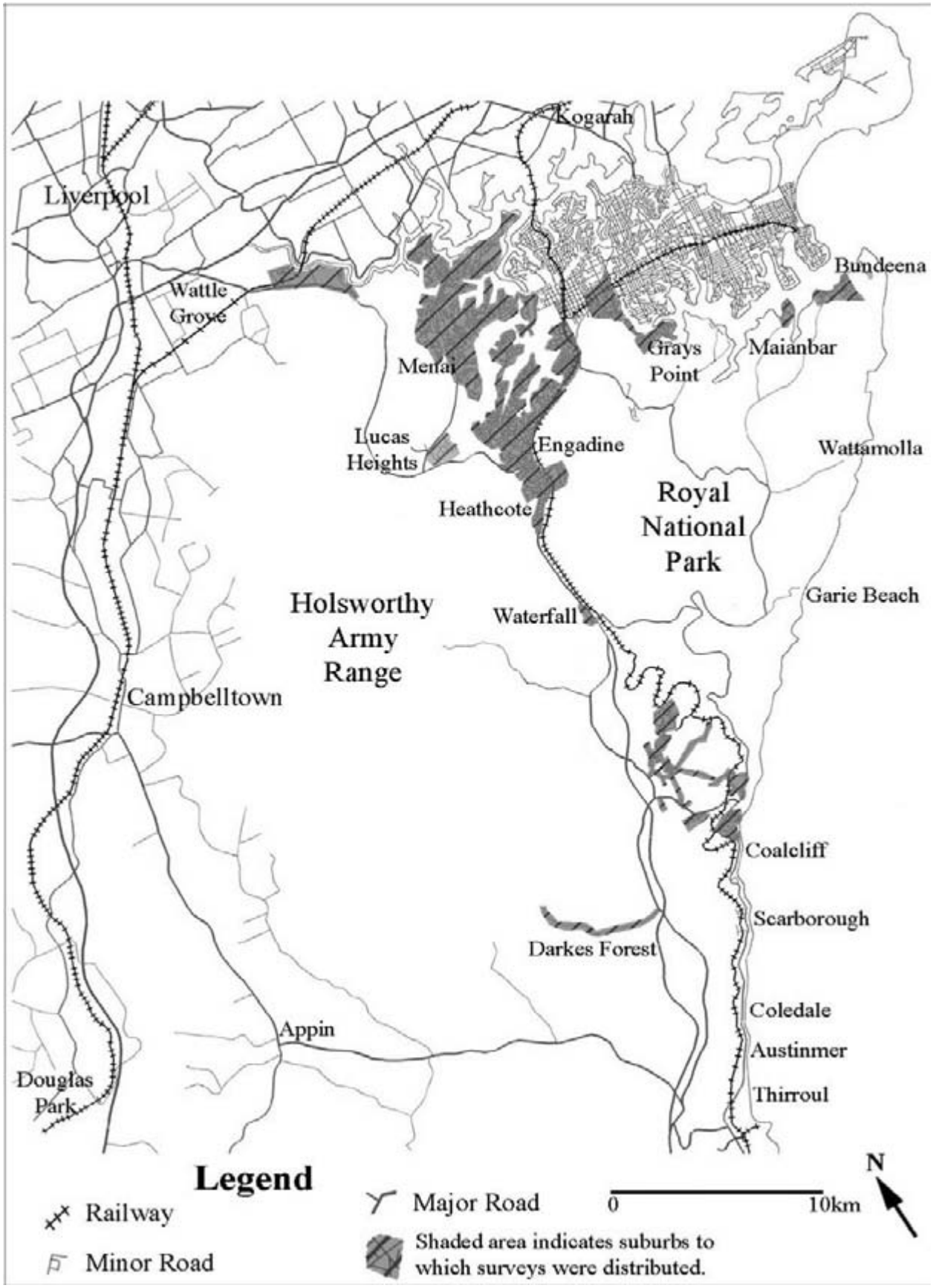

Figure 3. Map of the areas to which 25 925 postal surveys were distributed in the Sutherland region (note that minor roads are shown in greater detail for the Sutherland region). The surveys were hand delivered in October and early November 1999 to all residences in the following suburbs: Alfords Point, Bangor, Bundeena, Darkes Forest, Engadine, Grays Point, Kirrawee, Heathcote, Helensburgh, Illawong, Lucas Heights, Maianbar, Menai, Otford, Sandy Point, Stanwell Park, Stanwell Tops, Waterfall, Woronora, Woronora Heights and Yarrawarrah.

Table 2. Relative exploitation (RE) of vegetation by koalas within the Georges River catchment. Vegetation mapping is from NSW National Parks and Wildlife Service (2000). RE was determined using formulae adapted from White and Kunst (1990). A RE>1 indicates over-exploitation of that vegetation type, RE<1 indicates under-exploitation, and RE=0 indicates negligible exploitation. The double line separates over and under-exploited vegetation. Data on the area of vegetation types within the Georges River catchment and the percentage with <10% crown cover are used with permission of the NSW National Parks and Wildlife. * - Other category includes: Agnes Banks Woodland, Alluvial Woodland, Blue Gum High Forest, Castlereagh Ironbark Forest, Castlereagh Scribbly Gum Woodland, Castlereagh Swamp Woodland, Cooks River Clay Plain Scrub Forest, Freshwater Wetlands, Mangrove/Saltmarsh Complex, Moist Shale Woodland, O'Hares Creek Shale Forest, Riparian Forest, Shale Hills Woodland, Turpentine-Ironbark Forest, Turpentine-Ironbark Margin Forest, Unclassified Vegetation, Western Sydney Dry Rainforest, Woodland Heath Complex.

Vegetation Type	Area (ha)	% with <10% crown cover	Filtered Reports of Koala Sightings		Female Koalas with Young	
			No. Reports	RE	No. Reports	RE
Shale/Sandstone Transition Forest (High Sandstone)	1317	58.1%	51	4.64	5	3.29
Upper Georges River Sandstone Woodland	5831	11.8%	121	2.49	19	2.82
Western Gully Forest	7336	1.1%	138	2.25	17	2.01
Riparian Scrub	791	0.0%	7	1.06	2	2.19
Shale/Sandstone Transition Forest (Low Sandstone)	651	77.6%	5	0.92	0	0
Sandstone Ridgetop Woodland	15654	0.1%	93	0.71	17	0.94
Eastern Gully Forest	10005	0.0%	23	0.28	1	0.09
Shale/Gravel Transition Forest	662	40.2%	1	0.18	0	0
Sedgeland	1720	0.0%	1	0.07	0	0
Shale Plains Woodland	2642	71.9%	1	0.05	0	0
Other*	6202	37.6%	0	0	0	0
Total	52810	12.4%	441	n/a	61	n/a

the reporting of community sightings was obtained throughout the study area, but more publicity was generated in the Campbelltown local government area, so it is expected that community sightings would also have been biased towards this region. The large postal survey targeted residents in the east of the study region from Darkes Forest to Sutherland (Fig. 3). Reports collected from Australian Army personnel and the Water Board covered the Holsworthy Army Range and Water Board catchment, but were few in number. In combination, it is considered that there was a bias towards reports coming from areas close to human activity. Because of this bias, there may be additional undetected breeding groups within the study area, particularly the Holsworthy Army Range (Fig. 1). Koalas may also be breeding in the Darkes Forest area, and in scattered localities throughout the rest of the study region.

Forty-five percent of the koala sightings reported by respondents to the postal survey were classified as false alarms, hoaxes, unreliable or multiple reports. While valuable data were received for a region that had been poorly covered by the other data sources, care must clearly be taken in using postal survey data. We suggest that a database should be used where sightings can be placed into appropriate categories based on the reliability of each report. Data can then be filtered to remove dubious reports as desired.

The concentration of koalas immediately to the east of Campbelltown means that, despite the large area of remnant habitat (Fig. 4), this population is susceptible to impacts from the urban area. In particular, vegetation growing on shale substrates with preferred food trees was found by Ward (2002) to be important for female koalas, yet little of this vegetation remains (Fig. 2). The high RE index for Shale/Sandstone Transition Forest, with a high sandstone influence, indicates that this type of vegetation was highly preferred by koalas in the region. The apparent avoidance of for Shale/Sandstone Transition Forest with a low sandstone influence is probably because vegetation with less than 10% crown cover was included, which was 77.6% of this vegetation. Furthermore, we acknowledge that some of the remnant vegetation mapped in the NSW National Parks and Wildlife Service (2000) study of the Georges River catchment vegetation could not be used by koalas because of its isolation by urban development. Although the RE index values generated in this study were a crude assessment of koala habitat preferences, we feel that koala preferences for Shale/Sandstone Transition Forest, Upper Georges River Sandstone Woodland and Western Gully Forest have been demonstrated.

The low size of the koala population in the Campbelltown region means that loss of genetic variability, impacts from further urbanisation and stochastic events could threaten the population. Koala populations are also known to occur to the south in the Cordeaux, Nepean

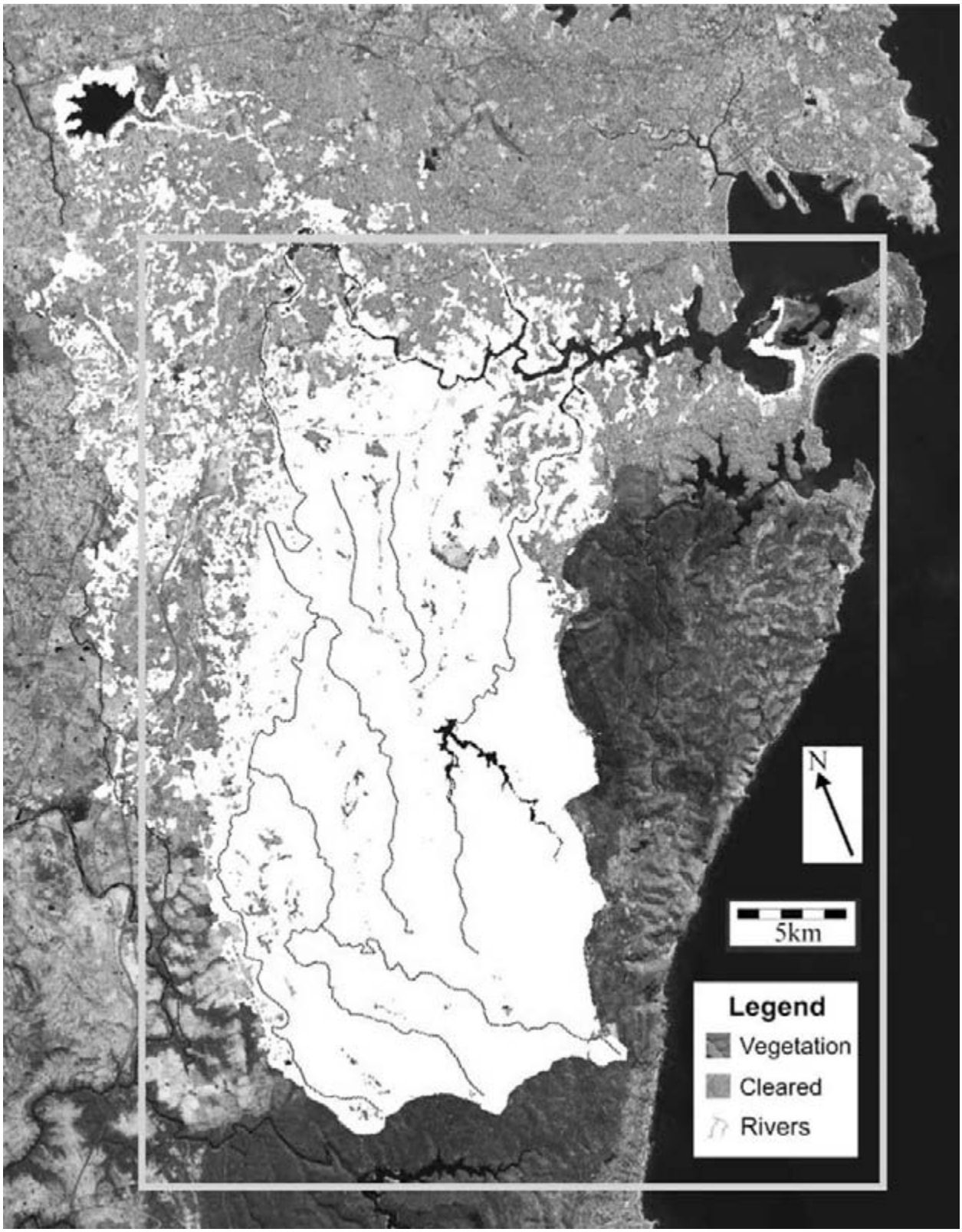

Figure 4. Satellite image with remnant vegetation identified in the NSW National Parks and Wildlife Service (2000) study of the Georges River catchment shown in white. The area covered in this study is delineated by the grey box.

and Avon Dam catchments (Tilley & Uebel 1990, Ward 2002). Maintaining current vegetation linkages to these populations will thus be important to allow gene flow. Preliminary genetic testing indicates that the populations to the south include different mitochondrial DNA haplotypes (B. Houlden pers. comm.), and additional studies are required to examine these populations.

We believe that given the low estimated size of the population, conserving the remaining vegetation on shale substrates and maintaining links to other populations to the south is crucial to long-term survival of the population. The listing of Shale/Sandstone Transition Forest as an Endangered Ecological Community under the *Threatened Species Conservation Act 1995* will be of great assistance, but because

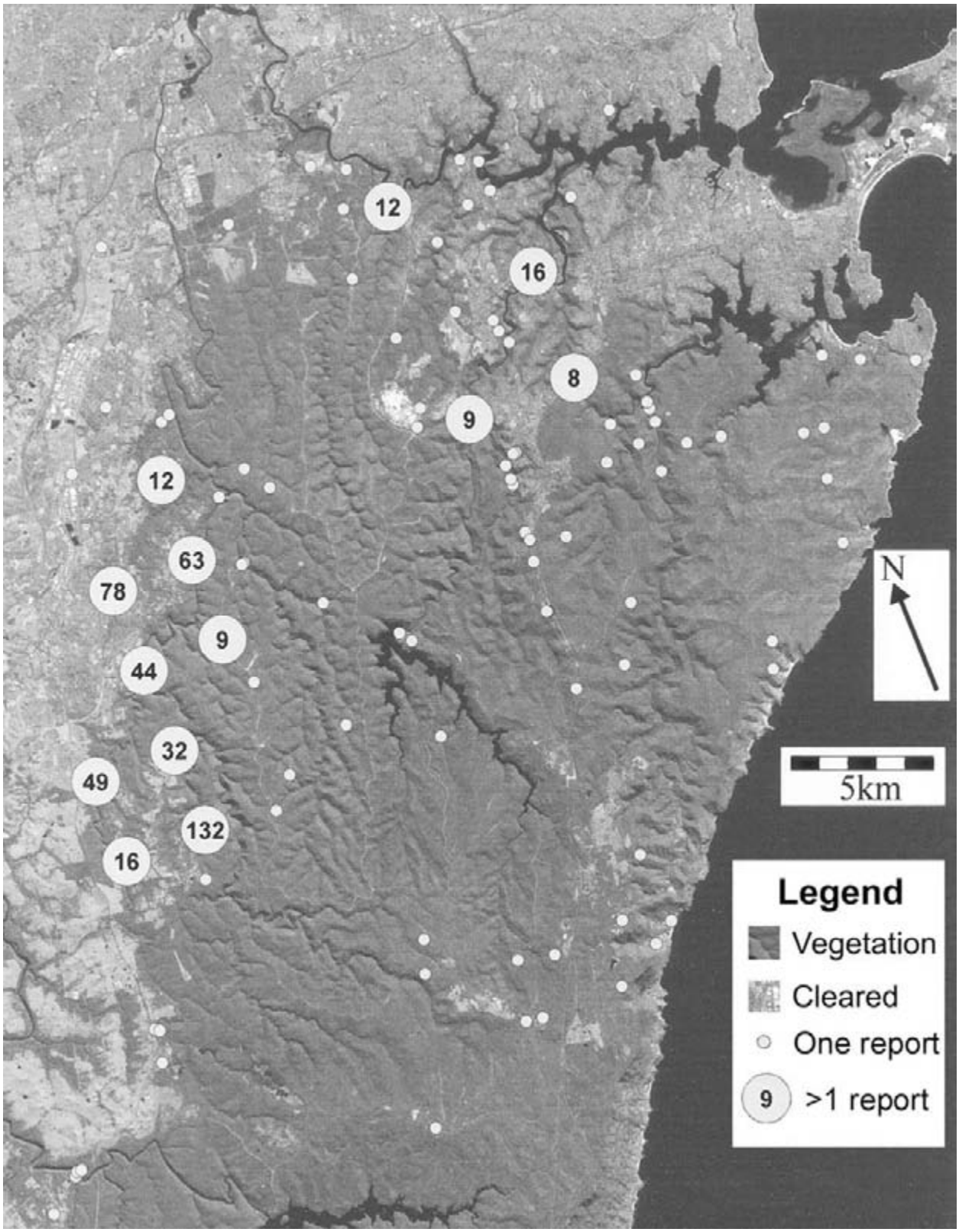

Figure 5. Satellite image with reports of koala sightings after filters to remove dubious sightings had been applied. A single dot represents one report, while large dots represent more than one report from a 9 km^2 area, with the number of reports shown in the middle of the dot.

the human population in the Campbelltown and other local government areas is expanding, and as vegetation on shale substrates occurs in prime areas for housing development, we believe there will be continuing pressure for clearing. Currently there are several areas where development is likely to impact on vegetation on shale substrates. These include a housing development at St Helens Park (Conacher 2001), a proposal to subdivide "Edge Scenic Protection Lands" (Campbelltown Council 2001), and on-going proposals to subdivide the Wedderburn Plateau. In addition, land has been reserved for a parkway designed to run from Appin to Liverpool through vegetation on shale substrates along the

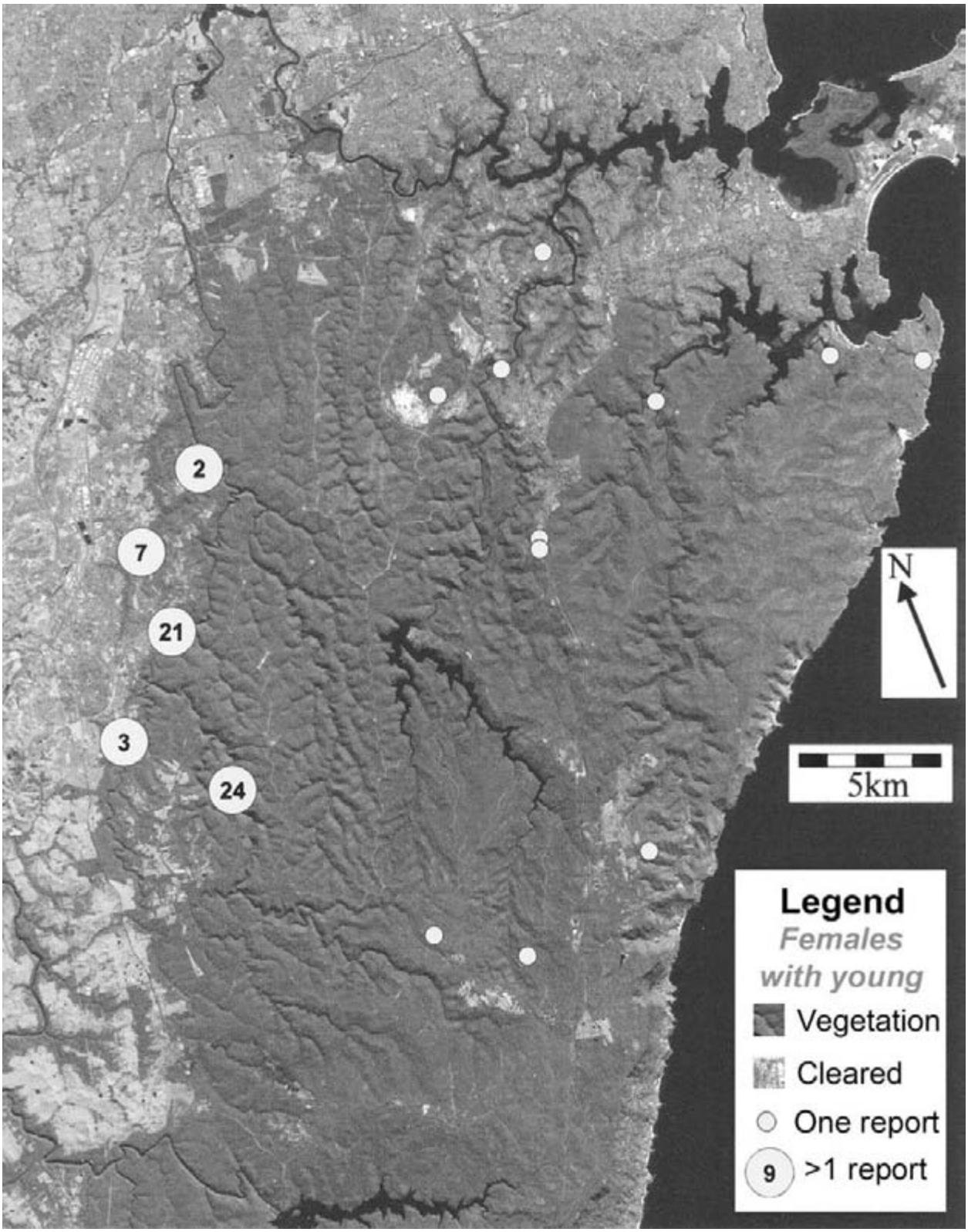

Figure 6. Satellite image with reports of female koalas with young, filtered to remove dubious sightings. A single dot represents one report, while large dots represent more than one report from a 9 km^2 area, with the number of reports shown in the middle of the dot.

eastern side of Campbelltown and west of the Georges River (State Planning Authority of NSW 1973).

We believe, however, that our work in identifying key areas and public education will assist with conserving the population of koalas south of Sydney. Furthermore, we have now developed a large database of sightings for the study region, and to a lesser degree to the south and west. This database will provide useful information for councils, particularly in the preparation and monitoring of Comprehensive Koala Plans of Management, such as for Campbelltown City Council, and also for consultants, community groups, and the Land and Environment Court.

Acknowledgments

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References

Australian Bureau of Statistics 2000. 1996 Census of Population and Housing – Basic Community Profiles: Australia, *AusStats*. Available: http://www.abs.gov.au/websitedbs/d3310108.nsf/f9996d24c8f22d024a256500001c8576/569af0d15c2201964a2565010007a32f?OpenDocument (Accessed: 17th August 2001).

Benson, D. and Howell, J. 1990. *Taken for granted: the bushland of Sydney and its suburbs*. Kangaroo Press, Sydney.

Campbell, P., Prentice, R., McRae, P. 1979. Report on the 1977 Koala Survey. *Wildlife in Australia* **16**: 2-6.

Callaghan, J., Phillips, S., Thompson, J., Curran, T. 1998. Draft Comprehensive Koala Plan of Management: Campbelltown Local Government Area. Australian Koala Foundation, Brisbane.

Campbelltown Council 2001. Rezoning Application – Edge Scenic Protection Lands. P and B Committee Meeting minutes 20/11/2001. Pp 225-241.

Close, R.L. 1993. Campbelltown's koalas: what is their future? *National Parks Journal* **37:** 22-5.

Conacher, P. 2001. Species Impact Statement. Proposed residential development Lot 7034 DP 1018242 and part Lot 8178 DP 881519 Kellerman Drive St Helens Park.

Cork, S.J. and Braithwaite, L.W. 1996. Resource availability, eucalypt chemical defences, and habitat quality for leaf-eating marsupials. Pp 9-16. in *Koalas - Research for Management. Proceedings of the Brisbane Koala symposium, 22nd-23rd September 1990* edited by G. Gordon. World Koala Research Inc., Brisbane.

Cork S.J., Margules C.R. Braithwaite L.W. 1988. A survey of koalas and their habitat near Wedderburn NSW, suggestions for management and an assessment of the potential effects of a proposed subdivision of four hectare lots (A report for Campbelltown City Council). CSIRO Div. of Wildlife and Ecology, Canberra.

Cork, S.J., Margules, C.R., Braithwaite, L.W. 1990. Implications of koala nutrition and the ecology of other arboreal marsupials in south-eastern New South Wales for the conservation management of Koalas. Pp 48-58 in *Koala summit. Managing koalas in New South Wales* edited by D. Lunney, C.A. Urquhart and P. Reed. NSW National Parks and Wildlife Service, Sydney.

Curtin A., Lunney D. and Matthews A. 2002. A survey of a low-density koala population in a major reserve system, near Sydney, New South Wales. *Australian Mammalogy* **23**: 135-44.

Dobson, S. 1990. Can you help us save the koalas at Wedderburn? P.178 in *Koala summit. Managing koalas in New South Wales,* edited by D. Lunney, C.A. Urquhart and P. Reed. NSW National Parks and Wildlife Service, Sydney.

Harris, J. 1999. A foundation for the development of a koala management plan for the Lismore local government area. Honours thesis, Southern Cross University.

Hundloe, T. and Hamilton, C. 1997. *Koalas and Tourism: An Economic Evaluation.* Australian Koala Foundation, Brisbane.

Keith, D. 1994. Floristics, structure and diversity of natural vegetation in the O'Hares Creek catchment, south of Sydney. *Cunninghamia* **3**:543-595.

Lunney, D., Esson, C., Moon, C., Ellis, M, Matthews, A. 1997. A community-based survey of the koala, *Phascolarctos cinereus*, in the Eden region of south-eastern New South Wales. *Wildlife Research* **24:** 111-28.

Lunney, D., Moon, C., Matthews, A. 1996. A 1990 survey of the koala *Phascolarctos cinereus* population at Iluka in northern New South Wales. Pp 102-22 in *Koalas - Research for Management. Proceedings of the Brisbane Koala symposium, 22nd-23rd September 1990* edited by G. Gordon. World Koala Research Inc., Brisbane.

Lunney, D., O'Neill, L., Matthews, A., Coburn, D. 2000. Contribution of community knowledge of vertebrate fauna to management and planning: A case study on the Iluka Peninsula, north coast New South Wales. *Ecological Management and Restoration* **1:** 175-84.

Lunney, D., Phillips, S., Callaghan, J., Coburn, D. 1998. Determining the distribution of koala habitat across a shire as a basis for conservation: a case study from Port Stephens, New South Wales. *Pacific Conservation Biology* **4:** 186-96.

Martin R. and Handasyde K. 1999. *The koala: natural history, conservation and management.* NSW University Press, Sydney.

NSW National Parks and Wildlife Service 2000. *Biodiversity study for the Georges River Catchment. Volume 1: Native Vegetation.* NSW National Parks and Wildlife Service, Sydney.

Patterson, R. 1996. The distribution of koalas in Queensland - 1986 to 1989. Pp75-81 in *Koalas - Research for Management. Proceedings of the Brisbane Koala symposium, 22nd-23rd September 1990* edited by G. Gordon. World Koala Research Inc., Brisbane.

Phillips, S. and Callaghan, J. 2000. Tree species preferences of koalas (*Phascolarctos cinereus*) in the Campbelltown area south-west of Sydney, New South Wales. *Wildlife Research* **27:** 509-16.

Reed, P.C., Lunney, D., Walker, P. 1990. A 1986-87 survey of the koala *Phascolarctos cinereus* (Goldfuss) in New South Wales and an ecological interpretation of its distribution. Pp 55-74 in *Biology of the Koala* edited by A.K. Lee, K.A. Handasyde and G.D. Sanson. Surrey Beatty and Sons Pty Ltd, Sydney.

Smith, P. and Smith, J. 1990. Decline of the urban koala (*Phascolarctos cinereus)* population in Warringah Shire, Sydney. *Australian Zoologist* **26:** 109-29.

Starr, J., Moran, E., Whitehouse, D. 1990. The Port Macquarie experience. Pp 67-8 in *Koala summit. Managing koalas in New South Wales* edited by D. Lunney, C.A. Urquhart and P. Reed. NSW National Parks and Wildlife Service, Sydney.

State Planning Authority of New South Wales 1973. The new cities of Campbelltown Camden Appin Structure Plan.

Threatened Species Conservation Act 1995. New South Wales Act No 101, updated 13 July 2001. *Government Gazette.*

Tilley D. and Uebel K. 1990. Observations of koala populations within the Sydney Water Board's Upper Nepean Region catchment area. Pp 81-4 in *Koala summit. Managing koalas in New South Wales* edited by D. Lunney, C.A. Urquhart and P. Reed. NSW National Parks and Wildlife Service, Sydney.

Ward, S.J. 2002. *Koalas and the Community: A study of low density populations in southern Sydney*. Ph.D. thesis, University of Western Sydney.

Ward, S.J. and Close, R.L. 1998. Community assistance with koala *Phascolarctos cinereus* sightings from a low density population in the south-west Sydney region. Pp 97-102 in *Ecology for Everyone: Communicating Ecology to the Scientists, the Public and the Politicians* edited by R.T. Wills and R.J. Hobbs. Surrey Beatty and Sons, Sydney.

White N.A. and Kunst N.D. 1990. Aspects of the koala ecology of the koala in southeastern Queensland. Pp 109-16 in *Biology of the Koala* edited by A.K. Lee, K.A. Handasyde and G.D. Sanson. Surrey Beatty and Sons Pty Limited, Chipping Norton, NSW.