DESERT KNOWLEDGE CRC

Mapping Socio-regions in Outback Australia

Yiheyis Maru
Vanessa Chewings
Mitchell Jones
Joseph Breen

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Abbreviations/Acronyms

ABS	Australian Bureau of Statistics
ARIA	Accessibility/Remoteness Index of Australia
ASFR	Age-specific Fertility Rate
ASGC	Australian Standard Geographical Classification
BRS	Bureau of Resource Sciences
CD	Collection District
CRC	Cooperative Research Centre
CV	Coefficient of Variation
DIS	Demographic Information System
DOHA	Department of Health and Ageing
DSS	Decision Support System
ER	Entity Relationship
ERP	Estimated Resident Population
FIFO	Fly In/Fly Out
IBRA	Interim Biogeographic Regionalisation for Australia
LGA	Local Government Area
NDVI	Normalised Differential Vegetation Index
PES	Post-enumeration survey
SEIFA	Index of relative socio-economic advantage/disadvantage
SLA	Statistical Local Area
SLF	Sustainable Livelihoods Framework
TSCRC	Tropical Savannas Cooperative Research Centre
UCL	Urban Centre or Locality
UR	Usual Residence

Executive summary

Outback settlements are markedly different from their coastal counterparts in terms of their socio-cultural, economic, demographic and environmental characteristics. Differences are also strong between outback settlements, although they share some basic characteristics. The population size distribution of outback settlements is markedly clumped. There are a small number of major service centres (population 20,000 to 30,000) as well as a much larger number of settlements that are two orders of magnitude smaller (i.e. population <200–500) and which have very different socio-economic characteristics. Standard regionalisation procedures mask this pattern and its significance for analysis. Standard procedures also take state/territory borders as hard boundaries, disguising the significance of cross border similarities and relationships. These differences have been a major challenge to regional policy making, research and investment decisions.

In this study, we have classified and mapped settlements into socio-regions. The study has considered a UCL (Urban Centre or Locality – a settlement with 200 or more people) as a basic unit for analysis. There are 222 UCLs in the rangelands excluding Darwin. A preliminary hinterland boundary or socio-region was created for each UCL as spatial mapping units. This process was primarily based on similarities and differences of key demographic and socio-economic indicators. Indicators of ecological characteristics were also considered in mapping the socio-regions.

There were three major insights gained from this study. The first relates to approaches used for creating UCL hinterland boundaries. In the absence of existing examples, an ArcINFO based technique was used to derive population-weighted hinterland boundaries for each UCL. The second insight relates to strong differences among UCLs in the rangelands making socio-regionalisation a challenge. Comparative analyses of indicators over all the UCLs indicate a threshold for population size (~ 5000), beyond which characteristics of the UCLs seems to stabilise. By contrast, there is a dramatic increase in the variability of indicator values for UCLs with population size below this threshold. In other words, UCLs with less than 5000 people show larger variability around a central tendency measure than the urban centres with a population greater than 5000. This high variation confirms the need to consider statistical units smaller than the Statistical Local Area (SLA). Using rangelands SLAs, other traditional regionalisation techniques aggregate and average indicator values over several socio-economically and culturally diverse smaller units. The high variability observed among the small population UCLs suggests that they have more diverse research, policy and investment needs than the larger urban centres.

The third insight involves looking at regions differently using a non-traditional perspective. The UCLs with a lower population than the threshold can be grouped into some significantly similar clusters forming a non-traditional region. These groups may cross traditional administrative borders and often form non-contiguous regions. The outcome is a very different geography of desert Australia than is presented through standard regionalisation, but one that better represents its characteristics. A geography based on these characteristics is likely to be invaluable when selecting case study areas for research projects, and, in the long term, other investment initiatives.

1. INTRODUCTION

Research background

This study initially arose from a research investment question related to a joint Desert Knowledge CRC and Tropical Savannas CRC project on understanding outback livelihoods. The linked social-ecological systems research project needed to know *how representative or strategically located were the case study areas*. This issue of conducting representative or strategically important socio-ecological research is challenging for many researchers as well as agencies involved in policy making and public investment decisions in outback regions.

The fundamental reason for this is that outback settlements are markedly different from their coastal counterparts in many socio-cultural, economic, demographic and environmental characteristics. Differences are also strong among outback settlements, although they share some basic characteristics.

Aggregated data for statistical areas such as Statistical Local Areas (SLAs) or other administrative regions provide a poor basis for understanding the socio-economic characteristics of desert regions. One reason is that the distribution of outback settlement sizes is markedly clumped with a small number of service centres (population 20,000 to 30,000) and a much larger number of settlements that are two orders of magnitude smaller (i.e. populations <200–500) and that have very different socio-economic characteristics. This is not obvious when standard regionalisation based on geography and population (both statistical and administrative regions) are used for analyses. Standard regionalisation also takes state/territory borders as hard boundaries, disguising the significance of cross jurisdiction similarities and relationships.

Other regionalisation schemes such as IBRA (Interim Biogeographical Regionalisation of Australia) (Environment Australia 2000), stronger regions (DoTARS 2001, Australian Local Government Association and National Economics 2004, Government of South Australia 2005), functional regions (Taylor 2003) and Indigenous language regions have respective ecological, administrative, economic, service and cultural focus and are not appropriate for a linked social-ecological analysis. There have been a few attempts to address this problem and reclassify the rangelands. Some of these methods are compared in Table 1.

Table 1: Comparison of methods used to characterise rangelands.

Characteristic	Socio-region study	Taylor 2003	Stafford Smith *et al*. (nd)	Holmes 1997
Smallest spatial analysis unit	Urban Centre/Locality (UCL)	Catchment area of Indigenous communities around each service town	Statistical Local Area (SLA)	Statistical Local Area (SLA)
Geographic extent	New (Nov, 2005) ACRIS boundaries for the rangelands	Remote inland Australia	Rangelands SLA boundaries, excluding Cairns	Rangelands SLA boundaries
Number of areas	222 UCLs	35 population catchments to service centres as functional regions in Northern Territory.	107 SLAs	29 regions
Data currency	2001 Census	1999	1996 Census	

Table 1 continued.

Characteristic	Socio-region study	Taylor 2003	Stafford Smith et al. (nd)	Holmes 1997
Socioeconomic data sources	1999 ABS Community Housing and Infrastructure Needs Survey (CHINS)		ABS Integrated Regional Database; ABARE surveys	Custom tables generated by ABS
Natural Resource Management data sources	–	largely based on research experience and expert knowledge of the rangelands	Mean NDVI from 13 years NOAA Pathfinder; Mean annual rainfall; rainfall coefficient of variation, temperature coefficient of variation, vegetation, and soil.	BRS indicators: threatened species, environmental sensitivity, total impact. Mean and variance for NDVI NOAA Pathfinder (1981–2004). SILO rainfall surfaces for 1880–2004.
Cluster Analysis/other	Frequent visits to service centres	Simple qualitative appraisal of regions based on current and potential resource use differences	Systat software	SPSS Software
Limitations	Regionalisation by one factor (mobility to service centre) only Concerning Indigenous communities only.	Indicative and intuitive categorisation of regions	Very large SLAs in low population areas	Settlements with less than 200 people (10–15% of population in rural area) not considered; unable to source business/ services data

This current project builds on unpublished work by Stafford Smith *et al*. but uses a different approach as suggested by Hugo et al. (2001) for identifying socio-economic regions. We have used the recently adjusted boundary by Australian Collaborative Rangeland Information System (ACRIS) 2005 (hereafter referred to as ACRIS) (AGDEH 2005) to define the rangelands study area. Figure 1 shows Urban Centres or Localities (UCLs) with corresponding population sizes for the ACRIS rangelands boundary. Within this boundary there are 222 Urban Centres or Localities (UCLs) that were the subject of analysis. Darwin as a demographic outlier was excluded due to its potential to mask important characteristics of smaller population centres and therefore influence data analysis. A UCL is a settlement with 200 or more people (Australian Bureau of Statistics (ABS) 2001). Settlements with less than 200 people were also excluded due to data constraints. The distribution of UCLs and settlements for the rangelands are shown in Figure 2. Secondary data from ABS and Bureau of Resource Sciences (BRS) on UCLs were used to:

- Identify UCL hinterland boundaries
- Develop a classified hierarchy of UCLs
- Map single indicators and sets of indicators over UCL hinterlands to observe emerging patterns
- Classify UCLs and their corresponding hinterland using indicators grouped under some social construct – e.g. five capitals of the sustainable livelihood framework or triple bottom line reporting of sustainable development theory.

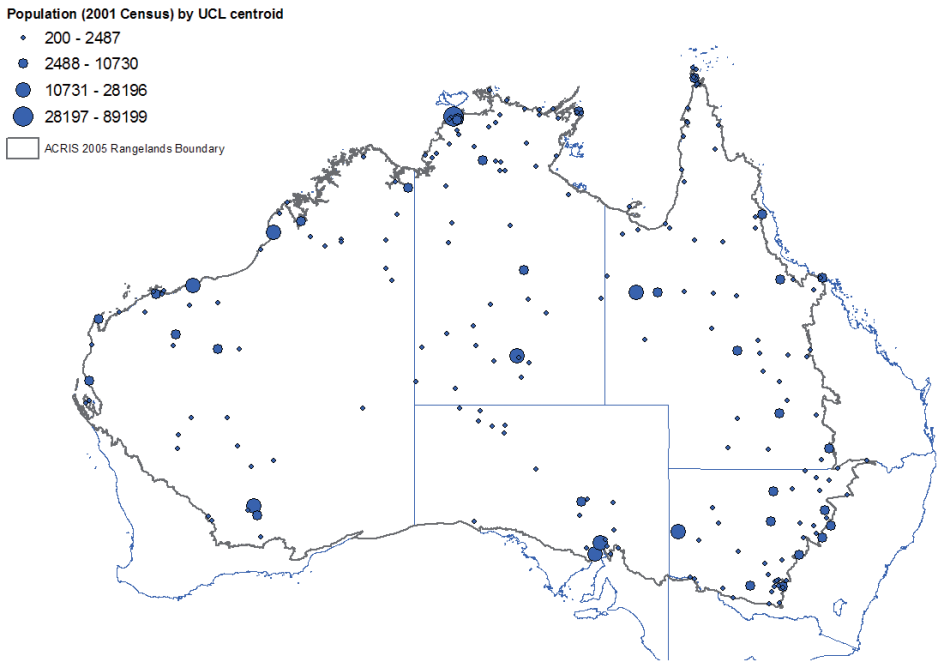


Figure 1: Population size for UCL centroids across the rangelands.

Of the 222 UCLs, population ranged from 200 to 249,999 within the rangelands boundary (Data source: ABS 2001).

Note: A UCL centroid is a point that designates the geographic centre of the area of a bounded Urban Centre/Locality.

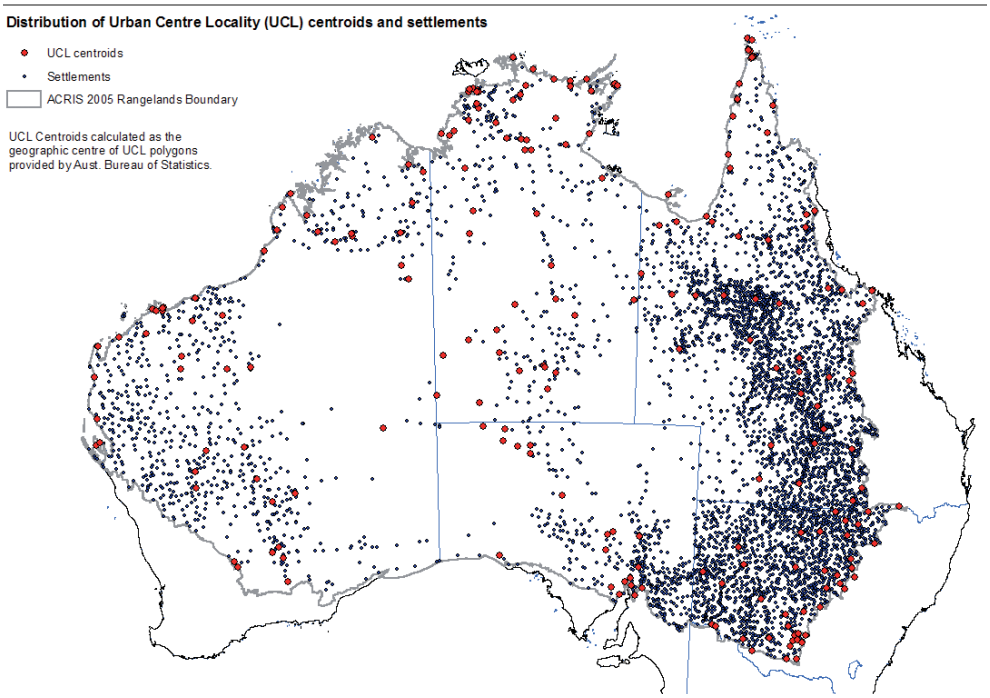


Figure 2: Distribution of settlement localities shown in conjunction with UCL Centroids.

Coverage of UCL centroids is limited in extent and omits settlement sizes with less than 200 persons (Data source: Geoscience Australia 2005).

Research objectives

The objective of this sub-project is to classify and map outback settlements into socio-regions. This profiling process is primarily based on the assessment of similarities and differences between settlements for key indicators of socio-economic and cultural issues, opportunities, and drivers. Indicators of ecological issues were also considered in mapping the socio-regions. Maps were produced which illustrate key differences and similarities. These could be used by research agencies to locate suitable case study areas and to make decisions on future investments or areas of concern.

Both the process and outputs of this project are important. Section 2 which follows this introductory section describes the approach developed to derive and classify UCL hinterlands and the selection of indicators. Section 3 explores graphs, clusters and maps developed using single and composite indicators to look for emerging patterns. Section 4 discusses the findings of the study. The main results include the technique used to derive hinterlands and the cross border regions formed using similarities and differences in social economic and environmental indicators. Section 5 contains a set of recommendations for further work.

2. APPROACH

UCL hinterlands derivation

The derivation of hinterland boundaries around each UCL centroid was a primary task that enabled mapping and visualisation of patterns for similarities and differences. Theoretical explanations of procedures using vectors to derive hinterlands around locations are described in Hugo et al. (2001). McGregor (2003) used the number of services to identify hinterland boundaries for a small number of centres. However, we were unable to obtain this data at the UCL level. Instead we have used population (Figure 3) and an index of industry diversity based on different types of industry and employment numbers (Figure 4) to derive hinterlands for all 222 UCL centroids. The index of industry diversity of a UCL was calculated as follows:

$$IID \approx (N_{SE} * N_{PE}) \div (T_{ES} * T_{EP})$$

Where IID = Index Industry Diversity

N_{SE} = *Number of employment sectors with one or more employee*

N_{PE} = *Number of persons employed*

T_{ES} = *Total number of employment sectors*

T_{EP} = *Total number of employable persons*

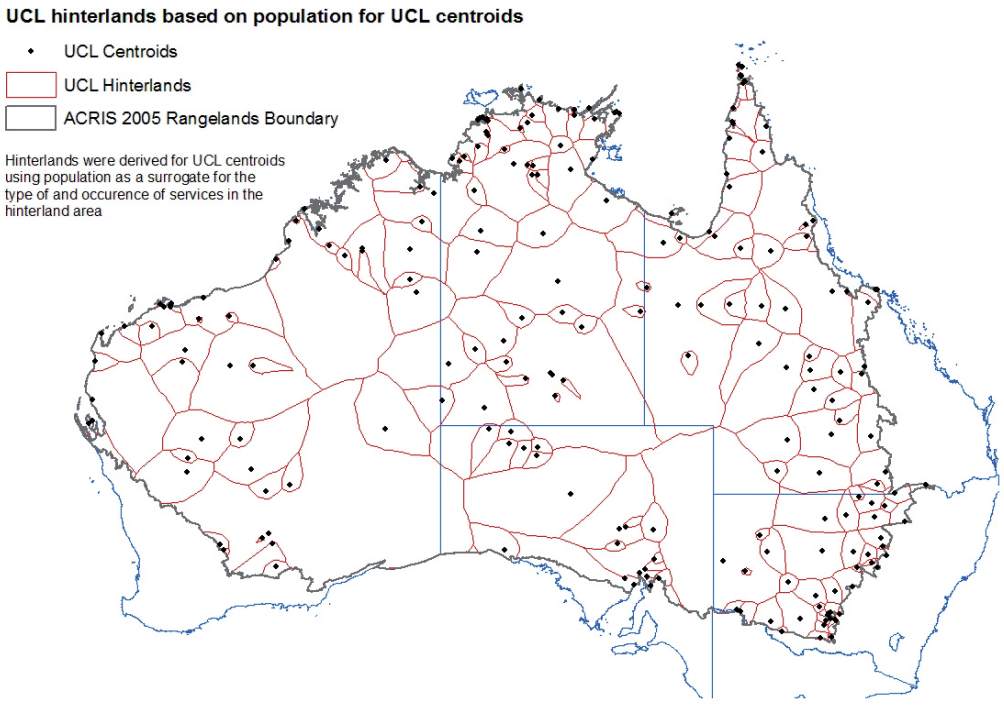


Figure 3: Hinterland boundaries based on population for UCL centroids.

Deriving hinterland boundaries was not a straightforward and simple task. Hugo *et al*. (2001) discussed the limitations of Voronoi diagrams to derive hinterlands and suggested weighted gravity models could be used to derive more realistic boundaries. As we use ESRI ArcGIS/ArcINFO software for GIS analyses we investigated approaches suggested in the user forum hosted on the ESRI website (www.esri.com) to find potential implementation procedures for 'Reilly's Law of Gravitation'. This material pointed to different approaches which could be used to find breakpoints separating neighbouring pairs of UCLs using combinations of raster (grid) and vector methods.

Although we used a complex series of calculations to derive breakpoints based on the population size of neighbouring UCLs, we were unable to find a simple way to derive polygon boundaries using breakpoints for a large number of locations. Voronoi algorithms are traditionally used to derive boundaries around points but the implemented algorithms do not allow points to use weights such as population numbers. Consequently we used the ArcINFO cost allocation grid function which produces a similar output to Voronoi polygons very rapidly.

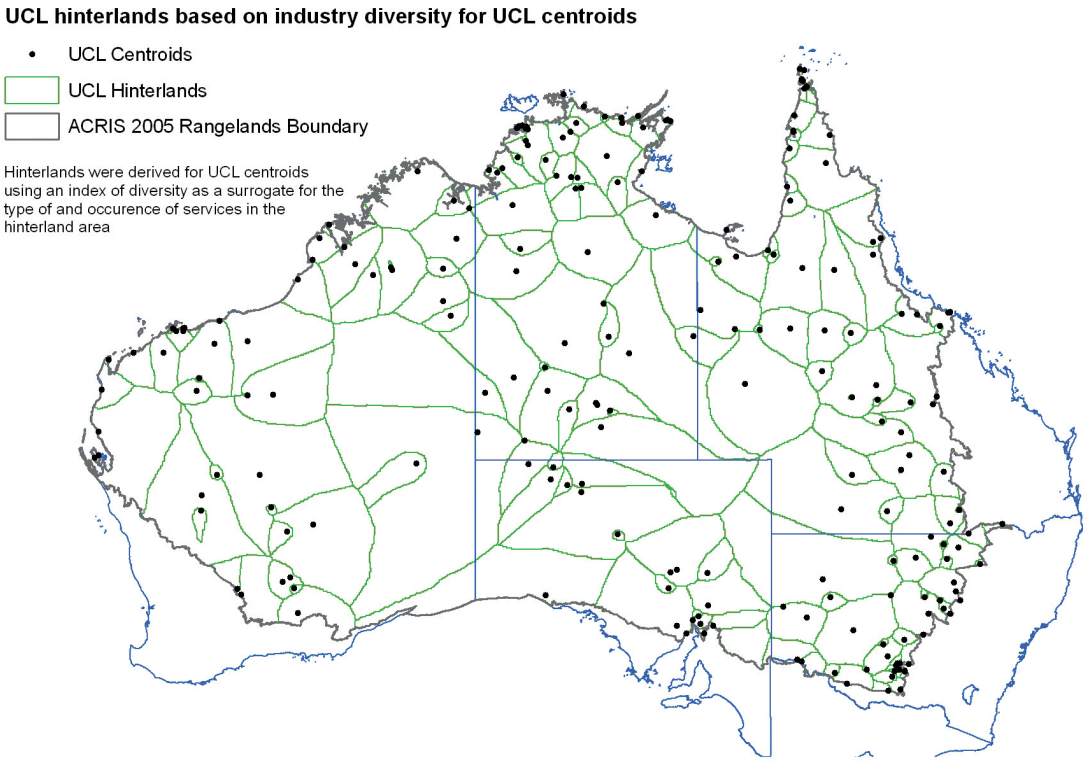


Figure 4: Hinterland boundaries based on industry diversity for UCL centroids.

The result of the ArcINFO allocation procedure for Urban Centres with population between 18,000 and 47,999 is shown in Figure 5. Resulting allocation areas use the population size of a UCL centroid; as the population increases the corresponding hinterland size increases.

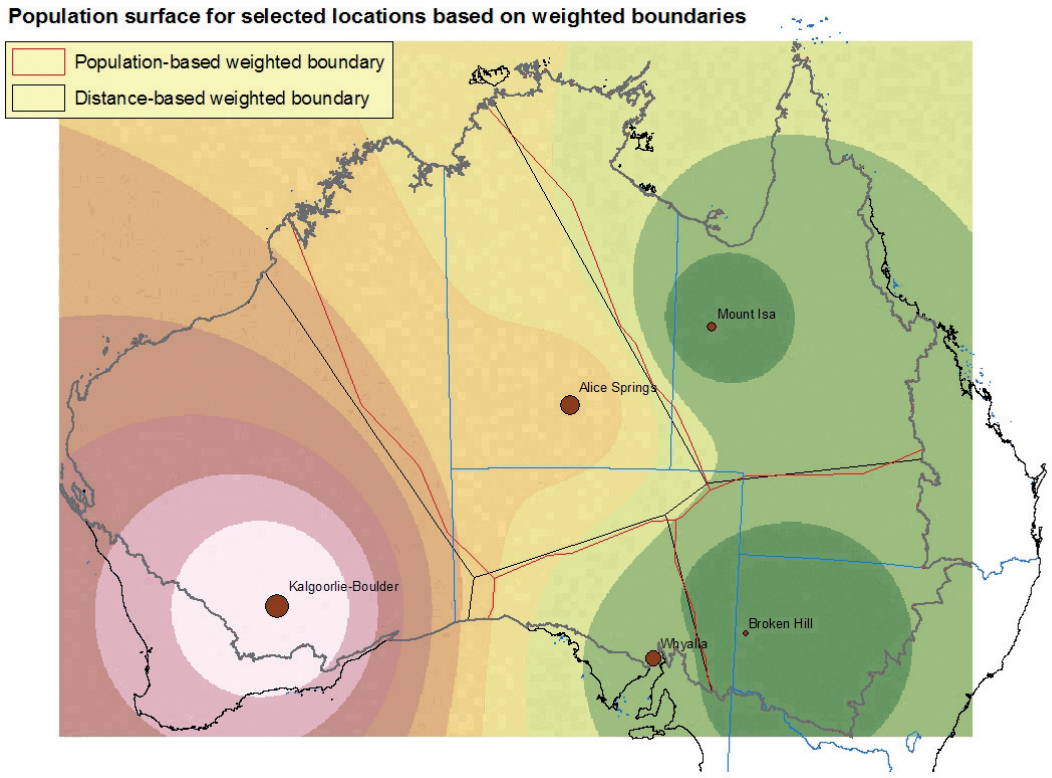


Figure 5: Weighted boundaries based on population using the ArcINFO allocation technique.

The following three figures (Figures 6–8) show the 222 population-based UCL hinterland boundaries overlaid with SLA, subIBRA and ABARE boundaries. The boundaries probably correspond most closely with the ABS SLAs (Figure 6) which is not surprising since population is a factor determining SLAs boundaries. However it is notable that there are different numbers of UCLs included in SLAs in different states. The ABARE regions used for presenting statistics for the pastoral zone (Figure 8) are very broad, especially in WA but show some correspondence with UCL hinterland boundaries. In contrast, the subIBRAs (Figure 7) match poorly, being based on environmental rather than population boundaries, even though there are a similar number of regions. Further examination of this relationship may be of value for specific projects.

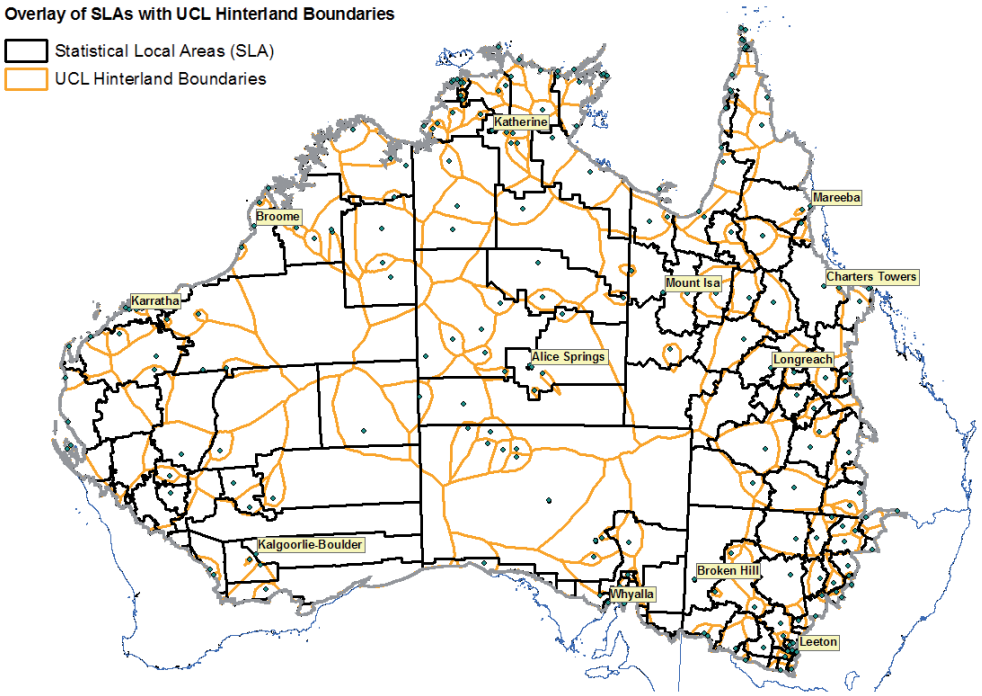


Figure 6: Overlay of ABS statistical local areas (SLAs) with UCL hinterland boundaries.

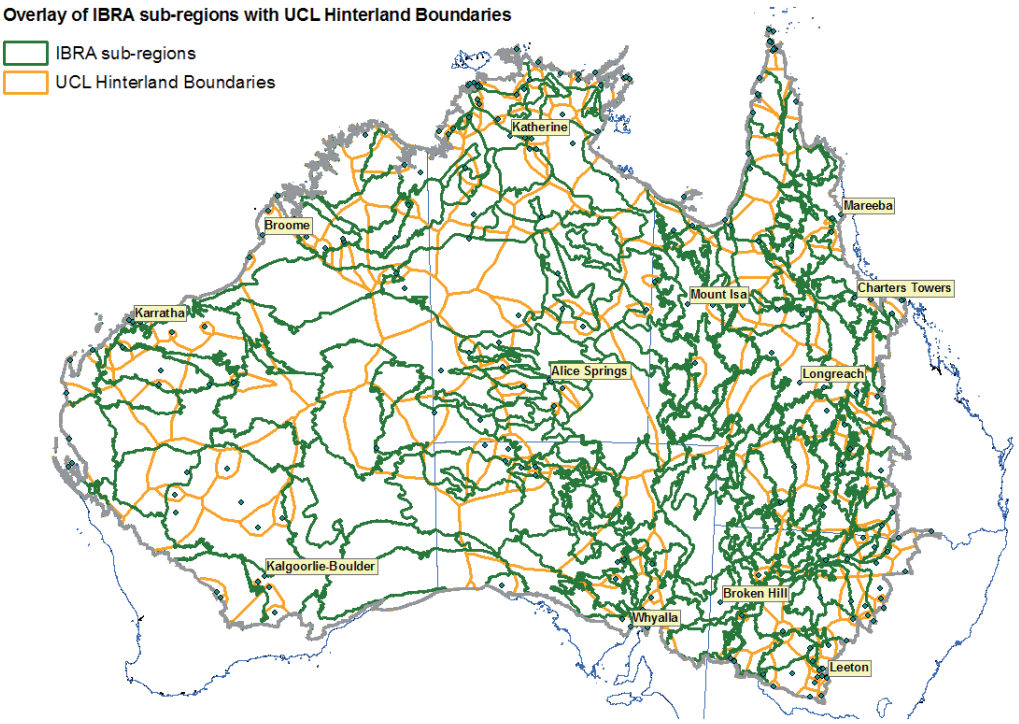


Figure 7: Overlay of IBRA sub-regions with UCL Hinterland Boundaries.

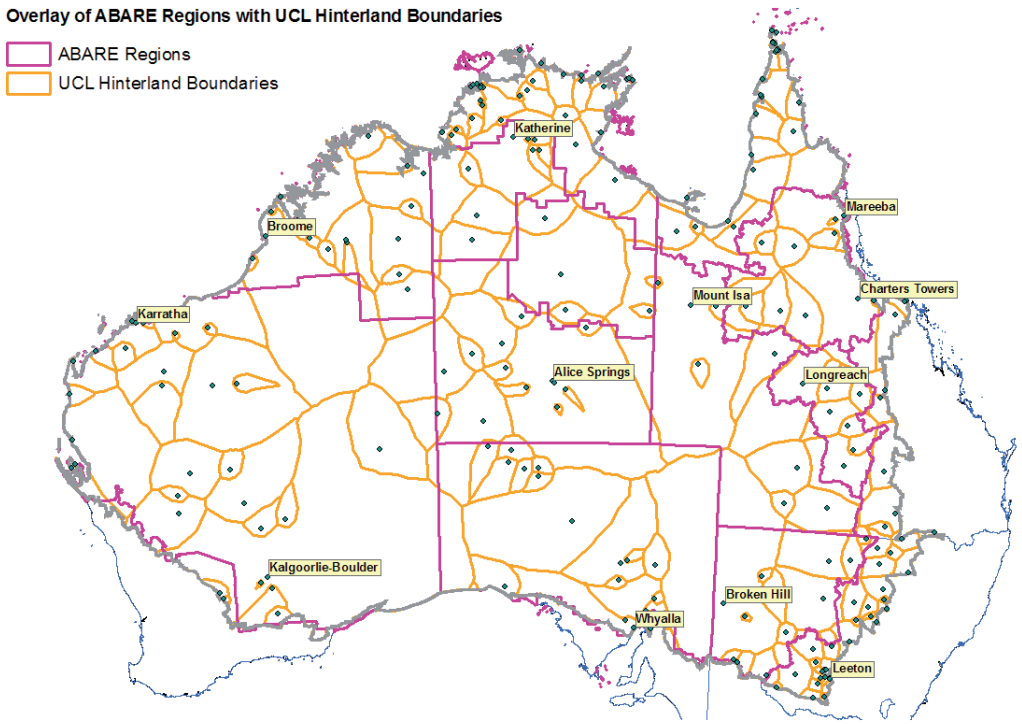


Figure 8: Overlay of ABARE regions with UCL hinterland boundaries.

UCL Classification

The UCLs in the rangelands, as shown in Figure 9, include a few urban centres with a large population and a large number of localities with very small populations. This required a classification of the UCLs by similarity in population size.

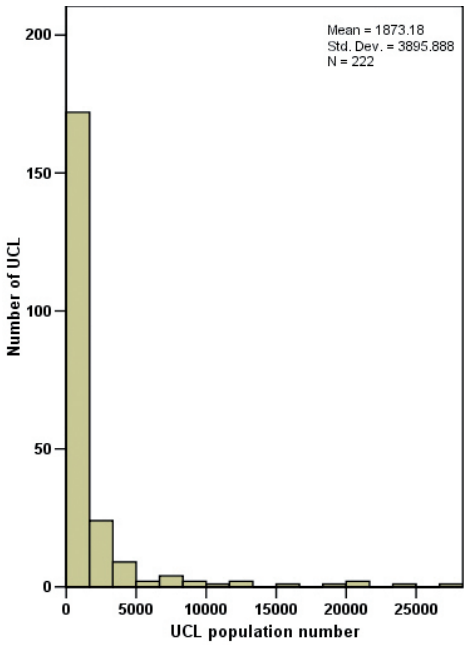


Figure 9: Distribution of UCLs by population size.

Ideally the classification should reflect the inherent service hierarchy among the UCLs in the rangelands. We have adopted the Accessibility/Remoteness Index of Australia ($ARIA^{++}$) classification which uses 6 categories: A to F (URL http://www.gisca.adelaide.edu.au/products_services/ariav2.html). Numbers of UCLs within the rangelands by $ARIA^{++}$ rating are shown in Table 2.

Table 2: $ARIA^{++}$ based UCL categories.

Category or hierarchy	UCL population	Number of UCLs
F	200 to 999	145
E	1000 to 4999	60
D	5000 to 17,999	12
C	18,000 to 47,999	5
B	48,000 to 249,999	1 (Darwin – removed)
A	250,000 or more	0

In outback Australia an overlap occurs between the influence of service centres based on remoteness, service level, population size and other factors. So the hinterland of a large population centre can contain smaller centres. To better understand this we derived hinterland boundaries for the categories in Table 2 separately to produce nested boundaries of UCLs from a lower hierarchy to a higher hierarchy. Maps in Figures 10.1–10.5 show hinterland boundaries of UCLs within and among the hierarchies.

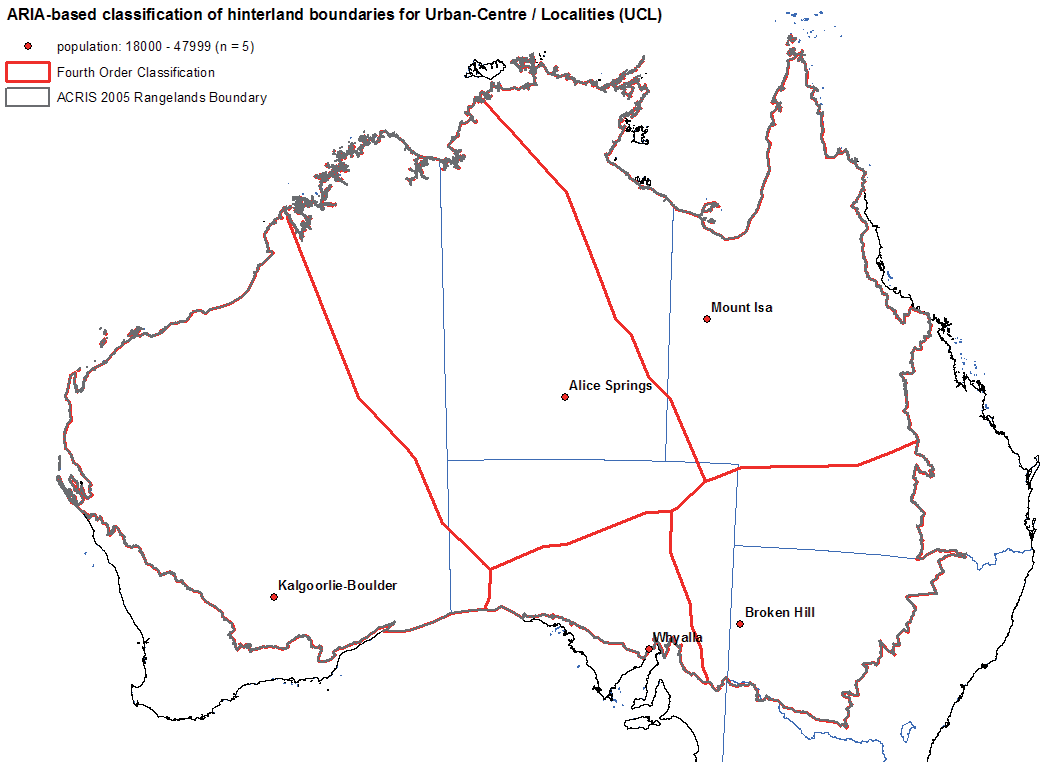


Figure 10.1: Fourth order hinterland boundaries based on population.

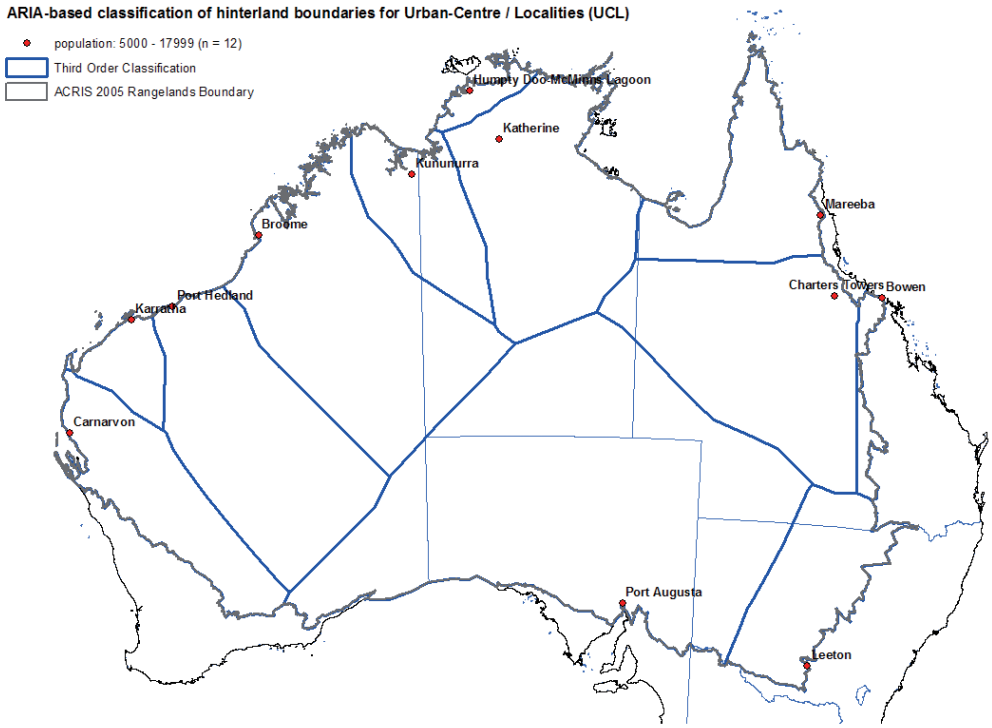


Figure 10.2: Third order hinterland boundaries based on population.

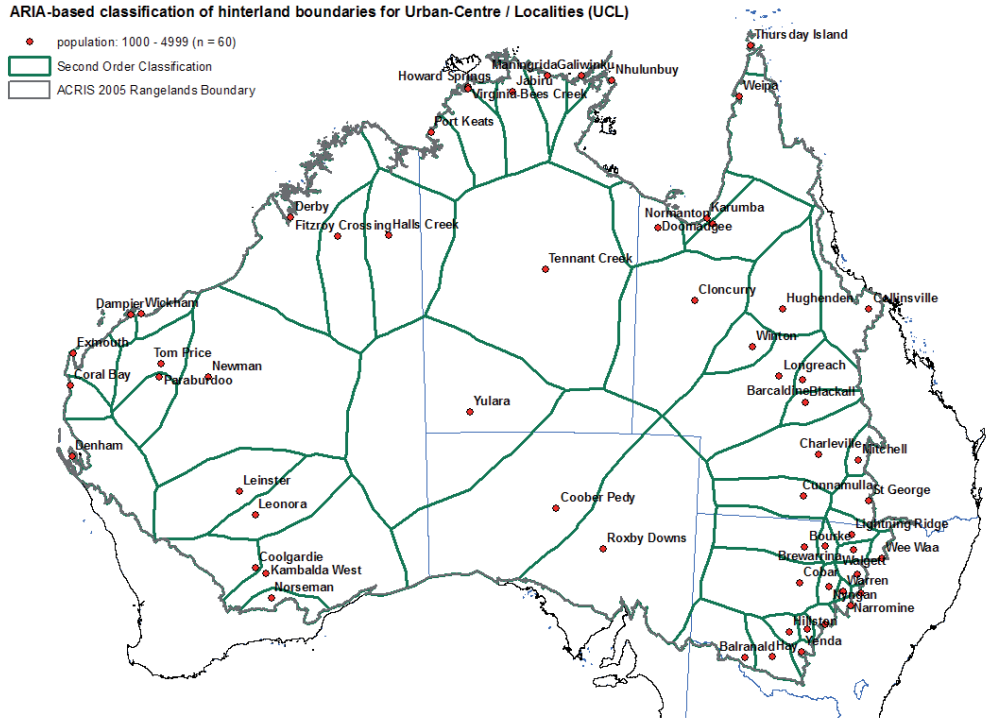


Figure 10.3: Second order hinterland boundaries based on population.

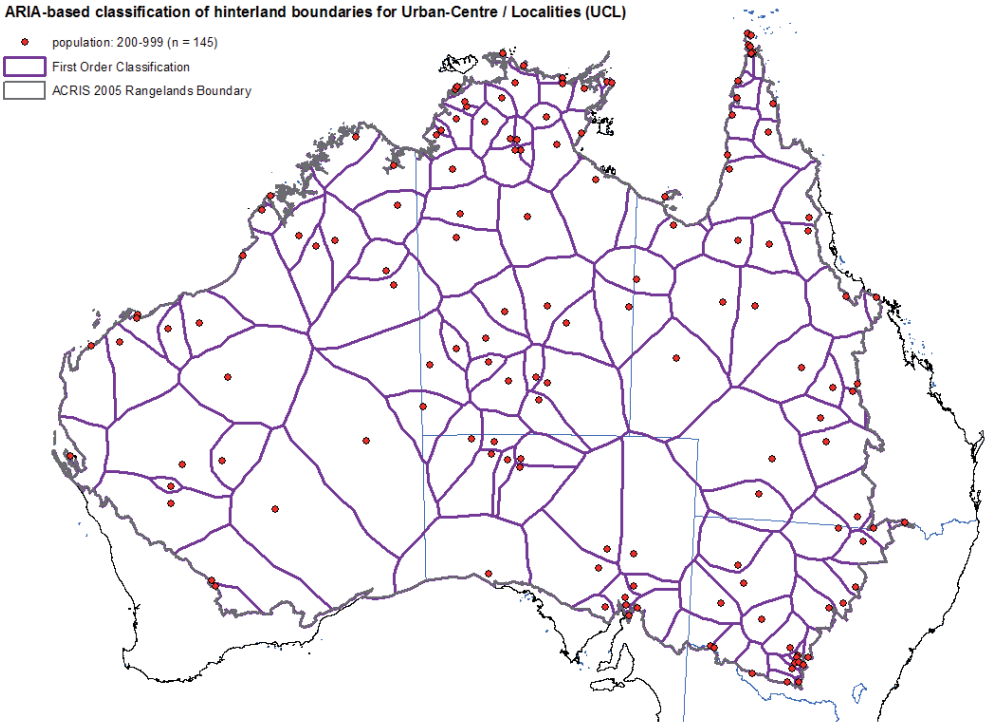


Figure 10.4: First order hinterland boundaries based on population.

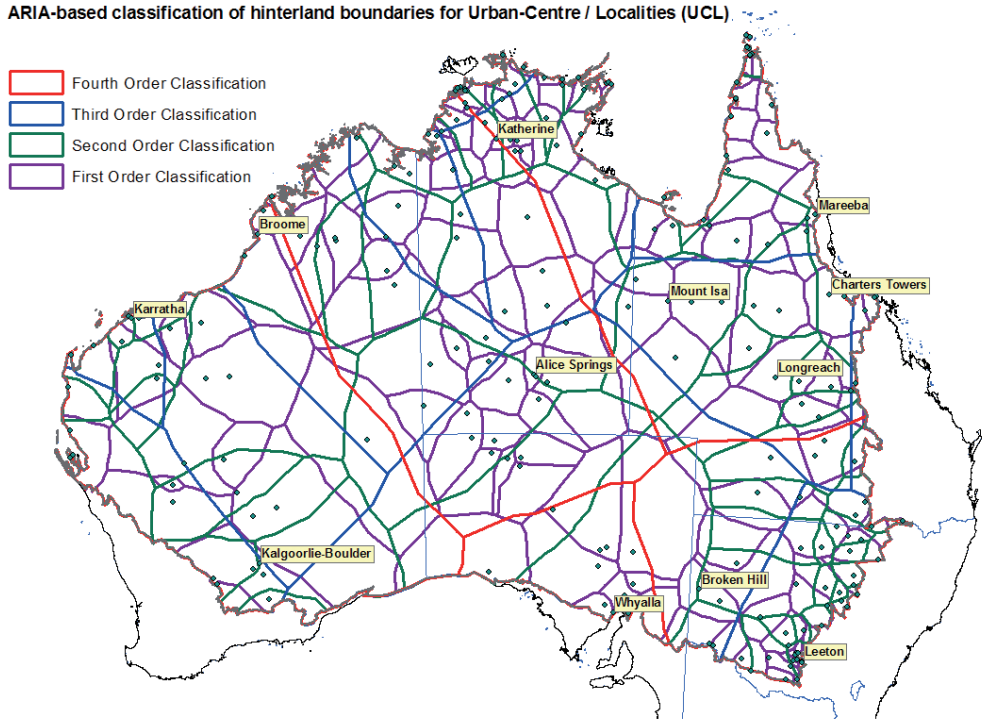


Figure 10.5: Overlay of derived hinterland boundaries for UCLs.

Figure 10.5 shows the hierarchy among groups of UCLs based on population size. Population numbers of UCLs are considered a proxy for determining the influence and hence the group to which each UCL belongs, and the size of its hinterland vis-a-vis neighbouring group members. The resulting nested hinterlands are only for demonstration. They are not used as a basis for analysis and mapping of the characteristics of UCLs nested hinterlands because of emergent complexity that is beyond the scope of this project. As well, the determination of groups and hierarchical boundaries of UCLs requires more appropriate proxy indicators than population numbers data used in this project. It was not possible to source data on more appropriate proxy indicators such as the number of services in each UCL.

While boundaries are derived using population size of UCLs, the characteristics of settlements below 200 people (see Figure 2) were not included in the analyses as very small settlements are lumped into what ABS defines as 'Rural Balance' for each state and territory. The implication of not including settlements below 200 people is raised in the discussion section.

Indicator selection

The Sustainable Livelihoods Framework (SLF) (Scoones 1998; Woodhouse, Howlett & Rigby 2000) provides an appropriate socio-economic and cultural focus for looking at outback regions as social-ecological systems. The framework has five capitals which are core assets: human, produced economic, socio-cultural, physical and natural. Initially we identified a set of capital indicators from various sources including indicators of regional capacity for natural resource management identified by Webb and Curtis (2002) and natural resource indicators by Donohue et al. (2005). However, for some of the capitals, data on indicators were limited or unavailable at the UCL level. For example, there were no specific indicators with available UCL level data for physical and cultural capital. In addition the indicators for natural capital were incomplete. Therefore, as shown in Table 3, capitals and their corresponding indicators were regrouped under broader social, economic and environmental dimensions.

Table 3: Indicators used for analysis.

Dimension / Actual Indicators
Social
Total Persons
Median Age
% proportion of Indigenous people
% proportion non-English background
% persons living alone
% change in number of residents
% persons have not obtained a tertiary qualification (including vocational training)
Number of persons per occupied dwelling
SEIFA[1] – Index of relative socio-economic disadvantage
Index of education and occupation
Economic
Median household income
Dependency or potentially active ratio
% persons qualified

	Index of business diversity
	Unemployment rate %
	SEIFA[1] – Index of relative socio-economic advantage/disadvantage
	Index of economic resources
Environmental	
	Total impact aggregate rank
	Environmental sensitivity aggregate rank
	Threatened species aggregate rank
	Normalised Differential Vegetation Index (NDVI)
	Rainfall variability

As expected UCL data for most of the indicators had an asymmetric distribution. Only a few indicators were normally distributed such as total dependency ratio and the index of advantage/ disadvantage presented in Table 4.

Table 4: Test of normality of distribution of UCL values on selected indicators.

Indicator/Index	Skewness	Std. error of skewness	Departure from normality Value (> +2 or < -2).
Total dependency ratio	0.21	0.16	1.30
Average index of advantage/disadvantage	0.02	0.16	0.13

There are also a number of outlier and extreme values in UCL data for most of the indicators (Figure 11). This suggested the need for careful selection of robust clustering and other statistical methods for use in this study. We have used clustering techniques which are appropriate for datasets which are not normally distributed.

[1] Socio-Economic Indexes for Areas (SEIFA) – by UCL bounded area is a composite index to allow ranking of regions/areas by determining the level of social and economic wellbeing in that region. All of the indexes have been constructed so that relatively disadvantaged areas have low indexes and less disadvantaged areas have higher indexes.

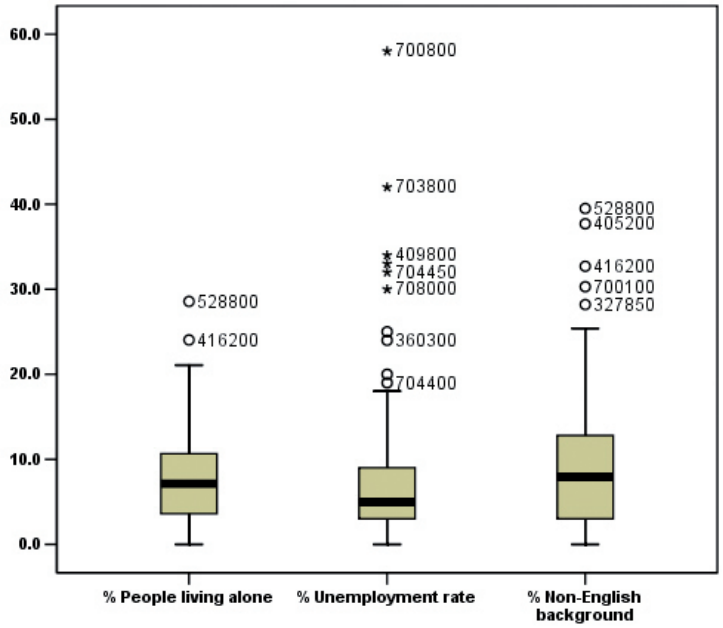


Figure 11: Box-plot for some indicators showing a number of outliers and extreme values.

Outliers are identified with an (O). Extreme values are marked with an asterisk (*). The numbers refer to the UCL codes.

Several steps were performed to ensure consistency across indicators. For example, as individual indicators within each dimension (i.e. social, economic and environmental) behaved quite differently, for consistency, indicators were expressed as proportions, ratios or ordinal scales. For ease of interpretation higher values for each indicator imply greater quantity. Furthermore, to accommodate normality assumptions, data for each indicator were further standardised between -1 and +1. A test of reliability was then conducted to measure how much data for each indicator in a category set was consistently contributing to each dimension. Although the indicators used were collected for different purposes, their reliability was acceptable as measured by Cronbach's statistic shown in Table 5.

Table 5: Reliability of indicators grouped by dimension.

Dimension	Cronbach's α Based on Standardised Items	Number of Indicators
Social	0.70	10
Economic	0.71	7
Environmental	0.54	5

Different clustering methods were tried and several cluster groups were developed. Finally a 'two step clustering method' was used to discriminate statistically significant and meaningful groups of UCLs. The method was chosen because of its ability to handle large continuous and categorical data and its robustness when normality assumptions are violated.

In this section we have described the methods used for preparing indicators and analysing data. In the next section we discuss the results of the analysis in terms of UCL properties, clusters and socio-regional maps.

3. INDICATOR GRAPHS, UCL CLUSTERS AND MAPS

UCL Properties

To explore patterns in UCL characteristics, we have plotted the relationship of indicators against total population size for Figures 12.1–12.10 and percentage of Indigenous persons for Figures 12.11–12.13.

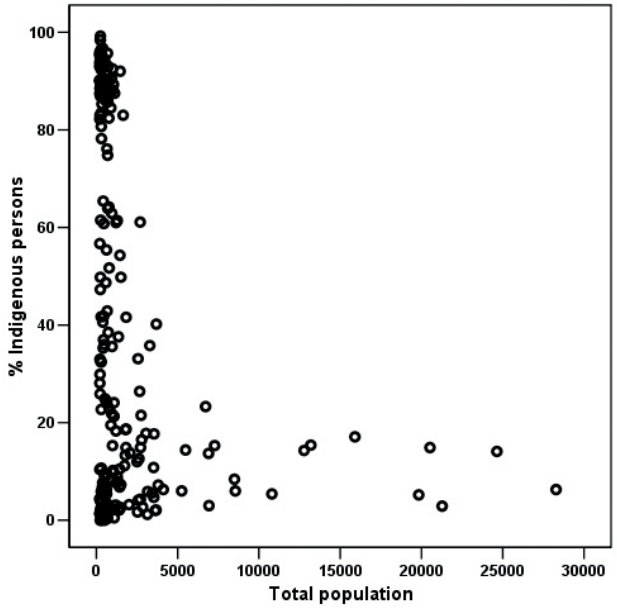


Figure 12.1: Percentage Indigenous persons by total UCL population

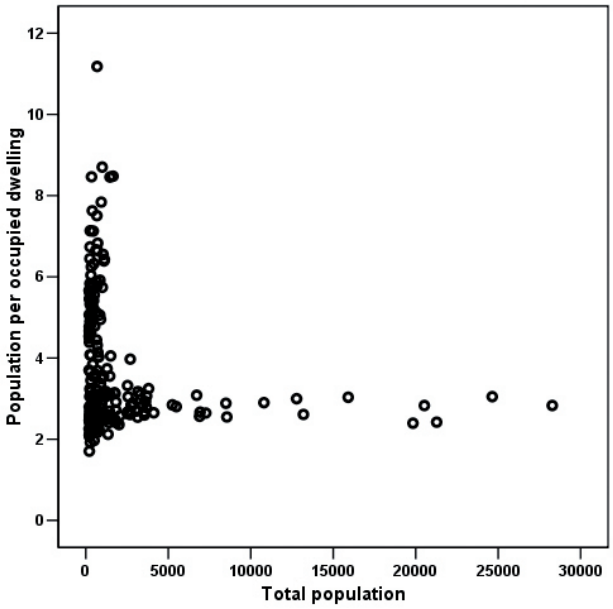


Figure 12.2: Number of people per occupied dwelling by total UCL population

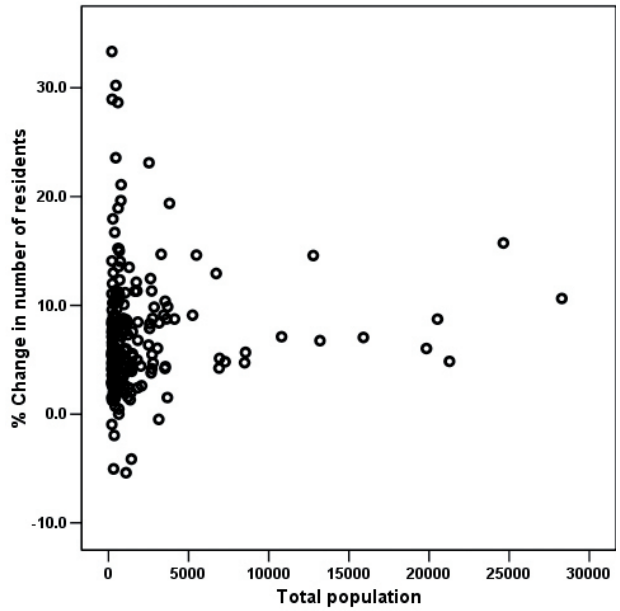


Figure 12.3: Percent change of number of residents by total UCL population

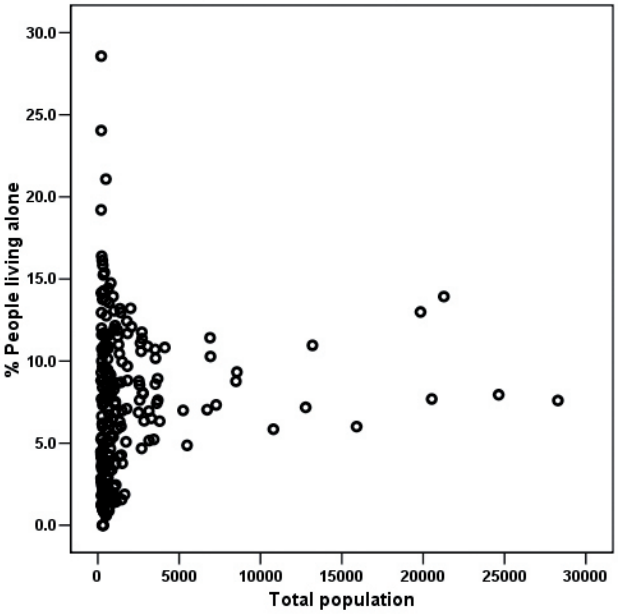


Figure 12.4: Percentage of people living alone by total UCL population.

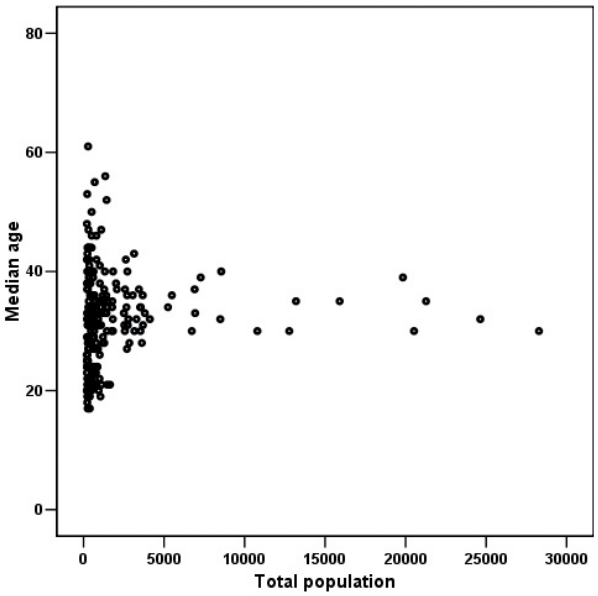


Figure 12.5: Median age by total UCL population

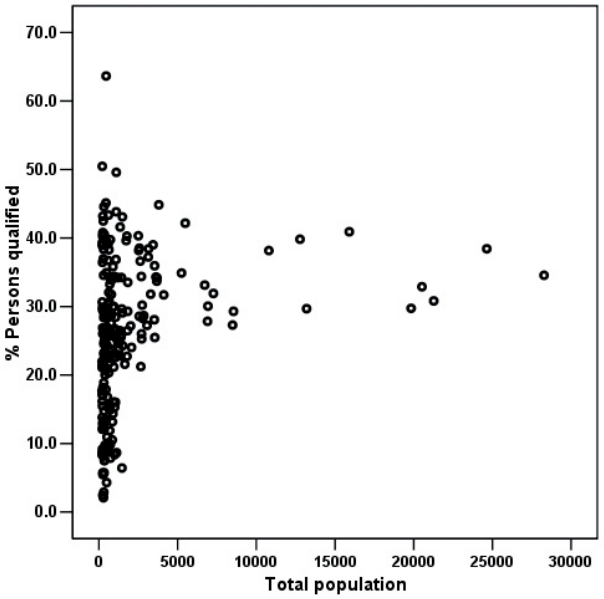


Figure 12.6: Percent persons qualified by total UCL population.

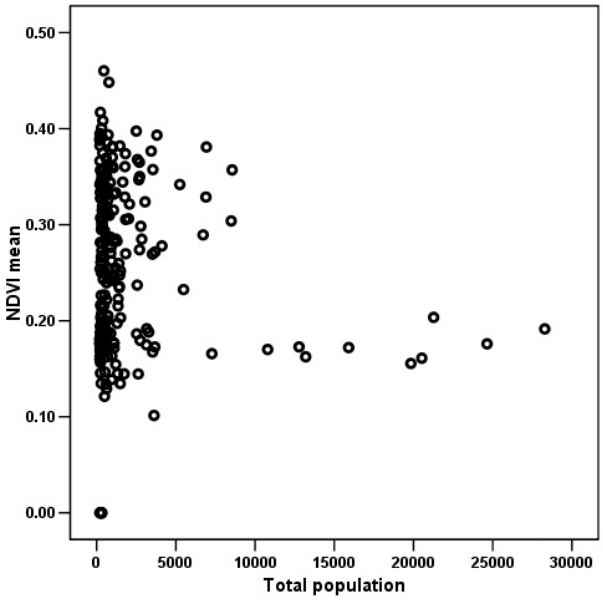


Figure 12.7: Average index of relative disadvantage by total UCL population

(higher values = greater relative advantage)

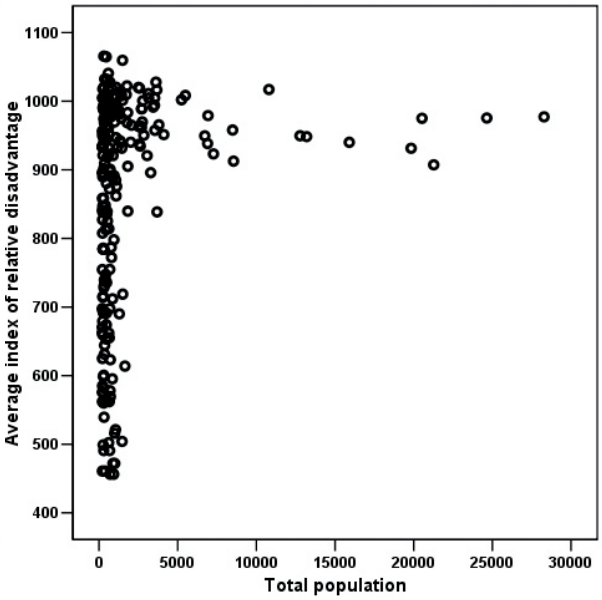
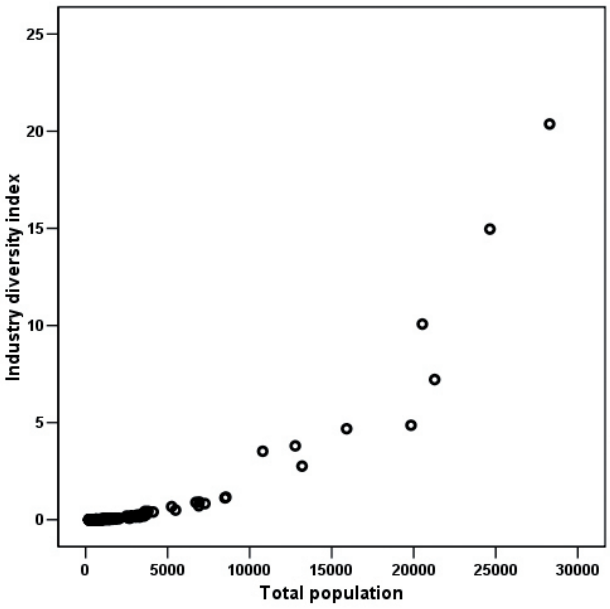


Figure 12.8: Normalised differential vegetation index (NDVI) mean by total UCL population.

(higher values = greater vegetation response)

To maintain consistency in the SEIFA indices, i.e. Index of Relative Socio-Economic Disadvantage; Index of Relative Socio-Economic Advantage/Disadvantage; Index of Economic Resources, high values of the indices always represent the more advantaged conditions. For example the higher the Index of Socio-Economic Disadvantage value is for a UCL, the less disadvantaged that UCL is compared with other UCLs with lesser index values.

Figures 12.1–12.8 show that there is a threshold of population size (~ 5000) beyond which characteristics of the UCLs seems to stabilise. By contrast there is very high variability of values in each of these indicators for UCLs with population size below the threshold. Further work is needed to establish what causes this increased variability in indicators for the many small rangeland settlements. The implication of this finding is to consider the differences among many of the small settlements in the design of research and policy for desert regions. Applicability of regional research conclusions and policy also need to test for fundamental similarity of contiguous settlements grouped in a traditional region. A way to address this problem is to cluster non-contiguous but similar UCLs into socio-regions.



Figures 12.9: Industry diversity index by total UCL population

(higher values = greater diversity in number and type of industries)

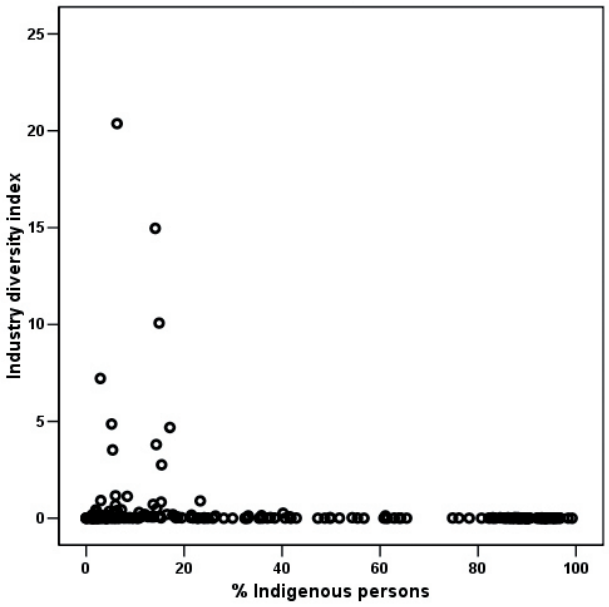


Figure 12.10: Industry diversity index by percentage Indigenous persons per UCL.

As shown in Figures 12.9 and 12.10, while the index of industry diversity increases as the total size of the UCL increases, it is consistently small for UCLs with a total population under 10,000 or higher than ~ 25 % Indigenous proportion.

Figures 12.11 and 12.12 below show demographic and socio-economic characteristics of UCLs with a high proportion of Indigenous people. Median age and average index of relative socio-economic advantage decrease with increasing percentage of Indigenous people, while the proportion of the population with no schooling increases.

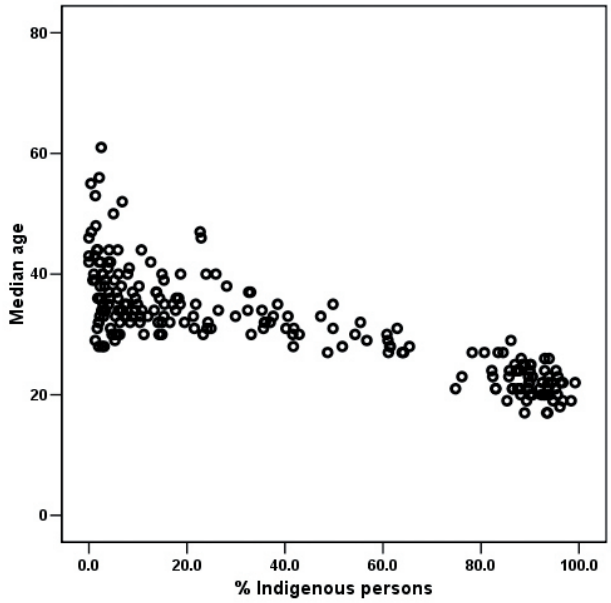


Figure 12.11: Median age by percentage Indigenous persons per UCL

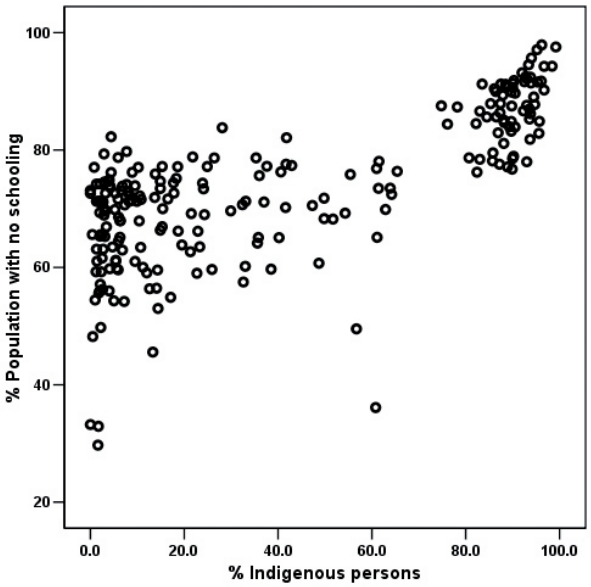


Figure 12.12: Percent population that have not attended school by percentage Indigenous persons per UCL.

(higher value = more people who have not attended school)

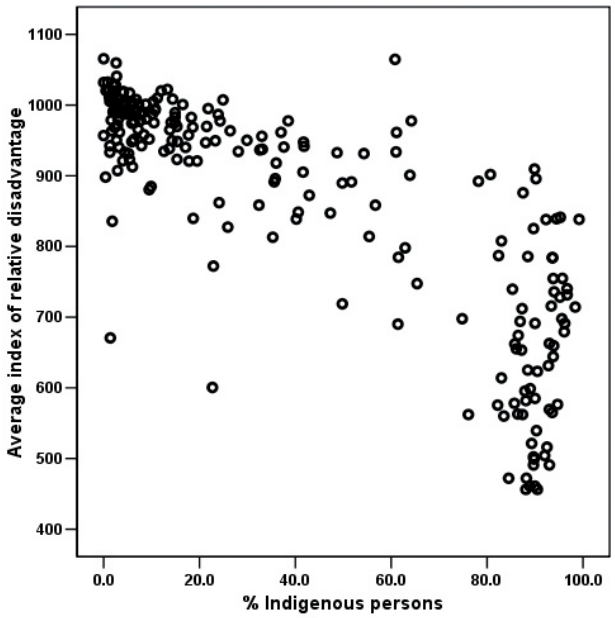


Figure 12.13: Average index of economic disadvantage by percentage Indigenous persons per UCL.

(low values = lesser relative socio-economic advantage)

For Figures 12.1 and 12.11–12.13 there is a distinct clustering of UCLs into two groups based on % Indigenous persons, i.e. those with less than 20–25% Indigenous proportion and those with greater than 75–80% Indigenous persons. There are few UCLs with percentage Indigenous persons between the 25–75% range.

UCL Clusters

Based on one or a set of indicators, relatively homogeneous groups of UCLs have been identified and mapped. One of the single indicators used for clustering UCLs is the level of employment by industry. Data for 1996 and 2001 census have been analysed, however, due to changes in ABS mapping some of the UCLs used in 2001 were not available for use with 1996 data. Table 6 and Figure 13 respectively show a map and a description of dominant industry sectors (livelihood activities) of each cluster for 1996. Table 7 and Figure 14 show clusters by dominant industry for 2001. Five clusters are identified from each data set. In 1996 three clusters of the UCLs had the following dominant industry sectors:

· Mining

· Health and community services

· Tourism and manufacturing

The remaining two clusters do not have a dominant industry as a livelihood source. For example cluster two, with 88 UCLs, has employment in a mixture of agriculture, health and community services and government sectors.

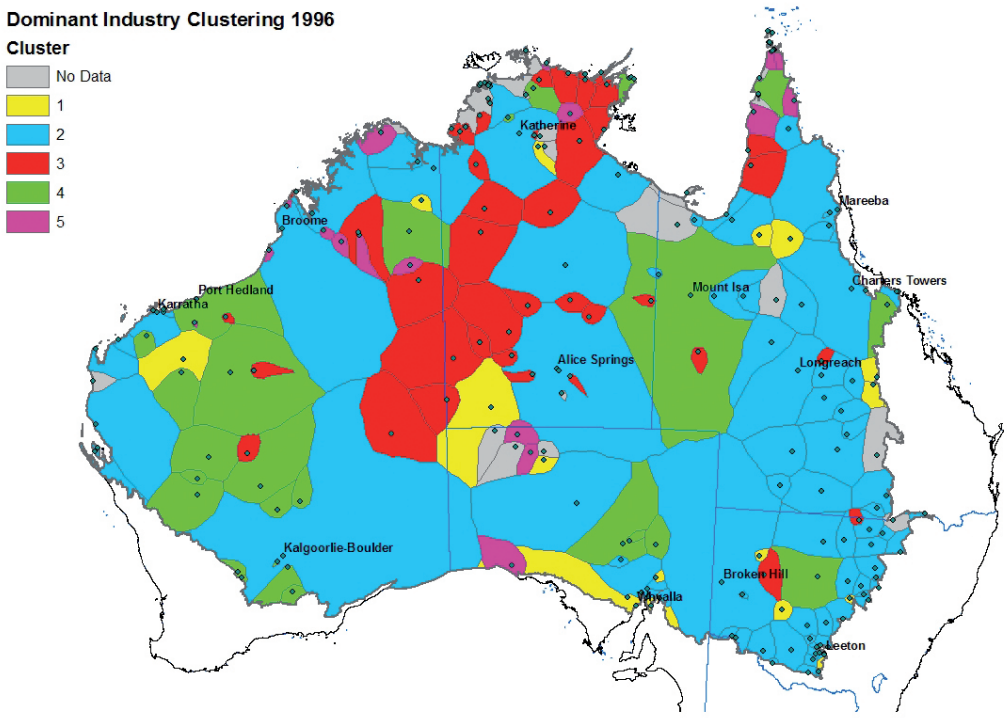


Figure 13: Dominant industry sectors (livelihood activities) in the rangelands in 1996.

Table 6: Clusters of UCLs by dominant industry sectors in 1996.

Cluster Number	Dominant Industry (Livelihood Activity)	Number of UCLs	Percentage
1	Tourism; manufacturing	18	8.8%
2	Agriculture; health and community services; government	88	43.1%
3	Government; education; health and community services	51	25.0%
4	Mining; construction	29	14.2%
5	Health and community services	18	8.8%
	Total	204	100%

The clusters derived from 2001 employment by industry data show some changes in the composition of dominant industry sectors. Mining and government sectors are clearly dominant employment sectors in 30% (67) of the UCLs. Cultural and recreational services and the accommodation sector have also emerged as part of a mixture of dominant employment sectors in the remaining clusters.

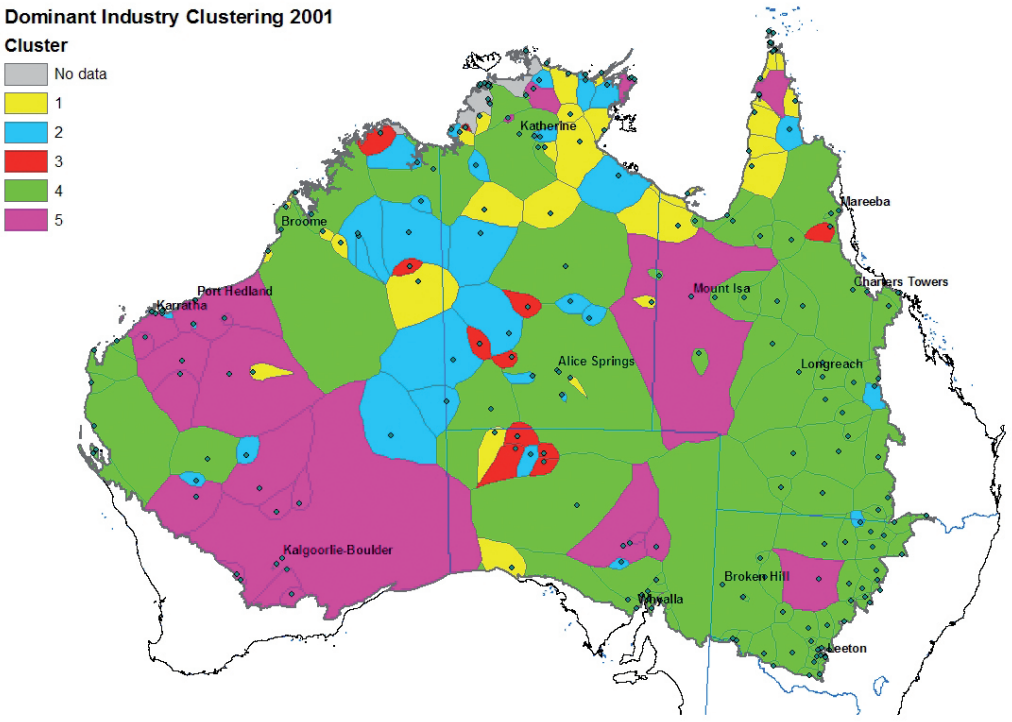


Figure 14: Dominant Industry sectors (livelihood activities) in the rangelands in 2001.

Table 7: Clusters of UCLs by dominant industry sectors in 2001.

Cluster Number	Dominant Industry (Livelihood Activity)	Number of UCLs	Percentage
1	Government	38	17.1%
2	Health and community services; government; education; cultural and recreational services	37	16.7%
3	Personal and other services; education; retail trade	13	5.9%
4	Retail and wholesale trade; agriculture; construction; manufacturing; accommodation; finance; communication; utilities	105	47.3%
5	Mining; education	29	13.1%
	Total	222	100%

Clusters by association of indicators

Here we explore the relationships between indicators and the dominant industry cluster discussed in the previous section. The UCLs in the rangelands were coded by dominant industry clusters derived from 1996 and 2001 ABS data sets for comparison with various indicators. We applied similar colour codes to clusters from both census years which had a similar dominant industry(s). Table 8 shows this colouring scheme.

Table 8: Colour coding scheme for dominant industry sectors in 2001 and 1996.

2001 census		Colour codes	1996 Census	
Cluster Number	Dominant Industry (Livelihood Activity)		Cluster Number	Dominant Industry (Livelihood Activity)
1	Government	■	3	Government
2	Health and community services; cultural and recreational services	▲ ▲	5	Health and community services
3	Personal and other services; retail trade	● ●	1	Tourism; manufacturing
4	Trade; agriculture; accommodation	■	2	Agriculture; health and community services; government
5	Mining; education	◆	4	Mining; construction

Examples of clustering by indicator association are presented in Figures 15.1–15.13 below. These figures show the threshold phenomenon observed in the previous section. However the threshold population size associated with dominant industry sectors seems to be lower (~ 2500 cf. ~ 5000 previously). While UCLs with less than the approximate threshold size seem to have all 5 clusters of dominant industry sectors (higher diversity of dominant industry sectors[2]), the UCLs with more than the threshold population size have only two dominant industry sectors in both 1996 and 2001. These dominant industry sectors for 1996 were mining and a mixture of agriculture, health and community services and government sector. For 2001 the dominant industry sectors were mining and a mixture of trade, agriculture and accommodation.

2 NB. Diversity in dominant industry sectors is different from industry diversity index shown in Figure 12.9.

For both dates UCLs with a higher proportion of employment in the government, health and community services had a higher Indigenous proportion. This is in contrast to UCLs dominated by the mining sector which had a lower Indigenous proportion.

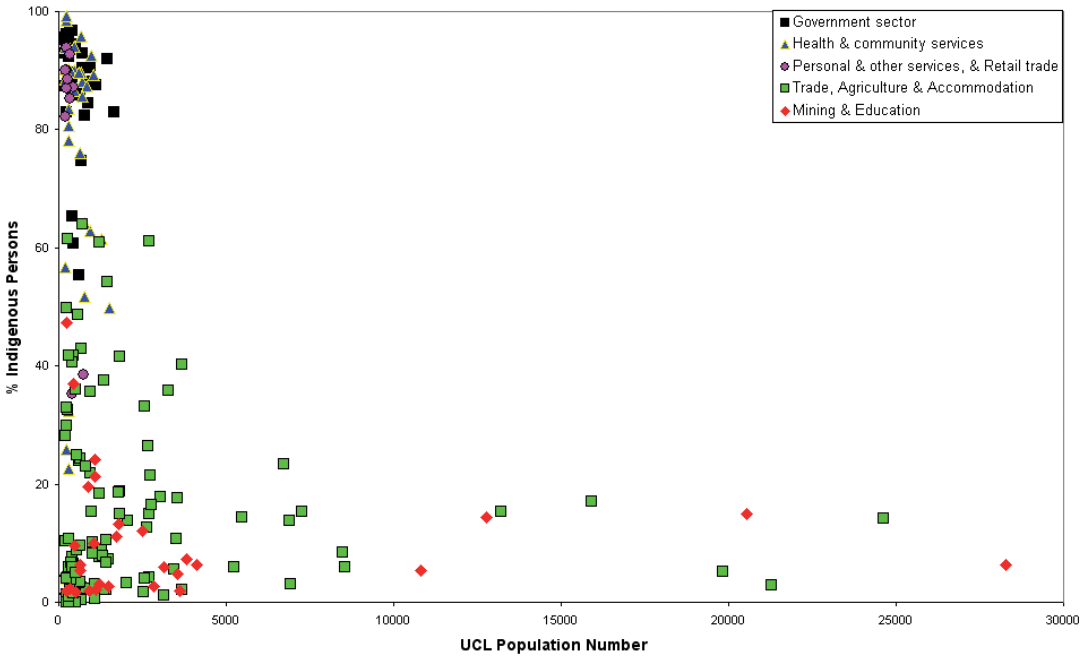


Figure 15.1: Percent Indigenous persons vs UCL population 2001.

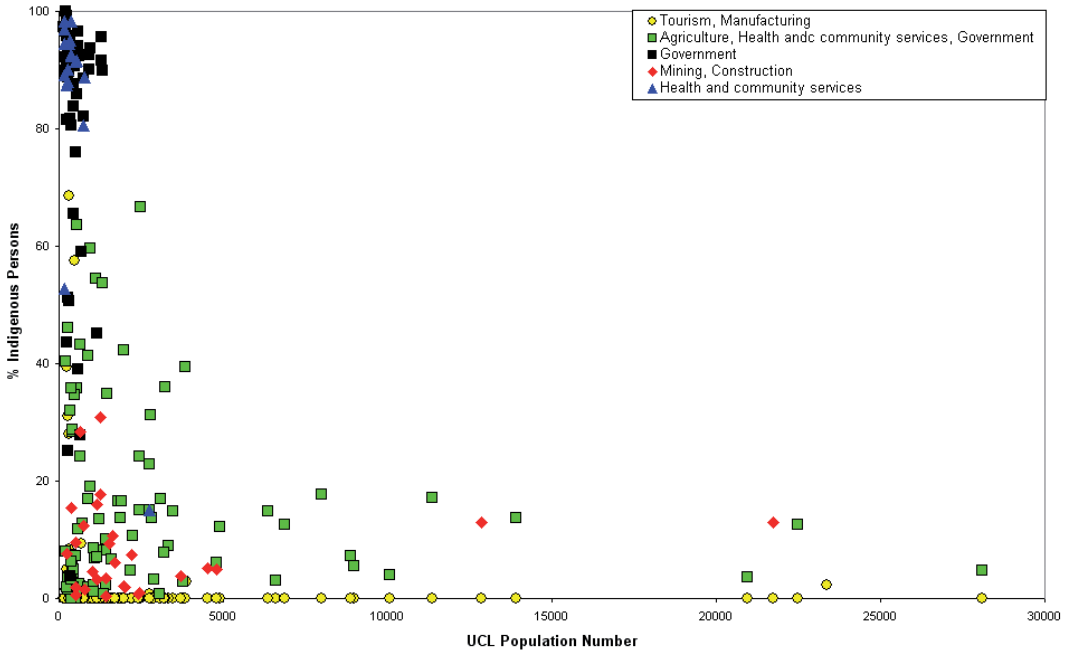


Figure 15.2: Percent Indigenous persons vs UCL population 1996.

There is a higher level of diversity of industries and of employment rates in mining and agriculture/ trade dominated UCLs. There is no apparent difference in diversity of industries between 1996 and 2001 (Figures 15.3 and 15.4). From Figures 12.9 and 12.10, we know that there is a high level of industry diversity in UCLs with more than 10,000 people and/or with less than 25% Indigenous population. An interesting question for future exploration is to determine possible causal relationships among characteristics of UCL population, level of industry diversity and types of dominant industries.

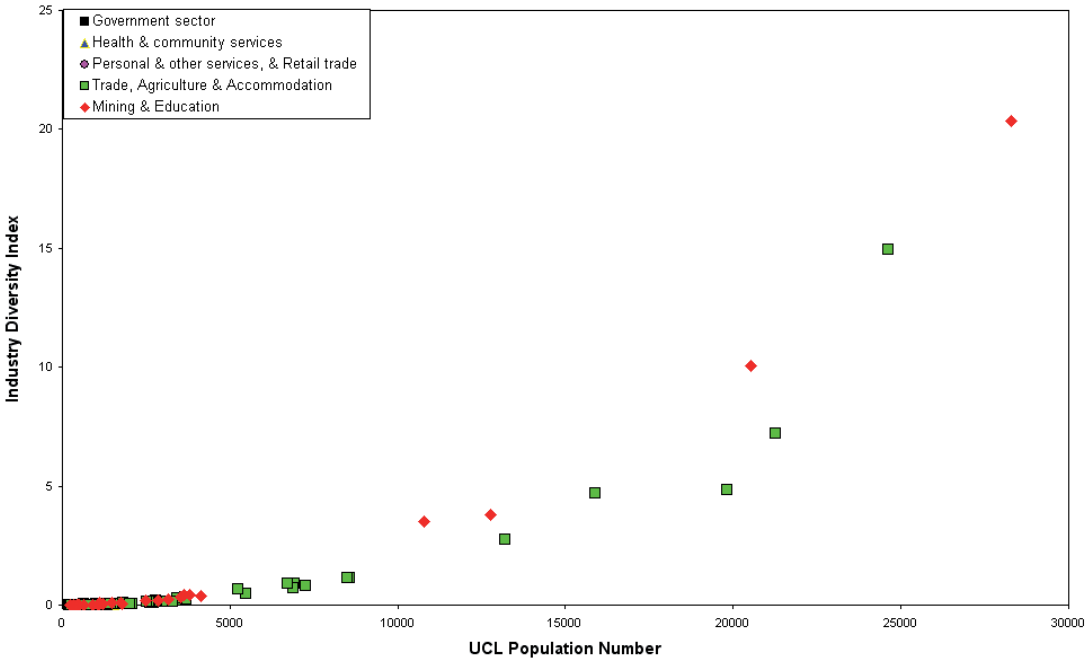


Figure 15.3: Industry diversity index vs UCL population 2001.

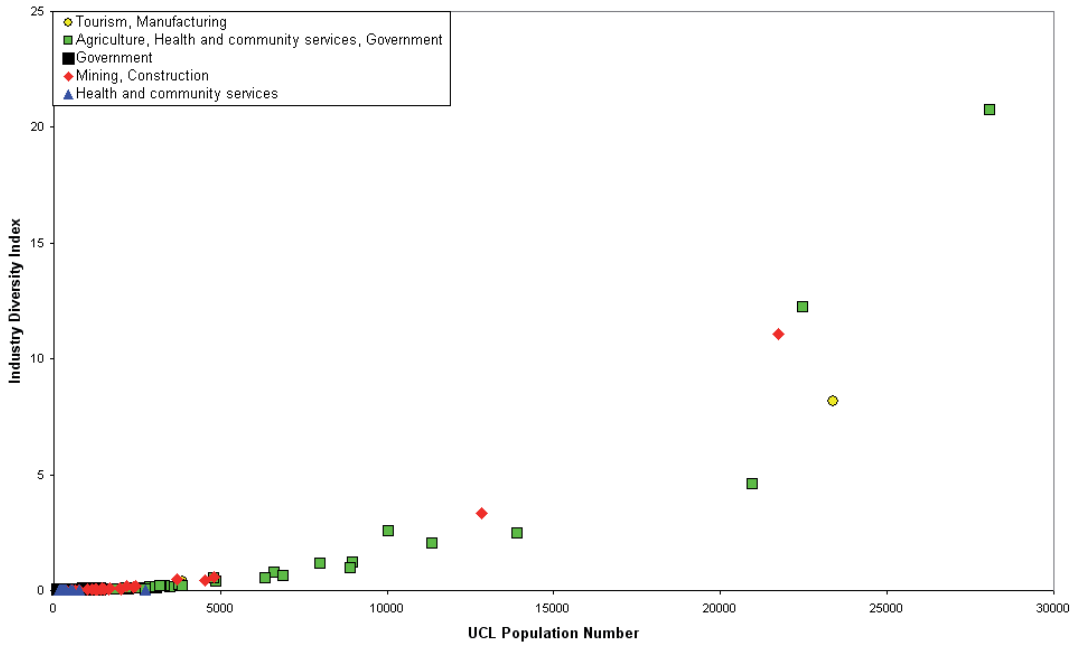


Figure 15.4: Industry diversity index vs UCL population 1996.

As shown in Figures 15.5 and 15.6, for both census years (1996 and 2001) the mining sector and agriculture/trade dominated UCLs had a consistently higher proportion of qualified persons. In 2001 the percentage of qualified persons has increased substantially.

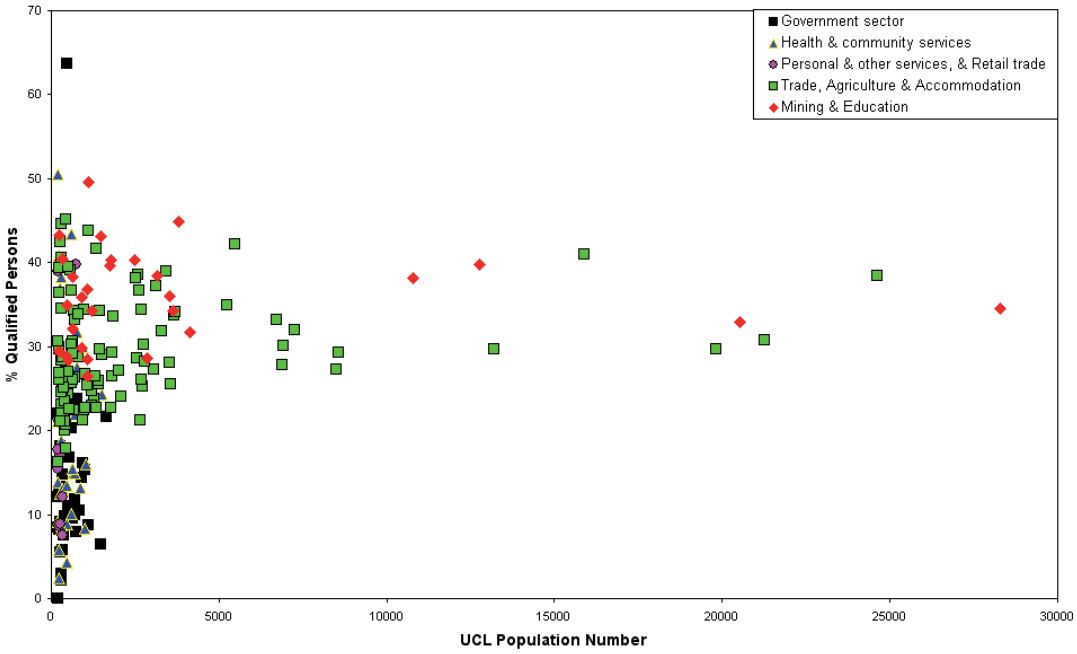


Figure 15.5: Percent qualified persons vs UCL population 2001.

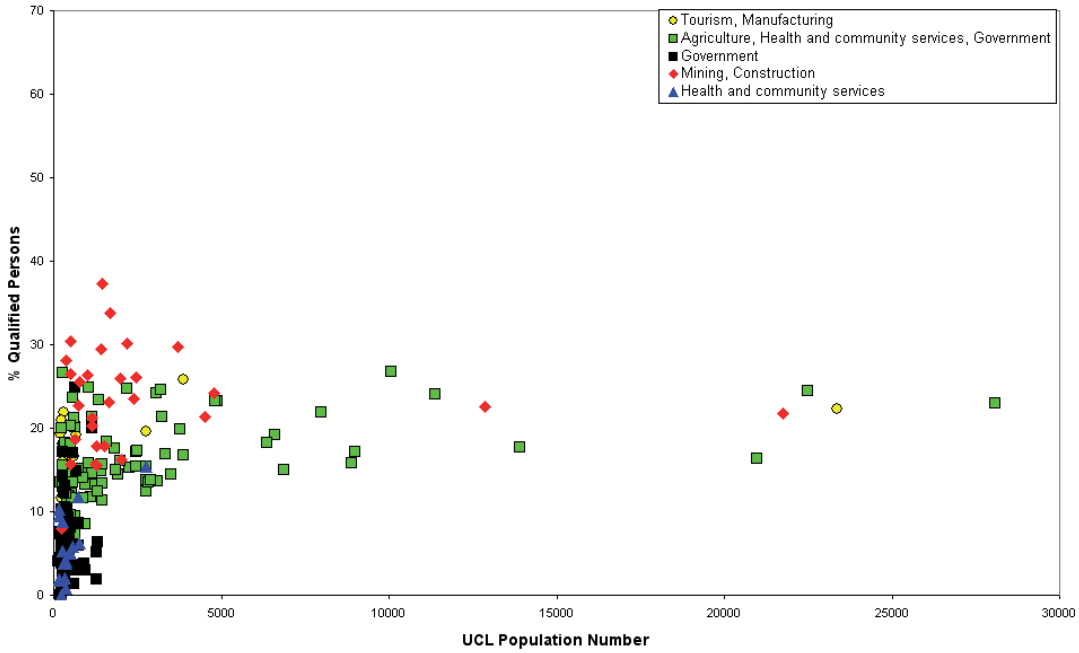


Figure 15.6: Percent qualified persons by UCL population 1996.

UCLs with government and health and community services as dominant employment sectors had a higher total dependency ratio (children and the aged) than those UCLs with mining as a dominant employment sector (Figures 15.7 and 15.8). Between these two ranges falls the dependency ratio of agriculture/trade dominated UCLs.

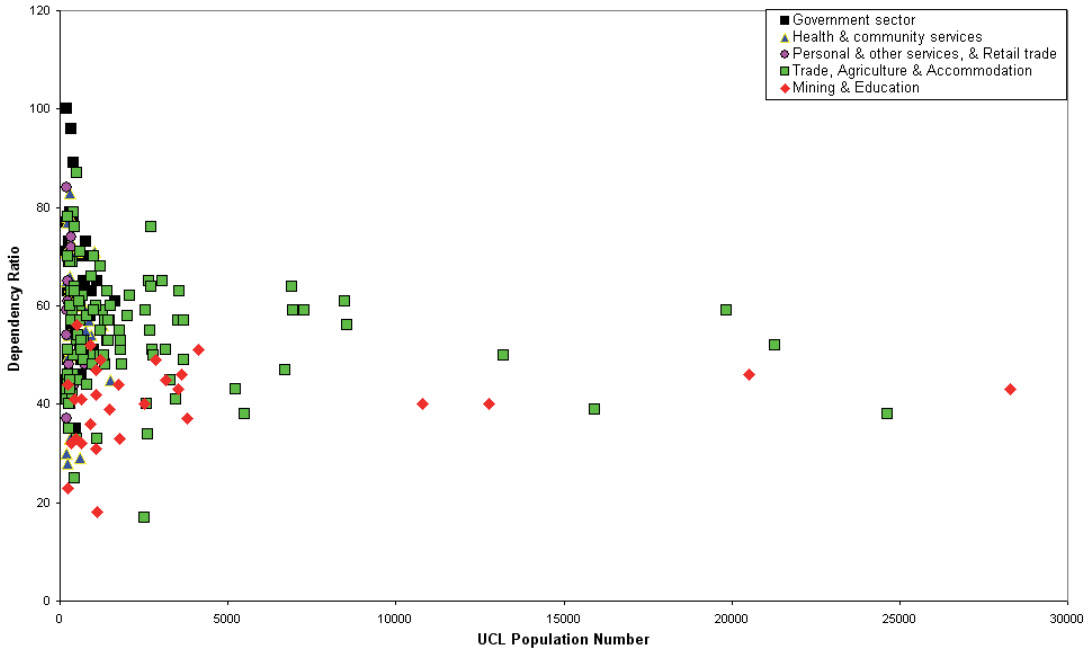


Figure 15.7: Dependency ratio vs UCL population 2001.

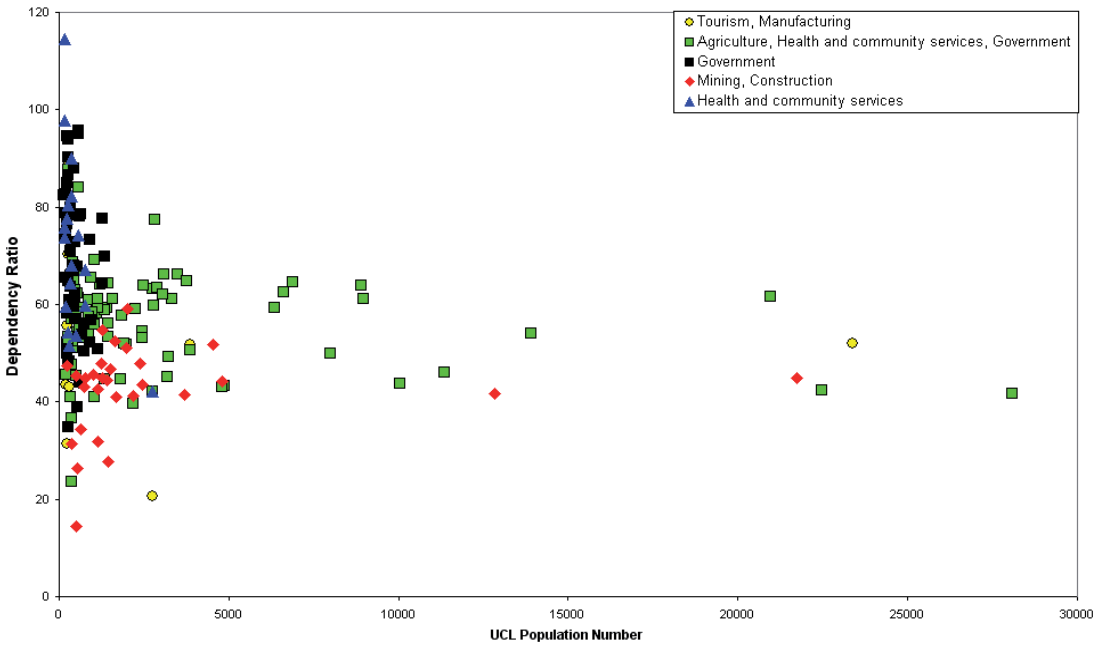


Figure 15.8: Dependency ratio vs UCL population 1996.

Unemployment rates in 2001 were higher in health and community services dominated UCLs than in government sector dominated UCLs (Figure 15.9). In 1996 the UCLs with health and community services as a dominant industry had a much lower unemployment rate than that in government sector dominated UCLs (Figure 15.10).

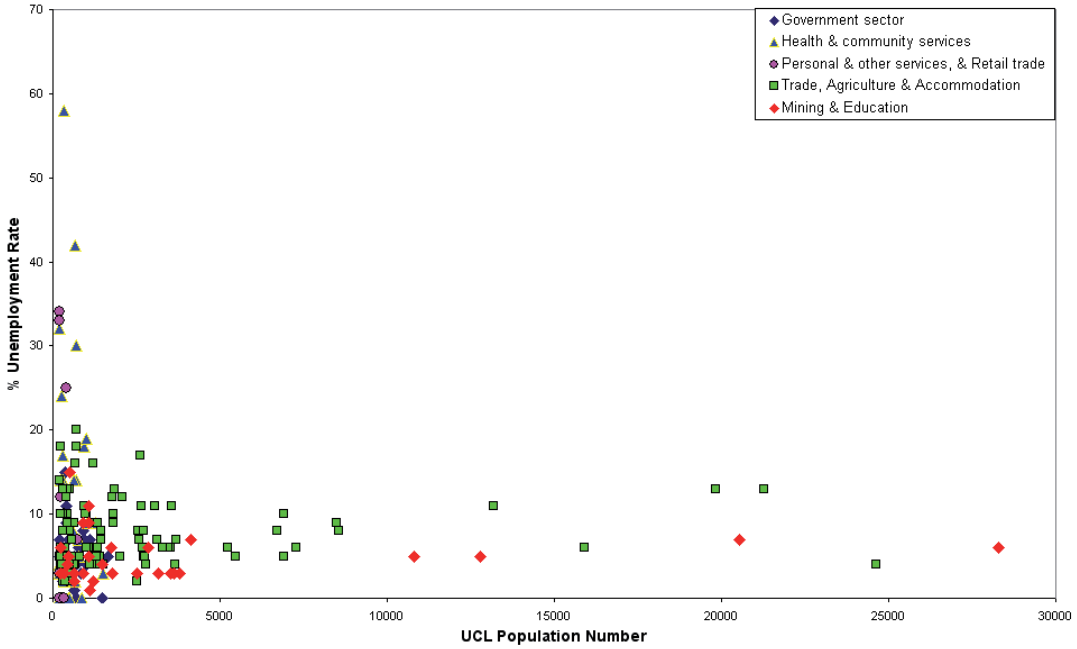


Figure 15.9: Percent unemployment rate vs UCL population 2001.

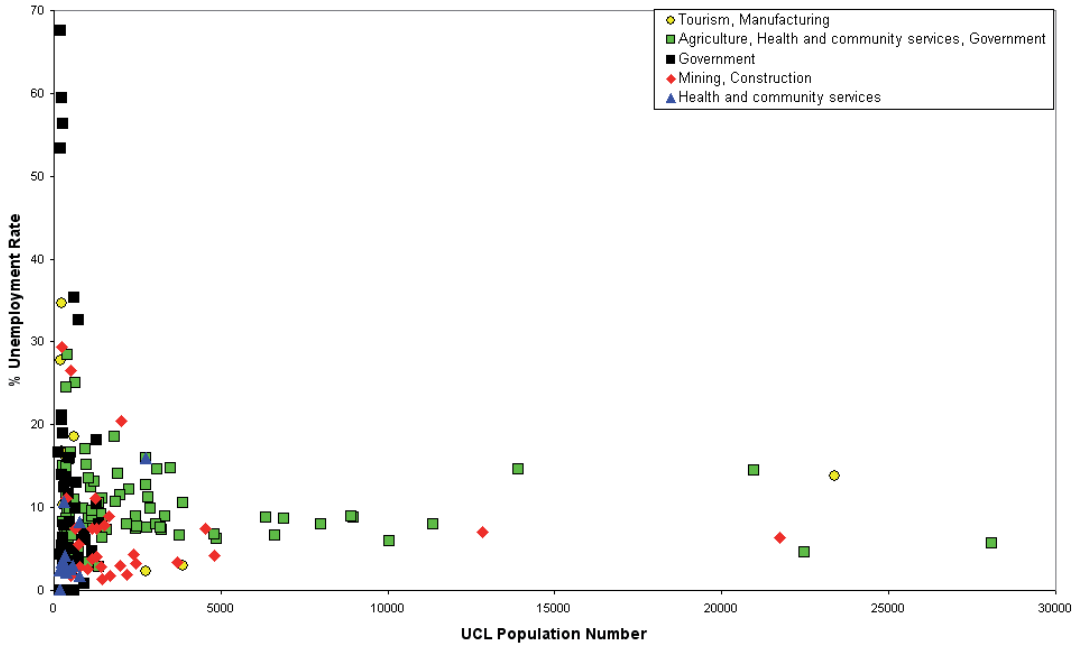


Figure 15.10: Percent unemployment rate vs UCL population 1996.

In both census years mining is consistently associated with higher median household weekly income than the remaining UCLs (Figures 15.11 and 15.12).

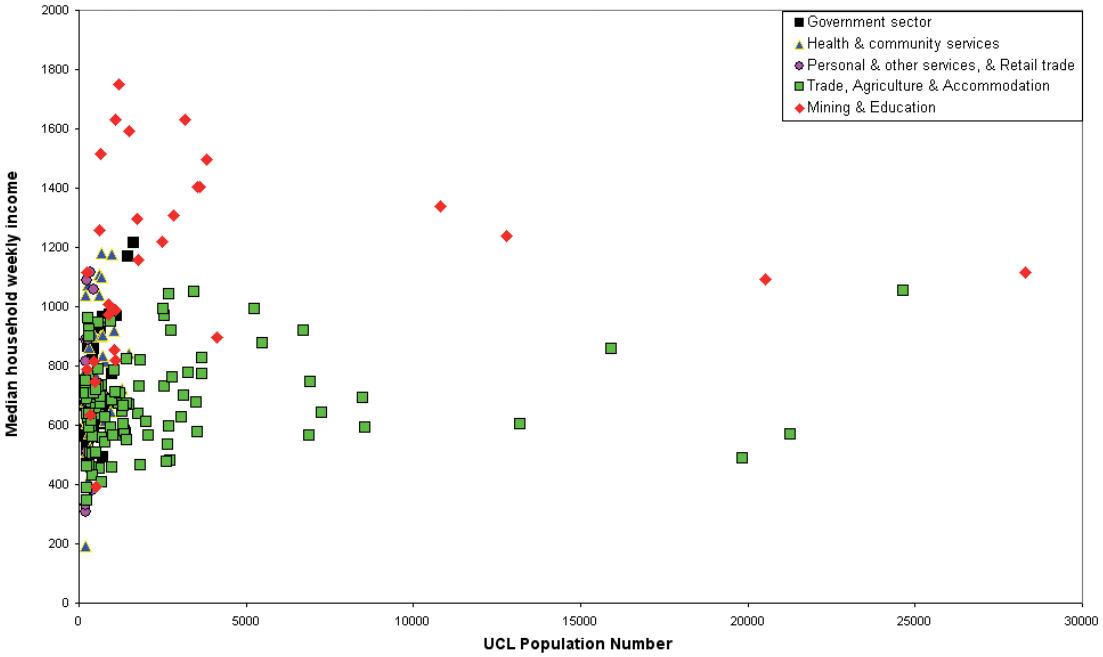


Figure 15.11: Median household weekly income vs UCL population 2001.

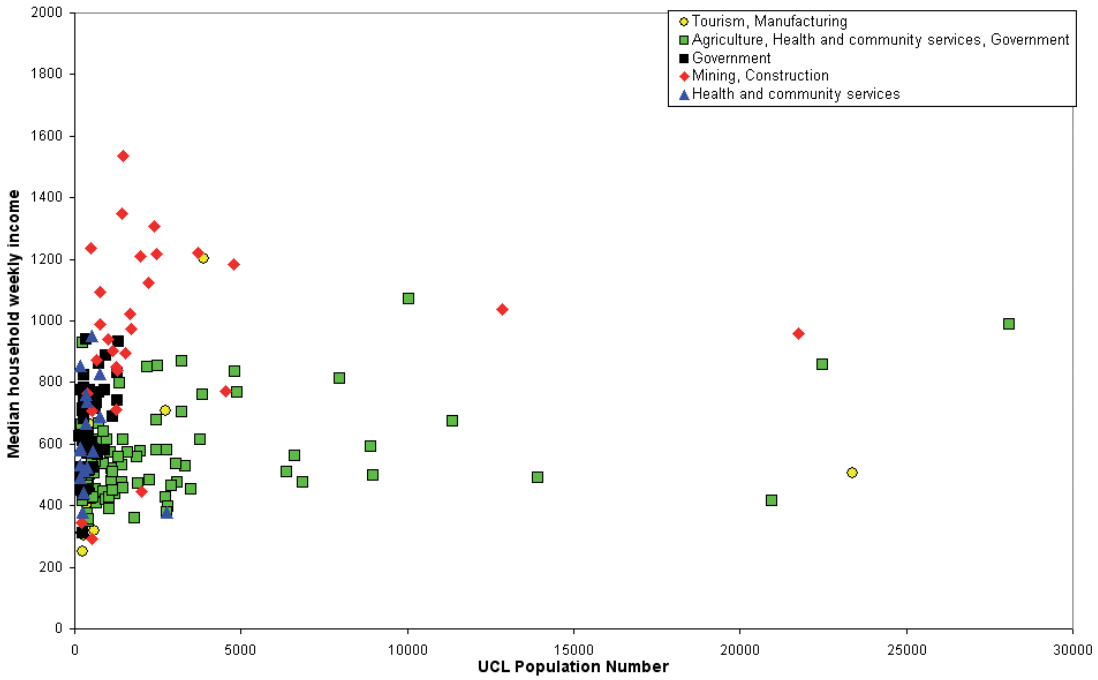


Figure 15.12: Median household weekly income vs UCL population 1996.

As shown in Figure 15.13 below, UCLs with dominant mining or agriculture/trade-based employment have consistently smaller number of persons per dwelling than UCLs with the other three dominant employment sectors.

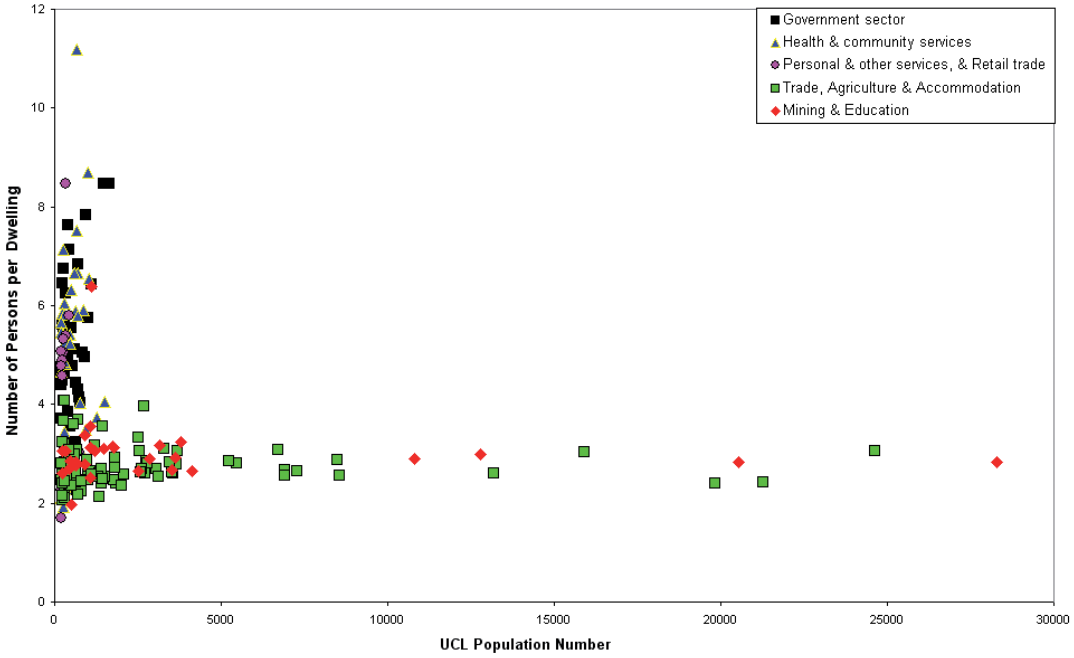


Figure 15.13: Number of persons per dwelling vs UCL population 2001.

Clusters by dimension indicators

Data from census collections by the ABS in 2001 were used to derive the economic and social dimensions. For the environmental dimensions several sources were used including modelled vegetation data from NOAA Pathfinder for 1981–2004, rainfall data from SILO[3] rainfall surfaces for 1880–2004 and values of composite indicators recently developed by Hill *et al*. (2005) and Donohue et al. (2005).

Economic dimension clusters

For the economic dimension clustering, we used the following indicators for 2001: median household weekly income, dependency (or potentially active ratio), percentage persons with a qualification, index of industry diversity, and unemployment rate (Figure 16). In addition we considered the index of economic resources and the index of relative socio-economic advantage/ disadvantage from the SEIFA. SEIFA is a composite index to allow ranking of regions/areas by determining the level of social and economic wellbeing in that region. All of the indices have been constructed so that relatively disadvantaged areas have low indices and vice versa. We conducted a reliability test using Cronbach's statistic to examine the internal consistency in the contribution of each set of individual indicators to corresponding dimension as a unifying construct. For the economic dimension the Cronbach's alpha on standardised values of the indicators considered was very high (α = 0.774). Tables 9 and 10 present the proportion of UCLs in, and the indicator values for, each economic cluster respectively.

3 A comprehensive archive of Australian rainfall and climate data provided by the Bureau of Meteorology.

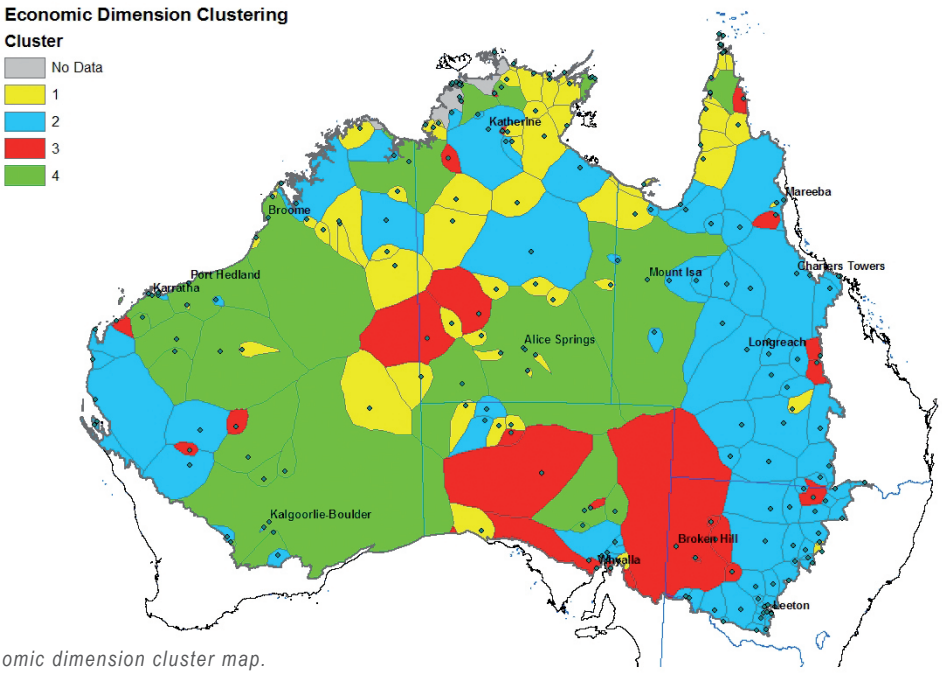


Figure 16: Economic dimension cluster map.

Table 9: Economic dimension clusters of UCLs in the rangelands (using indicators in Table 10).

Cluster Number	Cluster Descriptor	Number of UCLs	% of Combined
1	Lowest economic potential	70	31.5%
2	High economic potential	96	43.2%
3	Mixed economic potential	26	11.7%
4	Highest economic potential	30	13.5%
	Total	222	100.0%

Table 10: Characteristics of economic dimension clusters of UCLs in the rangelands.

Economic Dimension Indicators		Cluster				
		1	2	3	4	Combined
% Qualified of total	Mean	13.32	28.41	32.62	38.28	25.48
	Std. Dev.	6.14	5.54	11.41	4.73	11.02
Ratio of potentially active people (economically productive)	Mean	34.17	46.52	53.62	61.33	45.46
	Std. Dev.	12.14	9.13	11.20	8.54	13.73
Median HH weekly income	Mean	748.46	697.02	548.96	1206.80	764.79
	Std. Dev.	196.26	131.20	203.21	255.11	258.30
Average index of advantage/disadvantage	Mean	865.78	943.99	886.41	1030.20	924.24
	Std. Dev.	47.01	26.98	55.07	35.63	66.76
Average index of economic resources	Mean	872.36	951.02	870.85	1077.94	933.98
	Std. Dev.	40.15	31.56	45.55	51.29	78.25
Inverse industry diversity index	Mean	0.01	0.13	0.47	2.05	0.39
	Std. Dev.	0.01	0.36	1.67	4.79	1.96
% Unemployment rate	Mean	4.94	6.99	18.81	4.30	7.36
	Std. Dev.	4.72	3.39	13.06	1.82	7.09

Cluster 1 is a group of UCLs with relatively small values for most of the indicators considered for the economic dimension (Table 10). Relative to the other clusters, this cluster is more poorly placed economically as measured by this set of indicators.

As a demonstration of this process we have included graphs of the relative significance contribution of variables to the formation of each cluster (see Figures 17, 18, 19 and 20). The graphs are developed using a 'Bonferroni adjustment' – a simple but stringent statistical method of maintaining the significance level at a specified level (in our case at $\alpha = 0.05$ by controlling the effect of multiple comparisons of variables within or between clusters. The horizontal bars in each graph indicate the importance measure of each variable to the formation of the cluster in question. They are displayed in descending order of importance. Those bars which exceed the critical value ($\alpha = 0.05$) indicate variables that significantly contribute to the formation of the cluster at $p<0.05$. Those bars within the limits of the critical value lines indicate variables that are not significant at $p<0.05$. A negative t statistic indicates that the variable generally has smaller than average values within this cluster, while a positive t statistic indicates the variable has larger than average values.

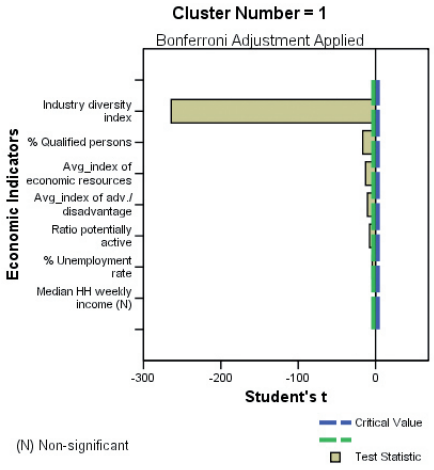
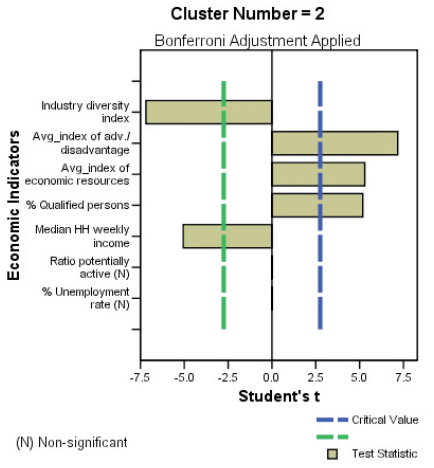


Figure 17: Contribution of indicators to cluster 1.



Cluster 2 has the largest number of UCLs (96, or 43% of all UCLs – Table 9). It has the second smallest values in all indicators except the indices for economic resources and advantage/disadvantage (Table 10). Two indicators, potentially active ratio and unemployment rate, had no significant contribution to the formation of the cluster (Figure 18). This cluster has UCLs with high economic potential.

Figure 18: Contribution of indicators to cluster 2.

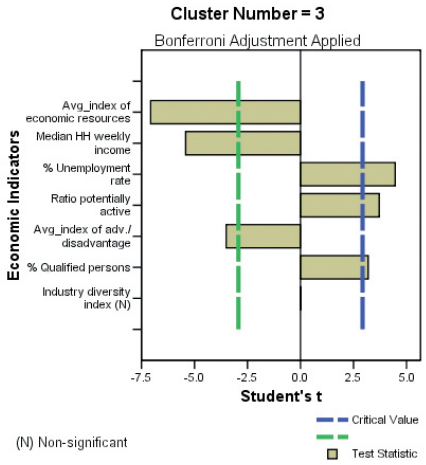


Figure 19: Contribution of indicators to cluster 3.

Cluster 3 is a group of UCLs with low index of advantage/disadvantage and economic resources as well as the lowest median household weekly income (Table 10 and Figure 19). This may be attributable to a high unemployment rate despite a marginally significant but positive contribution of potentially productive and qualified people.

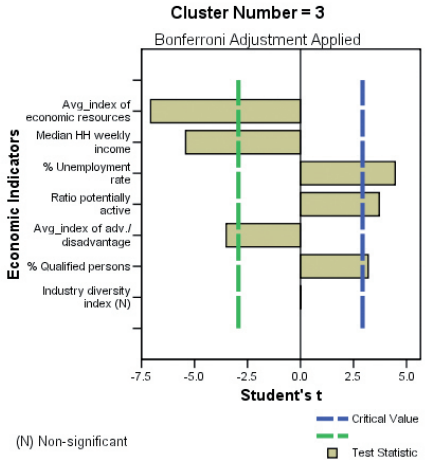


Figure 20: Contribution of indicators to cluster 4.

Cluster 4 has the smallest number of UCLs (30, or 14% of all the UCLs – see Table 10). Economically, this cluster is better placed than the other three clusters due to significantly higher values for advantage/ disadvantage and economic resources and the percentage of qualified and potentially active people (Figure 20). The cluster has also the highest diversity of functioning industries and the lowest unemployment rate as well as the highest median household weekly income.

Social dimension clusters

The social dimension clusters were developed using demographic, cultural and other social indicators including two SEIFA Indices:– the Index of education and Index of relative disadvantage.

For the social dimension, four clusters have been identified (Figure 21 and Table 11). The characteristics of each cluster in terms of the indicators of the social dimension are presented in Table 12.

Table 11: Social dimension clusters of UCLs in the rangelands (using indicators in Table 12).

Cluster Number	Cluster Descriptor	Number of UCLs	% of Combined
1	Small population, high % Indigenous disadvantaged people	71	32.0%
2	Highly mobile	72	32.4%
3	Highest % qualified, highest population	26	11.7%
4	Lowest social disadvantage, less mobile	53	23.9%
	Total	222	100.0%

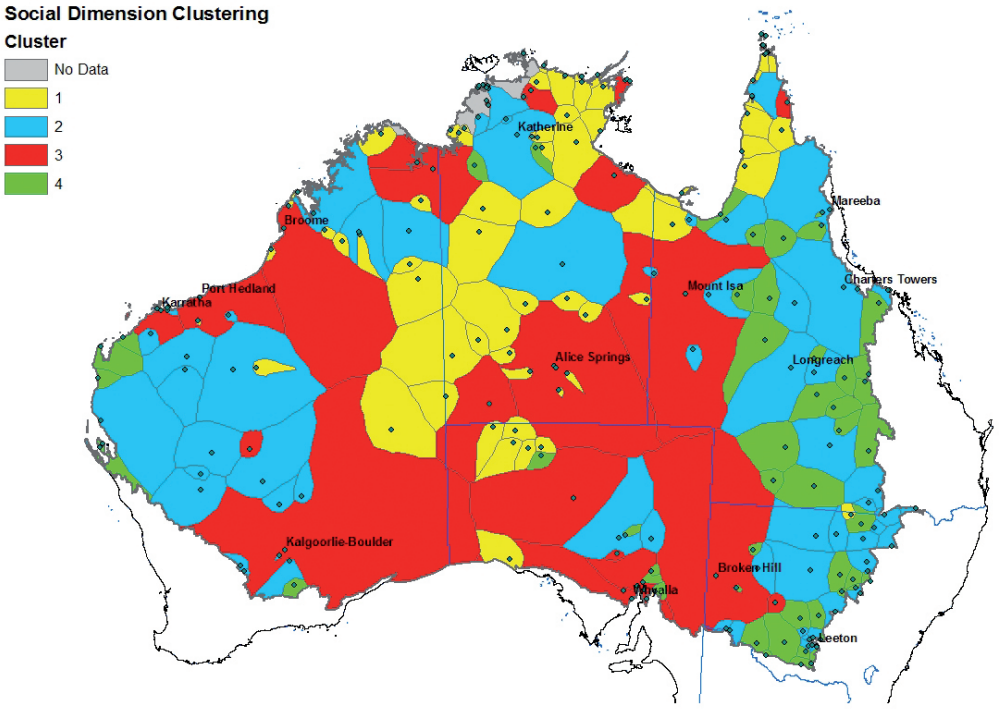


Figure 21: Social dimension cluster map. See Table 11 for summary description of each cluster.

Detailed information on clusters is given in Table 12.

Table 12: Characteristics of social dimension clusters of UCLs in the rangelands.

Social dimension indicators		Cluster				
		1	2	3	4	Combined
Total population	Mean	479.25	2008.86	7365.62	861.77	1873.18
	Std. Deviation	307.26	2063.16	9037.03	706.58	3895.89
Median age	Mean	22.39	32.90	33.62	40.58	31.46
	Std. Deviation	2.79	3.35	4.93	6.63	8.17
% Indigenous people	Mean	88.97	20.54	22.63	9.06	39.93
	Std. Deviation	6.64	18.45	21.52	9.88	36.84
% Non-English background	Mean	1.92	11.52	18.06	9.82	8.81
	Std. Deviation	2.06	3.47	8.62	5.92	7.06
% change in resident number 2000–2001.	Mean	6.13	7.55	15.32	3.36	7.00
	Std. Deviation	4.24	3.36	7.74	3.50	5.53
% People living alone	Mean	2.62	7.88	8.57	12.12	7.29
	Std. Deviation	1.76	2.01	5.38	3.61	4.64
% Qualified	Mean	13.11	31.41	43.77	29.38	26.52
	Std. Deviation	5.66	6.97	12.07	6.96	12.49
Inverse people per occupied dwelling	Mean	0.19	0.35	0.34	0.42	0.31
	Std. Deviation	0.04	0.04	0.06	0.04	0.10
Avg index of disadvantage	Mean	662.49	947.46	961.78	952.74	859.26
	Std. Deviation	126.67	68.12	54.98	85.41	164.12
Avg index of education	Mean	882.40	933.93	984.05	918.92	919.74
	Std. Deviation	65.04	31.16	51.26	37.06	57.20

Cluster 1 has UCLs with the smallest population size and high proportion of socially disadvantaged Indigenous residents. Consistent with a high proportion of Indigenous people the cluster has a low mean value for the change in the number of residents in a year (between 2000 and 2001).

Cluster 2 contains UCLs with slightly higher than average population size and median age but significantly smaller Indigenous proportion. Most of the UCLs in this cluster could be characterised as having highly mobile, educated and socially less disadvantaged people with high proportion of non-English background.

Cluster 3 has similar but more pronounced features than cluster 2. This cluster has the highest proportion of qualified, mobile people with non-English background.

Cluster 4 contains UCLs with the highest median age, the lowest Indigenous proportion and the smallest number of persons per occupied dwelling. It is a cluster with socially well off non-Indigenous less mobile residents.

Environmental dimension clusters

For the environmental dimension it was difficult to find data at UCL level. In order to characterise which regions are fragile or resilient in terms of production and biodiversity we needed to incorporate both (1) 'static' layers which include modelled or interpolated data, e.g. vegetation, soil type etc., and (2) 'Dynamic' layers which can be used to indicate actual system behaviour (e.g. Normalised Differential Vegetation Index (NDVI) and derivatives which can be used to investigate response to rainfall, e.g. Raupach et al. 2005). Indicators need to be able to identify/discriminate different areas/regions in the rangelands in terms of productivity and resilience. We were not aware of any reliable measures of these across the rangelands at this time so have used crude mean, variance and Coefficient of Variation (CV) of the long-term rainfall and NDVI signal as surrogates for system variability. The long-term rainfall variability was calculated from SILO interpolated rainfall surfaces from 1880–2004 using the formula (90 decile – 10 decile)/50 decile (see Bureau of Meteorology 2006).

Figures 22 and 23 are single indicator maps of rainfall variability and NDVI CV respectively. Long-term temporal mean NDVI and standard deviation values were calculated for each pixel. The average values for each hinterland were then calculated based on the values for each pixel, and the CV was then derived using the mean value divided by the standard deviation.

In addition to rainfall and NDVI derivatives, we used indices recently developed by the Bureau of Rural Science (BRS). These are composite indicators at 5km pixel resolution under three index groupings – natural resource base, production base and threatening processes (see Hill et al. 2005 and Donohue et al. 2005). Three indicators were used in this report – environmental sensitivity, total impact and conservation (threatened species). However we understand that these indicators are 'works in progress' and therefore need to be treated cautiously. Indicators were reduced, from the greater number of ranks used by BRS, to five ranks. Maps of reworked examples of each index with a reduced number of ranks are presented in Figures 24–26.

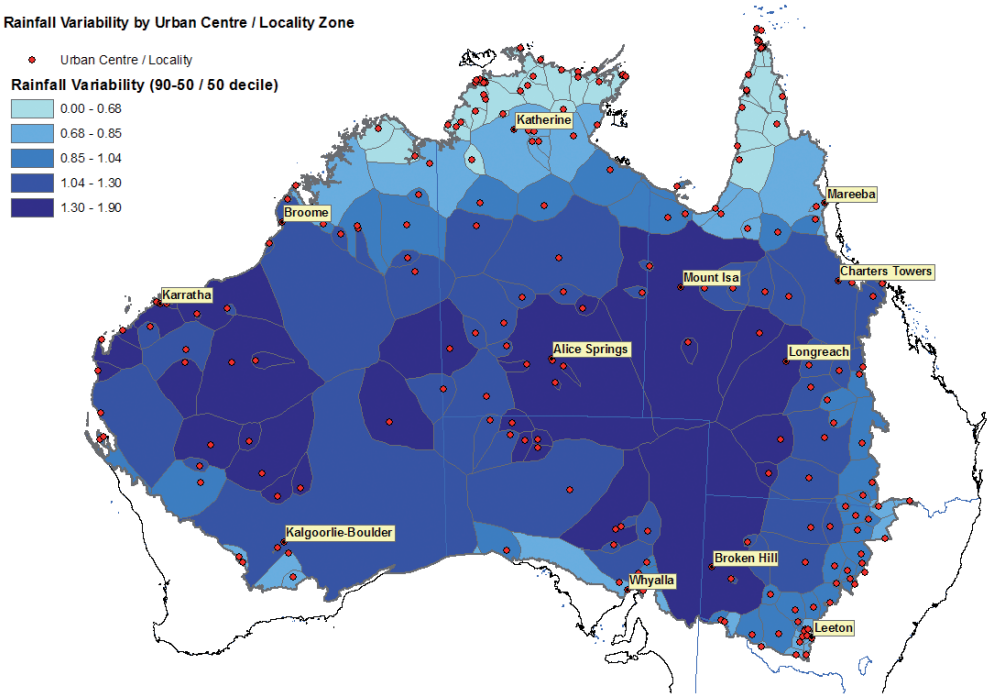


Figure 22: Map of rainfall variability.

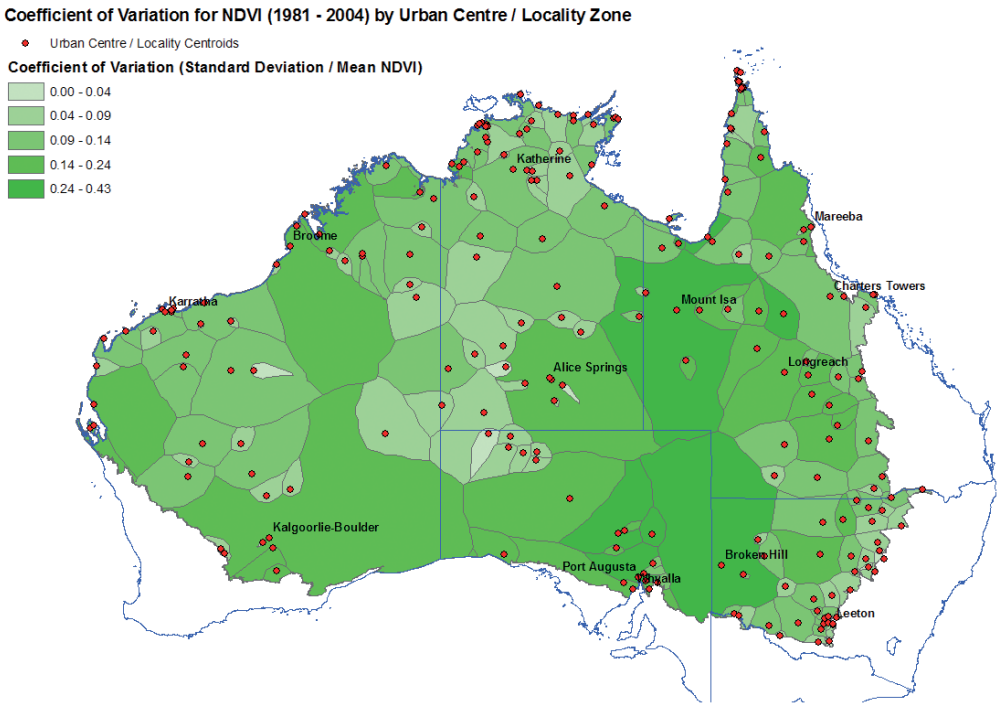


Figure 23: Map of the coefficient of variation of normalised differential vegetation index (NDVI).

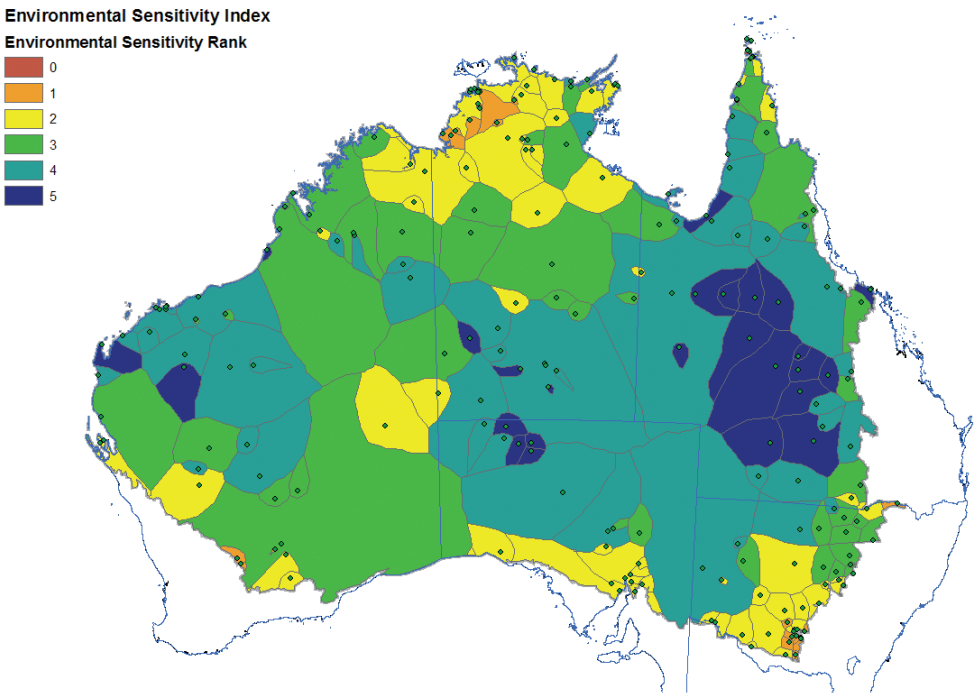


Figure 24: A reworked example of the environmental sensitivity index (0=low, 3=medium, 5=high sensitivity).

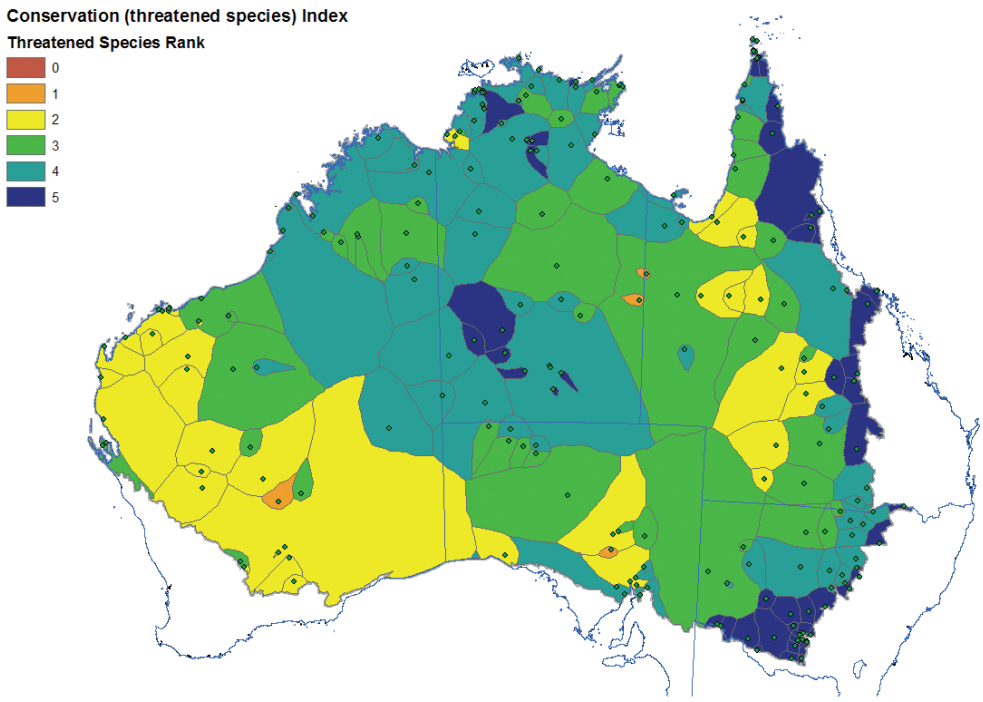


Figure 25: A reworked example of the conservation (threatened species) index

(0=low, 3=medium, 5=high number of threatened species).

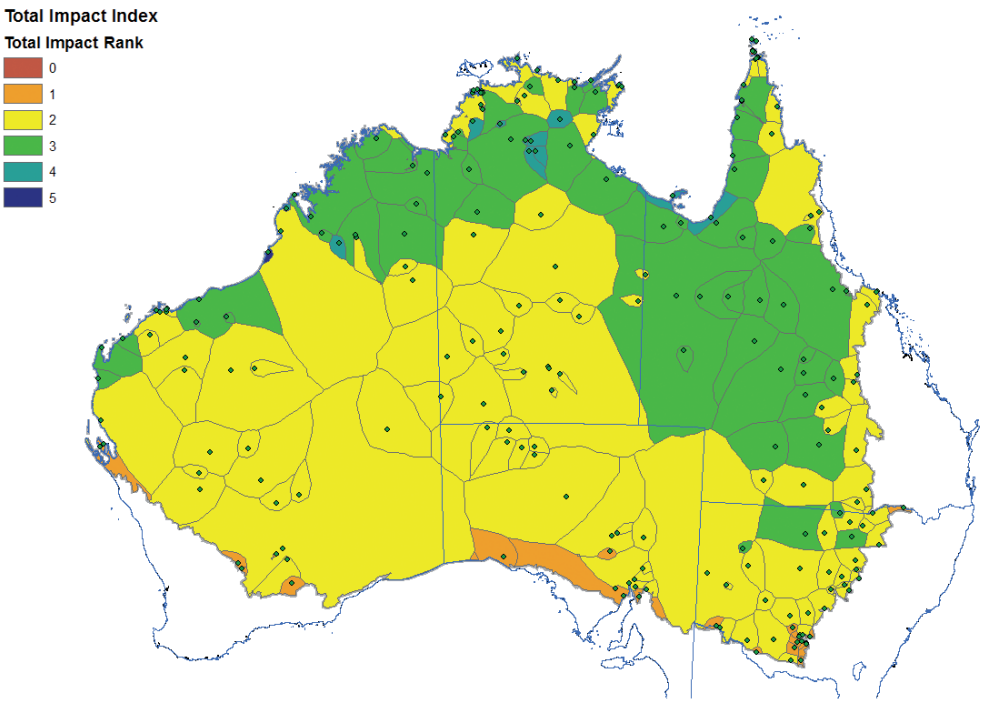


Figure 26: A reworked example of the total impact index

(0=low, 3=medium, 5=high impact).

The indices from BRS were then combined with rainfall and NDVI CV. The Cronbach's reliability statistic was $\alpha = 0.54$ indicating satisfactory internal consistency in the contribution of the individual indicators to the environmental dimension as a unifying construct. Based on significant similarity of values of the environmental indicators five clusters of UCLs were identified and presented in Table 13 and in Figure 27.

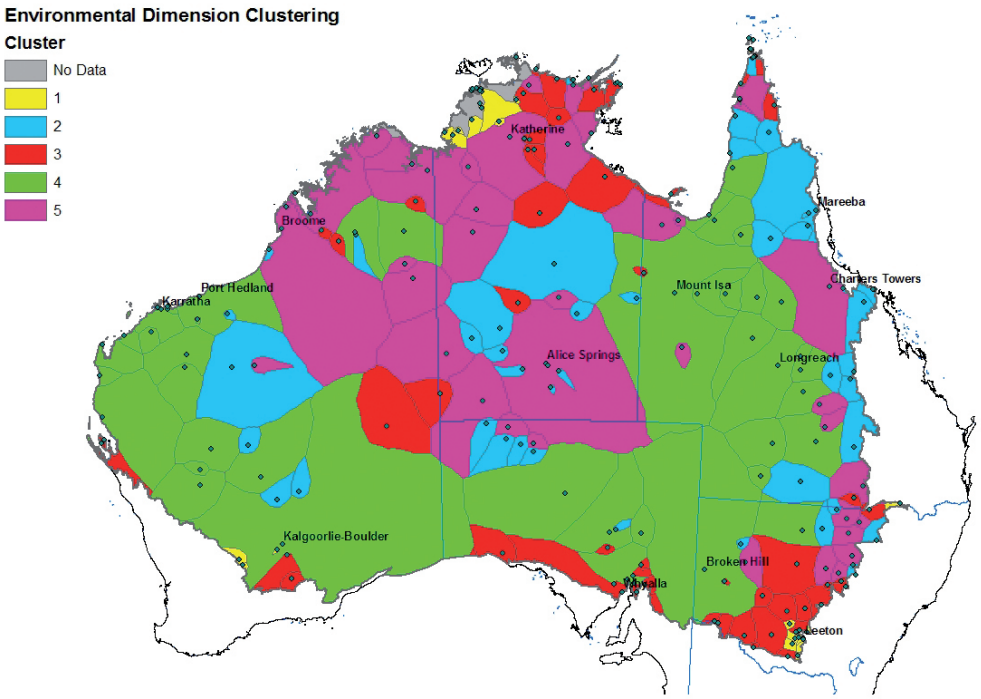


Figure 27: Environmental dimension cluster map.

Table 13: Environmental dimension clusters of UCLs in the rangelands (using indicators in Table 14).

Cluster Number	Descriptor	Number of UCLs	Percentage
1	Relatively benign environment suggesting considerable resilience	40	18.1%
2	Fairly benign but vulnerable environment	46	20.7%
3	Highly impacted and moderately variable environment	54	24.3%
4	Variable, vulnerable and impacted environment	41	18.5%
5	Variable and moderately vulnerable/impacted environment.	41	18.5%
	Total	222	100%

Table 14: Indicator values of the environmental clusters.

Environmental dimension indicators	Clusters				
	1	2	3	4	5
Rainfall CV	very small	small	medium	very high	high
NDVI CV	very small	small	medium	very high	high
Total impact	low	medium	very high	high	medium
Environmental sensitivity	low	high	medium	high	medium
Threatened species	very low	very high	low	high	medium

Cluster 1 scores low for all indicators, particularly low total impact and environmental sensitivity (although fire is frequent and extensive in the northern mapped area).

Cluster 2 has the largest number of threatened species which is probably the main driver for this group. Environmental conditions are slightly less favourable than for cluster 1.

Cluster 3 contains areas with a high level of total impact. This may be due to agricultural practices in the south (e.g. tree clearing, possible salinisation), and possibly due to frequent and extensive fire in the north.

Cluster 4 is the most environmentally variable and impacted of the clusters. All indicators score high or above.

Cluster 5 is a less severe case of cluster 4.

4. DISCUSSION

After a review of existing regionalisations of rangelands, we concluded that a smaller spatial unit was required for meaningful analysis of socio-regions. The subsequent task of this project was to establish a weighted hinterland (or socio-region) for each UCL based on its functional or service influence on neighbouring areas. There were two main challenges: the first was that, for confidentiality reasons, data on the number and type of services at the UCL level were not available to the project team; the second challenge was finding practical examples of hinterland boundaries derived using a weighted gravity model. No useful examples were found and an alternative procedure was used based on an ArcINFO cost allocation procedure. Hinterland boundaries based on weighted population provided an improved approximation of the influence of service centres compared with that derived from an index of industry diversity.

While hinterland boundaries were set based on the influence of population size, the characteristics of settlements below 200 people could not be included because ABS lumps data for very small settlements at a state or territory level. This may have contributed to the absence of pastoralism (agriculture) as one of the dominant livelihood activities (industry sectors) in the outback regions. Pastoral settlements are isolated and dispersed with population sizes often much smaller than 200.

A number of data issues were identified. Access to important data sets such as the number of services by locality was restricted. ABS data are generally made available by Place of Enumeration (place on Census night), with some datasets adjusted to Place of Usual Residence. All Urban Centre Location (UCL) data and that derived for the 2001 SEIFA supplied by the ABS for this project are based on place of enumeration which includes usual residents and visitors but excludes overseas visitors. Enumerated data is likely to vary from usual residence, particularly when Census collection coincides with tourist season. This issue is particularly important for areas of low population.

Furthermore the quality of some of the data obtained was questionable. These datasets were the best available, however, caution must be used in placing value on the interpretation of some of the results. Data on the change in resident numbers between 2000 and 2001 are questionable particularly in areas with a high percentage of Indigenous persons where mobility makes census counts less reliable. As well, the composite environmental indicators developed by BRS need further testing and evaluation to confirm that they reflect actual processes.

Composite indicators such as the environmental indices by BRS and SEIFA by ABS were included to increase the number of indicators considered for this study. These indices may have duplicated some of the single indicators used, but the influence is insignificant because our major concern was for relative differences and similarities as opposed to absolute values. Moreover duplications were few and were applied uniformly to all the analyses of UCLs.

Some important indicators are obviously missing from the analysis. These include demographic indicators such as net migration, indicators of social health (e.g. infant mortality rates, levels of alcohol related deaths, crime rates) and cultural and natural resource indicators (e.g. number of sacred sites/heritage areas preserved, land entitlements and uses). This scoping project could

be followed by a series of projects focused on each of these areas. Desert Knowledge CRC management may need to negotiate with respective data custodians to facilitate access to existing data.

Most indicators were static in that they provided snapshot measures for a census year. Other indicators such as rainfall and NDVI were derived using available time series data. For others, change was inferred by comparing data for the same indicator over two census years (1996 and 2001). The census in 2006 will provide another opportunity to refine the study to consider temporal changes in indicators (although the change in ABS boundaries to mesh blocks will pose further challenges on spatial correspondence of multi-temporal datasets). There are still gaps in datasets which will need further work to address indicator dynamics through time and space. Spatial changes and interactions of variables (particularly of key drivers such as population mobility and net migration rates) need to be investigated in future work.

Some of the key internal drivers observed in this study include settlement pattern, population size, percentage Indigenous persons, other demographic features and the resource base. These drivers interact with external drivers such as core–periphery socio-economic relations (Peterson 2000). The key indicators of internal and external drivers need to be identified before 'what if' scenarios for exploring research policy and business investments can be developed.

The composition and order of dominant industry (livelihood) sectors among clusters of UCLs have changed over time as shown in Figures 13 and 14; Tables 5 and 6). The dominant industry sectors for 1996 were mining and a mixture of agriculture, health and community services and government sector, while for 2001 the dominant industry sectors were mining and a mixture of trade, agriculture and accommodation. Cultural and recreational services and the accommodation sector have also emerged as part of the mixture of dominant employment sectors in 2001.

An overview of the graphs in Figures 15.1–15.13 shows us the different characteristics based on population size for each of two broad categories of UCLs in the rangelands. At a threshold population of around 5000 there was a marked change from differing values to consistently similar values for several indicators. UCLs below 5000 population show a higher degree of variability than urban centres with a population of more than 5000. This high variation confirms the need to consider statistical units smaller than the SLA. Statistical Local Areas in the rangelands are typically large so that indicator values are averaged over several socio-economically and culturally diverse smaller units.

A similar threshold phenomenon was also observed with diversity of dominant industry sectors at UCLs with ~2500 population. UCLs with less than the approximate threshold size seem to have all 5 clusters of dominant industry sectors; the UCLs with more than the threshold population size have only two dominant industry sectors in both 1996 and 2001. These dominant industry sectors for 1996 were mining and a mixture of agriculture, health and community services and government sector. For 2001 the dominant industry sectors were mining and a mixture of trade, agriculture and accommodation. An interesting question for future exploration is to determine possible causal relationships among characteristics of UCL population, level of industry diversity and types of dominant industries.

The higher variation observed among UCLs with small populations suggests that they require more targeted research, policy and investment than large urban centres. However, small UCLs (i.e. smaller than the threshold population of 5000) can be grouped into similar clusters. The groups of similar small UCLs may cross traditional administrative borders and can form non-contiguous regions. Defining regions using such clusters provides options for selecting one or many strategic case study – and research validation – areas and would assist research investment for regional outcomes.

This study attempted to create just that: significant socio-ecological clusters as regions for the purpose of selecting areas for strategic regional research. The groups created under each dimension demonstrate that a population threshold exists beyond which variation of several of the indicators and dominant industry sectors among UCLs decreased.

Given the limitations of data quality and availability the social, economic and environmental clusters suggested can only be a start in the right direction. The mean indicator values shared by UCLs in a cluster are indicative only and can be considered as hypotheses that need further testing based on improved knowledge of the individual UCLs in each cluster. In the long term a more grounded hypothesis of the similarities of the UCLs in each cluster can be developed based on improved availability and quality of data and indicators. In turn, the outcomes of undertaking this work will assist regional policy making and strategic business investment.

5. RECOMMENDATIONS

This preliminary study shows the potential of further fruitful work on socio-regionalisation. Recommendations below outline actions to improve:

- Data availability, access and reliability
- Development of a comprehensive set of indicators and alternative approaches
- Regionalisation mismatches as a result of a new way of conceptualising regions.

The set of indicators used was determined by the availability of relevant and accessible datasets. Ideally, we would have used the type and number of services in an UCL to derive hinterland boundaries. Although this data exists for use by government and is collected via the Australian Business Number (ABN) registration process the data was not accessible for confidentiality reasons. Access to this sort of data in an anonymous form needs to be negotiated.

ABS enumerated data were used for this project. Enumerated data includes visitors so is likely to vary from usual residence, particularly when Census collection coincides with tourist season. A detailed comparison of enumerated and usual resident datasets using various geographies is needed for desert areas.

There were several important indicators that were not included in the study because the data was not available at the UCL level. These include different health, environmental, geographic and demographic indicators such as birth and mortality rates. For further refined work on socio-regions and other projects requiring similar data the Desert Knowledge CRC needs to negotiate with respective data custodians such as territory/state and federal departments and agencies.

Some of the composite indices used in this study duplicate individual indicators. This could be addressed by analysing indices separately, or by dropping some of the indices when a wider range of data on individual indicators becomes available in the future.

This study has largely used indicators which are static, so a temporal comparison is largely missing. A further study on dynamics of indicators is needed to show changes over time, space and the interaction of drivers. This can be done through the modelling of selected indicators and simulation of ‘what if’ scenarios.

The regions created for the set of dimensional or other individual indicators show emerging social-environmental patterns among UCLs located in different jurisdictions. This requires a change in thinking from a traditional concept of geographic regions to more flexible regions containing non-contiguous UCLs that span state and territory administrative boundaries. To facilitate such a change an important task is an elaboration of the difference and mismatches with traditional administrative regions. The Desert Knowledge CRC is involved in many cross-jurisdictional projects and there is an opportunity for the CRC to take the lead in conducting research on cross-boundary socio-economic and cultural issues using this new way of classifying UCLs into socio-regions.

6. REFERENCES

Australian Bureau of Statistics (ABS) 2001, *UCL level data from 1996 and 2001 census*, ABS Darwin.

Australian Government Department of the Environment and Heritage 2005, http://www.environment.gov.au/land/management/rangelands/index.html

Australian Local Government Association and National Economics 2004, Migration, Ageing and the Region, *State of the Regions Report*, 2003–04, at: http://www.alga.asn.au/policy/regional/sor/2003/

Bureau of Meteorology 2006, *Three-month and Annual Rainfall Variability Maps*, Online: http://www.bom.gov.au/climate/averages/variability.shtml, accessed: 24 March 2006. Bureau of Meteorology, Australia.

Department of Transport and Regional Services (DoTARS) 2001, *Stronger Regions, A Stronger Australia: The Federal Government's framework for developing Australia's regions through the next decade*, Policy Statement, at: http://www.dotars.gov.au/regional/statement/contents.htm

Donohue R, Hill MJ, Holloway J, Houlder P, Lesslie R, Smith J and Thackway R 2005, Australia's *Rangelands: an analysis of natural resources, patterns of use and community assets*, Report to the Natural Resource Management Business Unit, Department of Agriculture, Fisheries and Forestry, January.

Environment Australia 2000, *Revision of the Interim Biogeographic Regionalisation for Australia (IBRA) and Development of Version 5.1*, Summary Report, Environment Australia.

Geoscience Australia 2005, Free Data Downloads, Online: https://www.ga.gov.au/products/servlet/controller?event=DEFINE_PRODUCTS, accessed: 4 April 2006. Geoscience Australia.

Government of South Australia 2005, *State of the Outback Report*, Sept 2005.state_of_outback_main.pdf http://www.pir.sa.gov.au/dhtml/ss/section.php?sectID=2366

Hill MJ, Lesslie R, Donohue R, Houlder P, Holloway J, Smith J and Ritman K 2005, 'Assessment of Tensions between Different Claims on the Natural Resource Base in Australian Rangelands using a Multi-Criteria Approach', *Journal Environment Management*, accepted for publication.

Holmes JH 1997, 'Diversity and change in Australia's rangeland regions: translating resource values into regional benefits', *The Rangeland Journal*, 19 (1), pp. 3–25.

Hugo G, Smailes P, Macgregor P, Fenton M and Brunckhorst D 2001, *Defining Social Catchments in Non-metropolitan Australia*, BRS.

McGregor CJ 2003, 'Working towards sustainability in small towns: perspectives from northern Australia', *Int. J. Environment and Sustainable Development*, Vol. 2, No. 4, pp. 342–363.

Peterson G 2000, 'Political ecology and ecological resilience: an integration of human and ecological dynamics', *Ecological Economics*, (35): 323–336.

Raupach MR, Schoettke B, Briggs PR, Lovell JL, Oubelkheir K, Marks A, Brando VE, Byrne G and Dekker AG 2005, 'Use of Earth Observation to Assess Land Condition and Sediment Delivery in Great Barrier Reef Catchments over the last 25 Years', A report for the Great Barrier Reef Region Node of the CSIRO Water for a Healthy Country Flagship Program, Draft report for internal review, *LandSedReport*,V10.doc

Scoones I 1998, 'Sustainable rural livelihoods: a framework for analysis', *International Development Studies*, (72) pp.1–22.

Taylor J 2003, 'Data Issues for Regional Planning in Aboriginal Communities', Seminar presented in the *Contemporary Indigenous Issues in North Australia series*, Darwin, <http: //naru.anu.edu.au/publications.php>

Webb TJ and Curtis A 2002, *Mapping regional capacity*, Final report to Land and Water Australia, Dec. BRS. URL http://www.lwa.gov.au/downloads/final_reports/BRR20.pdf

Woodhouse R, Howlett P and Rigby C 2000, *Sustainable Rural Livelihoods (SRL) framework: A Framework for Research on Sustainability Indicators for Agriculture and Rural Livelihoods.* Development and Planning Centre, University of Bradford, UK.