The Future of Australian Rural Communities: How Powerful are the Forces of Change?

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Abstract
This paper tests how far population change in 412 rural communities of south-eastern Australia is predetermined by five ‘drivers’: remoteness, amenity, town size, rural population density, and concentration/dispersal of the population. Testing their combined impact through multiple correlation analysis, it finds that over the ten-year period 1996-2006, the status of the five drivers measured in 1996 explains (statistically) some 53% of the variance in the actual population change in the communities. When the density, town size and relative dispersal drivers are measured as established trends over the 15 years preceding 1996, this statistical explanation rises to 57%. Thus these background drivers heavily load the dice, but scope remains for other factors (including planning) to influence population outcomes in particular communities.

Introduction
In a period of optimism about the country’s potential for closer land settlement, Griffith Taylor’s ‘stop-go determinism’ unpopularly argued that the natural environment set limits to the spread of close farming-based settlement and population in Australia. Our late colleague and friend Les Heathcote too made a huge contribution to the understanding of the impact of the natural environment on human settlement. While Taylor sought to persuade Australians to ‘accept their isohyets’, Heathcote demonstrated the large and unpredictable annual shifts in the isohyets themselves in his extensive studies of the impact of drought (see Heathcote, this volume, for a full bibliography). Countless other studies have demonstrated the undeniable impact of the natural environment on human settlement in Australia. In this paper, which we dedicate to Les, we critically examine a different set of influences on Australian rural settlement, which together almost take on the character of a kind of spatial determinism affecting the fortunes of human communities.

In the literature, non-metropolitan communities are frequently seen as a more and more pronounced spatial dichotomy, with a restricted, (mostly near-coastal) growth cluster on the one hand, and an extensive (mostly inland) residue experiencing long-term decline on the other (Holmes 1994; Hugo and Bell 1998, p. 111; Hugo 2005, p. 63; Budge 2005; Race et al. 2011, p. 10; Argent et al. 2011, p. 29). There is no doubt that as a broad-brush generalisation this interpretation is reasonable, although at a local level a great deal of variation remains in the demographic fortunes of local communities, and intermediate categories exist between the ‘dichotomous’ extremes (Smailes et al. 2005). But, how far is this two-way split inexorable and inevitable, and what are the forces held to be driving it? In this paper we critically examine five major drivers of change identified in the literature, and assess their relative strengths as predictors. We seek to measure the extent to which population outcomes are predestined by powerful forces – and more importantly, what scope remains for local leadership, initiative and other forms of comparative advantage to influence the
The study area and the database

Our analysis is based on a set of 412 localities in south-eastern Australia, including all of Victoria and the settled areas (agricultural, irrigation-based, and marginal agricultural/pastoral) of New South Wales and South Australia, but excluding uninhabited public lands, major urban areas and their peripheries, and very remote low-density rangelands (Figure 1). The way these 412 localities are defined has been described in detail elsewhere (Smailes et al. 2002a); basically, each one centres on a significant country town with a surrounding area corresponding as closely as possible to its immediate social catchment, with overlaps split along median lines to give a full and mutually exclusive coverage of the study area. Census collection district (CCD) units were then allocated to these catchments for the 1981, 1996, 2001 and 2006 censuses, using a concordance. For convenience, they are frequently referred to below as ‘communities’, in which term we include the central town, the dispersed surrounding population, and any minor, subsidiary clustered centres that fall within the catchment. Space here allows only the broadest outline of differing trends within these three population segments, and the catchments are treated as wholes.

For simplicity, the 412 social catchments are also treated as a single hierarchical order. Most of the catchments are quite small in total population (median 3605 persons, 1458 households in 2006), focusing on central towns with a 2006 median population of just 1913 persons, or 811 households. However they also include the immediate daily to weekly social interaction catchments of the larger regional centres, whose economic functions extend over a much wider area, at a higher level in the urban hierarchy. Twenty-three of the 412 catchments had central towns with populations of over 20,000, with a further 32 in the 10,000–19,999 range. Such centres are included despite their higher-order functions, as they too are impacted by the same drivers of change. Moreover, town size itself is one of the postulated ‘drivers’ of growth, and a full range of size is needed.

Specific aims

In what follows, we first give an overview of the broad changes in the study area population over the 25 year period of the study. We then

1. Identify the five ‘drivers’ (the independent variables) as: remoteness/accessibility; amenity; size of central town; local density of population; and concentration/ dispersal of settlement, held in the literature to be major influences on the rate of population change.

2. For population change itself (the dependent variable) over a given time interval we use two measures: persons and households. The former is more commonly used; but being units of both settlement and population, households give a less volatile and more stable measure of population change, than does the movement of individual persons. After examining the way the driver variables interlock and overlap through an inter-correlation matrix, we use a multiple correlation technique to assess their impact

   a. as ‘status’ variables; that is, use their values at the start of a period as
Figure 1. The 412 Social Catchments
predictors of population change over that period;
b. as “dynamic” variables: that is, to predict population change over a given period of time, use established trends in the drivers over a preceding period as predictors; and
c. combining the dynamic and selected status variables.

3. Using the most “successful” model from the preceding analysis, we then compare the actual population change over the period 1996–2006 with the predictions of the model.
4. Finally, we present conclusions on the use and limitations of this and similar approaches to forecasting population change in rural communities.

Overview: a quarter century of change
Despite excluding the major cities, (including Wollongong, Newcastle and Geelong) and their environs, the study area contains a substantial section (some 16%) of Australia’s population, having grown, in round figures, from 2½ million in 1981 to 3¼ million in 2006 – a 25% increase over 25 years. The overall change is shown graphically in Figure 2.

Table 1 shows the varied rate of growth over the period, also indicating the proportion of the growth attributable to the largest country towns. Most of the overall change in population (persons) took place in the first fifteen years, when it averaged about 1.2% per year, but slowed considerably to average about 0.6% after 1996.

Figure 2. Population change by components of social catchments, 1981–2006

Four major points emerge from the Table.

First, the 412 central towns in aggregate maintained a fairly dominant share (about two thirds) of the total study area population almost exactly throughout the period.

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Table 1. Aggregate population change in the 412 social catchments 1981–2006, by settlement components (thousands)

|                      | Total 1981 | Total 1996 | Total 2001 | Total 2006 | Change 81-06 % | Change 96-06 % |
|----------------------|------------|------------|------------|------------|----------------|----------------|
| Central towns in total (n=412) | 1,681      | 1,934      | 2,023      | 2,115      | 25.8           | 9.5            |
| Towns of ≥20,000 (n=23) | (610)      | (731)      | (782)      | (833)      | (36.7)         | (14.0)         |
| Other central towns (n=389) | (1,071)    | (1,203)    | (1,241)    | (1,282)    | (19.7)         | (6.4)          |
| Minor townships       | 145        | 262        | 282        | 305        | 124.1          | 16.4           |
| Rural balance         | 754        | 858        | 843        | 822        | 9.0            | – 4.2          |
| Total (persons)       | 2,580      | 3,054      | 3,148      | 3,243      | 25.7           | 6.6            |
| Total (households)    | 803        | 1,129      | 1,196      | 1,271      | 58.3           | 12.6           |
| Average persons per household | 3.21    | 2.70       | 2.63       | 2.55       |                 |                |

Noteworthy, however, is the strong contribution of the 23 largest towns, as compared with the other 389 centres. Although the latter still increased by some 20% in aggregate, almost half of them experienced decline. The 23 large centres include most, but not all, of the study area’s ‘regional capitals’, which are not identifiable by a particular population size threshold. Rather, they are marked out by relative dominance over the lesser places in their region, their absolute population size being a function of the local industrial base and prevailing regional density at a given time.

Second, the much slower growth of the dispersed ‘rural balance’, which experienced an actual slow decline after its high point in 1996. In part, these losses result from minor clusters reaching separate CCD status for the first time.

Third, the sharp rise of minor, subsidiary townships within the social catchments, especially in the first fifteen years. These minor centres are not found in all the 412 catchments, and by 2006 they still had only some 9% of the total population: nevertheless, this was a significant phenomenon, heavily concentrated in the high-amenity areas close to the east coast.

And finally, the average number of persons per household fell steadily over the period. With smaller families and more one- and-two person households, the percentage growth rate of households substantially exceeded that of persons.
The above aggregate changes reflect a slow but steady change in the balance between the population components making up a typical social catchment. Over the 25 years, the ratio between the median central town population and the median dispersed element rose from about 1¼:1 to about 1½:1, exclusive of any minor clusters in the catchment. Thus, most of the communities held their town populations better than their open country residents.

The above broad overview, of course, masks the apparent sharp division between growing, mostly near-coastal, and declining, mostly inland and remote communities referred to in the Introduction. We turn now to the main question: what appears to be driving a wedge between these two disparate groups, and to what extent does demographic change in rural communities, over a given period, flow from certain fundamental qualities or attributes of their situation?

Identifying the main drivers of demographic change

From the literature, a broad measure of agreement exists about the main drivers of population growth or decline in Australian rural communities. Race et al. (2011:8–9) sum up the consensus view: population growth occurs ‘primarily in districts close to major cities, along the coast (especially the east and southwest coasts) and in some regional centres, particularly those located on major transport routes’ while ‘the decline of inland districts is not just a factor of people moving to the cities for better opportunities, but is partly driven by the greater attractiveness of some coastal and rural areas compared to, primarily, more remote and arid inland areas’. In the same strain, Hugo (2005, p. 61, updated in Swan (2010, p. 87)) has shown the very close links between remoteness, population density and the rate of population change. Distilling these views and combining with related research on fundamental factors that shape the nature of rural communities (Coombes and Raybould 2001; Smailes et al. 2002b, 2005; Griffin et al. 2012), we examine the five key independent variables listed in the Introduction, and hypothesised to influence demographic change at the local community level. All of these have frequently been cited as explanatory variables for differential population growth rates within a nation or region, and/or as the most fundamental qualities of settlements.

To take the five factors in order, Remoteness/proximity in relation to major urban centres is stressed by nearly all observers (some already cited) as an obvious major impact on a community’s prospects for growth. Remoteness/proximity also correlates strongly with population density, though the two are conceptually distinct and not interchangeable (see Holmes’ (2009) critique of Zhao and Guthridge’s (2008) proposed ‘remoteness and incapacity’ index). Hugo (2005, 2007) demonstrates the broad-brush relationship between remoteness and Australian rates of population growth, while a recent study on the impact of industrial diversity on growth (Davies and Tonts 2010) identifies remoteness as an important contributing factor. We therefore expect a strong negative relationship between remoteness of the central town (as measured by the ARIA-Plus ‘Accessibility/Remoteness Index of Australia’) and population increase.

Secondly, especially from the 1970s onward, amenity has emerged as a highly significant predictor of change. The impact of the other four factors may be expected
to dominate in rural communities dominantly dependent on land-based production. However, many in-migrants are attracted by the consumption rather than production value of rural property. The role of amenity in attracting lifestyle-motivated ‘sea change’ and ‘tree change’ migration has been clearly demonstrated in Victoria by Barr (2005, 2009) and for Australia as a whole by Burnley and Murphy (2004). Particularly valuable is Barr’s demonstration of the demographic consequences of the ‘amenity premium’ that tree-changers are willing to pay for land in attractive locations (Barr 2005). Argent et al. (2007, 2011) have provided a composite index of amenity for south-eastern and south-western Australia and demonstrated its strong relationship with net in-migration, at the same time stressing the inherent complexity and diversity of amenity-led migration flows. Thus, using the index produced by Argent et al. as a measure, we hypothesise a strong positive relationship between amenity and population growth, due to the selective influence of amenity on the choice of migration destinations.

Thirdly, town size is perhaps the most commonly used rule of thumb among Australian commentators as indicators of community growth prospects, usually in relation to some particular regional setting. Thus for example Black, (2005, p. 37) points to adverse effects of trends in the wider economy on ‘inland settlements with fewer than 2000 inhabitants’, while a South Australian rule of thumb suggests that ‘towns with a population of more than 1000 have generally grown’ (Government of South Australia, 2008). Some commentators, e.g. Forth (2001) and Forth and Howell (2002), write off small towns as more or less inevitably doomed to decline and disappearance, while Sorensen (1998, p. 105) even suggests euthanasia for ‘the more terminal places’. While many of these comments erroneously treat ‘town’ and ‘community’ as synonymous, (ignoring the dispersed population element) there is no doubt that ceteris paribus, in most cases communities centred on small towns are at a competitive disadvantage. We hypothesise a strong positive relationship between the population size of the central town at the start of a period, and total catchment population growth over that period: the bigger the initial town size, the more likely that the population will increase.

Fourthly, as to density, the strong and consistent relationship between this variable (measured as net local density) and community population change, as well as a series of important spatial and socio-economic characteristics of rural communities across south-eastern Australia has been demonstrated (Smailes et al. 2002; Griffin et al. 2012). High densities bespeak habitable and desirable rural areas with relatively small holdings, many opportunities for social interaction, and short travel distances. In Finland, the most sparsely peopled country of the EU, Muilu and Rusanen (2004) have shown the almost linear relationship of rural density with personal income and with the proportions of primary, secondary and tertiary employment in the workforce, as well as differential susceptibility to the 1989–93 economic depression. Thus we expect a moderately strong positive relationship between the initial rural population density in the catchment, and population growth over the period.

Finally, any change in the degree of concentration, or clustering, of population within a social catchment by definition changes the balance between the town population and its immediate service area. High relative dispersal will give greater exposure to
farm rationalisation, and will generally be associated with relatively small central towns and with greater travel inputs. For country towns that are predominantly service centres change in this variable in many cases produces demographic flow-on effects affecting the whole community. Coombes and Charlton (1994) have also argued convincingly that population concentration is a more important and direct influence on the cost of service provision per capita than is the gross density of population. Population concentration varies enormously in the present study area, ranging between extremes of 98.8% (Whyalla, S.A. – an industrial town in an almost empty semi-arid setting) and 17.5% (Swan Reach, a small service town in a closely settled second home and retirement zone along the Murray River). We hypothesise, then, a negative relationship between the dispersed proportion of the catchment population in 1996 and total catchment growth by 2006.

The five variables as individual and collective predictors
These five factors may be seen as a set of pervasive background conditions which correlate significantly with many important qualities of rural communities and cannot but have some impact on the unequal endowment of social, human and institutional capital vital to small communities seeking to maintain viability in a competitive environment. We go on to put their separate and collective influences on population change over time to the test, focussing on the period 1996–2006. Three of the five (town size, remoteness, and rural density) required transformation to normalise their distributions before applying simple correlation analysis.

As a first step, we tested the simple correlation between each of the five drivers as status variables (1996 values), and population change by persons and households for 1996-2006. In every case, the hypotheses outlined above were upheld in the expected direction, and at the .stringent .001 level of significance. For total persons, the strength of correlation (Pearson’s $r$) was greatest for density (+.53), followed by amenity (+.49), remoteness (-.49), dispersal (-.34) and town size (+.32). For households, the respective values of $r$ are slightly higher for the (same) three leading variables, while the town size and dispersal $r$ values show minimal change. Scatter diagrams of the relation between each driver variable and 1996–2006 population change were produced. All of these bear some similarities, in that the bulk of the 412 communities cluster quite closely along the regression line, but the strength of the relationship is limited by a number of outliers, most of which have experienced stronger-than-predicted growth. To illustrate, Figure 3 shows the strongest relationship, that with rural population density. On this graph, all the points show the density/population change relation, but communities with very high urban proximity (i.e. low remoteness scores, with ARIA-Plus index below 1) are plotted as triangles. For these communities, rapid population growth appears to relate more to their peri-urban location rather than local population density; similarly, for some of the other outliers such as Bonny Hills (NSW) or Robe (SA) amenity factors may have been more important. Thus we may expect the five factors in combination to account for a greater part of the variance in population change than any one of them alone.

Intercorrelation between the five ‘drivers’
To separate out the specific influence of the five driver variables, we first measure their degree of correlation with each other (Table 2). The Table shows the pair-wise
inter-correlation between these drivers, and the consistency of this inter-correlation over time, for the four censuses for which we have data. For each initial variable in turn, its correlations with each of the other four variables are listed in decreasing order of strength, with the strongest average correlation on the first row, and the lowest on the fourth.

Results show a particularly strong and consistent correlation between a) local rural density and amenity; b) local rural density and remoteness; and c) relative dispersal and town size. The Pearson’s r coefficients for these pairs of variables average over ±0.7 for all four censuses. On the other hand the least correlated, or most independent, pairs are a) local rural density and relative dispersal, and b) amenity and relative dispersal. Coefficients for both these pairs average less than ±0.3, but remain statistically significant at the .001 level.

Over time, with few exceptions, the five variables slowly but surely became more and more intercorrelated, the average r value for the matrix rising from |.48| in 1981 to |.54| in 2006. This increase was most marked between 1996 and 2001, stabilising somewhat in the following five years. Together, then, these five presumptive drivers of population change should form a powerful predictive battery.

**How far can community population change over a given period be ‘predicted’ from the values of the five driver variables at the start of the period?**

Because of the overlapping and intermeshed influence of the five drivers, a technique is required that establishes their relative importance in ‘explaining’ population change, and eliminates any that are redundant. Multiple correlation analysis is employed, using the ‘backward elimination’ variant of the procedure. All five of the
key dimensions discussed above are first entered into the equation as independent variables, and their joint impact as predictors of population change is expressed as the multiple correlation coefficient $R$. Their relative contribution to multiple $R$ is unequal, however. If any one of the five fails to make a significant extra contribution (at a given level of probability) to the value of $R$ (after taking into account the impact of the four strongest variables), it is eliminated from the next iteration. This process continues until only the variables that contribute significantly, at the .001 level, remain in the equation.

The independent variables describe fundamental elements of the socio-economic ground rules for each catchment, and are likely to exert a slow and incremental, rather than rapid or dramatic change. Initially, therefore, it is useful to examine the time horizons over which the presumed influence of the driver variables works most strongly, and also if possible, whether their combined influence has increased or declined over time (Table 3).

Table 2. Pairwise intercorrelations between five independent variables thought to influence community population change, 1981, 1986, 2001 and 2006 Censuses

| Initial Variable       | Correlated with: | 1981 | 1996 | 2001 | 2006 |
|------------------------|------------------|------|------|------|------|
| Local rural density    | Amenity index    | +0.73| +0.77| +0.79| +0.78|
| Remoteness index       | -0.69            | -0.73| -0.73| -0.74|
| Town size              | +0.34            | +0.47| +0.49| +0.51|
| Relative dispersal     | -0.22            | -0.26| -0.30| -0.32|
| Relative dispersal     | Town size        | -0.73| -0.71| -0.72| -0.72|
| Remoteness index       | +0.38            | +0.34| +0.36| +0.37|
| Amenity index          | -0.29            | -0.27| -0.28| -0.30|
| Local rural density    | -0.22            | -0.26| -0.30| -0.32|
| Town size              | Relative dispersal| -0.73| -0.71| -0.72| -0.72|
| Remoteness index       | -0.47            | -0.54| -0.56| -0.58|
| Local rural density    | +0.34            | +0.47| +0.49| +0.51|
| Amenity index          | +0.32            | +0.41| +0.43| +0.44|
| Remoteness index       | Local rural density| -0.69| -0.73| -0.73| -0.74|
| Amenity index          | -0.67            | -0.67| -0.67| -0.67|
| Town size              | -0.47            | -0.54| -0.56| -0.58|
| Relative dispersal     | +0.38            | +0.34| +0.36| +0.37|
| Amenity index          | Local rural density| +0.73| +0.77| +0.79| +0.78|
| Remoteness index       | -0.67            | -0.67| -0.67| -0.67|
| Town size              | +0.32            | +0.41| +0.43| +0.44|
| Relative dispersal     | -0.29            | -0.27| -0.28| -0.30|

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Table 3. Multiple correlation: the joint effects of the five driver variables* on population change (by persons and households) over different periods of time

| Period       | 1981–2006 | 1981–2001 | 1981–1996 | 1996–2006 | 1996–2001 | 2001–2006 |
|--------------|-----------|-----------|-----------|-----------|-----------|-----------|
| Length of period | (25 yr)   | (20 yr)   | (15 yr)   | (10 yr)   | (5 yr)    | (5 yr)    |
| Multiple R (households) | 0.71      | 0.69      | 0.68      | 0.61      | 0.55      | 0.50      |
| Multiple R (persons)   | 0.72      | 0.71      | 0.72      | 0.61      | 0.55      | 0.48      |

*Local rural density, relative dispersal, town size, remoteness index and amenity index

Over the longer time periods, the five drivers together exert an apparent strong influence on population outcomes, whether these are measured by change in households or change in persons. For periods of between 15 and 25 years, multiple R is around or very close to .70, but over the shorter and more recent five-year periods, this drops sharply to around .50 or below. During the 15 years from 1981 to 1996, the average annual rate of growth in total population (persons) was approximately 1.2%, whereas for the next ten years (1996–2006) it averaged only around 0.6%. In a situation of relatively muted population change rate, other factors (including random effects) were playing a greater part.

Despite the high R values for 1981–2006, however, using the driver variables as a predictor of change in community populations 25 years into the future is unrealistic for most practical purposes. Over such a period, not only the economic and climatic ground rules for rural communities, but in some cases the driver variables themselves may change quite dramatically. Yet these powerful factors are still likely to exert a time-lagged influence over a more realistic time horizon of five to ten years ahead, and in the remainder of the paper we concentrate on the prediction of change over the period 1996–2006. In the series of tables that follows, first we use the 1996 level of the driver variables as predictors of population change by 2006; then we use the 1981–96 trends in the driver variables as predictors; and finally, a combination of selected elements of the two. The objective is to find the model that appears to be the most accurate predictor, and then to compare it with a map of actual population change.

Table 4, then, uses the 1996 levels of the five drivers as ‘status’ variables as predictors for 2001 and 2006, and shows which of the five make significant contributions to the collective multiple R. Again, the dependent variable (community population change) is alternatively measured either as persons or as households.

The results below show that the combined impact of these five intrinsically powerful factors on population change (multiple R) is much stronger measured over a ten-year than over a five-year period. Yet overall their combined impact adds less explanatory
value than might be expected to that of the strongest individual driver. (For density alone $r = 0.53$, while multiple R for all five drivers is 0.61) The coefficient of determination ($R^2$) shows that for the 10-year period 37% of the total variation in the dependent variable is statistically explained.

The lower part of Table 4 indicates which variables make a significant contribution to each model. Variables eliminated from the final equation are shown as blank cells. Rural density and relative dispersal are by far the most consistently significant explanatory variables. Town size drops out of all four models; amenity appears to have had a major positive impact on growth in households, while remoteness had a moderate negative impact on change in persons.

Table 4. Multiple correlation analysis: the joint impact, on community population change over 10-year and 5-year periods, of the five ‘status’ variables, and their relative contributions to multiple R

| Period     | % change in households | % change in persons |
|------------|------------------------|---------------------|
| (10 yrs)   | (5 yrs)                | (10 yrs)            |
| Multiple R | 0.61 0.55              | 0.61 0.55           |
| $R^2$      | .37 .30                | .37 .30             |

| Partial for variables remaining in the model | Partial for variables remaining in the model |
|----------------------------------------------|----------------------------------------------|
| Local rural density                         | +0.26 +0.18                                 |
| Relative dispersal                          | -0.19 -0.19                                 |
| Town size                                   | - -                                         |
| Remoteness                                  | - -                                         |
| Amenity                                      | +0.19 +0.19                                 |

Testing the impact of established trends in the driver variables on subsequent population change

The relatively modest increase in collective explanatory power achieved by the five indicators as status variables, then, raises an important new question: could it be that the critical factor impelling change over a given period is not the absolute level of density, remoteness, town size etc. at the start of the period, but rather the established trends in these variables over a preceding period? Are there cumulative spirals of growth or decline in which communities may become trapped until some new population equilibrium is reached? To test this, dynamic rather than ‘status’ versions...
of the ‘driver’ variables are used as input to the multiple correlations. Thus the independent variables in Table 5 are percentage change in town size, rural density, and relative dispersal in each catchment, all of which can and do change quite rapidly. This percentage change is measured over the 15 years preceding the periods covered by the dependent variables. Fifteen years is perhaps too long a period for expressing an established trajectory, as the net change may mask considerable fluctuations, but as the social catchment database is not available for 1986 and 1991 our capacity to compare different trajectory durations is limited. Table 5 compares the impact of the 1981-96 change in the three dynamic variables, with population change over the subsequent five years (1996–2001) and ten years (1996–2006).

Table 5. Multiple correlation analysis: the joint impact of established trends in local rural density, relative dispersal and town size over the preceding 15 years (1981-1996), on community population change after 1996

| Period        | % change in households | % change in persons |
|---------------|------------------------|---------------------|
|               | 1996–2001              | 1996–2001           |
|               | (10 yrs)               | (10 yrs)            |
| Multiple R    | 0.74                   | 0.73                |
| R²            | .55                    | .53                 |
| Density change, 81–96 | +.73                  | +.70                |
| Dispersal change, 81–96 | -.62                  | -.62                |
| Town size change, 81–96 | _                     | _                   |

Immediately obvious from these results is the apparent great importance of an established trajectory of change (whether upward or downward) as an influence on population outcomes. Even without taking into account the relatively static impact of amenity and remoteness, established changes in the other three driver variables raise multiple R to very close to 0.7 even for the shorter 5-year period. The coefficient of determination (R²) rises to over 0.5 for 1996–2006, showing that these dynamic variables together account for some 53 to 55% of the variance in community population change. Also important is the fact that the two significant variables remaining in the model are density change and dispersal change. As was shown in Table 2, these two variables are the least intercorrelated of the five ‘drivers’, and hence exert a significant and relatively separate influence, while change in town size is eliminated from the final equation. This suggests that the principal
generators of change in total population are the falling density through loss of dispersed population; at the same time, the nature of the community is changed by a disturbance of the former balance between the populations of the central towns themselves, and their rural catchments.

**Combined impact of the dynamic (trend) and status or constant driver variables**

The above findings, however strong, cause some surprise. It is hard to believe that all the status variables, especially amenity and remoteness which are so often cited in the literature as ‘driver’ variables, have no significant extra explanatory power. To test whether either or both of these would improve the explanatory power of the model, therefore, they were included as status variables, together with the three dynamic variables used in Table 5, in a further five-variable multiple correlation analysis. Dependent variables were exactly as for Table 5.

Results appear in Table 6. Adding the extra ‘status’ variables does make a minor improvement to the explanatory power of the model for the ten-year period 1996–2006, raising multiple R from 0.74 to 0.76 for households, and from 0.73 to 0.75 for persons, while remoteness (but not amenity) remains as a significant (negative) contributor to the final model. For the shorter (five-year) period 2001–2006, adding the two status variables makes no measurable difference: multiple R remains unchanged at 0.68 (households) and 0.69 (persons), and neither amenity nor remoteness remains in the final model.

**Comparing the models with actual change**

The above models must now be tested against a map of the actual changes in population that they seek to replicate. For this comparison, we use the predictive model that gives the best approximation (highest R² value) for population change, using combined dynamic and status variables and shown in bold type on Table 6. It uses the communities’ ‘track record’ of change in density and dispersal over the preceding fifteen years, along with the influence of remoteness, to predict actual change in households over the full ten-year time-period 1996–2006. Figure 4 shows the actual, quite dramatic, pattern of population change. It is easy to see why the idea of a dichotomy between growing (coastal, accessible, high amenity) and declining (inland, remote, low amenity) communities has arisen; but also, that this generalisation is subject to many local variations.

**The distribution of residuals from regression: how well does the model fit?**

Figure 5 shows, for each community, how far it deviates from its ‘predicted’ value. With a multiple R value of 0.76, this model accounts for a remarkable 57% of the variance in community population change, though no simple model is ever going to capture all the complex variations and circumstances of such a large and heterogeneous study area. No less than 320 of the 412 social catchments fall within ±1 standard deviation of divergence from their predicted value; but for the other 92, the model substantially over- or under-predicts the actual population change. These residuals may arise in part from possible inadequacies in our measures for the independent variables, but their distinctive spatial distribution also helps to identify other powerful explanatory factors. It should be noted that the broad features of this spatial distribution of residuals (Figure 5) are very similar in equivalent maps (not
Table 6. Multiple correlation analysis: the joint impact of three dynamic and two status variables on community population change, 1996–2001 and 2001–2006, showing partials for significant variables remaining in the model

| Period       | % change in households | % change in persons |
|--------------|------------------------|---------------------|
|              | 1996–2006 (10 yrs)     | 1996–2001 (5 yrs)   |
| Multiple R   | 0.76                   | 0.68                |
| R²           | 0.57                   | 0.46                |
| Density change, 81-96 | +0.59                  | +0.66               |
| Dispersal change, 81-96 | -0.58                  | -0.54               |
| Town size change, 81-96 | –                      | –                   |
| Remoteness   | -0.23                  | –                   |
| Amenity      | –                      | –                   |
| Partials for variables remaining in the model | | |

The areas shaded in light grey show where the model fits best, generally forming a discontinuous belt along the tablelands and immediate western slopes of New South Wales, from Queensland to the Victorian border. In Victoria, the pattern of residuals is particularly complex and suggestive. The model fits well in the higher-rainfall parts of that State, in an irregular belt along the flanks of the Alpine high country and the south-eastern (Gippsland) coastline; west of Melbourne, it becomes more discontinuous, but still includes a large number of communities along the central divide, the Wimmera and Mallee districts and along the Murray valley. This well-predicted area includes 15 of the 23 catchments based on the largest towns, with populations of over 20,000.

The areas shaded with a large dot pattern indicate communities where the 1996-2006 population growth was greater than predicted by the model, where the residuals from regression reached or exceeded +1.0 standard deviations from the predicted value. Although these areas are widely scattered, and in some of the small communities may be chance results based on small absolute numbers, there are three consistent categories of places where household numbers have increased much more.
Figure 4. Change in Number of Households 1996–2006

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Figure 5. Residuals from Regression 1996–2006

Legend
- Under-predicted (> +1 std. error from predicted)
- Well-predicted (< +1 std. error from predicted)
- Over-predicted (> -1 std. error from predicted)
- Public Lands
- Metropolitan Areas

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than expected by the model. The first is the very rapid growth of many newly suburbanising communities close to the expanding peri-metropolitan fringes of Adelaide, Canberra and (particularly) Melbourne – though not Sydney, which was more generously over-bounded in defining the study area. The forces of peri-urban expansion have clearly not been adequately expressed by our remoteness-proximity indicator (the ARIA score). Secondly, a string of irrigation-based and/or transport hub communities along the Murray and Murrumbidgee rivers grew more rapidly than expected, based on resort, tourism and residential/retirement developments as well as a period of relative prosperity in the viticulture industry. Up to 2006, irrigation-based farming in the Murray-Darling basin had largely withstood the effects of water restrictions, and a boom in the wine industry encouraged a wave of vineyard expansions, also affecting South Australian wine districts.

The third and in many ways most interesting area of positive residuals is the western half of South Australia, particularly the Eyre and Yorke Peninsulas and Kangaroo Island. In terms of their accessibility to the national urban system, these are the most remote parts of the whole study area and amongst the most sparsely populated. Here a combination of a major expansion in aquaculture employment, growth in tourism and coastal retirement and lifestyle oriented in-migration has more than offset losses in traditional dryland farming. Although small in absolute numbers, population growth here has been greatly in excess of expectations based on the five predictor variables. The unpolluted waters surrounding the very extensive, thinly peopled coastline have attracted tuna, oyster, abalone and marine finfish farming to supplement the traditional fishing industry. This region currently accounts for 99% by value of South Australia’s aquacultural production; taking into account the downstream and flow-on effects, employment in the industry grew from about 1500 in 1997 to 3500 by 2010 (Econsearch, 2011). Further impetus has been provided by the early effects of South Australia’s mineral and mining boom.

Turning to the negative residuals, shaded black on Figure 5, two major spatially consistent zones stand out. The first is coastal New South Wales, where with very few exceptions the model has over-predicted the growth of population in the string of densely populated communities east of the dividing ranges along the entire coast to the Victorian border. Comparison of Figures 4 and 5 shows that while these areas, strongly favoured by sea- and tree-change in-migration, have indeed increased their populations between 1996 and 2006, these increases fell below the expectations of the model. Over-predicted also are some small high-amenity but remote communities in the Victorian high country. The second consistent area of negative residuals is the dry inland, western and northern margins of the study area, where agriculture grades into rangeland, from around Mungindi on the Queensland border to Peterborough on the Flinders Ranges in South Australia. Negative residuals also extend southwards into the Mallee and Wimmera country of Victoria, where dryland farming dominates the economic resource base, there is relatively little potential for irrigation and most of the catchments centre on relatively small towns. The actual population losses in this extensive area have been greater than those predicted by the model, where not mitigated by access to water for irrigation (mainly of cotton and rice).
Figure 6. The relationship between predicted and actual change (1996–2006) in number of households, showing the distribution of residuals from multiple regression

To supplement Figure 5, Figure 6 illustrates the distribution of the residuals for each community graphically, in relation to the predictions of the model. Each point on the scatter diagram represents a social catchment, and its vertical distance from the trend line shows its residual from regression. The axes are on a logarithmic scale. To allow for the fact that many communities lost population over the period, 100 was added to the observed percentage change for each community before converting to the log scale, on which negative values cannot be shown. Thus on both axes, the index value of 2.00 equates to zero change. All values below 2 lost population (on the Y axis), or were predicted to lose it (on the X axis). Index values above 2 are positive. Actual values ranged between a 74% increase in households (Wallan, on the outskirts of Melbourne) and a 20% decrease (Goolgowi, western New South Wales). The points on the scatter diagram marked with a cross correspond to the most under-predicted category of communities on the map, while the points marked with a triangle indicate the most over-predicted one (cases where the residual diverges from its predicted value by more than ±1SD).

From the scatter diagram it is clear that the major divergence from the model’s predictions is due to a limited number of communities which have increased very much more than expected. These are the cases that most seriously restrict the explanatory power of the model. The major divergences on the negative side are fewer and less substantial. There is, however, a considerable number of moderately negative residuals, including many of the New South Wales coastal communities whose
population had increased, but by less than the model predicted.

Discussion and conclusions
The foregoing results illustrate both the advantages and limitations of attempts to ‘predict’ community viability by a quantified combination of well-known influential factors. We have concentrated on actual population change over the target period 1996-2006, using the 412 communities as units of analysis. To summarise the results of the modelling briefly:

The effects of the status type driver variables are more strongly expressed over longer periods of time (15–25 years) than over shorter periods of five to ten years. In effect, they express background conditions that set fairly strong probabilities affecting a community’s prospects for population growth. Over the ten-year target period for this study, they achieve R² values of about .37 for change in households and persons.

Three of the drivers (rural density, concentration/dispersal, and central town size) can be expressed as dynamic variables, using their established trends over the fifteen years preceding the target period. Using just these three dynamic variables sharply increases the predictive power of the model, raising multiple R² to well over 0.5 for households and persons.

Finally, by including the status variables remoteness and amenity to the above ‘dynamic’ model, only a slight increase in predictive power of the model is achieved, raising R² by only .01 or .02 in each case.

Notably, for each of the models, the correlations with actual population change are higher for the full ten year period 1996–2006 than for the shorter period 1996–2001.

The five drivers make unequal contributions to the overall predictability of the actual population change. Foremost among the five as predictors are the local rural density within the social catchment, and the relative rural dispersal/urban concentration of the community population, whether these are expressed as status or dynamic variables.

Several important points emerge from these results. First, given the heavy emphasis in the literature on the importance of amenity, remoteness, and central town size, the dominance in this study of local rural density and the degree of concentration/dispersal of the catchment population as explanatory variables is rather counter-intuitive. In particular, it is very surprising that amenity, the ‘new comparative advantage’ heralded as a major driver of change (McGranahan 1999) plays a relatively minor part in the multiple regression models. Likewise remoteness, stressed as a driver variable by so many writers, remains in the final model (used for Figures 5 and 6) only as a minor contributor. While this reinforces earlier findings on the importance of local density and relative dispersal as fundamental qualities of settlement systems (Griffin et al. 2012), it does not of course mean that amenity, remoteness and towns size are unimportant: rather, the search for parsimony in the construction of the model may place perhaps too much emphasis on some of the driver variables, while
excessively downplaying the influence of the rest. A likely explanation is that both remoteness and amenity are very strongly correlated with rural population density (Table 2), so that part of their influence is expressed indirectly through density, a very strong and dominant variable. Additionally, amenity as a positive attraction occurs in a minority of communities, which are also spatially concentrated, so that its influence is somewhat muted in the study area taken as a whole. In a similar way, the impact of town size of the main community centre is in all probability expressed, in part, indirectly through the dominant variable rural dispersal (Table 2). The strong role of local concentration/dispersal of population is perhaps the most surprising of our conclusions, vindicating the pivotal role accorded to it on a broader regional scale by Coombes and Raybould (2001). Of course, the strong correlations demonstrated here do not necessarily establish causality.

Secondly, it appears that when communities are caught up in an established trajectory of change, whether upward or downward, there is a high probability of this trend continuing.

There is no doubt that the 1981-96 trajectory of change of the three dynamic driver variables, along with the two status variables amenity and remoteness, do ‘predict’ the actual observed changes in Australian rural community populations from 1996 to 2006 rather too well for comfort. However, the distribution of the residuals shows that this approach too has limitations. An established trajectory of change in a preceding period is not certain to continue, perhaps through a major change in the climatic, economic or political ground rules affecting the area, or through achievement of a new equilibrium following a period of change. Thus in western South Australia, the period 1981–96 included a long, intense regional drought, on top of the nation-wide collapse of the wheat and wool markets and the ‘Recession we had to have’. (Smailes 1998) The following period, though still including unfavourable farming years, saw a readjustment and recovery in dry-land farming, as well as the advent of a modest sea-change in-migration of retirees and other lifestyle-motivated people, along with the growth of aquaculture, mentioned earlier. Thus, although modest in absolute numbers and mainly coastal, the trajectory-based variables greatly under-predicted the positive population change. On the other hand, past trajectories of rapid growth can also be misleading. Thus the period 1981–96 witnessed a very pronounced sea-change in-migration to the New South Wales coast, both north and south of Sydney. However, from the late 1990s this migration flow slowed down substantially. Burnley and Murphy (2004, pp. 235–237) summarise a series of reasons for this, including a narrowing of the metro/country house price gap, improved metropolitan labour markets, and increased planning restrictions on rural developers; hence our model’s over-prediction of population growth in the sea-change areas.

Thirdly, a limitation in the modelling undertaken here may be weaknesses in the independent variables used. For the status variables, our measure of amenity would undoubtedly be improved by the incorporation of an ‘amenity premium’ element as used by Barr (2005, 2009). The amenity premium is an estimate of values actually realised in sales of land, in relation to its productive value for agriculture, a powerful indicator of attractiveness for lifestyle-motivated in-migrants. However this indicator
is available only by SLA and hard to allocate to the social catchment units used here. Our measure of remoteseness, while effective in outlying areas, also appears to understated the strong attraction of peri-urban locations on population growth. As to the dynamic or trajectory variables, limitations caused by the lack of data for the 1986 and 1991 have already been acknowledged. It should also be noted that our data are based on place of enumeration rather than place of usual residence (not available in 1981).

So to return to the questions posed in the Introduction, how far are the fortunes of rural communities shaped by the spatial determinism implied by the model? And how inexorable are the forces producing the divide between growth and decline? The fact that these five powerful explanatory variables alone are able to explain (statistically) 57% of the variance in population change over a ten-year period gives rise to some unease about the scope remaining for rural and regional planning to alter the course of events.

However the variance in the results indicates that a host of other factors also influence the outcome – including leadership, comparative advantage, sporadic industrial activities, the impact of public policy and the differential impacts of drought. Our discussion has, deliberately, taken no direct account of other massive formative factors that also have had or will have profound impacts on Australian rural populations, such as the long drought up to 2010, the potential for climate change, the global economic crisis, and the Murray-Darling Basin plan to cut irrigation quotas. Results show that even well established trends can be halted, and clearly there is scope for some communities to buck the trend, or to exploit the advantages, though for others the analysis indicates situations where the crushing burdens of drought and recession have exceeded the losses predictable by the model. Either way, the results form a broad frame of reference for public policy, though the deterministic flavour of the model needs to be offset by further studies analysing the actual processes of demographic change that give rise to these results, in different settings.

Les Heathcote devoted much of his working life to fostering a deeper understanding of people/environment interactions in this continent, seeking to elucidate the impacts of a colonial developmental ethos on a fragile ecology and evolving economy and society. In publication after publication Les held a mirror up to Australian society, including its policy makers, reflecting back to them the many trials and tribulations, successes and failures of European attempts to ‘settle’ the continent. As a truly ‘all round’ geographer, Heathcote amply demonstrated the practical utility and conceptual power of key geographical ideas and concepts. In a kind of ‘soft determinism’, his scholarship recognised the real environmental bounds of human settlement and economic expansion in this country but also acknowledged the great lengths that rural people have gone to in order to graft a living out of, and a society on to, this at times inhospitable setting. As the debate over the optimum size of the national population and its geographic distribution continues, it is timely to consider again the powerful insights that such fundamental attributes of settlement systems as density and dispersal can shed on the forces driving change in non-metropolitan settlement systems.
Overall, though, this paper suggests that predictions of population change based on a combination of these commonly quoted explanatory variables may be a good servant in public policy formation, but they would be an exceedingly bad master. They represent facts of life relating to the economic and physical environment that load the dice for or against individual communities in maintaining their population numbers, rather than inevitable predictions.

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End notes
1. The Pearson correlation coefficient between households and occupied dwellings for the study area is .9997.
2. These variables are: total community population, size of catchment area, proportion of the workforce employed in primary industry, industrial diversity index, percent born overseas, masculinity ratio, residential mobility, workforce participation rate, fertility index, proportion unemployed, and children under 15 as a proportion of the population. These empirical relationships require due caution in their interpretation.
3. Amenity and remoteness are not available as dynamic measures as they change only slowly over time and are treated as constants in this paper.
4. I.e., the status of density, concentration/dispersal, central town size, amenity and remoteness as measured at the outset of the period.

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