Out of Reach: New approaches to modelling low-SES access to destinations in Australian cities

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Authors:

1. Rick Evans

2. Matthew Burke

3. Jago Dodson

4. Neil Sipe

Affiliation:

Authors 1, 2 and 3: Urban Research Program, Griffith University, Australia

Author 4: Griffith School of Environment, Griffith University, Australia

Email addresses:

rick.evans@griffith.edu.au

m.burke@griffith.edu.au

j.dodson@griffith.edu.au

n.sipe@griffith.edu.au

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Abstract:

Access to essential goods and services is increasingly recognised as a key factor influencing household socio-economic vulnerability and disadvantage within cities. Socio-economic status and spatial location partly determine differential accessibility. Previously, the access made available to low socio-economic status (SES) groups via the transport system has been conceived subjectively, based on a collective perception of factors that contribute to a disadvantaged household. Further, spatial variation of these low-SES groups across cities, and their travel patterns, are mostly ignored by strategic transport models, which are concerned more with traffic volumes on the road network and peak hour travel. This paper summarises a promising method using cluster analysis techniques to identify low-SES groups on the Gold Coast directly from a large regional household travel survey. This allows for the identification of actual travel behaviour by key low-SES groups. Using this information, the paper then advances a new origin-destination-based land use and transport accessibility model. The model uses outputs from the cluster analysis, in conjunction with 2006 census data, to highlight differential accessibility to goods and service needs for a set of low-SES groups on the Gold Coast. The method being developed provides unique and significant opportunities for research into spatial disadvantage and accessibility in Australian cities. The use of freely available inputs, shrewd conceptualisation of the transport network, and outputs provided at the census collection district level, ensures the model may run concurrently with conventional strategic transport modelling. The method used and the results obtained have clear implications for transport infrastructure and service delivery planning.

Introduction

Accessibility to the goods and services one needs in daily life is a fundamental aspect of human health and well-being, particularly for people with limited opportunities, low incomes or physical disabilities (Vandenbulcke, Steenberghen and Thomas 2009:39). This paper derives from an Australian Research Council - Linkage project (LP0775236) exploring transport accessibility for low socio-economic status (low-SES) groups on Queensland's Gold Coast. This paper focuses on low-SES population groups found on the Gold Coast, their location within the city, and their most commonly accessed destinations. These are key elements in operationalising a useful accessibility model, which improves the understanding of urban structural factors (e.g. spatial mismatches) that increase the vulnerability of population groups, and subsequently assist governments to better align transport services with socio-economic needs.

Key aspects of our work are beyond the scope of this paper. In particular, the method and results of a series of cluster analyses performed to identify a set of low-SES groups on the Gold Coast, and aspects of the methodology of the accessibility model, are not discussed in full detail here (please see Dodson et al. (2009) for an expanded account).

This paper is arranged as follows. First we provide a brief definition of accessibility, our method and the study area. The summary results of the low-SES group identification process are provided, identifying four key groups. The residential locations on the Gold Coast where these groups are over-represented are then identified and mapped using ABS census data. The services/destinations that these groups most commonly access are identified from household travel survey data. Then the physical locations of such services/destinations on the Gold Coast are mapped, using secondary sources. This information (low-SES residential location, travel behaviour and destination location) are then modelled using the pedestrian, and public transport networks. The results are presented for each low-SES group.

The method we are developing demonstrates a new approach to assessing the vulnerability of low-SES groups to transport disadvantage. By using only freely available inputs, by conceptualising the

transport network in a shrewd fashion, and by providing outputs at the Census Collection District (CCD) level, this model may be run concurrently with conventional strategic transport modelling.

Defining accessibility

The definition of accessibility is generally accepted as the ease of reaching key services from a point or several points of origin (Halden, Jones and Wixey 2005). However, simply defining accessibility across a population can be difficult due to the differing circumstances of each individual. It is important to adopt a holistic view of accessibility, wherein people can "get to key services at a reasonable cost, in reasonable time and with reasonable ease" (Social Exclusion Unit 2003:1). This infers a nexus between the transport system and the distribution of destinations, within the city. Applying this approach to low-SES groups highlights the need to ensure adequate modal choice, apart from the motor vehicle, when accessing key services. There is also a need to empirically define which services/destinations are those that are important to low-SES groups.

This paper highlights an approach to measure accessibility using pedestrian and public transport networks. We defined accessibility as the ability to access key services, relevant to each user group, by means other than the private motor vehicle. Accessibility is measured from low-SES CCDs on the Gold Coast, to the key services which are most commonly accessed by each of the low-SES groups.

Method

Assessing low-SES groups' accessibility to key services on the Gold Coast requires four interlinked research activities, as follows:

1. A set of low-SES groups on the Gold Coast are identified. A cluster analysis technique is used on individual record data from the *South East Queensland Travel Survey 2003-04 – Coastal Survey (SEQTS-CS)*, which includes a set of socio-demographic and transport indicators.
2. The locations where low-SES groups are over-represented on the Gold Coast are identified and mapped. The characteristics attributed to low-SES groups from the cluster analysis are

applied to Australian Bureau of Statistics (ABS) 2006 Census data to locate low-SES group concentrations on the Gold Coast.

3. Key services/destinations for each low-SES group are identified. The most common services/destinations that are accessed by each low-SES group are calculated using the *SEQTS-CS* travel survey. These services/destinations are then located and geocoded.
4. The outputs above are operationalised in an origin-destination-based accessibility model. This involves assigning an origin-destination cost matrix, applied to low-SES group locations and key services, to define each group's accessibility via available transport networks. Travel time is measured across the pedestrian and public transport network. These networks are developed from 2009 road and path network, and public transport route and stop information for the Gold Coast provided by the Department of Transport and Main Roads and by Translink.

Study area overview

This research draws on work undertaken as part of an ARC Linkage Grant (LP0775236) investigating transport accessibility for disadvantaged households on the Gold Coast. The Gold Coast, located south of Brisbane in Queensland on the New South Wales border, was chosen for this study because it is Australia's sixth largest municipality and the second-fastest growing metropolitan area but has received relatively limited attention from urban researchers. At the 2006 Census the Gold Coast population was just over 400,000, with projections that around an extra 320,000 people will move into the area in the next 25 years (DIP 2008). Spatially the Gold Coast urban area is linear, predominantly running along the coast. It is defined by two major north-south arterial roads with the Gold Coast Highway running along the coast and the Pacific Motorway running towards the western edge of the current urban area.

The Gold Coast is highly dispersed and heavily car dependent with fewer than five percent of trips undertaken by public transport. Private motor vehicle travel dominates the transport landscape on the Gold Coast, accounting for 85.8% of all weekday trips made in 2004 (Dodson et al. 2009). In addition, persons on the Gold Coast on average travel over 32km per day, with 29km by private motor vehicle. Public transport is provided primarily by scheduled bus and school bus services (3.3% of weekday

trips), and by the rail line from Robina to Brisbane (0.7%). Walking accounts for 8.0% of weekday trips, and cycling for only 1.5%. Even compared to other Australian and New Zealand cities, the Gold Coast is particularly car dependent (see Vivier 2001).

Previous studies have shown that the Gold Coast features socio-economic disadvantage, with limited access to alternative forms of transport. A Gold Coast City Council (GCCC) (2003) report indicates that higher levels of disadvantage exist in areas of the Gold Coast relative to other parts of Queensland and Australia. Taylor (1997) identified spatial differences in socio-economic disadvantage across the Gold Coast through the use of ABS Census data and the Socio-Economic Indexes for Areas (SEIFA) highlighting locations such as Coolangatta and Nerang as sites of disadvantage. Dodson et al. (2007) provide an indication of the difficulty that low-SES groups on the Gold Coast have in accessing health and employment clusters using alternative modes to the motor vehicle.

Identifying low-SES groups on the Gold Coast through cluster analysis

Low-SES groups on the Gold Coast in this paper are identified using a cluster analysis technique on the *South East Queensland Travel Survey 2003-04 – Coastal Survey (SEQTS-CS)*. The *SEQTS-CS* itself used a multi-stage, variable-proportion, clustered sampling of households within CCDs within 10 regions. The *SEQTS-CS* achieved a response rate of 55% and obtained information on the travel behaviour of 3,763 respondents living in 1,473 households. Diaries were completed by respondents aged 5 and over with diaries reconstructed for children aged 0-4. *SEQTS-CS* respondents completed travel diaries for a single weekday during the period October-December 2004. In total 13,024 trip stages were recorded for the Gold Coast survey area. Respondent's exact travel routes are not captured in the survey, with trip distances calculated using shortest path algorithms in GIS via the available street and path network. In the *SEQTS-CS*, motor vehicles are defined either as a car, 4WD, van, or truck (Queensland Transport et al. 2005:87-89,133-134).

The use of a cluster analysis technique enables the classification of low-SES groups without preconceptions of their defining attributes. Cluster analysis, described in Ryley (2006) and Hair et al. (1998), is a non-discriminant multivariate technique used to group cases based on the characteristics

they possess. It allows analysis without any preconceptions of the composition of groups, although the identification of the resulting groups is subjective.

Low-SES groups are identified by a similar method to Ryley (2006), using nine categorical variables (age, gender, main activity, household size, household type, household structure, household income, and ability to drive) from individual unit records of the *SEQTS-CS.* It is these nine dataset variables that are perceived to influence whether a person is socio-economically disadvantaged. The cluster analysis identified six low-SES groups, of which only four could be analysed and modelled due to dataset limitations[1]. Table 1 provides summary characteristics of the four low-SES groups included in our analysis and modelling.

Table 1: Disadvantaged groups identified using cluster analysis ← INSERT HERE

Group A (known henceforth as *Single Parent Families*) represents single parent households on a sole low-middle income, and are either renting or currently paying off a mortgage. This group is significantly disadvantaged due to the financial burdens of raising children and paying either rent or a mortgage (i.e. do not own their own home), without high income support. *Group B* (*Low Income Couples*) represents persons who are living with a partner and currently have no children. Persons in this group are employed, but are either the sole-supporting income for the household, or both persons' combined income falls into the low-middle income bracket. Their household income is relatively similar to *Single Parent Families*, and they too have the financial burden of renting or paying off a mortgage without high income support. *Group C* (*Licensed Widows*) represents single retired females, most likely widowed, who are living alone on a low income, which is mainly a pension. This group however still has the ability to use a private motor vehicle, which while potentially increasing their mobility, could also increase pressure on their budget through higher transport costs. *Group D* (*Unlicensed Widows*) is similar to *Licensed Widows*, except this group of single retired females does not have the ability to use a private motor vehicle. They are also living alone on a low income, which is mainly a pension. This group should find it more difficult than any of the other five groups to access facilities, with no partner or other household member to provide transport.

Licensed and *Unlicensed Widows*[2] provide an interesting comparison for examining differences between similar groups, one of which is able to use a private motor vehicle and the other having to rely on alternative modes.

Mapping low-SES groups on the Gold Coast

With the four low-SES groups defined, concentrations of these groups on the Gold Coast are identified. Each group's characteristics, derived from the cluster analysis, are applied to the ABS 2006 Census to identify all CCDs where a concentration of low-SES persons exists. These concentrations are defined by *i)* having at least 30 members of a low-SES group resident within the CCD, and *ii)* the low-SES group represents at least 10% of the total population within the CCD.

Table 2 displays for each of the four groups the number of 'low-SES CCDs' identified and the number of low-SES persons in these CCDs. A comparison between the selected low-SES CCDs and the Gold Coast overall is also provided. Note there are significantly less CCDs identified for *Single Parent Families* than the other three groups. Figures 1-4 map the low-SES CCDs for the Gold Coast local government area.

Table 2: Number of low-SES CCDs and low-SES persons, compared with Gold Coast overall ← INSERT HERE

The low-SES CCDs identified as concentrations of *Single Parent Families* are located along the Pacific Motorway to the west of the urban area. These areas are relatively new and have mostly developed in the last twenty years. The Gold Coast housing market features a steep decline from expensive coastal land towards the western hinterland, and housing affordability has limited single-parent low-middle income households to these locations. The CCDs selected for *Low Income Couples* are distributed further towards the coastal strip than *Single Parent Families*. However, most of these CCDs fall in areas without waterfront access property or high-rise development. In general household income in these areas is lower than the Gold Coast overall. The CCDs for *Licensed Widows* are typically in older, more established areas of the Gold Coast, including Labrador, Southport and Palm Beach. Many of these locations do not feature any form of supported accommodation, but are located

near the higher-quality public transport services that run north-south near the shoreline. The CCDs for *Unlicensed Widows* tend to be around areas where more health facilities are located, such as hospitals, and in locations where there is often supported accommodation.

Figure 1: Location of low-SES CCDs for Single Parent Families ← INSERT HERE

Figure 2: Location of low-SES CCDs for Low Income Couples ← INSERT HERE

Figure 3: Location of low-SES CCDs for Licensed Widows ← INSERT HERE

Figure 4: Location of low-SES CCDs for Unlicensed Widows ← INSERT HERE

Mapping services commonly accessed by low-SES groups

Our approach has been to select services/destinations for accessibility modelling based on observed travel behaviour of the identified low-SES groups, which is derived from household travel survey data. Examining trip purpose for each group, based on trip record data from the *SEQTS-CS*, allows for the identification of key services/destinations. Excluding trips to homes, the three most commonly accessed destinations are listed in Table 3, noting the percentage of all trips made by the group to these destinations.

Table 3: Low-SES groups' most commonly accessed destinations ← INSERT HERE

Employment services

The single biggest trip generator for *Single Parent Families* and *Low Income Couples* is employment. Industry occupation breakdowns from the ABS 2006 Census for each group are then used to determine employment locations. This identified five industry occupation categories that constituted the majority of employment for both *Single Parent Families* and *Low Income Couples*, namely:

- retail trade;
- construction;
- manufacturing;
- accommodation and food services; and
- health care and social assistance.

Identifying thse employment locations on the Gold Coast requires the use of ABS 2006 Census Working Population Profile (WPP), where Statistical Local Areas (SLAs) above the median value of total persons employed in the five categories are selected and mapped.

Retail services

Trips to retail locations are the only service to feature in all four groups. More than 54% of retail trips in the *SEQTS-CS* were to supermarkets or grocery stores. For the purposes of the accessibility analysis, only supermarkets and local grocery stores are geocoded using the data source 'Australia on Disc'[3] (United Directory Systems, 2009).

Health services

Licensed and *Unlicensed Widows* both have significant proportions of trips to health services such as general practitioners and hospitals. Three health service types are geocoded for this analysis, with 'Australia on Disc' also used for locating these services. These health types are categorised into three levels of service:

- Access to general practitioners (GPs) only (a minimum level of health service)
- Access to a health cluster, where a minimum of a GP, chemist and pathologist exist within a single CCD (a higher level of health service)
- Access to a hospital (optimal level of health service)

Education services

Single Parent Families are the only group to have a significant proportion of trips to education services. Education services here refer to trips to primary and secondary schools, generally where at least one dependent in the household requires transport to an education facility. Primary and secondary schools are also mapped using 'Australia on Disc'. The schools used for the accessibility analysis included all government and non-government (Catholic) primary schools, and only state secondary schools. All other schools were excluded.

Other services

Due to their diffuse nature, three of the destinations (Personal services for *Low Income Couples*, Recreational for *Licensed Widows*, and Social for *Unlicensed Widows*) are not mapped for the analysis. This is because each of these services covers a broad array of services/destination types.

Calculate travel length and accessibility

Accessibility in this analysis is conceived in terms of travel time, rather than actual distance travelled, on the pedestrian and public transport networks for each group. These networks are operationalised within ArcGIS. The pedestrian network is based on the road network, excluding some road types due to pedestrian inaccessibility, and with the addition of a set of key known pedestrian links. Travel times distance based upon a walking speed of 4km/h is assigned on accessible parts of the road network.

The public transport network is derived from a combination of the pedestrian network and route and stop public transport data. Travel on the public transport network requires all trip origins and destinations to be accessed from the pedestrian network, with walk access and egress to/from public transport nodes. The public transport network allowed any number of public transport transfers to be made across the system. Travel speeds assumed for the public transport network are calculated as follows:

- Walking to and from public transport services calculated by pedestrian network (walking speed 4km/h);
- Travel speeds on public transport services are based on public transport stop temporal data for each route, which provides an average speed of each route; and
- Wait and transfer times (impedance function) between the pedestrian network and public transport, which is set at 7.5 minutes.

Note that our assumptions in simplifying the public transport network includes not accounting for bus routes that loop or backtrack, or for variations in the frequencies of daily or weekend services.

Origin-destination cost matrix

Since points of origin (low-SES CCDs) are defined for this analysis the accessibility model can use an OD cost matrix instead of a destination-based service area accessibility analysis that is typically used when defining accessibility. Origins within the cost matrix represented the low-SES CCDs. Distances for these groups are measured from the centroid of the CCD, snapped to the nearest road intersection. Destinations within the cost matrix represented each group's most commonly accessed destinations. For all services except employment, the geocoded service locations are allocated to the centroid of the CCD they fall within, and snapped to the nearest road intersection. Employment service locations are allocated to the centroid of the SLA, and snapped to the nearest road intersection.

Limitations

The method is subject to limitations common to the datasets used (including the household travel survey data, ABS Census data, road and public transport network data, etc.) as well as a number of problems specific to this research. As in many analyses, each dataset used was produced at different time periods with some spatial boundary variations. In particular, the *SEQTS-CS* dataset used for identifying low-SES CCDs and their most commonly accessed key services was created in 2004 using ABS 2001 Census boundaries. The survey boundaries excluded the northern part of the current Gold Coast local government area (i.e. Ormeau). Due to the dataset availability, the road and public transport networks are restricted to Queensland only. With the exception of locations in New South Wales, this limitation is partly resolved by including services/destinations within 10 kilometres of the Gold Coast LGA to accommodate for the potential of cross boundary travel. But perhaps one of the most interesting limitations relates to our conception of the public transport network, including the pedestrian walk access/egress trips, and using only one network for modelling purposes. This produced some results whereby a 'public transport' trip from an origin to a destination could be undertaken solely by walking. Almost all 'public transport' trips between origins and destinations of 10 minutes or less are of this form and therefore need to be considered when interpreting the results, below.

Results

Tables 4 to 7 present the results for each of the four identified low-SES groups on the Gold Coast. Six timeframes are used to display the number of low-SES CCDs within a specified travel time of the key service. Travel time thresholds selected relate to 'common conceptions' of personal travel, as follows:

- 5 minutes or less;
- More than 5 minutes but less than or equal to 10 minutes;
- More than 10 minutes but less than or equal to 15 minutes;
- More than 15 minutes but less than or equal to 30 minutes;
- More than 30 minutes but less than or equal to 60 minutes; and
- More than 60 minutes.

For the purpose of the analysis walk travel times of 10 minutes or less are seen as optimal, 15 minutes or less are seen as satisfactory. Walking times in excess of 15 minutes are deemed unsatisfactory. Public transport travel times of less than 30 minutes are seen as optimal, with trips between 30 and 60 minutes satisfactory and trips in excess of 60 minutes unsatisfactory.

Out of the ten *Single Parent Families* CCDs none reached the satisfactory level of pedestrian access to employment, and only seven of the ten locations achieve optimal public transport access (see Table 4). Three CCDs in Coomera, Upper Coomera and Elanora only achieved satisfactory public transport access. These results reflect the dispersed nature of employment locations in key categories on the Gold Coast. However, this group has better access to retail with nine out of ten locations reaching optimal pedestrian or public transport access, with the other location at Elanora achieving satisfactory public transport access. While pedestrian access to education is relatively poor with only one reaching optimal pedestrian access, eight out of ten locations have optimal public transport access to education, and the other location in Elanora has satisfactory public transport access.

Table 4: Single Parent Families travel time analysis to nearest key service ← INSERT HERE

The 57 CCDs where *Low Income Couples* is over-represented fare somewhat better than *Single Parent Families* in their access to employment and retail (see Table 5). 39 of the 57 locations achieve optimal pedestrian and public transport access to employment, with two locations in Mount Nathan and Lower Beechmont failing to achieve satisfactory pedestrian or public transport access. This result effectively forces *Low Income Couples* to use a motor vehicle to access employment. Also, 50 locations had optimal pedestrian or public transport access to retail, with two locations in Mount Nathan and Lower Beechmont failing to achieve satisfactory levels of access.

Table 5: Low Income Couples travel time analysis to nearest key service ← INSERT HERE

Out of the 49 *Licensed Widows* CCDs ten reached optimal pedestrian access to retail, with a further 35 reaching optimal public transport access (see Table 6). However, four locations only achieve satisfactory public transport access to retail, resulting in more than 30 minute journeys to supermarkets or grocery stores. This group has relatively good access to base level health services (GPs), with 45 locations reaching either optimal pedestrian or public transport access, although again four locations only achieve satisfactory public transport access to GPs. Their access to health clusters is slightly less than to GPs, with only nine locations achieving satisfactory access by public transport and one location in Ormeau having unsatisfactory access. This group has even less public transport access to hospitals, with the location in Ormeau having unsatisfactory access.

Table 6: Licensed Widows travel time analysis to nearest key service ← INSERT HERE

The 25 locations where *Unlicensed Widows* is over-represented achieve better results than *Licensed Widows* for pedestrian and public transport access to the same services (see Table 7). Notably, all 25 locations achieve optimal pedestrian or public transport access to retail *and* to GPs. Again, *Unlicensed Widows* had slightly less access to health clusters than to GPs, with three locations in Coombabah and Paradise Point only achieving satisfactory public transport access to these services. Four locations had optimal pedestrian access to hospitals, 17 optimal public transport access, and four locations in Coombabah, Paradise Point and Miami only satisfactory public transport access – but no locations failed to achieve satisfactory access.

Table 7: Unlicensed Widows travel time analysis to nearest key service ← INSERT HERE

Conclusion

The method described here demonstrates the possibilities of identifying low-SES groups and their travel behaviour from household travel survey datasets, identifying the locations where those groups are over-represented in a city, and then determining their levels of transport access to the key services/destinations to which they actually travel. The use of a non-discriminate cluster analysis to empirically define low SES groups and their most commonly accessed services builds on the work by Taylor (1997) and Dodson et al (2007). It allows this method to examine each group's accessibility without preconceptions of who is disadvantaged and which services are seen as essential. Though there are refinements needed to our method, and these are only preliminary results, there are numerous advantages of this approach. The use of freely available inputs for origins and destinations in the accessibility analysis is an advance. Using 'Australia on Disk' saves time and money gathering extensive data on the location of shops, GPs or other land uses. Further, by conceptualising the transport network in a shrewd fashion and by providing outputs at the census collection district level, this model may also be run concurrently with conventional strategic transport modelling.

There are several limitations of this research that are resolvable via further work. These include developing a refined set of public transport, pedestrian and also car accessibility measures, derived directly from household travel survey data; incorporating service choices to better reflect opportunities within the accessibility modelling; developing a car access model to complement the pedestrian and public transport models, using available travel speed and intersection delay parameters from strategic transport models; and improving the public transport accessibility analysis to resolve problems of short trips. These tasks inform our current work program.

Acknowledgements

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Table 1: Disadvantaged groups identified using cluster analysis

Group	Characteristics
A	Single parent households Employed With children Low-middle income Renting or with a mortgage
B	Employed Living with a partner No children Low-middle income Renting or with a mortgage
C	Single Retired Female Living alone Low income With a licence
D	Single Retired Female Living alone Low income Without a licence

Table 2: Number of low-SES CCDs and low-SES persons, compared with Gold Coast overall

	Single Parent Families	Low Income Couples	Licensed Widows	Unlicensed Widows
Identified Low-SES CCDs				
No. of Low-SES CCDs	10	57	49	25
Low-SES population within these CCDs	353	2119	2565	1131
Low-SES population as a % of total population within these CCDs	11.8%	11.7%	16.1%	14.6%
Gold Coast Local Government Area				
Low-SES population	6094	14288	9777	5532
Low-SES population as a % of total population	3.3%	7.8%	5.4%	3.0%

Figure 1: Location of low-SES CCDs for Single Parent Families

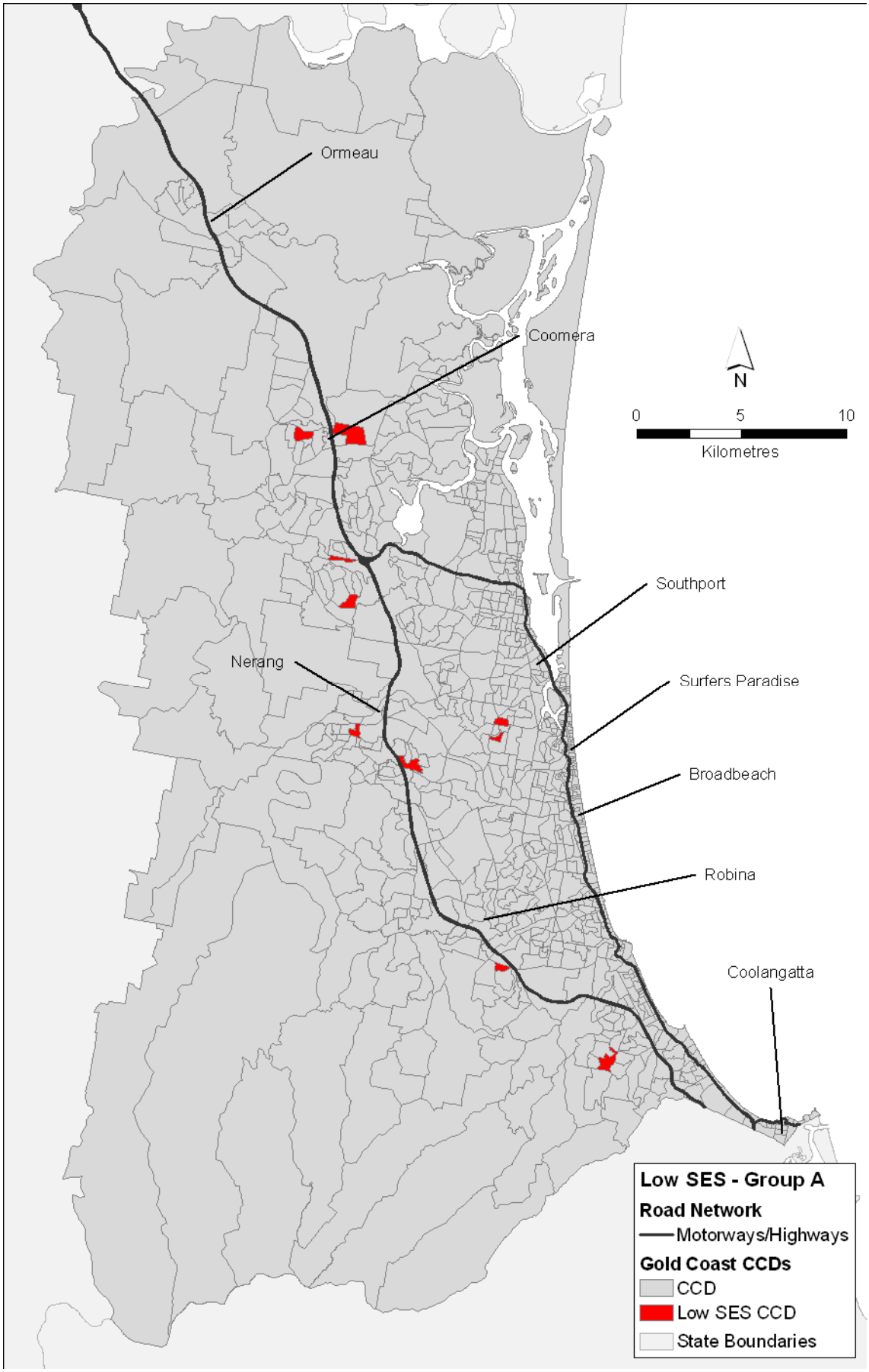

Figure 2: Location of low-SES CCDs for Low Income Couples

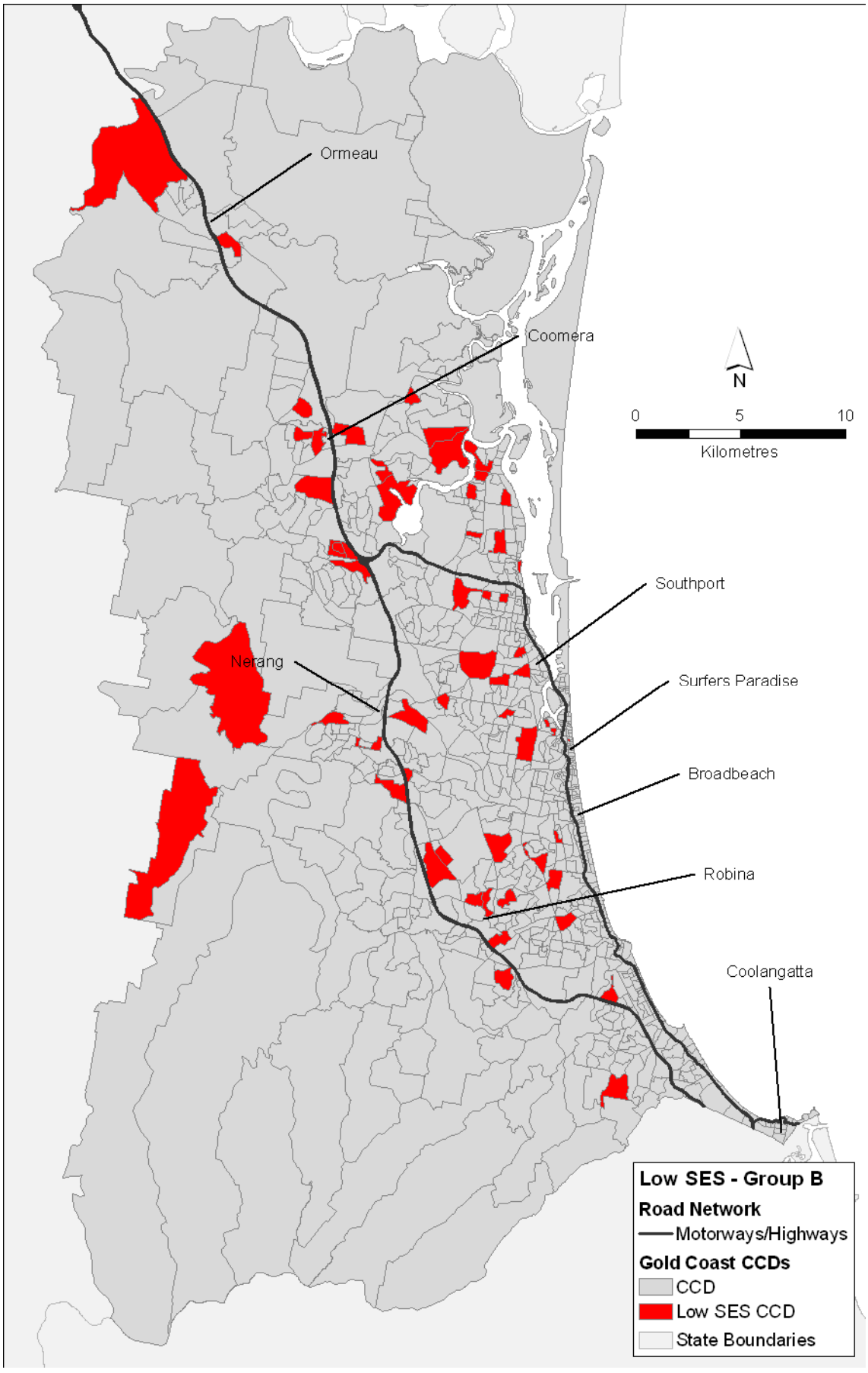

Figure 3: Location of low-SES CCDs for Licensed Widows

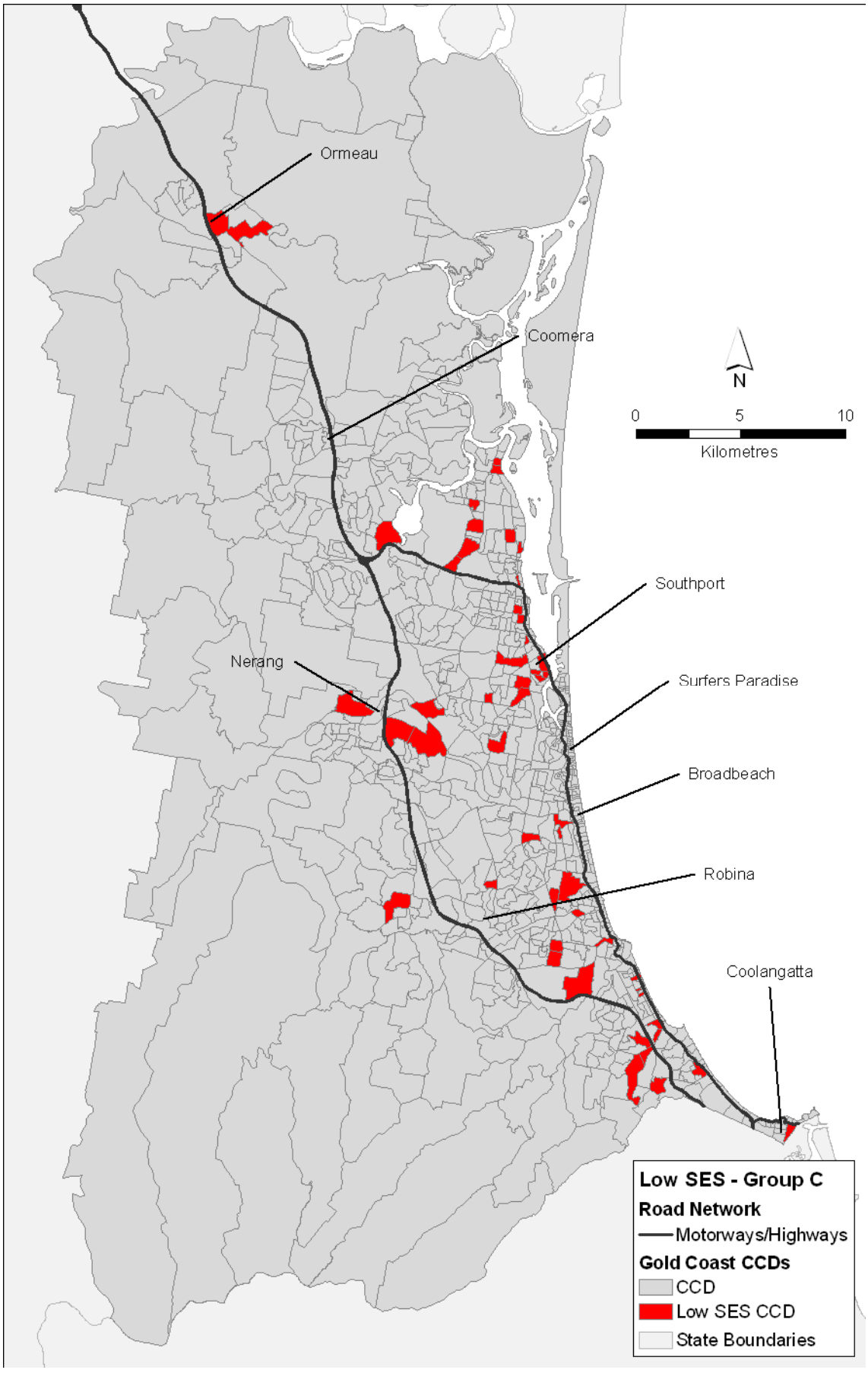

Figure 4: Location of low-SES CCDs for Unlicensed Widows

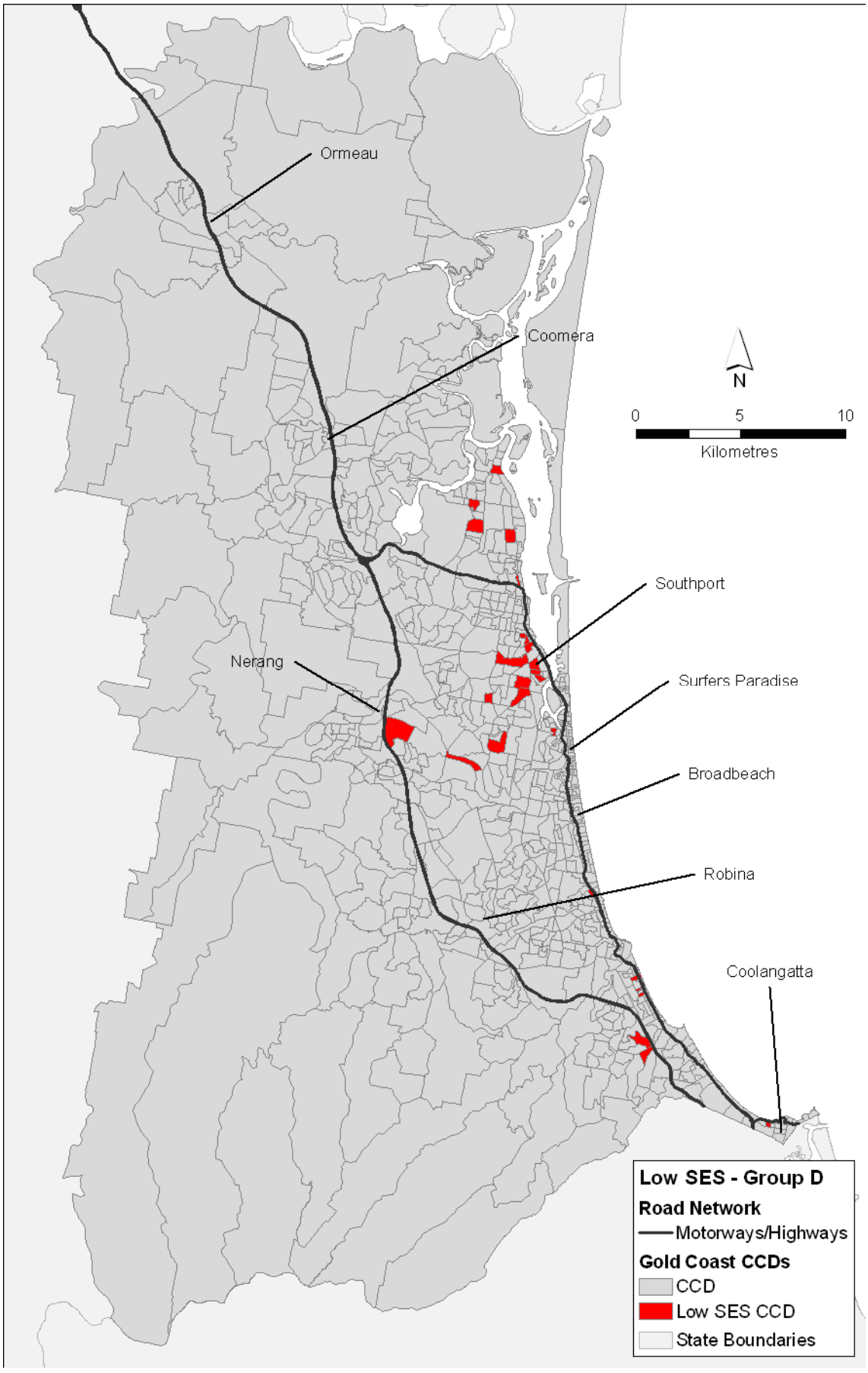

Table 3: Low-SES groups' most commonly accessed destinations

Single Parent Families	Low Income Couples	Licensed Widows	Unlicensed Widows
Employment (35.06%)	Employment (46.69%)	Retail (43.42%)	Retail (53.11%)
Education (27.67%)	Retail (28.35%)	Health (12.67%)	Social (10.46%)
Retail (18.14%)	Personal services (7.17%)	Recreational (10.76%)	Health (6.25%)

Table 4: Single Parent Families travel time analysis to nearest key service

	Number of CCDs able to reach nearest key service within specified travel time					
Employment	5 minutes or less	5 to 10 minutes	10 to 15 minutes	15 to 30 minutes	30 to 60 minutes	More than 60 minutes
Pedestrian	0	0	0	2	3	5
Public transport	0	0	0	7	3	0
Retail	5 minutes or less	5 to 10 minutes	10 to 15 minutes	15 to 30 minutes	30 to 60 minutes	More than 60 minutes
Pedestrian	1	1	1	2	3	2
Public transport	1	1	1	6	1	0
Education	5 minutes or less	5 to 10 minutes	10 to 15 minutes	15 to 30 minutes	30 to 60 minutes	More than 60 minutes
Pedestrian	1	0	1	6	2	0
Public transport	1	0	1	7	1	0

Table 5: Low Income Couples travel time analysis to nearest key service

	Number of CCDs able to reach nearest key service within specified travel time					
Employment	5 minutes or less	5 to 10 minutes	10 to 15 minutes	15 to 30 minutes	30 to 60 minutes	More than 60 minutes
Pedestrian	2	3	3	8	16	25
Public transport	2	3	4	30	16	2
Retail	5 minutes or less	5 to 10 minutes	10 to 15 minutes	15 to 30 minutes	30 to 60 minutes	More than 60 minutes
Pedestrian	5	1	6	16	15	14
Public transport	5	1	7	33	9	2

Table 6: Licensed Widows travel time analysis to nearest key service

	Number of CCDs able to reach nearest key service within specified travel time					
Retail	5 minutes or less	5 to 10 minutes	10 to 15 minutes	15 to 30 minutes	30 to 60 minutes	More than 60 minutes
Pedestrian	8	2	8	15	15	1
Public transport	8	2	8	27	4	0
Health (GP)	5 minutes or less	5 to 10 minutes	10 to 15 minutes	15 to 30 minutes	30 to 60 minutes	More than 60 minutes
Pedestrian	20	6	3	11	8	1
Public transport	20	6	4	15	4	0
Health (Cluster)	5 minutes or less	5 to 10 minutes	10 to 15 minutes	15 to 30 minutes	30 to 60 minutes	More than 60 minutes
Pedestrian	2	1	3	11	15	17
Public transport	2	1	4	32	9	1
Health (Hospital)	5 minutes or less	5 to 10 minutes	10 to 15 minutes	15 to 30 minutes	30 to 60 minutes	More than 60 minutes
Pedestrian	3	1	3	4	8	30
Public transport	3	1	3	20	21	1

Table 7: Unlicensed Widows travel time analysis to nearest key service

	Number of CCDs able to reach nearest key service within specified travel time					
Retail	5 minutes or less	5 to 10 minutes	10 to 15 minutes	15 to 30 minutes	30 to 60 minutes	More than 60 minutes
Pedestrian	3	6	4	8	3	1
Public transport	3	6	4	12	0	0
Health (GP)	5 minutes or less	5 to 10 minutes	10 to 15 minutes	15 to 30 minutes	30 to 60 minutes	More than 60 minutes
Pedestrian	10	5	3	5	1	1
Public transport	10	5	3	7	0	0
Health (Cluster)	5 minutes or less	5 to 10 minutes	10 to 15 minutes	15 to 30 minutes	30 to 60 minutes	More than 60 minutes
Pedestrian	1	2	3	6	6	7
Public transport	1	2	3	16	3	0
Health (Hospital)	5 minutes or less	5 to 10 minutes	10 to 15 minutes	15 to 30 minutes	30 to 60 minutes	More than 60 minutes
Pedestrian	2	2	3	3	5	10
Public transport	2	2	3	14	4	0

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Endnotes

[1] The two excluded groups were characterised by i) students in late secondary and tertiary education without a license (*Students*), and ii) by members of low-middle income retired-couple households who are without a license (*Retired couples*). We are examining transport accessibility for these groups. However due to particularities in their travel behaviours, and the absence of license-holding information in the ABS Census, they require slightly different approaches, and could not be adequately covered in this paper.

[2] The use of the term 'widows' for both *Licensed Widows* and *Unlicensed Widows* is a generalised and may not apply to all persons within these groups.

[3] 'Australia on Disc' is a commercially available electronic business directory with businesses categorised into both Standard Industry Classification (SIC) and Australian and New Zealand Standard Industrial Classification (ANZSIC). It offers a broad coverage of most services/destinations with the advantages of being both affordable and readily available.