Projecting Aboriginal and Torres Strait Islander populations for remote communities: a small number approach

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Contents

Executive summary iv
1. Introduction 1
2. Background 2
3. Data and method 4
4. Cohort model – linear regression results 8
4.1 Apparent fertility rates 13
5. Projections 14
6. Conclusion 19
References 22
Appendix Table A1: Descriptive statistics for variables included in the regression model (n=19,776 for all variables) 24
Appendix Table A2: Aboriginal and Torres Strait Islander populations by ILOC: 2011 Census estimates and 2016 projections 26

Tables

Table 1: Australian population estimates by Aboriginal and Torres Strait Islander status and remoteness, 2011 Census 4
Table 2: Definitions for independent variables used in the regression model 9
Table 3: Regression estimates, cohort population changes 2006–2011 10
Table 4: Aboriginal and Torres Strait Islander populations: 2006 and 2011 census estimates and 2016 projections, by remoteness 16
Table 5: Projected Aboriginal and Torres Strait Islander population growth rates, by age and remoteness (per cent change from 2011 to 2016) 17
Table 6: Projected Aboriginal and Torres Strait Islander population growth rates, by remoteness and community size (per cent change from 2011 to 2016) 18
Table 7: Projected Aboriginal and Torres Strait Islander populations by state/territory and remoteness 19

Figures

Figure 1: Cohort structure of the Census population data 6
Figure 2: Model fit – actual versus predicted 2011 populations (aged 5+), 618 ILOCs 13
Figure 3: Projected changes in Aboriginal and Torres Strait Islander populations by ILOC: 2011–2016 15
Figure 4: Projected distribution of the Aboriginal and Torres Strait Islander population in Outer regional, Remote and Very remote Australia, 2016 16
Figure 5: Age structure of the Aboriginal and Torres Strait Islander population in Outer regional, Remote and Very remote Australia: 2011 (actual) and 2016 (projected) 17

Executive summary

There is considerable uncertainty surrounding population estimates for Aboriginal and Torres Strait Islander Australians at both the aggregate and subregional levels. Given well-documented limitations of efforts to enumerate the existing population at a point in time, the task of projecting future populations is even more problematic, and currently no regular projections are produced below the state level. However, information on future trends in the Aboriginal and Torres Strait Islander populations at more disaggregated geographical and demographic levels would be of enormous value for policy and planning. This is particularly so for remote Australia and the remote Aboriginal and Torres Strait Islander communities for which there has been ongoing controversy about the provision of services and infrastructure and even their very 'viability'. Policies, planning and funding models based on inaccurate assumptions of future populations are likely to lead to misallocation of resources and sub-optimal outcomes for Aboriginal and Torres Strait Islander people. This paper sets out a proposed methodology for generating projections of Aboriginal and Torres Strait Islander populations in Outer regional and Remote Australia, down to the community (or 'Indigenous Location') level. Based on 2006 and 2011 Census data, projections for remote Aboriginal and Torres Strait Islander communities for 2016 are presented by age group and gender, and the implications of those estimates for policy are discussed. These estimates should be considered experimental and are selected from a range of models under development. Release of 2016 Census data will enable validation of the different models and provide a panel dimension that can be used to substantially enhance modelling for generating 2021 projections and beyond.

1. Introduction

There is a substantial and well-documented disparity in outcomes for Aboriginal and Torres Strait Islander and other Australians across virtually all mainstream indicators of social and economic wellbeing. 'Closing the gap' is the broad label for the Council of Australian Governments' National Indigenous Reform Agenda aiming to reduce this statistical inequity faced by Aboriginal and Torres Strait Islander Australians. The role of remoteness in this narrative is both pivotal and controversial. Relative to other Australians, a far higher proportion of Aboriginal and Torres Strait Islanders are found in remote areas of the continent. Based on data from the 2011 Census, 21.4% of Aboriginal and Torres Strait Islander Australians live in areas classified as Remote or Very remote, compared to just 1.7% of other Australians. Only 34% of Aboriginal and Torres Strait Islanders live in a major city, compared to 71% of other Australians. While the large population centres generally offer greater access to services and infrastructure and better labour market opportunities, for many Aboriginal and Torres Strait Islander Australians those centres cannot offer the connections to homelands, culture and kinship networks that are intrinsic to their wellbeing.

Australia's current policy discourse expresses reservations over the 'viability' or 'sustainability' of remote Aboriginal and Torres Strait Islander communities. Implicitly, and in some cases explicitly, it seems governments would prefer a rationalisation of these communities, such that there was a migration out of the smaller and more remote communities, and their eventual disappearance. Examples of this policy mindset can be seen in the Northern Territory Government's 2009 *Working Future* policy statement (Northern Territory Government 2009), which identified 20 'Territory Growth Towns' as part of a hub-and-spoke model of service delivery; and more recently the Western Australian Government foreshadowing the withdrawal of services to up to 150 of the smaller and more remote communities in that state (*WA Today* 2014a, 2014b). The Western Australian Government's strategy set out in the recently formulated 'roadmap' for the reform of service delivery in remote communities is to focus efforts and investment on communities that have 'significant educational and employment opportunities', explicitly acknowledging that:

> In concentrating on towns and larger communities, the State Government expects to support fewer communities over time, particularly as migration away from small outstations continues. (Regional Services Reform Unit 2016, p. 12)

If some Aboriginal or Torres Strait Islander communities are seen to be unviable then, broadly speaking, there are two policy approaches that could be taken. One is to promote economic development and employment in those communities, to make them more self-sufficient. The second is to promote adjustment that would see people move out of those communities. Such adjustment may be achieved by pull factors, which provide positive incentives for out-migration or reduce the cost associated with moving; push factors, such as withdrawing services, activity testing and welfare quarantining that make life in those communities more difficult; or some combination of the two. However, Australia's history is littered with examples of failed attempts to manipulate the geography and mobility of Aboriginal and Torres Strait Islander people, stemming largely from the failure to recognise the importance of cultural drivers to their wellbeing (Dockery 2016).

The effectiveness of policy and service funding allocations for remote communities will be highly sensitive to the degree of consistency between assumed and actual population trends. The need for separate estimates for Aboriginal and Torres Strait Islander and other populations arises from the vastly differing demographies, service requirements and migration patterns (Taylor et al. 2006, Wilson 2009). In addition

to the total population of remote communities, projections of the age structure of individual communities are important in determining the likely mix of services required, such as the number of school places, available health services and aged care facilities. Such forecasting exercises are inherently difficult for Aboriginal and Torres Strait Islander populations in remote Australia. This paper proposes an empirical approach to dealing with some of those challenges and reports results from one of a suite of models being developed for forecasting Aboriginal and Torres Strait Islander population changes at the community level by age and gender. The focus here is on broad population trends from 2011 to 2016 by remoteness and community size. With the release of the actual 2016 Census data, expected in the second half of 2017, there will be potential for considerable further development of each of the models and an improved basis for model selection. The preferred models will be used to extend detailed projections out to 2021 and 2026.

The following section provides background on existing approaches to projecting the Aboriginal and Torres Strait Islander population, and Section 3 then lays out the approach under development and the data to be used. Section 4 reports the results from the modelling of 2011 populations on 2006 data, and Section 5 presents the 2016 projections that are obtained by applying the modelling results to the 2011 data. Projections by individual community are provided in Appendix 2. The final section discusses scope for further development and application of the method.

2. Background

The Census of Population and Housing, conducted every five years by the Australian Bureau of Statistics (ABS), is the principal source of estimates of Australia's population and its demographic composition. It is also the main means by which the Aboriginal and Torres Strait Islander population is counted and, since 1971, the intention has been for a full enumeration of that population (Wilson 2009). The ABS 2011 Census initially recorded 548,000 people of Aboriginal or Torres Strait Islander descent, representing 2.5% of the total population. The ABS also produces estimates of the Aboriginal and Torres Strait Islander resident population based on a post-enumeration survey and statistical methods to adjust for the net undercount and the substantial number of people for whom Aboriginal or Torres Strait Islander status is unknown. Table 1 shows how the Aboriginal and Torres Strait Islander share of the population increases with remoteness according to the original 2011 Census estimates. Only 34% of Aboriginal and Torres Strait Islander Australians live in Major cities but 14% live in areas classified as Very remote; 71% of other Australians live in Major cities and less than 1% live in areas classified as Very remote. So while Aboriginal and Torres Strait Islander Australians make up around 2.5% of the overall population, they represent 41% of people living in Very remote Australia.

One of the main approaches to population projection is the cohort-component method (see Booth 2006 for a review). For given age cohorts in a base year, assumptions regarding deaths, births, in-migration and out-migration are applied to arrive at projections for that group at a future time. For a range of reasons, applying this method to project populations of Aboriginal and Torres Strait Islander people living in remote communities, which we do in this paper, is fraught with additional complications that are likely to compound projection errors.

First, the accuracy of even the baseline data is questionable. The ABS post-enumeration estimate of the total Aboriginal and Torres Strait Islander population was 21% higher than the original census estimate as a result of both undercounting of people and non-identification of people as being of Aboriginal or Torres Strait Islander descent. There is evidence that earlier censuses undercounted young children and young to middle-aged adults, with inaccuracies more pronounced in remote areas (Taylor 1997). Despite

considerable efforts on the part of the ABS, such problems persisted for more recent censuses (Wilson & Barnes 2007). One issue is that kinship structures and mobility among Aboriginal and Torres Strait Islander families do not match assumptions underlying the enumeration strategies that individuals can be traced to a unique household and reported upon by a unique reference person within that household. In the 2011 Census, there were twice as many people for whom Aboriginal or Torres Strait Islander status was not stated as there were people who identified as being of Aboriginal or Torres Strait Islander descent, meaning error margins around those population estimates are very large.

In addition to its effect on baseline estimates, the issue of identification means there is a further source of population change within a cohort in addition to the three standard components of mortality, fertility and migration. For cohort-component models that attempt to derive separate projections of the Aboriginal and Torres Strait Islander and other populations, this can include the question of how children from mixed families are likely to be identified, or identify themselves, in future censuses and the impact of policy changes on the propensity to identify (Biddle & Wilson 2013, Taylor 1997, Wilson 2009).

These challenges are specific to the enumeration of Aboriginal and Torres Strait Islander Australians. On top of these, Taylor (2014) notes general problems associated with projecting populations for sparsely populated areas, including that they are more vulnerable to vagaries of exogenous impacts that may impact upon them, such as weather events and policy changes; data collection is more resource-intensive; and proportional errors in projections tend to increase the smaller the population size of the units being analysed and if there is rapid change occurring in the period in which the baseline data is compiled. Moreover, most projection methodologies are based on the assumption of large population counts and cannot be applied to small populations. Taylor et al. (2006, p. 17) suggest a regional population size of around 10,000 people is required to meaningfully apply age-conditional mortality analyses. Wilson (2011) suggests that exponential models have favourable properties over linear models. However, if there are zero counts in the component categories (such as in certain gender-by-age categories) exponential models cannot be used, and inferences can be distorted by extreme values in terms of percentage change where counts are small.

An example of how these difficulties impact upon population forecasts for sparsely populated areas is provided by Taylor's (2014) assessment of the accuracy of ABS projections for the Northern Territory from the 1970s through to 2012. Even at this territory level, the mean absolute percentage errors in the ABS projections are far higher than for Australia as a whole. Several relatively naive models, based on simple extrapolation of growth trends, out-performed the more sophisticated ABS cohort-replacement model.

Wilson (2009, p. 232) compiles a summary table of studies providing projections for the Aboriginal and Torres Strait Islander population. Of the 13 publications included, 11 produced estimates at the national or state/territory level, with Taylor and Bell (2002) and Taylor (2003) being the exceptions. Using a composite approach that combines ABS census population estimates with other data sources, such as health clinic registrations and school enrolments, Taylor and Bell (2002) produced projections to 2021 for Cape York Peninsula (then the Peninsula ATSIC region), commencing from an adjusted baseline population in 1986 of 6,500 Aboriginal and Torres Strait Islander people. Taylor (2003) produced projections for 2006 to 2021 from the 2001 baseline of 37,000 Aboriginal and Torres Strait Islander people in the Australian desert region, which focused on the arid zone covering much of Western Australia, the Northern Territory, South Australia and parts of Queensland and New South Wales. Following the same approach, Taylor et al. (2006) later generated separate projections for the arid, semi-arid and savanna biogeographical zones to 2021, with the 2001 baseline Aboriginal and Torres Strait Islander populations in

the semi-arid and savanna zones put at 51,000 and 84,000, respectively. More recently, Biddle and Taylor (2009) applied the cohort-component approach to generate projections of the Aboriginal and Torres Strait Islander population from 2006 to 2031 for each of 37 ABS defined 'Indigenous Regions'. The smallest of those regions in terms of the Aboriginal and Torres Strait Islander population was Ceduna, with 2,248 people.

Taylor et al. (2006, p. 3) nominate methodological developments in the treatment of small areas and subsequent small number analysis as a key imperative to improving demographic information for Aboriginal and Torres Strait Islanders in desert Australia. Of the studies discussed above, only Biddle and Taylor's (2009) report, and possibly Taylor and Bell's (2002) projections for the Cape York Peninsula, commencing from a baseline Aboriginal and Torres Strait Islander population of 6,500, could be considered as dealing with a small area or small population. In contrast, we generate projections for communities with as few as nine Aboriginal and Torres Strait Islander inhabitants. In addition, existing exercises often attempt long projection horizons. While some projections for Aboriginal and Torres Strait Islander populations are for five or 10 years beyond the baseline, typically they are for 20, 30 or even 50 years forward, well beyond the planning and policy cycles that Aboriginal and Torres Strait Islander communities are subject to.

Table 1: Australian population estimates by Aboriginal and Torres Strait Islander status and remoteness, 2011 Census

Remoteness area (ARIA level)	Aboriginal and Torres Strait Islander		Non–Aboriginal and Torres Strait Islander		Total		Aboriginal and Torres Strait Islander share
	People	%	People	%	People	%	
Major cities (1)	188,537	34.4	14,094,903	70.8	15,006,519	69.8	1.3
Inner regional (2)	121,301	22.1	3,695,423	18.6	3,998,424	18.6	3.0
Outer regional (3)	118,491	21.6	1,735,627	8.7	1,963,404	9.1	6.0
Remote (4)	39,751	7.2	234,833	1.2	300,107	1.4	13.2
Very remote (5)	77,493	14.1	98,564	0.5	190,266	0.9	40.7
Total	548,366	100.0	19,900,767	100.0	21,507,719	100.0	2.5

Source: ABS CData online Table Builder facility. Note: columns sum to less than the total as the categories of 'Migratory – offshore – shipping' and 'No usual address' have not been reported. Rows do not sum, as people for whom Aboriginal and Torres Strait Islander status was 'not stated' have not been reported.

3. Data and method

To explore demographic changes in remote Aboriginal and Torres Strait Islander communities in more detail, we model intercensal changes based on the ABS defined geography of 'Indigenous Locations':

> Indigenous Locations (ILOCs) are aggregates of one or more SA1s. ILOCs generally represent small Aboriginal and Torres Strait Islander communities with a minimum population of 90 Aboriginal and Torres Strait Islander usual residents. An ILOC is an area designed to allow the production of census statistics relating to Aboriginal and Torres Strait Islander people with a high level of spatial accuracy while maintaining the confidentiality of individuals. For the 2011 Census, 1,116 ILOCs have been defined to cover the whole of geographic Australia.

> There are non-spatial ILOCs for Migratory - Offshore - Shipping and No Usual Address in each state and territory (S/T). (ABS 2011)

The approach is to develop an empirical model of the 2011 Aboriginal and Torres Strait Islander population counts for communities based on the 2006 Census counts and selected characteristics of the communities. It utilises the fact that with the census undertaken every five years, and the data being available in five-year ranges, population changes for each community can be derived by age group. Treating those age-specific changes as multiple observations for a community, we adopt a multilevel modelling approach. Using this framework, it is possible to estimate community-specific effects to identify growth communities from those in decline, conditional upon factors such as their remoteness and initial size. Projections for the 2016 population are then generated by applying the coefficients from the model to the 2011 data as the base year, under the assumption that the 2006–2011 trends identified in the model continue. Potentially, population projections for 2021 and beyond could be generated treating the 2016 forecasts as the base year, and so on.

Census population estimates were downloaded from the ABS Table Builder online facility for all 1,098 spatial ILOCs defined in 2011 (i.e. excluding the non-spatial ILOCs) and for all 838 spatial ILOCs that were defined for 2006. The data extracted for each ILOC include the population in five-year age groups by sex and Aboriginal or Torres Strait Islander status. The status variable has five categories: non-Indigenous, Aboriginal, Torres Strait Islander, both Aboriginal and Torres Strait Islander, and not stated. There have been considerable changes to the ILOC geography since 2006. The ABS provided a concordance of 838 2006 ILOCs to the 2011 ILOCs, which reports estimates of the percentage of the population within each 2006 ILOC that would correspond to a 2011 ILOC, with the proportions weighted according to the respective Aboriginal and Torres Strait Islander populations. These were used to generate 2006 population estimates corresponding to the 2011 geography. For example, the 2011 ILOC of Amoonguna corresponds to the 2006 ILOCs of Amoonguna (100%) and some of Sandover and Outstations (10%). Hence for each 'age by gender by Indigenous status' cell, we derive the 2006 estimates as a weighted sum: 1 times the Amoonguna estimate + 0.1 of the Sandover and Outstations estimate. These concordances will be less appropriate for the non–Aboriginal and Torres Strait Islander cells, but this will be of little consequence since the analyses concentrates upon estimates of the Aboriginal and Torres Strait Islander population.

The resulting data include 2006 and 2011 population estimates for 1,098 ILOCS that are geographically comparable between the two years. As described below, we utilise a subset of 618 ILOCs in Outer regional, Remote and Very remote Australia in the modelling.

The census counts of the number of Aboriginal, Torres Strait Islander and both Aboriginal and Torres Strait Islander people were aggregated to a single Aboriginal and Torres Strait Islander population estimate. For each ILOC in each census year, population data are available for 42 gender-by-age cohorts: 21 age groups (0–4, 5–9, 10–14 … 90–94, 95–99, 100+) each for males and females. In the older cohorts, a large proportion of these cells have either zero or very small population counts and this posed a problem for a number of the models we attempted to estimate. Consequently, we aggregated the older age cohorts as shown below in Figure 1.

Following the cohort-component method, note that the number of Aboriginal and Torres Strait Islanders aged 5–9 in a given ILOC in 2011 will be the number who were aged 0–4 in 2006 minus deaths, net migration and net changes associated with identification of Aboriginal or Torres Strait Islander status. The data set-up is demonstrated in Figure 1, where the arrows trace the cohort movement through time.

Census	Age					
i	1	2	…	15	16	17
2006	0–4	5–9	…	70–74	75+	
2011	0–4	5–9	…	70–74	75–79	80+

Figure 1: Cohort structure of the Census population data

Using *i* to index the age categories, it can be seen that there are 16 such cohort progressions or flows in which the population (P) in 2011 can be related to the population in the earlier age category in 2006:

(1) $P_{i-1.2006} \rightarrow P_{i.2011}$

With population data for males and females, this gives 32 flows observed for each ILOC. We treat this as a multi-level model structure in which there are 32 observations for each ILOC. Following the convention in the econometric multi-level modelling literature (Rabe-Hesketh & Skrondal 2008, p. 65, for example) we denote the entity or the 'cluster' by subscript *j* and the 'occasions' providing repeat observations for that cluster by subscript *i*. Hence, in this case communities are denoted by subscript *j* (*j*=1 to 1,098) and the 2011 age groups by subscript *i* (*i*=2 to 17). For convenience, we ignore the gender distinction for the purposes of setting out the model. Rewriting (1) to incorporate clustering at the ILOC level gives:

(2) $P_{i,j,2011} = f\left(P_{i-1,j,2006}\right)$

We do not attempt to impose estimates of the components of migration, deaths or changes in identification. Rather, the functional relationship between $P_{j,i,2011}$ and $P_{j,i-1,2006}$ is estimated stochastically taking account of observable community characteristics and unobservable community-specific effects. A range of options are available for modelling the changes in cohort populations between 2006 and 2011. Exploration with these options indicated that it is preferable to model the change in population in linear terms (or 'levels') rather than in growth terms. Models based on the proportionate change, such as the growth rate, are highly sensitive to extreme values that mostly arise where cell counts are small. For example, percentage changes in some age categories in smaller communities were in the thousands, and are likely to be affected by concordance and enumeration issues. Modelling changes in growth rates also means omitting observations for which the base number is zero, even though that is a legitimate value. Given we are dealing with small area counts of Aboriginal and Torres Strait Islander people by gender and age, there are many zero cells in the data.

A preferable alternative is to model the population in 2011 as a direct function of the lagged (2006) population. Explaining current population levels with past ones, especially over a short number of time observations, raises several econometric concerns, such as endogeneity, non-stationarity and the strong possibility of being adversely affected by the spurious regression problem. Indeed, in a simple regression, the lagged dependent variable exhibited signs of these issues, with the estimated coefficient being very close to unity in value and with an extremely high *t*-statistic. Further, cells with zero counts and very small counts continue to pose a problem.

Thus the preferred strategy is to model the change in population for each cohort. That is, the dependent variable becomes:

(3) $c_{i,j,2011} = P_{i,j,2011} - P_{i-1,j,2006}$

With 32 observations of $c_{j,i,2011}$ for each ILOC (*i*=2 to 16 for males and females), the resulting data has a multi-level structure. Population changes can be modelled as:

(4) $c_{i,j,2011} = \alpha_j + \beta x_{i,j,2006} + \epsilon_{i,j},\ \epsilon_{i,j} \sim N(0, \sigma^2)$

Where $x_{i,j,2006}$ represents the matrix containing the independent variables (all defined in 2006); β is a vector of coefficients to be estimated; α_j consists of unobservable community-level effects and $\epsilon_{i.j}$ denotes the errors in the model.

For most applied work, there are two major approaches to estimating unobserved effects: fixed-effect and random-effects. The primary consideration in choosing between them involves the assumption regarding the relationship between the α_j's and *x*'s. The fixed-effects model assumes those components are correlated, whereas the random-effects model assumes they are uncorrelated. In this context, the group effects relate to unobserved ILOC effects.

The model set out in (4) can be estimated by simple linear regression, but there is a potential censoring problem as the dependent variable has a lower bound given the population cannot decrease by more than the starting population. For example, consider an ILOC with five male Aboriginal and Torres Strait Islander people aged 20–24 in 2006. The change in the population from 2006 to 2011 can only range from -5 upwards, since the population of males aged 25–29 in 2011 cannot be less than zero.

Note also that if the population of males aged 25–29 in 2011 is also five, then there has been no change and the dependent variable, $c_{i,j,2011}$, equals zero. This zero is a legitimate value indicating no change in the population, and indeed the expected value of $c_{i,j,2011}$ would be close to zero. However, consider the case in which there are no people in a particular age-by-gender category in 2006, as is common for older age cohorts. In this case the population can increase ($c_{i,j} > 0$), but has a lower bound of zero, and the probability of observing zero change is much higher than for observations with a positive initial population.

In such situations where there is a 'latent' potential change in the population that cannot be observed because of the lower bound, linear regression models will produce biased results. An alternative is to implement a Tobit model with varying censoring limits. As noted above, in the current context the limit is equal to the 2006 population for a specific gender-by-age group at a given ILOC.

(5) $c^*_{i,j,2011} = \alpha_j + \beta x_{i,j,2006} + \epsilon_{i,j},\ \epsilon_{i,j} \sim N(0, \sigma^2)$

Where $c^*_{i,j,2011}$ denotes the change in ILOC *j* for age group *i*. This is the latent underlying change. However, this cannot be observed due to the fact that the change cannot be less than the current population. In other words, there is lower tail censoring such that we can only observe $c_{i,j}$:

(6) $If\ c^*_{i,j,2011} < -P_{i-1,j,2006}\ then\ c_{i,j,2011} = -P_{i-1,j,2006}$

In contrast to the standard Tobit model in which the lower limit is assumed to be zero for all *i* and *j*, we can impose the 2006 population as a varying lower limit for each observation.

Like the linear model, the Tobit model can be estimated assuming either random or fixed effects, although the latter will suffer from the well-known incidental parameters problem, if the dimension over which these are constant is small.

Extensive modelling of the observed population changes between 2006 and 2011, with explanatory variables based on 2006 Census data, was undertaken using the linear regression and Tobit models. For the reasons set out above, we believe the censored Tobit model to be the theoretically superior model in this context. Note that when fitting the linear model to the data for population changes between 2006 and 2011,

it is possible for the predicted value from the model to correspond to a fall in excess of the initial population. Model 'prediction' here refers to the within-sample fitted value, as distinct from a projection for a future time period. Thus the linear model produces fitted estimates for $c_{i,j,2011}$ which imply the 2011 population in some cohorts is negative. Of course negative populations are impossible in reality. In contrast, for the Tobit model, the fitted values are constrained to a lower bound of zero and hence negative populations cannot result.

Despite this, the linear regression model with random effects has so far marginally out-performed other specifications on the criteria of how well the predicted values fit the observed changes. That is, the linear model with random effects returns a superior within-sample fit. In particular, the Tobit models under-predict changes for cohorts with larger population counts. Thus while work to develop alternative models continues, this paper reports results from the random-effects linear regression model and projections for 2016 populations based on those results. We are hopeful that the release of 2016 Census data will enable further refinement of the Tobit models. Currently the data contain only one observation on each $c_{i,j}$, namely the change from 2006 to 2011. In this sense, the model is cross-sectional rather than longitudinal. The release of 2016 Census data will provide a second such observation, and hence a true multi-level panel structure. Denoting census years by *t*, (*t*=2011, 2016), Model (4) could thus take the more general form:

(7) $c_{i,j,t} = \alpha_j + \beta x_{i,j,t-1} + \epsilon_{i,j,t},\ \epsilon_{i,j,t} \sim N(0, \sigma^2)$

Observations on changes across multiple time periods will provide more rigorous estimation of community-level unobserved effects plus scope for further development and, hopefully, to address estimation issues experienced to date with the Tobit models.

Referring back to Figure 1 above, the model estimates changes in the population of people aged 5–9 in 2011 from the number aged 0–4 in 2006; of people aged 10–14 in 2011 from the number aged 5–9 in 2006; and so on. However, it cannot provide estimates for the population aged 0–4 in 2011, as there is no younger cohort in 2006 to use as the baseline. To enable projections for the total populations by ILOC, a separate fertility model is developed to generate estimates of the number of males and females aged 0–4 in 2016 (see 4.1).

4. Cohort model – linear regression results

Projections presented in this paper are based on the estimation of a random-effects linear regression of the form set out in (3) and (4) above. A key motivation behind the exercise is to generate projections for remote Aboriginal and Torres Strait Islander communities, and, given that population changes in the major cities and regional centres are likely to be driven by markedly different processes, only ILOCs in Outer regional, Remote and Very remote Australia were included in the sample for estimation (corresponding to ARIA levels of 3, 4 and 5). For the purpose of comparing performance, models were fitted using linear regression and Tobit models with random and fixed effects. For the Tobit models, ILOCs with a large number of zero counts in the age-by-gender cells continued to pose estimation problems. Consequently a small number of other ILOCS were excluded and the older age categories aggregated as discussed above. In addition to excluding ILOCS in ARIA levels 1 (Major cities) and 2 (Inner regional), the exclusions were:

- Lord Howe Island, off New South Wales. The 2006 Census recorded no Aboriginal or Torres Strait Islander usual residents of Lord Howe Island
- The external territories of Christmas Island and the Cocos Islands (in part to enable state dummies to be included among the dependent variables)

- The Northern Territory ILOCs of Apatula (Finke) Homelands and Walungurru Outstations. The data for these ILOCs had zero counts in the vast majority of age-by-gender cells.

The final sample is based on data from 618 ILOCs, generating 19,776 observations for the regression analysis (32 observed cohort changes per ILOC). Included in the vector x' of explanatory variables is the natural logarithm of the total population of the ILOC (including non–Aboriginal and Torres Strait Islander people) to capture differences by community size; dummy variables for cohort age, gender, ARIA and state/territory; the gender and age-specific five-year survival rate for each cohort; and interaction terms between the age group and ILOC size, and between age group and ARIA. The interaction terms are included to allow for possible differential effects of age in smaller versus larger communities and in less remote versus more remote communities. For example, previous studies have identified trends in which younger Aboriginal and Torres Strait Islander people tend to move away from smaller and more remote communities into larger regional centres, while older people move back out to country. A dummy variable was also included to indicate whether the community was nominated as a Territory Growth Town under the Northern Territory Government's 2009 *Working Future* policy (see Sanders 2010). Table 2 provides definitions of the explanatory variables. Descriptive statistics for these, along with the dependent variable, are provided in Appendix Table A1.

Table 2: Definitions for independent variables used in the regression model

Variable(s)	Description
ILOC size	The natural logarithm of the usual resident total population of the ILOC in 2006 (including Aboriginal and Torres Strait Islander people, other Australians and those for whom Aboriginal or Torres Strait Islander status is not stated).
Remote, Very remote	Two mutually exclusive dummy variables indicating whether the ILOC is in ARIA level 4 (Remote) or ARIA level 5 (Very remote). The omitted or 'reference' category is Outer regional (ARIA level 3).
Victoria, Queensland, South Australia, Western Australia, Tasmania, Northern Territory	Six mutually exclusive dummy variables indicating the state or territory of the ILOC. New South Wales is the omitted category. There are no Outer regional, Remote or Very remote ILOCs in the Australian Capital Territory.
Female	Dummy variable equal to 1 if the observation is for a female cohort, and equal to 0 if it relates to a male cohort.
Growth town	Dummy variable taking on a value of 1 if the ILOC contains or corresponds to one of the communities nominated as growth towns under the Northern Territory Government's *Working Future* policy announced in 2009. While the policy named 20 towns, one of these (Daguragu-Kalkarindji) falls across two ILOCs (Daguragu and Kalkarindji), meaning there are 21 ILOCs coded with a value of 1.
Age 10–14; Age 15–19, … Age 75–79, Age 80+	Sixteen mutually exclusive dummy variables indicating the age of the cohort in 2011. The omitted category is Age 5–9.
Survival rate	Based on ABS Catalogue 3238.0 – *Estimated and projected Aboriginal and Torres Strait Islander population Series B for Australia* (ABS 2014). We took the ratio of the estimated population in each age cohort *i* in 2011 to the estimated population of age cohort *i-1* in 2006. This gives an age-specific 'apparent survival rate' and is calculated separately for males and females. The survival rates are close to unity for younger cohorts and decline to under 0.7 for cohorts beyond the age of 70 years.
ILOC size * age interaction terms	Fifteen separate variables are generated by interacting the continuous ILOC size variable with the age group dummies. The omitted age category is Age 5–9. The coefficients on these variables indicate whether, within each specific age group, there is any further effect of community size in addition to the average effect of community size observed across all age cohorts.

Outer regional * age and Remote * age interaction terms	Thirty separate dummy variables generated by interacting the Outer regional dummy variable (ARIA level 3) with age cohort and the Remote dummy variable (ARIA level 4) with age cohort. The omitted categories are Very remote (ARIA level 5) and Age 5–9. The coefficients on these variables indicate whether, within each specific age group, there is any further effect of remoteness in addition to the average effects observed across all age cohorts.

Full results from the random-effects linear regression are reported in Table 3. The low R-squared of 0.055 is typical of models based on differences in variables, as opposed to levels. Many of the variables are statistically significant; however, their interpretation is not straightforward. Of the dummy variables for the ARIA levels of remoteness, the estimated coefficient for Very remote is +2.645 and highly significant. On face value this positive coefficient suggests that Aboriginal and Torres Strait Islander populations in Very remote communities are growing faster than in Outer regional communities, all other things equal. The direct interpretation is that populations in Very remote communities are increasing by around 85 people (2.645*32 cohort groups) more than in 'like' communities every five years. The catch is with the 'all other things equal' clause. Making such inferences means taking into account differences in ILOC size and age structures between Outer regional and Very remote communities, as well as the various interaction-term effects. An easier way to interpret the regression results is to use the estimated coefficients to generate projections by key dimensions of interest. These are presented in Section 5.

Table 3: Regression estimates, cohort population changes 2006–2011

Variable	Coefficient		Standard Error	z	Prob. |z|>Z*
ILOC size	2.000	***	0.160	12.48	0.000
ARIA					
Outer regional	—				
Remote	-0.157		0.578	-0.27	0.786
Very remote	2.645	***	0.573	4.62	0.000
State/territory					
New South Wales	—				
Victoria	0.131		0.787	0.17	0.868
Queensland	0.451		0.327	1.38	0.168
South Australia	0.433		0.431	1.00	0.316
Western Australia	0.745	**	0.343	2.17	0.030
Tasmania	0.142		0.557	0.25	0.799
Northern Territory	0.341		0.331	1.03	0.303
Female	0.146		0.121	1.21	0.227
Growth town	-1.526	***	0.564	-2.71	0.007
Cohort age (2011)					
Age 5–9	—				
Age 10–14	4.442	***	1.167	3.81	0.000
Age 15–19	11.122	***	1.167	9.53	0.000
Age 19–24	13.688	***	1.167	11.73	0.000
Age 25–29	7.659	***	1.168	6.56	0.000
Age 30–34	7.475	***	1.168	6.40	0.000
Age 35–39	7.443	***	1.170	6.36	0.000
Age 40–44	7.973	***	1.172	6.80	0.000
Age 45–49	7.127	***	1.177	6.06	0.000

Variable	Coefficient		Standard Error	z	Prob. |z|>Z*
Age 50–54	8.370	***	1.186	7.06	0.000
Age 55–59	9.259	***	1.204	7.69	0.000
Age 60–64	8.481	***	1.245	6.81	0.000
Age 65–69	7.746	***	1.349	5.74	0.000
Age 70–74	8.698	***	1.540	5.65	0.000
Age 75–79	7.655	***	1.751	4.37	0.000
Age 80+	8.899	***	1.806	4.93	0.000
Survival rate	-5.491		3.677	-1.49	0.135
ILOC size by Age interaction terms					
ILOC Size*Age 10–14	-1.338	***	0.194	-6.89	0.000
ILOC Size*Age 15–19	-2.387	***	0.194	-12.28	0.000
ILOC Size*Age 19–24	-2.678	***	0.194	-13.78	0.000
ILOC Size*Age 25–29	-1.688	***	0.194	-8.69	0.000
ILOC Size*Age 30–34	-1.674	***	0.194	-8.61	0.000
ILOC Size*Age 35–39	-1.703	***	0.194	-8.77	0.000
ILOC Size*Age 40–44	-1.763	***	0.194	-9.07	0.000
ILOC Size*Age 45–49	-1.639	***	0.194	-8.44	0.000
ILOC Size*Age 50–54	-1.832	***	0.194	-9.43	0.000
ILOC Size*Age 55–59	-2.073	***	0.194	-10.67	0.000
ILOC Size*Age 60–64	-1.913	***	0.194	-9.84	0.000
ILOC Size*Age 65–69	-1.915	***	0.194	-9.85	0.000
ILOC Size*Age 70–74	-2.149	***	0.194	-11.06	0.000
ILOC Size*Age 75–79	-2.037	***	0.194	-10.48	0.000
ILOC Size*Age 80+	-2.318	***	0.194	-11.93	0.000
ARIA by Age interaction terms					
Outer Reg*Age 10–14	5.978	***	0.694	8.62	0.000
Outer Reg*Age 15–19	3.436	***	0.694	4.95	0.000
Outer Reg*Age 19–24	1.811	***	0.694	2.61	0.009
Outer Reg*Age 25–29	3.293	***	0.694	4.75	0.000
Outer Reg*Age 30–34	3.432	***	0.694	4.95	0.000
Outer Reg*Age 35–39	3.899	***	0.694	5.62	0.000
Outer Reg*Age 40–44	3.528	***	0.694	5.09	0.000
Outer Reg*Age 45–49	3.100	***	0.694	4.47	0.000
Outer Reg*Age 50–54	3.545	***	0.694	5.11	0.000
Outer Reg*Age 55–59	3.776	***	0.694	5.44	0.000
Outer Reg*Age 60–64	2.796	***	0.694	4.03	0.000
Outer Reg*Age 65–69	3.019	***	0.694	4.35	0.000
Outer Reg*Age 70–74	3.312	***	0.694	4.78	0.000
Outer Reg*Age 75–79	3.073	***	0.694	4.43	0.000
Outer Reg*Age 80+	3.412	***	0.694	4.92	0.000
Remote*Age 10–14	2.954	***	0.706	4.19	0.000
Remote*Age 15–19	2.344	***	0.706	3.32	0.001
Remote*Age 19–24	1.774	**	0.706	2.51	0.012
Remote*Age 25–29	2.395	***	0.706	3.39	0.001

Variable	Coefficient		Standard Error	z	Prob. |z|>Z*
Remote*Age 30–34	2.703	***	0.706	3.83	0.000
Remote*Age 35–39	3.199	***	0.706	4.53	0.000
Remote*Age 40–44	3.530	***	0.706	5.00	0.000
Remote*Age 45–49	2.943	***	0.706	4.17	0.000
Remote*Age 50–54	2.712	***	0.706	3.84	0.000
Remote*Age 55–59	3.067	***	0.706	4.35	0.000
Remote*Age 60–64	2.744	***	0.706	3.89	0.000
Remote*Age 65–69	2.930	***	0.706	4.15	0.000
Remote*Age 70–74	3.170	***	0.706	4.49	0.000
Remote*Age 75–79	2.784	***	0.706	3.94	0.000
Remote*Age 80+	2.965	***	0.706	4.20	0.000
Constant	-7.478	*	3.880	-1.93	0.054
Observations	19,776				
R-Squared	0.055				

Notes: ***, ** and * denote that the estimated coefficient is significantly different from zero at the 1%, 5% and 10% level, respectively.

To provide an indication of the model performance, the within-sample model predictions of population changes for each of the 19,776 observations of changes were added to the relevant 2006 baseline population. These were then used to calculate predicted 2011 aggregate populations for each ILOC for people aged 5–9 and older and were compared to the corresponding actual 2011 populations aged 5–9 and older. Figure 2 shows the correspondence between the actual ILOC populations and predicted values from the model. A perfect fit would result in all values lying on the 45° line.

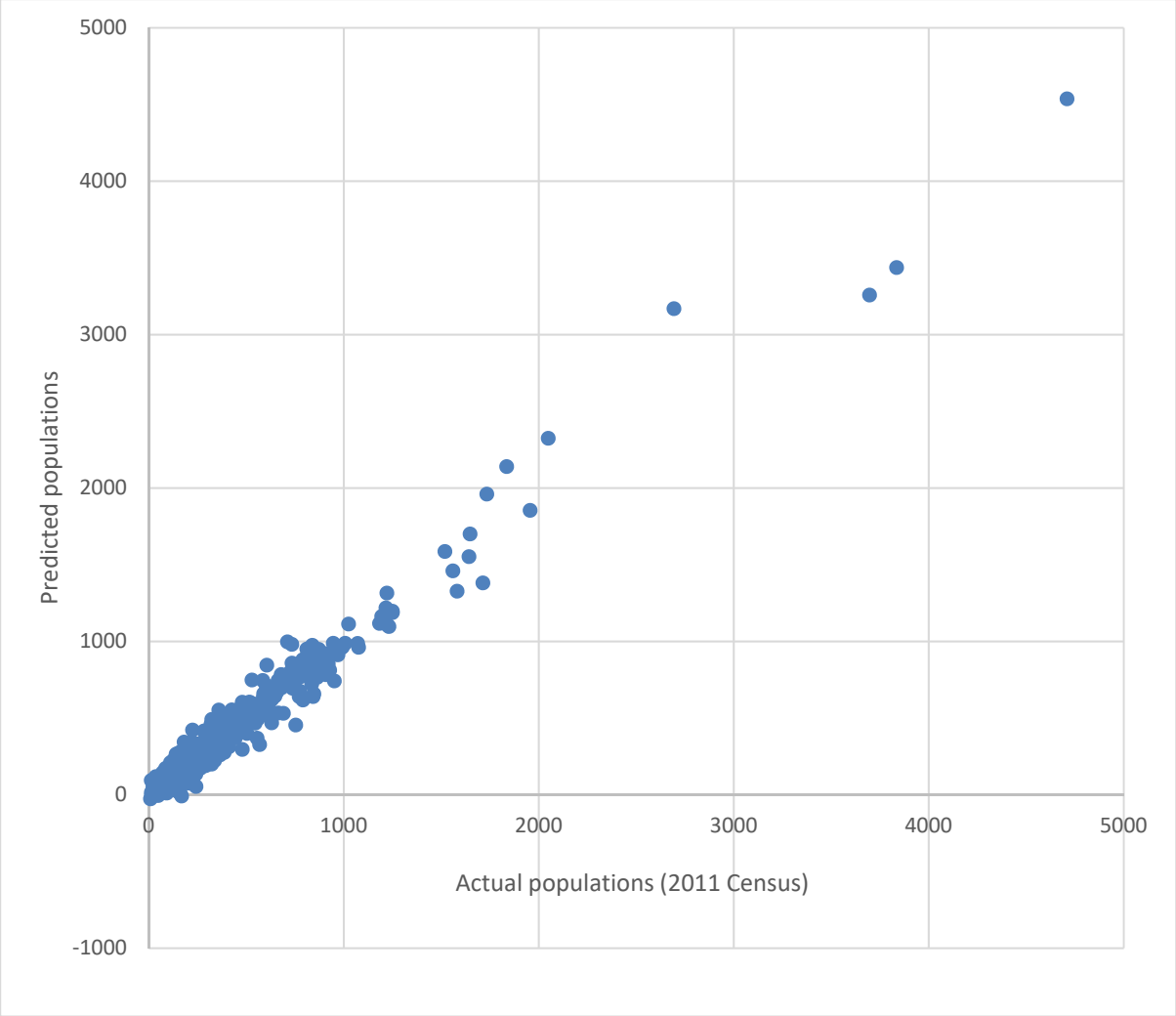

Figure 2: Model fit – actual versus predicted 2011 populations (aged 5+), 618 ILOCs

4.1 Apparent fertility rates

To develop a model to predict the Aboriginal and Torres Strait Islander population aged 0–4 in each ILOC, a linear regression model was estimated across ILOCs with the 2011 Aboriginal and Torres Strait Islander population aged 0–4 as the dependent variable. Models were tested with a variety of specifications that included summations of the male and female Aboriginal and Torres Strait Islander populations in the ILOC in 2006, initially focusing on what were considered to be adults of child-bearing age. However, experimenting with which age groups to include and allowing differential effects by age and by region to maximise the R-squared statistic returned the relatively simple model set out in (8) below. A model that included the number of Aboriginal and Torres Strait Islander children aged 0–14 in the ILOC in 2006 interacted with ARIA dummies was found to have the best predictive capability. For the full sample of ILOCs across all of Australia, the model returned an R-squared of 0.96.

The number of Aboriginal and Torres Strait Islander males aged 15–34 marginally added to the predictive power, but this component of the model applied only to projections for ILOCs in the major cities (i.e. ARIA level 1). For ILOCs in Outer regional, Remote and Very remote Australia, the predicted number of Aboriginal and Torres Strait Islander people aged 0–4 years is given by:

(8)

$$P_{1.j.t} = -2.37 + 0.42 * OREG_j \sum_{i=1}^{3} P_{i.j.t-1} + 0.35 * REM_j \sum_{i=1}^{3} P_{i.j.t-1} + 0.35 * VREM_j \sum_{i=1}^{3} P_{i.j.t-1}$$

Where P_1 ... P_3 denote the Aboriginal and Torres Strait Islander population aged 0–4, 5–9 and 10–14, respectively. OREG, REM and VREM are dummy variables indicating that the ILOC is in Outer regional, Remote and Very remote Australia. In the estimated model of the 2011 population on 2006 values, each of the estimated coefficients (including the intercept term) was significant at the 1% level.

The coefficients were applied to the 2011 data to obtain projections for the population aged 0–4 in 2016 for each ILOC in our analysis sample. The projected population was allocated as 50% boys and 50% girls. Where the predicted population is negative, the projection is set to zero.

5. Projections

Applying the estimated coefficients from the cohort and fertility models to the 2011 data provides a projection of populations for each ILOC in 2016 conditional upon each ILOC's measurable characteristics and the estimated community-specific effect. In contrast to the Tobit model, it is possible with the linear regression model to have projected populations that are negative in some age-by-gender cells, most commonly for the older age groups in smaller communities. Given it is impossible to have negative population counts, and allowing for rounding, all cells with a projected population of less than 0.5 of a person were set to a population of zero. Appendix Table A2 provides a listing of all ILOCs included in the analysis along with their 2011 Census baseline population estimates, the projected population for 2016 and the calculated percentage change from 2011 to 2016. These are for the total Aboriginal and Torres Strait Islander population in each ILOC, but can be broken down by gender and five-year age group. In absolute terms, projected population changes range from an increase of 864 for Thuringowa in Queensland to a decline of 33 people in the Very remote community of Kalkarindji in the Northern Territory. In terms of percentage changes, the ILOC called Port Augusta – surrounds, in South Australia, is projected to have the highest growth rate (92.0%) and the Remote community of Inarlenge in the Northern Territory the most rapid decline (-24.1%). A map of the percentage changes by community is shown in Figure 3, where the dots indicate the centroid of the ILOC region. A map of the resultant population distribution is provided in Figure 4.

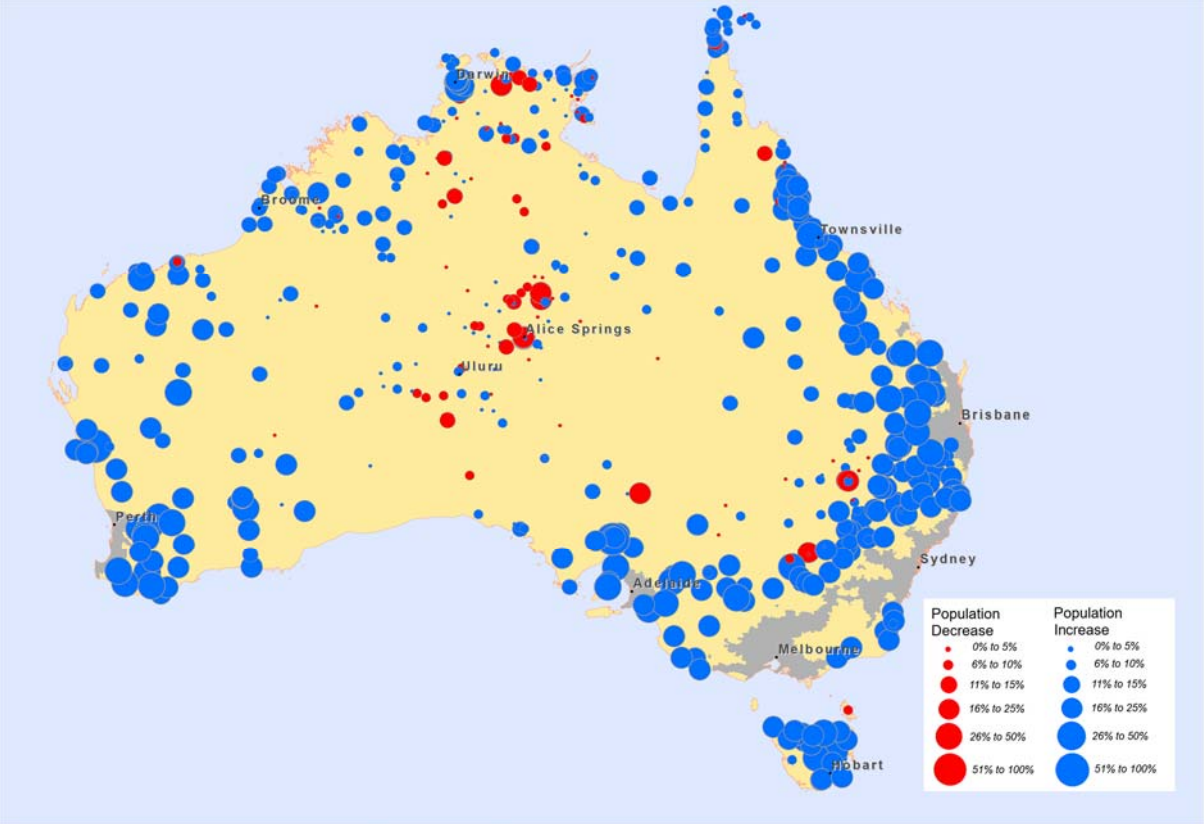

Figure 3: Projected changes in Aboriginal and Torres Strait Islander populations by ILOC: 2011–2016

For the many reasons stressed above, estimates for individual communities should be treated with caution. Certainly the use of projections based on modelling results for individual communities in any decision-making – particularly where they indicate unusually high or low growth – should only be undertaken following robust verification of trends through alternative data sources, local knowledge and local consultation. More confidence can be placed in results pertaining to trends at more aggregated spatial and demographic levels, as these will be less subject to community-idiosyncratic and potentially misleading factors. Selected aggregated results of potential interest are presented below, commencing with projected changes in the Aboriginal and Torres Strait Islander population by remoteness. Overall, the Aboriginal and Torres Strait Islander population living in Outer regional, Remote and Very remote Australia is projected to increase by 30,553 people between 2011 and 2016. In absolute terms, this is larger than the increase recorded by the census between 2006 and 2011 of 27,476. However, in percentage terms it represents a slightly lower population growth rate of 13.1% between 2011 and 2016, compared to 13.4% between 2006 and 2011 in that same regional area. As shown in Table 4, populations in each of the three ARIA categories are projected to increase, but with growth strongest in Outer regional Australia (18.4%) and lowest in Very remote communities (7.2%).

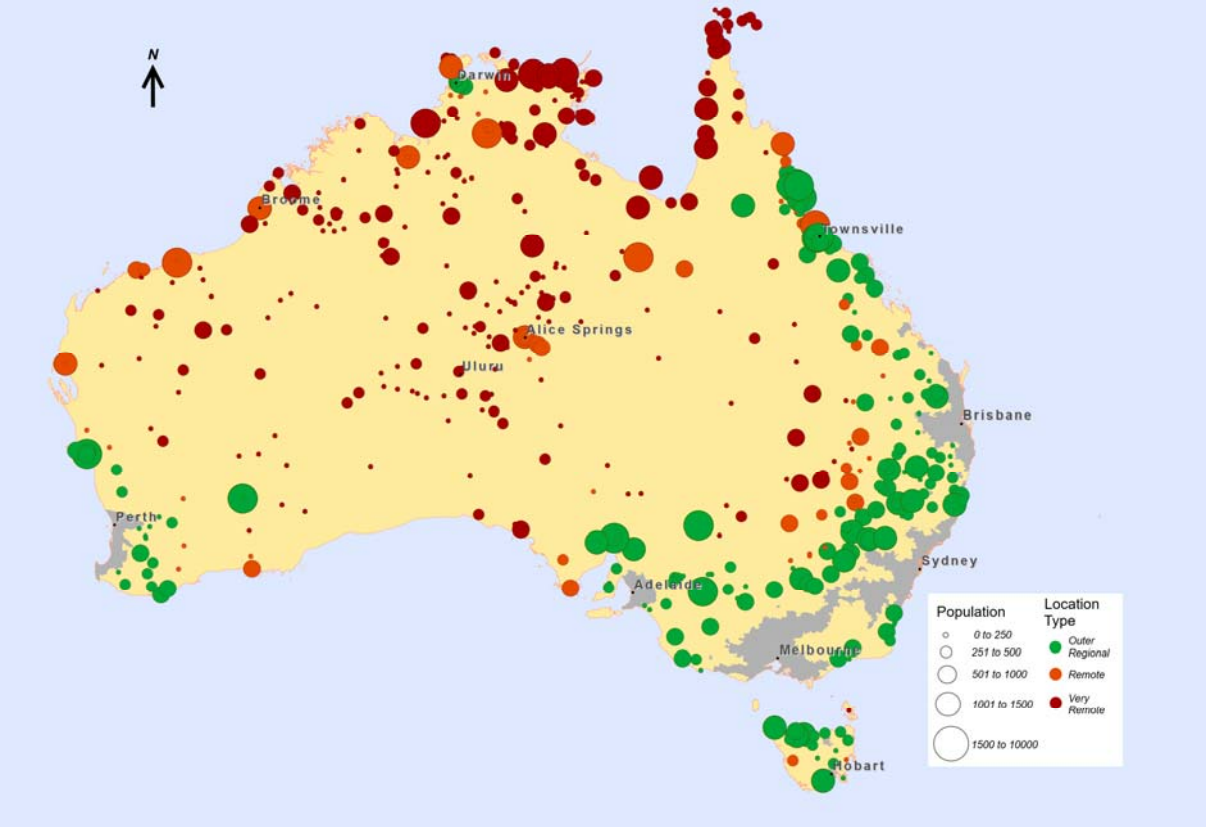

Figure 4: Projected distribution of the Aboriginal and Torres Strait Islander population in Outer regional, Remote and Very remote Australia, 2016

Table 4: Aboriginal and Torres Strait Islander populations: 2006 and 2011 census estimates and 2016 projections, by remoteness

ARIA	Number of ILOCs	Population			Per cent change	
		2006	2011	2016	2006–2011	2011–2016
3 – Outer regional	245	97,929	116,891	138,416	19.4	18.4
4 - Remote	95	35,537	38,930	42,411	9.5	8.9
5 – Very remote	278	72,067	77,188	82,736	7.1	7.2
Total	**618**	**205,533**	**233,009**	**263,562**	**13.4**	**13.1**

The projections suggest increases in the Aboriginal and Torres Strait Islander population in all five-year age groups for both males and females. The detailed comparative population pyramids for the 2011 population as recorded by the census and the projected 2016 population are shown in Figure 5.

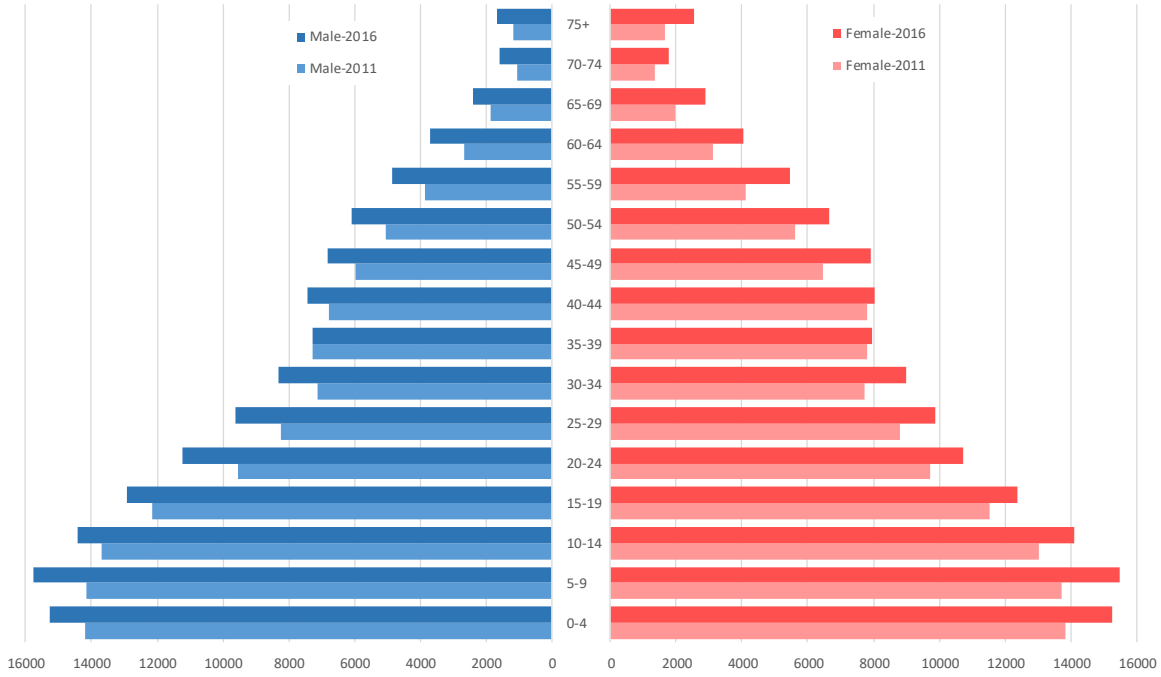

Figure 5: Age structure of the Aboriginal and Torres Strait Islander population in Outer regional, Remote and Very remote Australia: 2011 (actual) and 2016 (projected)

This cohort analysis suggests a rapid ageing of the regional Aboriginal and Torres Strait Islander population, with the number of people aged 60 and over projected to increase by almost 40% between 2011 and 2016 (Table 5). This is on top of a 28% increase in the previous intercensal period.

Table 5: Projected Aboriginal and Torres Strait Islander population growth rates, by age and remoteness (per cent change from 2011 to 2016)

	Age (years)			
ARIA	0–19	20–59	60+	**Total**
3 – Outer regional	14.6	18.8	43.6	18.4
4 – Remote	1.8	10.8	41.7	8.9
5 – Very remote	2.6	8.4	30.9	7.2
Total	**8.8**	**13.8**	**39.3**	**13.1**

Within each ARIA region, ILOCs were classified as relatively small, medium or large on the basis of their 2011 Census total population estimates (that is, including the non–Aboriginal and Torres Strait Islander population), with the bands chosen such that roughly one-third of ILOCs are in each category. Growth in the Aboriginal and Torres Strait Islander population is projected to be relatively even across communities of different size in Outer regional Australia (Table 6). However, in both Remote and Very remote Australia, population growth between 2011 and 2016 is projected to be markedly lower in the smaller communities, and in fact declining marginally in communities in Remote Australia that had overall populations of less than 700.

Table 6: Projected Aboriginal and Torres Strait Islander population growth rates, by remoteness and community size (per cent change from 2011 to 2016)

ARIA/ILOC size in 2011	Number of ILOCs	Population		Per cent change	
		2011	2016	2006–2011	2011–2016
Outer Regional					
Small (0–2,750 people)	75	16,306	19,080	0.7	17.0
Medium (2,751–6,500 people)	75	26,453	31,553	18.9	19.3
Large (6,501+ people)	95	74,132	87,782	24.6	18.4
Remote					
Small (0–700 people)	35	5,438	5,376	-3.8	-1.1
Medium (701–2,000 people)	21	8,046	8,565	12.2	6.4
Large (2,001+ people)	39	25,446	28,470	12.0	11.9
Very remote					
Small (0–200 people)	99	10,319	10,354	0.3	0.3
Medium (201–500 people)	94	23,975	25,562	7.7	6.6
Large (501+ people)	85	42,894	46,820	8.5	9.2
Total	**618**	**233,009**	**263,562**	**13.4**	**13.1**

Finally, Table 7 shows projected changes in the regional Aboriginal and Torres Strait Islander populations by state and territory. The growth rate of the Aboriginal and Torres Strait Islander population is projected to be lowest in the Northern Territory, at just 7.5% between 2011 and 2016. With this exception, projected growth rates are relatively uniform across jurisdictions, ranging from 13.9% for Western Australia to 19.5% for Victoria. Projected growth rates are also quite uniform in Outer regional areas across the states and territories. The projections for Remote and Very remote areas are more variable. A decline in the population is projected only for Very remote Tasmania, but this is from a low base and represents a projected decrease of just 10 people. In terms of the absolute number of Aboriginal and Torres Islander people, the largest increase is projected to occur in Queensland with an additional 11,560 people, well above New South Wales (5,033 additional Aboriginal and Torres Strait Islander people) and Western Australia (up by 5,219 people).

The one policy variable included was the dummy indicating whether the ILOC included a town that had been nominated as a Northern Territory Growth Town. As reported in Table 3, the coefficient on this variable was negative and highly significant, meaning that these towns were in fact associated with lower population increases between 2006 and 2011 than would have been expected given their characteristics. All the Growth Towns are in ILOCs classified as Very remote. The projections to 2016 are for the populations of those ILOCs to increase by 4.8%, marginally above the 4.5% overall growth projected for the Aboriginal and Torres Strait Islander population in Very remote Northern Territory.

Table 7: Projected Aboriginal and Torres Strait Islander populations by state/territory and remoteness

	Outer regional	Remote	Very Remote	Total
	(a) Projected 2016 population			
New South Wales	35,202	4,602	2,838	42,642
Victoria	6,068	n.a.	n.a.	6,068
Queensland	54,150	11,888	21,193	87,230
South Australia	8,754	1,265	4,268	14,287
Western Australia	12,070	12,133	18,490	42,693
Tasmania	9,072	500	115	9,687
Northern Territory	13,100	12,023	35,832	60,955
Total	**138,416**	**42,411**	**82,736**	**263,562**
	(b) Projected change from 2011 (people)			
New South Wales	5,030	191	132	5,353
Victoria	989	n.a.	n.a.	989
Queensland	8,436	1,204	1,921	11,560
South Australia	1,476	149	184	1,809
Western Australia	2,210	1,238	1,771	5,219
Tasmania	1,369	33	-10	1,392
Northern Territory	2,015	666	1,550	4,231
Total	**21,525**	**3,481**	**5,548**	**30,553**
	(c) Per cent change 2011–2016			
New South Wales	16.7	4.3	4.9	14.4
Victoria	19.5	n.a.	n.a.	19.5
Queensland	18.5	11.3	10.0	15.3
South Australia	20.3	13.3	4.5	14.5
Western Australia	22.4	11.4	10.6	13.9
Tasmania	17.8	7.1	-7.8	16.8
Northern Territory	18.2	5.9	4.5	7.5
Total	**18.4**	**8.9**	**7.2**	**13.1**

Notes: There are no areas classified as Remote or Very remote in Victoria and none classified as Outer regional, Remote or Very remote in the Australian Capital Territory.

6. Conclusion

This working paper reports work in progress in the development of statistical modelling to generate projections of Aboriginal and Torres Strait Islander populations in remote communities. It has been motivated by the need for such projections to complement survey data on mobility patterns and labour market status in remote communities collected as part of the CRC for Remote Economic Participation's Population Mobility and Labour Markets project. However, there is a much wider need for such estimates, should they prove sufficiently reliable. Existing projections of the Aboriginal and Torres Strait Islander population disaggregated by detailed age group are available on a regular basis only at the state/territory level. As noted, the literature has stressed the need for such small area estimates for practical purposes of policy and planning for remote Aboriginal communities and the more general need for methodological advances in small number analysis to meet the demographic informational needs of Aboriginal and Torres Strait Islanders in desert Australia (Taylor et al. 2006, p. 3). As noted by Wilson (2011, p. 62):

> Probably the logical starting point in the design of any projection system is to consider its purpose … what question or problems does it need to solve? What projections are required to solve these problems? And of the required outputs, what is the most important and should be prioritised given the resources available?

The approach taken here has been designed for handling small population numbers while still providing projections by age categories that are critical for decisions relating to service demand, such as education and health. As such the model focuses on changes in population levels by cohort, thereby negating the difficulties associated with models based on growth rates when handling small populations. A second motivation is to generate policy-relevant information on what communities are shrinking and growing, and what are the characteristics that distinguish these. Here the multi-level modelling approach allows estimation of unobservable community-specific effects, as well as statistical estimates of effects such as remoteness, community size and state/territory.

Another critical difference is with respect to the projection horizon. While demographic projections are often prepared with projections 20, 30 or even 50 years into the future, this paper has focused on generating projections five years ahead of a baseline census: namely projecting the 2016 populations based on 2011 data. With the release of the 2016 Census data by ILOC, expected early in the second half of 2017, it will be possible to generate projections to 2021. It is relatively straightforward to use the method to project further ahead; however, projection errors will increase, and a projection horizon of around five years seems more in line with the typical policy cycles impacting upon Aboriginal and Torres Strait Islanders in remote Australia. The approach is very economical in its resource requirements, with almost all input data coming from the ABS census and being publicly accessible from the ABS website. Neither of the two variables used that were not derived from census data were significant. These are the age-specific survival rate (also readily accessible from the ABS) and our one experiment with a policy variable capturing Northern Territory Growth Town status.

The need for caution in the use of estimates must be reiterated, particularly with respect to estimates for individual communities. They should be considered experimental given that the model fit has only been tested ‘within sample’. The real test of such models is their ability to predict out of sample, and it will only be possible to assess the performance of the models out of sample when the 2016 Census data become available. With these reservations in mind, it would be unwise to dwell on the implications of the projections for policy and planning. We note that at a broad level, the Aboriginal and Torres Strait Islander populations in both Remote and Very remote Australia are projected to increase substantially. However, there is variation across communities by size. The Aboriginal and Torres Strait Islander population in Very remote Australia is projected to grow in small communities (populations of less than 200 people), and considerably faster in medium-sized communities (201–500 people) and larger communities. Hence the projections do not suggest that Aboriginal and Torres Strait Islander people are moving out of smaller communities in Very remote Australia. Only in Remote Australia do the projections imply some rationalisation of smaller communities. Strong growth in Outer regional Australia of around 18% between 2011 and 2016 is projected irrespective of community size. Given limitations of the census estimates that form our baseline data, it could be said that in effect we are projecting census estimates of the population, rather than actual populations. Be that as it may, this is still important information as those census estimates are used extensively in decision-making.

On the positive side, there is a great deal more that can be done to refine and further develop the modelling. As noted, the availability of an additional year of census data will provide an opportunity to

assess out-of-sample predictive performance of different models. Some potential avenues to build on this initial exercise are as follows.

Only a very limited range of explanatory variables have been tested in the model, and this could be expanded considerably, even with the existing census data. For example, information on the number of people for whom Aboriginal or Torres Strait Islander status is not stated could be incorporated to capture identification effects. The proportion of each ILOC's population that are identified as Aboriginal and Torres Strait Islander could be added as a further community-level characteristic.

Deviations of the age structure from that for the total Aboriginal and Torres Strait Islander population could be added as an ILOC- and cohort-specific variable that might also partially capture identification effects.

The analysis here has included only ILOCs in Outer regional, Remote and Very remote Australia due to our focus on regional and remote communities and likely differences in trends influencing demographic change in remote and non-remote Australia. However, ILOCs are defined to spatially cover all of Australia, and those in inner regional and major capital cities can be included in the sample. Using the full sample would mean that the sum of projections would constitute a projection of the total Aboriginal and Torres Strait Islander population for Australia. This would allow for 'top down' adjustment of the estimates to match existing projections of the total Aboriginal and Torres Strait Islander population if that was considered desirable.

Random-effects and fixed-effect models of population changes have been estimated using both ordinary least squares regression and censored Tobit models with varying lower bounds with clustering at the ILOC level. We have presented results from the random-effects linear model as this returned marginally superior within-sample fit. However, there are strong grounds to believe the Tobit model offers the superior theoretical specification, and we anticipate that with further development, the incorporation of additional 2016 data and assessment of out-of-sample performance, this will prove to be the preferred specification. Conceptually, the specification should not have a problem with observations of zero populations. However, with the very large number of parameters to be estimated when fixed-effects and interaction terms are included, estimation issues were experienced with the Tobit model. We hope the availability of additional data and moving to a true panel framework will overcome these problems.

The release of the 2016 Census data will mean there will be observations on population changes for each ILOC-by-gender-by-age cohort for two time periods, providing a true multi-level, panel structure for the modelling. The availability of repeat observations should improve capacity of the modelling to identify unobserved community-specific effects; the effects of observable community characteristics, such as remoteness and size; and to uncover various time trends in the population data. It is hoped that the ABS' area definitions under the 'Indigenous location' geography will be more stable between 2011 and 2016, so that fewer baseline observations need to be imputed by a concordance matrix than was the case in the current sample.

Upon release of the 2016 data, we plan to re-assess the preferred specification for modelling population changes and then apply the coefficients from that model to forecast populations for 2021. The process can readily be repeated using the 2021 projections as baseline data to generate projections for 2026. The projections will be used in a range of exercises for the CRC-REP's Population Mobility and Labour Markets project, such as mapping labour supply, for forecasting service demand within remote communities and modelling traffic volumes for the road network in remote Australia.

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Appendix Table A1: Descriptive statistics for variables included in the regression model (n=19,776 for all variables)

Variable	Mean	Std.Dev.	Minimum	Maximum
Population change (dependent variable)	-0.0295	6.0961	-79.71	100.78
ILOC size (log)	6.9704	1.6393	2.17	11.36
Remote	0.1537	0.3607	0	1
Very remote	0.4498	0.4975	0	1
Victoria	0.0162	0.1262	0	1
Queensland	0.2104	0.4076	0	1
South Australia	0.0744	0.2625	0	1
Western Australia	0.2120	0.4087	0	1
Tasmania	0.0356	0.1853	0	1
Northern Territory	0.2961	0.4566	0	1
Female	0.5000	0.5000	0	1
Growth town	0.0340	0.1812	0	1
Cohort age (2011)				
Age 10–14	0.0625	0.2421	0	1
Age 15–19	0.0625	0.2421	0	1
Age 19–24	0.0625	0.2421	0	1
Age 25–29	0.0625	0.2421	0	1
Age 30–34	0.0625	0.2421	0	1
Age 35–39	0.0625	0.2421	0	1
Age 40–44	0.0625	0.2421	0	1
Age 45–49	0.0625	0.2421	0	1
Age 50–54	0.0625	0.2421	0	1
Age 55–59	0.0625	0.2421	0	1
Age 60–64	0.0625	0.2421	0	1
Age 65–69	0.0625	0.2421	0	1
Age 70–74	0.0625	0.2421	0	1
Age 75–79	0.0625	0.2421	0	1
Age 80+	0.0625	0.2421	0	1
Survival rate	0.9012	0.1252	0.60	1.00
ILOC Size*Age 10–14	0.4356	1.7364	0	11.36
ILOC Size*Age 15–19	0.4356	1.7364	0	11.36
ILOC Size*Age 19–24	0.4356	1.7364	0	11.36
ILOC Size*Age 25–29	0.4356	1.7364	0	11.36
ILOC Size*Age 30–34	0.4356	1.7364	0	11.36
ILOC Size*Age 35–39	0.4356	1.7364	0	11.36
ILOC Size*Age 40–44	0.4356	1.7364	0	11.36
ILOC Size*Age 45–49	0.4356	1.7364	0	11.36
ILOC Size*Age 50–54	0.4356	1.7364	0	11.36
ILOC Size*Age 55–59	0.4356	1.7364	0	11.36
ILOC Size*Age 60–64	0.4356	1.7364	0	11.36
ILOC Size*Age 65–69	0.4356	1.7364	0	11.36

Variable	Mean	Std.Dev.	Minimum	Maximum
ILOC Size*Age 70–74	0.4356	1.7364	0	11.36
ILOC Size*Age 75–79	0.4356	1.7364	0	11.36
ILOC Size*Age 80+	0.4356	1.7364	0	11.36
Outer Reg*Age 10–14	0.0248	0.1555	0	1
Outer Reg*Age 15–19	0.0248	0.1555	0	1
Outer Reg*Age 19–24	0.0248	0.1555	0	1
Outer Reg*Age 25–29	0.0248	0.1555	0	1
Outer Reg*Age 30–34	0.0248	0.1555	0	1
Outer Reg*Age 35–39	0.0248	0.1555	0	1
Outer Reg*Age 40–44	0.0248	0.1555	0	1
Outer Reg*Age 45–49	0.0248	0.1555	0	1
Outer Reg*Age 50–54	0.0248	0.1555	0	1
Outer Reg*Age 55–59	0.0248	0.1555	0	1
Outer Reg*Age 60–64	0.0248	0.1555	0	1
Outer Reg*Age 65–69	0.0248	0.1555	0	1
Outer Reg*Age 70–74	0.0248	0.1555	0	1
Outer Reg*Age 75–79	0.0248	0.1555	0	1
Outer Reg*Age 80+	0.0248	0.1555	0	1
Remote*Age 10–14	0.0096	0.0975	0	1
Remote*Age 15–19	0.0096	0.0975	0	1
Remote*Age 19–24	0.0096	0.0975	0	1
Remote*Age 25–29	0.0096	0.0975	0	1
Remote*Age 30–34	0.0096	0.0975	0	1
Remote*Age 35–39	0.0096	0.0975	0	1
Remote*Age 40–44	0.0096	0.0975	0	1
Remote*Age 45–49	0.0096	0.0975	0	1
Remote*Age 50–54	0.0096	0.0975	0	1
Remote*Age 55–59	0.0096	0.0975	0	1
Remote*Age 60–64	0.0096	0.0975	0	1
Remote*Age 65–69	0.0096	0.0975	0	1
Remote*Age 70–74	0.0096	0.0975	0	1
Remote*Age 75–79	0.0096	0.0975	0	1
Remote*Age 80+	0.0096	0.0975	0	1

Appendix Table A2: Aboriginal and Torres Strait Islander populations by ILOC: 2011 Census estimates and 2016 projections

Indigenous Location (ILOC)	State	ARIA	Population 2011	Population 2016	Per cent change
Balranald	NSW	3	93	103	11.2
Balranald - Wentworth - Surrounds	NSW	3	279	331	18.8
Baryulgil - Malabugilmah	NSW	3	107	115	7.9
Bega	NSW	3	233	286	22.8
Bega - Surrounds	NSW	3	430	520	20.9
Bellingen	NSW	3	375	443	18.1
Bodalla	NSW	3	77	77	0.3
Bogan	NSW	4	415	450	8.5
Boggabilla	NSW	3	369	422	14.4
Bourke	NSW	5	760	831	9.3
Bourke - Surrounds	NSW	5	105	104	-1.2
Bowraville	NSW	3	259	298	14.9
Brewarrina	NSW	5	607	650	7.1
Brewarrina - Surrounds	NSW	5	259	263	1.5
Broken Hill	NSW	3	1398	1630	16.6
Broken Hill - Surrounds	NSW	5	151	146	-3.4
Carrathool - Murrumbidgee - Surrounds	NSW	3	111	141	27.3
Central Murray	NSW	3	494	593	20.1
Clarence Valley	NSW	3	286	349	22.1
Cobar	NSW	4	505	548	8.4
Collarenebri	NSW	4	188	185	-1.6
Condobolin	NSW	3	710	829	16.7
Coolamon - Temora - West Wyalong	NSW	3	510	606	18.9
Coomealla	NSW	3	130	137	5.4
Coonabarabran	NSW	3	430	501	16.6
Coonabarabran - Surrounds	NSW	3	377	457	21.2
Coonamble	NSW	4	903	992	9.9
Coonamble - Surrounds	NSW	4	102	99	-2.7
Dareton	NSW	3	184	203	10.2
Darlington Point	NSW	3	190	215	13.1
Dubbo - Surrounds	NSW	3	345	410	18.9
Eden	NSW	3	226	263	16.2
Eurobodalla	NSW	3	481	563	17.1
Forbes	NSW	3	884	1038	17.4
Gilgandra	NSW	3	533	621	16.5
Gingie Reserve	NSW	4	64	54	-16.2
Glen Innes	NSW	3	496	571	15.2
Goodooga	NSW	5	178	173	-2.9
Griffith	NSW	3	998	1154	15.7
Gulargambone	NSW	3	170	185	9.0

Indigenous Location (ILOC)	State	ARIA	Population 2011	Population 2016	Per cent change
Gunnedah	NSW	3	1099	1293	17.7
Gunnedah - Surrounds	NSW	3	245	284	16.0
Guyra	NSW	3	272	318	17.1
Gwydir	NSW	3	190	228	20.0
Hillston	NSW	4	100	91	-9.2
Inverell	NSW	3	1059	1243	17.4
Jubullum Village	NSW	3	137	148	8.4
Kempsey - Surrounds	NSW	3	878	1010	15.0
Lachlan	NSW	4	135	137	1.5
Lake Cargelligo	NSW	4	229	225	-1.5
Leeton	NSW	3	650	783	20.4
Lightning Ridge	NSW	4	426	455	6.8
Liverpool Plains	NSW	3	145	176	21.4
Macksville	NSW	3	215	256	18.9
Menindee	NSW	5	180	172	-4.4
Mirriwinni Gardens - Bellbrook	NSW	3	152	175	15.1
Moree - North	NSW	3	338	379	12.2
Moree - South	NSW	3	969	1105	14.0
Moree - West	NSW	3	194	220	13.5
Moree Plains	NSW	3	219	262	19.8
Mudgee	NSW	3	963	1127	17.1
Muli Muli - Woodenbong	NSW	3	201	226	12.3
Mungindi	NSW	4	127	123	-3.2
Murrin Bridge	NSW	4	99	81	-18.1
Nambucca - Surrounds	NSW	3	295	351	19.1
Nambucca Heads	NSW	3	578	683	18.1
Namoi Reserve	NSW	4	91	71	-22.0
Narooma	NSW	3	128	153	19.4
Narrabri	NSW	3	634	738	16.4
Narrabri - Surrounds	NSW	3	403	481	19.4
Narrandera	NSW	3	582	687	18.1
Narromine	NSW	3	916	1092	19.3
Narromine - Surrounds	NSW	3	166	195	17.5
Parkes	NSW	3	751	890	18.5
Parkes - Surrounds	NSW	3	220	261	18.7
Peak Hill	NSW	3	205	227	10.8
Quirindi	NSW	3	334	386	15.5
South West Rocks	NSW	3	262	320	22.1
Stanley Village	NSW	3	319	358	12.1
Tamworth - Surrounds	NSW	3	1006	1193	18.5
Tenterfield	NSW	3	310	372	20.1
Tingha	NSW	3	175	204	16.3
Toomelah	NSW	3	230	259	12.8
Trangie	NSW	3	224	256	14.3

Indigenous Location (ILOC)	State	ARIA	Population 2011	Population 2016	Per cent change
Uralla	NSW	3	330	381	15.6
Walcha	NSW	3	225	265	17.9
Walgett	NSW	4	819	885	8.1
Walgett - Surrounds	NSW	4	208	206	-0.9
Walhallow Reserve (Carooma)	NSW	3	87	91	4.3
Wallaga Lake	NSW	3	118	126	6.7
Warren	NSW	3	360	414	15.1
Wee Waa	NSW	3	340	394	15.8
Wellington	NSW	3	1135	1321	16.4
Wellington - Surrounds	NSW	3	600	654	8.9
Wentworth	NSW	3	138	151	9.5
Wilcannia	NSW	5	466	499	7.1
Bairnsdale	Vic	3	538	650	20.9
East Gippsland	Vic	3	677	797	17.8
Glenelg North - Heywood	Vic	3	211	262	24.2
Lake Tyers	Vic	3	124	127	2.2
Mildura	Vic	3	1843	2197	19.2
Portland	Vic	3	184	229	24.2
Swan Hill	Vic	3	432	529	22.5
Swan Hill - Robinvale	Vic	3	293	352	20.1
Swan Hill - Surrounds	Vic	3	155	196	26.1
Wimmera	Vic	3	622	730	17.3
Atherton	Qld	3	763	913	19.6
Aurukun	Qld	5	1201	1325	10.3
Ayr	Qld	3	601	721	19.9
Badu Island	Qld	5	708	797	12.5
Balonne exc. St George and Dirranbandi	Qld	4	131	142	8.4
Bamaga and Surrounds	Qld	5	860	962	11.9
Banana - North	Qld	3	297	367	23.4
Banana - South	Qld	4	43	53	23.0
Barcaldine	Qld	5	200	229	14.3
Barron	Qld	3	1021	1205	18.0
Biloela	Qld	3	227	289	27.3
Blackall - Tambo	Qld	5	88	99	12.3
Blackwater	Qld	3	238	303	27.2
Boigu Island	Qld	5	189	198	4.6
Boulia	Qld	5	185	202	9.4
Bowen (Qld)	Qld	3	873	1023	17.1
Bulloo - Quilpie - Barcoo	Qld	5	185	207	11.7
Burdekin	Qld	3	309	380	23.0
Cairns - City	Qld	3	700	785	12.1
Cairns - North	Qld	3	539	657	21.9
Cairns - Southern Hinterlands	Qld	3	424	504	18.8
Cairns - West	Qld	3	839	986	17.5

Indigenous Location (ILOC)	State	ARIA	Population 2011	Population 2016	Per cent change
Cairns - White Rock - Mt Sheridan	Qld	3	1471	1748	18.8
Camooweal	Qld	5	105	111	5.6
Cape Tribulation - China Camp - Zig Zag	Qld	4	42	40	-4.1
Cape York Wilderness	Qld	4	150	159	6.2
Cardwell	Qld	3	349	422	20.9
Carpentaria exc. Doomadgee	Qld	5	257	285	10.9
Central Highlands	Qld	4	340	396	16.3
Charters Towers	Qld	3	834	988	18.4
Cherbourg	Qld	3	1199	1397	16.5
Chinchilla	Qld	3	238	293	23.0
Cloncurry - McKinlay	Qld	4	744	822	10.5
Coen	Qld	5	271	286	5.5
Cooktown	Qld	4	370	410	10.8
Dauan Island	Qld	5	133	134	0.6
Diamantina	Qld	5	73	70	-4.8
Dirranbandi	Qld	5	111	119	7.0
Doomadgee	Qld	5	1168	1320	13.0
Dysart	Qld	3	80	110	37.0
Eacham	Qld	3	301	376	24.8
Edmonton	Qld	3	2060	2507	21.7
Eidsvold	Qld	3	188	219	16.7
Emerald	Qld	3	448	533	19.0
Erub (Darnley) Island	Qld	5	360	385	7.0
Etheridge Tablelands	Qld	3	1325	1481	11.8
Flinders - Richmond - Dalrymple	Qld	5	290	328	13.0
Gayndah	Qld	3	143	192	34.3
Gladstone - South Coast	Qld	3	141	180	28.0
Goondiwindi	Qld	3	323	404	25.0
Goondiwindi - Surrounds	Qld	3	194	245	26.0
Gordonvale	Qld	3	758	906	19.6
Hammond Island	Qld	5	222	235	5.7
Herberton	Qld	3	200	252	26.0
Herberton Tablelands	Qld	3	344	415	20.6
Hinchinbrook	Qld	4	247	278	12.6
Hope Vale	Qld	4	927	1015	9.5
Horn Island	Qld	5	333	367	10.1
Iama (Yam) Island	Qld	5	305	335	9.8
Ingham	Qld	3	408	483	18.4
Injinoo	Qld	5	461	518	12.3
Innisfail	Qld	3	1348	1560	15.7
Johnstone	Qld	3	540	657	21.7
Jumbun	Qld	4	101	94	-7.0
Kowanyama	Qld	5	940	1028	9.4
Kowrowa - Mantaka - Mona Mona	Qld	3	222	260	17.3

Indigenous Location (ILOC)	State	ARIA	Population 2011	Population 2016	Per cent change
Kubin (Moa Island)	Qld	5	164	171	4.3
Laura	Qld	5	53	47	-11.4
Lockhart River	Qld	5	439	472	7.6
Longreach	Qld	5	283	333	17.7
Mabuiag Island	Qld	5	257	288	11.9
Mackay - Surrounds	Qld	3	422	520	23.3
Manunda - Portsmith	Qld	3	4241	4904	15.6
Mapoon	Qld	5	237	244	2.9
Maranoa exc. Roma and Mitchell	Qld	4	193	215	11.2
Mareeba	Qld	3	1249	1451	16.1
Mer (Murray) Island	Qld	5	356	385	8.2
Millmerran	Qld	3	95	128	35.2
Mirani	Qld	3	237	303	27.7
Mitchell	Qld	5	158	176	11.2
Moranbah	Qld	3	233	293	25.6
Mornington	Qld	5	1002	1132	13.0
Mossman	Qld	3	325	391	20.4
Mossman - Surrounds	Qld	3	453	546	20.4
Mossman Gorge	Qld	3	96	103	7.2
Mount Garnet	Qld	4	87	81	-7.3
Mount Isa exc. Camooweal	Qld	4	3110	3524	13.3
Mount Whitfield	Qld	3	638	760	19.1
Muralag and Inner Islands	Qld	5	50	45	-10.7
Murgon	Qld	3	417	503	20.7
Murilla - Wandoan	Qld	3	115	158	37.3
Murweh	Qld	5	531	604	13.7
Napranum	Qld	5	820	907	10.6
Nebo - Clermont	Qld	4	293	337	14.9
New Mapoon	Qld	5	276	292	5.7
Normanton	Qld	5	670	734	9.6
North Burnett - Rural	Qld	3	275	341	24.0
Palm Island	Qld	4	2209	2451	10.9
Paroo	Qld	5	573	648	13.2
Pormpuraaw	Qld	5	606	653	7.7
Port Kennedy (Thursday Island)	Qld	5	889	987	11.1
Poruma (Coconut) Island	Qld	5	150	152	1.3
Proserpine - Whitsunday	Qld	3	475	584	22.9
Ravenshoe	Qld	3	165	205	24.2
Roma	Qld	3	592	704	18.9
Saibai Island	Qld	5	359	396	10.4
Sarina	Qld	3	645	780	21.0
Seisia	Qld	5	149	146	-2.0
St George	Qld	4	564	641	13.7
St Pauls (Moa Island)	Qld	5	251	260	3.4

Indigenous Location (ILOC)	State	ARIA	Population 2011	Population 2016	Per cent change
Stanthorpe	Qld	3	248	313	26.1
Tara (Qld)	Qld	3	236	288	22.1
Thuringowa	Qld	3	4524	5388	19.1
Townsville	Qld	3	5391	6232	15.6
Townsville - Northern Beaches	Qld	3	203	257	26.4
Townsville - Southern Rangelands	Qld	3	601	651	8.3
TRAWQ (Thursday Island)	Qld	5	817	901	10.3
Trinity	Qld	3	868	1021	17.7
Tully	Qld	3	280	345	23.4
Ugar (Stephens) Island	Qld	5	50	48	-3.8
Umagico	Qld	5	270	292	8.1
Wambo	Qld	3	155	208	34.1
Warraber Island	Qld	5	223	237	6.5
Weipa	Qld	5	630	719	14.1
Winton	Qld	5	123	132	7.1
Wondai	Qld	3	242	307	26.8
Woorabinda	Qld	4	880	979	11.3
Wujal Wujal	Qld	4	253	251	-1.0
Yarrabah	Qld	3	2348	2707	15.3
Yorke Island	Qld	5	241	255	5.8
Amata - Tjurma Homelands	SA	5	451	479	6.2
Anilalya Homelands	SA	5	123	120	-2.1
Barmera	SA	3	203	250	23.2
Berri	SA	3	287	352	22.7
Ceduna	SA	5	473	522	10.4
Coober Pedy	SA	5	254	275	8.4
Copper Coast - Barunga West	SA	3	314	395	26.0
Davenport	SA	3	174	190	9.4
Dunjiba (Oodnadatta)	SA	5	116	114	-1.4
Eyre Peninsula	SA	4	260	300	15.5
Flinders Ranges	SA	3	884	1053	19.1
Iga Warta Homeland	SA	5	61	52	-15.2
Indulkana and Indulkana Homelands	SA	5	299	317	5.9
Kalka and Homelands	SA	5	70	64	-8.7
Kaltjiti (Fregon) and Irintata Homelands	SA	5	240	246	2.4
Kanpi - Nyapari - Angatja	SA	5	110	104	-5.1
Koonibba	SA	5	137	141	3.1
Lake Eyre - Lake Torrens	SA	5	213	228	6.8
Leigh Creek - Copley	SA	5	64	67	4.8
Limestone Coast	SA	3	514	615	19.6
Loxton - Waikerie	SA	3	214	280	30.7
Maralinga Tjarutja	SA	5	67	63	-6.6
Meningie	SA	3	82	106	29.0
Mimili and Mimili Homelands	SA	5	248	257	3.6

Indigenous Location (ILOC)	State	ARIA	Population 2011	Population 2016	Per cent change
Mount Gambier	SA	3	577	710	23.1
Murray Mallee	SA	3	197	252	27.7
Pipalyatjara	SA	5	90	85	-5.3
Point Pearce	SA	3	127	151	19.0
Port Augusta - Central	SA	3	1374	1571	14.3
Port Augusta - Surrounds	SA	3	14	27	92.0
Port Augusta - West	SA	3	611	731	19.6
Port Lincoln	SA	4	781	882	12.9
Pukatja (Ernabella)	SA	5	440	476	8.2
Quorn	SA	3	132	160	21.1
Raukkan	SA	3	95	111	16.9
Renmark Paringa	SA	3	163	218	33.4
Roxby Downs	SA	4	75	83	10.8
South-West Coast	SA	5	53	52	-1.2
Stirling North	SA	3	174	209	20.0
Tjutjunaku Worka Tjuta - Inner Homelands	SA	5	174	184	5.9
Tjutjunaku Worka Tjuta - Outer Homelands	SA	5	74	80	7.5
Umoona	SA	5	22	22	1.1
Watarru and Outstations	SA	5	42	38	-10.5
Whyalla	SA	3	932	1104	18.5
Yalata	SA	5	263	281	7.0
Yorke Peninsula	SA	3	210	270	28.7
Albany - Central	WA	3	597	723	21.0
Albany - Surrounds	WA	3	475	573	20.6
Argyle	WA	5	132	148	12.5
Balgo	WA	5	459	505	10.0
Bardi (One Arm Point)	WA	5	310	351	13.1
Bayulu	WA	5	316	358	13.2
Beagle Bay	WA	5	255	284	11.3
Beverley	WA	3	71	105	47.5
Bidyadanga	WA	5	530	596	12.5
Bridgetown - Scott River East	WA	3	92	135	47.2
Brookton	WA	3	121	163	34.7
Broome - Central	WA	4	1359	1487	9.4
Broome - North	WA	4	312	351	12.7
Broome - Surrounds	WA	5	163	180	10.1
Broome Town Camps	WA	4	240	251	4.6
Burringurrah	WA	5	104	111	6.7
Carnarvon Town exc. Mungullah	WA	4	917	1041	13.6
Carnegie South exc. Mount Magnet	WA	5	202	233	15.6
Cheeditha - Mingullatharndo	WA	4	298	309	3.7
Coolgardie	WA	5	200	223	11.5
Coonana	WA	5	43	43	0.9
Cosmo Newberry	WA	5	66	65	-2.0

Indigenous Location (ILOC)	State	ARIA	Population 2011	Population 2016	Per cent change
Dampier	WA	5	55	74	33.7
Denmark - Plantagenet	WA	3	202	271	34.0
Derby	WA	5	810	911	12.5
Djarindjin - Lombadina	WA	5	208	232	11.4
Djugerari	WA	5	79	81	2.5
Doon Doon	WA	5	89	93	3.9
East Pilbara - Surrounds	WA	5	212	234	10.3
Esperance	WA	4	442	514	16.3
Esperance - Ravensthorpe - Surrounds	WA	4	154	175	13.3
Exmouth - Ashburton - Surrounds	WA	5	360	408	13.3
Fitzroy Crossing	WA	5	212	235	10.9
Fitzroy Crossing - Surrounds	WA	5	50	49	-1.6
Fitzroy River - Surrounds	WA	5	138	144	4.1
Geraldton - Central	WA	3	1409	1676	18.9
Geraldton - North	WA	3	766	920	20.1
Geraldton - Surrounds	WA	3	683	789	15.6
Gnowangerup	WA	4	144	172	19.7
Great Sandy Desert	WA	5	89	92	3.5
Greenough - Chapman Valley	WA	3	42	75	79.0
Halls Creek - Surrounds	WA	5	380	427	12.5
Halls Creek exc.Town Camps	WA	5	613	692	12.9
Injudunna	WA	4	159	161	1.3
Irrunuytju	WA	5	131	135	2.9
Irwin - Morawa	WA	3	337	419	24.3
Jameson	WA	5	111	116	4.8
Jarlmadangah Burru	WA	5	66	69	5.2
Jigalong	WA	5	329	364	10.6
Joy Springs	WA	5	53	53	-0.6
Junjuwa	WA	5	355	394	11.0
Kalgoorlie	WA	3	1995	2342	17.4
Kalgoorlie - Dundas	WA	5	54	65	20.2
Kalumburu	WA	5	408	459	12.5
Kambalda	WA	3	98	143	46.0
Karalundi	WA	5	44	55	25.2
Karmarlinunga - Djimu Nguda - Budulah	WA	5	110	108	-1.9
Karratha	WA	4	874	992	13.5
Katanning	WA	3	384	475	23.8
Kellerberrin	WA	3	115	151	31.1
Kiwirrkurra	WA	5	201	213	5.9
Kojonup	WA	3	278	355	27.6
Kooraby	WA	5	54	57	5.9
Kulin	WA	4	171	203	18.9
Kunawarritji	WA	5	73	73	0.0
Kundat Djaru	WA	5	178	198	11.3

Indigenous Location (ILOC)	State	ARIA	Population 2011	Population 2016	Per cent change
Kununurra exc. Town Camps	WA	4	1048	1194	13.9
Kupungarri	WA	5	57	65	13.7
Kurrawang	WA	5	77	85	10.2
Laverton - Ngaanyatjarraku - Surrounds	WA	5	332	371	11.7
Leonora	WA	5	190	215	12.9
Looma	WA	5	371	405	9.2
Manjimup	WA	3	244	328	34.5
Marble Bar - Mirtunkarra (Goodabinya)	WA	5	126	140	10.8
Mardiwah Loop - Lundja	WA	5	355	393	10.7
Meekatharra exc. Karalundi	WA	5	405	450	11.0
Menzies - Leonora - Surrounds	WA	5	120	140	16.6
Merredin	WA	3	252	328	30.3
Mindi Rardi - Kurnangki	WA	5	184	196	6.3
Mindibungu	WA	5	248	284	14.6
Minyirr - Cable Beach	WA	4	1000	1139	13.9
Mirima	WA	4	156	161	3.0
Moora	WA	3	306	379	23.9
Mount Magnet	WA	5	232	259	11.6
Mount Margaret	WA	5	88	94	6.6
Mowanjum	WA	5	301	331	10.0
Mugarinya (Yandeyarra)	WA	5	97	97	0.4
Mukinbudin	WA	4	92	109	18.4
Mulan	WA	5	137	146	6.7
Mullewa	WA	4	160	173	8.1
Muludja	WA	5	127	133	4.5
Mungullah	WA	4	185	195	5.6
Narrogin - Wagin	WA	3	502	617	23.0
Newman	WA	5	550	639	16.1
Ningia Mia	WA	3	104	122	17.6
Norseman	WA	5	104	120	15.1
Northampton	WA	4	182	210	15.2
North-East Kimberley	WA	4	189	202	7.0
North-West Kimberley	WA	5	157	171	9.2
Nullagine	WA	5	117	128	9.0
Nulleywah	WA	4	130	132	1.9
Onslow	WA	5	176	196	11.3
Outer Derby - West Kimberley	WA	5	131	154	17.5
Pandanus Park	WA	5	129	135	4.7
Papulankutja	WA	5	165	178	8.0
Paraburdoo	WA	5	139	166	19.5
Parnngurr	WA	5	120	126	4.8
Pingelly	WA	3	130	166	27.8
Port Hedland - Surrounds	WA	5	90	106	17.3
Port Hedland exc. Tjalka Brooda	WA	4	192	215	11.9

Indigenous Location (ILOC)	State	ARIA	Population 2011	Population 2016	Per cent change
Punmu	WA	5	141	148	4.9
Quairading	WA	3	136	174	27.8
Roebourne	WA	4	334	352	5.3
Shark Bay - Coral Bay - Upper Gascoyne	WA	5	117	130	11.0
South Hedland	WA	4	1767	1965	11.2
Southern Beaches	WA	3	521	639	22.7
Tjalka Boorda	WA	4	88	83	-5.8
Tjuntjuntjarra	WA	5	181	186	2.6
Tom Price	WA	5	294	348	18.4
Wanarn	WA	5	135	141	4.5
Wangkatjungka	WA	5	172	182	5.6
Warakurna	WA	5	154	166	7.8
Warburton	WA	5	395	433	9.7
Warmun	WA	5	227	248	9.5
Warralong	WA	5	167	178	6.8
Wickham	WA	4	302	346	14.4
Wiluna	WA	5	284	317	11.4
Wyndham	WA	5	411	455	10.7
Yakanarra	WA	5	100	107	6.7
Yardgee - Nicholson Town Camps	WA	5	115	119	3.1
Yungngora	WA	5	259	285	10.0
Break O'Day	Tas	3	232	290	25.0
Burnie	Tas	3	1110	1297	16.9
Campbell Town	Tas	3	105	135	28.9
Central Highlands (Tas.)	Tas	3	110	141	27.8
Circular Head - King Island	Tas	3	968	1126	16.3
Cygnet	Tas	3	183	199	8.6
Dorset	Tas	3	220	269	22.1
Flinders	Tas	5	125	115	-7.8
Geeveston	Tas	3	67	77	15.4
George Town	Tas	3	288	361	25.4
Glamorgan - Spring Day	Tas	4	160	165	3.1
Huonville - South Cape	Tas	3	1055	1226	16.2
Kentish	Tas	3	240	282	17.4
Latrobe - Hawley Beach	Tas	3	397	457	15.1
Meander Valley	Tas	3	261	325	24.7
Southern Midlands	Tas	3	260	311	19.6
Tasman	Tas	3	111	134	21.0
Ulverstone - Penguin	Tas	3	1111	1278	15.0
Ulverstone - Penguin - Surrounds	Tas	3	139	168	21.1
Waratah	Tas	3	211	259	22.6
Wynyard	Tas	3	635	736	15.9
Zeehan - Franklin	Tas	4	307	335	9.2
Acacia-Larrakia	NT	3	83	103	24.5

Indigenous Location (ILOC)	State	ARIA	Population 2011	Population 2016	Per cent change
Adelaide River - Coomalie	NT	4	155	162	4.2
Alawa	NT	3	187	224	19.7
Ali Curung	NT	5	487	481	-1.2
Alpurrurulam	NT	5	416	442	6.2
Alyangula	NT	5	88	100	13.9
Amanbidji (Mialuni)	NT	5	83	79	-4.9
Amoonguna	NT	4	272	278	2.2
Ampilatwatja and Outstations	NT	5	370	402	8.8
Angurugu	NT	5	792	829	4.7
Angurugu Outstations	NT	5	93	87	-6.7
Anmatjere - Surrounds	NT	5	108	98	-9.1
Anmatjere - Ti Tree	NT	5	62	55	-11.4
Anthelk Ewlpaye	NT	4	81	65	-19.4
Anthepe - New Llparpa - Tyeweretye	NT	4	176	170	-3.4
Anula	NT	3	320	385	20.3
Apatula (Finke)	NT	5	145	146	0.6
Areyonga	NT	5	220	220	-0.1
Atitjere	NT	5	167	170	2.1
Atitjere - Akarnenehe Outstations	NT	5	107	103	-3.8
Atneltyey	NT	5	23	18	-22.3
Bagot Community	NT	3	196	216	10.4
Bakewell - Rosebery - Mitchell	NT	3	729	878	20.4
Barkly Tablelands - Outstations	NT	5	109	113	3.9
Barunga	NT	5	291	312	7.1
Batchelor	NT	4	71	64	-10.2
Bees Creek - Virginia	NT	3	139	178	28.1
Belyuen	NT	4	175	171	-2.3
Binjari	NT	4	228	235	3.1
Borroloola exc. Mara - Yanyula	NT	5	359	349	-2.7
Brinkin - Nakara	NT	3	127	158	24.8
Bulla	NT	5	130	130	-0.3
Bulman - Weemol	NT	5	279	296	6.2
Canteen Creek	NT	5	199	210	5.7
Charles	NT	4	709	789	11.2
Cobourg Peninsula - Demed Homelands	NT	5	103	97	-5.5
Coconut Grove - Ludmilla	NT	3	249	291	16.8
Cox - Finniss	NT	4	119	116	-2.9
Daguragu	NT	5	191	167	-12.8
Daguragu Outstations	NT	5	18	17	-6.6
Darwin - Central	NT	3	202	225	11.3
Darwin River - Berry Springs - Southport	NT	3	149	189	26.9
Dhalinybuy	NT	5	115	111	-3.5
Douglas-Daly	NT	5	117	116	-1.2
Driver	NT	3	321	398	24.1

Indigenous Location (ILOC)	State	ARIA	Population 2011	Population 2016	Per cent change
Elliott	NT	5	290	262	-9.5
Elliott Surrounds - Outstations	NT	5	60	57	-5.5
Elsey Roper - Surrounds	NT	5	43	40	-8.1
Emu Point	NT	5	93	94	1.0
Engawala	NT	5	135	129	-4.3
Ewyenper - Ilpeye - Irklancha	NT	4	208	204	-2.0
Fannie Bay - Parap	NT	3	286	314	9.6
Farrar - Durack - Marlow Lagoon	NT	3	340	404	19.0
Flynn	NT	4	697	777	11.4
Galiwinku	NT	5	1895	2091	10.3
Gan Gan	NT	5	69	67	-2.4
Gapuwiyak	NT	5	819	849	3.6
Gapuwiyak Outstations	NT	5	172	173	0.7
Gray	NT	3	520	609	17.2
Gumatj - Surrounds	NT	5	9	11	18.8
Gunbalanya	NT	5	1038	1101	6.1
Gunyangara	NT	5	142	141	-0.6
Haasts Bluff and Outstations	NT	5	148	149	0.7
Heavitree	NT	4	179	173	-3.3
Hermannsburg	NT	5	538	546	1.5
Howard Springs - Gunn Point	NT	3	266	319	19.8
Humpty Doo - Elizabeth Valley	NT	3	613	727	18.6
Illeuwurru - Inkawenyerre	NT	5	68	57	-16.5
Ilparpa community	NT	4	19	15	-21.4
Ilperle-Tyathe - Mt Nancy - Aper-Alwerr	NT	4	172	169	-1.7
Imangara	NT	5	91	88	-3.3
Imanpa (Mount Ebenezer)	NT	5	175	175	0.1
Inarlenge	NT	4	41	31	-24.1
Ingkerreke Outstations	NT	5	68	58	-14.3
Irrultja	NT	5	87	84	-3.4
Jabiru	NT	4	212	222	4.8
Jilkminggan	NT	5	276	303	9.6
Jingili	NT	3	208	253	21.5
Julalikari - Outstations	NT	5	194	197	1.8
Kakadu - Marrakai - Surrounds	NT	4	226	237	5.0
Kalkarindji	NT	5	276	243	-12.0
Kaltukatjara (Docker River)	NT	5	262	267	1.8
Kaltukatjara Outstations	NT	5	69	65	-5.7
Karama	NT	3	790	949	20.1
Kargaru	NT	5	19	16	-14.9
Katherine exc. Town Camps	NT	4	1738	1949	12.1
Knuckey Lagoon	NT	3	91	107	17.7
Kulaluk	NT	3	36	31	-13.5
Lajamanu	NT	5	587	610	3.9

Indigenous Location (ILOC)	State	ARIA	Population 2011	Population 2016	Per cent change
Laramba	NT	5	234	237	1.4
Larapinta	NT	4	957	1078	12.6
Larrakeyah - The Gardens	NT	3	234	283	20.8
Laynhapuy	NT	5	311	332	6.8
Lyons - Lee Point - Leanyer	NT	3	393	475	20.9
Mabunji - Mungoorbada Outstations	NT	5	283	301	6.5
Malak	NT	3	544	654	20.3
Mamadawerre	NT	5	56	49	-12.7
Maningrida	NT	5	2038	2211	8.5
Maningrida Outstations	NT	5	270	284	5.3
Manmoyi	NT	5	61	53	-13.3
Manyallaluk	NT	5	105	101	-4.1
Mara	NT	5	192	199	3.5
Marla Marla - Village Camp	NT	5	127	123	-3.4
Marrara - Winnellie - Berrimah	NT	3	893	952	6.6
Marthakal Homelands exc. Galiwinku	NT	5	404	445	10.1
Mataranka - Mulggan	NT	5	91	86	-5.4
Miali Brumby - Warlpiri	NT	4	290	282	-2.8
Milikapiti	NT	5	406	439	8.1
Milingimbi	NT	5	1020	1082	6.1
Millner	NT	3	228	260	13.9
Milyakburra and Outstations	NT	5	156	150	-3.9
Minjilang	NT	5	270	286	5.8
Minmarama Park	NT	3	139	154	10.9
Minyerri	NT	5	444	496	11.8
Moil	NT	3	237	286	20.8
Moulden	NT	3	675	808	19.7
Mount Johns	NT	4	350	374	7.0
Mount Liebig and Outstations	NT	5	169	170	0.6
Mudginberri	NT	4	60	48	-19.9
Mutitjulu - Uluru	NT	5	249	262	5.3
Nauiyu Nambiyu	NT	5	391	424	8.5
Ngalpa Ngalpa - Wuppa	NT	5	396	416	5.0
Nganmarriyanga (Palumpa)	NT	5	343	381	11.0
Ngukurr	NT	5	973	1036	6.5
Nhulunbuy	NT	5	374	425	13.5
Nightcliff	NT	3	185	221	19.4
Nturiya	NT	5	97	92	-5.2
Numbulwar and Outstations	NT	5	627	632	0.7
Nyewente - Akngwertnarre - Namatjira	NT	4	123	108	-12.2
Nyirripi	NT	5	187	191	2.4
Palmerston Indigenous Village	NT	3	80	79	-1.8
Papunya	NT	5	381	360	-5.4
Papunya Outstations	NT	5	77	73	-5.5

Indigenous Location (ILOC)	State	ARIA	Population 2011	Population 2016	Per cent change
Peppimenarti	NT	5	165	168	1.7
Pigeon Hole	NT	5	120	124	3.1
Pine Creek	NT	4	150	153	1.9
Pirlangimpi	NT	5	333	351	5.3
Pmara Jutunta	NT	5	193	201	4.3
Ramingining	NT	5	775	795	2.5
Ramingining - Milingimbi Outstations	NT	5	219	225	2.8
Rapid Creek	NT	3	185	224	21.2
Rittarangu	NT	5	93	93	0.5
Robinson River (Mungoorbada)	NT	5	243	262	8.0
Rockhole	NT	4	125	122	-2.5
Ross	NT	4	742	815	9.8
Santa Teresa (Ltyentye Purte)	NT	4	504	548	8.7
South MacDonnell Ranges	NT	4	821	835	1.7
Stuart Park - Bayview - Woolner	NT	3	198	237	19.9
Tanami Outstations	NT	5	23	23	-0.2
Tara	NT	5	54	50	-6.7
Tennant Creek exc. Town Camps	NT	5	1040	1144	10.0
Thamarrurr exc. Wadeye	NT	5	189	196	3.9
Timber Creek	NT	5	154	163	5.7
Timber Creek - Surrounds	NT	5	61	55	-10.1
Titjikala	NT	4	189	185	-2.1
Tiwi	NT	3	238	280	17.6
Tiwi Islands - Wilderness	NT	5	180	189	5.2
Tjuwanpa Outstations	NT	5	205	209	1.8
Umbakumba and Outstations	NT	5	429	463	8.0
Utopia - Arawerr - Arlparra	NT	5	483	523	8.3
Wadeye	NT	5	1929	2139	10.9
Wagaman	NT	3	145	179	23.4
Walangeri Outstations	NT	5	48	46	-4.6
Wallace Rockhole	NT	5	65	58	-11.5
Walungurru (Kintore)	NT	5	415	446	7.6
Wanguri	NT	3	155	191	23.4
Warruwi	NT	5	395	439	11.0
Willowra	NT	5	204	214	5.0
Wilora	NT	5	111	105	-5.8
Woodroffe	NT	3	438	532	21.4
Wugular (Beswick)	NT	5	500	540	8.1
Wulagi	NT	3	266	326	22.4
Wurrumiyanga (Nguiu)	NT	4	1358	1435	5.7
Wutunugurra	NT	5	200	214	6.8
Yanyula	NT	5	187	195	4.4
Yarralin	NT	5	252	260	3.2
Yarrenyty-Arltere	NT	4	90	75	-17.0

Indigenous Location (ILOC)	State	ARIA	Population 2011	Population 2016	Per cent change
Yilpara	NT	5	125	119	-4.5
Yirara College and Surrounds	NT	4	120	140	16.4
Yirrkala	NT	5	652	651	-0.2
Yuelamu	NT	5	197	202	2.6
Yuendumu and Outstations	NT	5	587	585	-0.4
Yugul Mangi Outstations	NT	5	29	26	-9.3

PARTNERS IN THE CRC FOR REMOTE ECONOMIC PARTICIPATION

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Centre for Appropriate Technology

Centre for Remote Health

Charles Darwin University

CSIRO

Newmont The Gold Company

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Government of South Australia

Outback Communities Authority

Outback Spirit

Queensland Government

Robins Foods Pty Ltd

Karoo Development Foundation

Waltja Tjutangku Palyapayi
"doing good work with families"

Centrefarm

CleanGROW

coles

Precision Pastoral

The Smith Family
everyone's family

a place of mind
UBC

Spinifex Country

Minerals Council of Australia

Iga Warta...
the place of the native plum

NAP

Government of **Western Australia**
Department of **Aboriginal Affairs**
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