How dense are we? Another look at urban density and transport patterns in Australia, Canada and the USA

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Abstract

For at least two decades, urban policy in Australia has been based on the belief that high levels of car use and poor public transport are mainly the result of low urban densities. There has been considerable debate about the evidence on which these policies are based, but until recently there has been no common data-set that allows densities and transport patterns to be compared on a consistent and rigorous basis. As a result of recent changes to data collection and publication systems by the Australian, Canadian and United States national census agencies, it is now possible to compare urban densities and transport mode shares (for the journey to work) across the three countries' urban areas on a consistent basis. This paper presents the results of this comparison. Australian cities have similar densities to those of Canadian cities and the more densely-populated US cities. There are variations in density among cities, but these show little or no relationship to transport modes share, which seems more closely related to different transport policies. These findings are very different from those on which current urban policies are based, and suggest the need for a radical rethinking of those policies.

The sustainable city

The twin challenges of climate change and insecure oil supplies require a rethinking of the way Australian cities have been planned and serviced (Garnaut, 2008; Dodson & Sipe, 2008). There is widespread agreement that cities must become more sustainable, including shifting travel from the automobile to public transport, walking and cycling. Most commentators treat this challenge as synonymous with the policies that have come to be known as urban consolidation, or the compact city.

Professor David Karoly, a member of the International Panel on Climate Change, recently told *The Age* that lifestyles need to change. Australians 'have been encouraged over time to aspire to individual homes with a backyard', but must now 'move to higher-density living with parks and parklands, efficient transport, and a return to the shopping strip, to which people would walk.' (Blakston, 2009) Professor Karoly is a meteorologist, not an urban planner, but presumably felt that the relationship between backyards and unsustainable transport is now conclusively established. The idea has become orthodoxy among Australian governments and urban planners, and has been enshrined in metropolitan plans across the country.

The Victorian government's *Melbourne 2030* strategy paints a picture of a sprawling, inefficient metropolis:

> the average density of the metropolitan area at around 14.9 persons per hectare (pph) is low by international standards. Montreal has 33.8 pph, for example, and Toronto has 41.5 pph; both cities compare in population, size and function to Melbourne. (Victoria, 2002, p. 60.)

The solution is urban consolidation, a policy which in practice in Melbourne amounts to deregulation of the development control system to allow flats to be built virtually anywhere. This policy has been politically unpopular, and in 2005 a group of researchers based at Monash University called for a 'fundamental re-think' (Birrell et al, 2005). In response, the Victorian Premier warned that Melbourne would become 'a Los Angeles-style city' if the metropolitan strategy was not maintained (Boulton, 2005).

Los Angeles is the most popular symbol of the relationship between low-density urban sprawl and automobile-dominated transport systems. By contrast, Portland, Oregon is presented as the paradigmatic example of the antidote to LA-style sprawl: urban consolidation, or 'smart growth' as it is called in the United States.

The density-transport connection is accepted by critics of urban consolidation, as well as supporters. For example, Alan Moran of the Institute of Public Affairs, attacks consolidation in his 2006 booklet *The Tragedy of Planning*. Moran (2006, p. 15) argues that attempts to revive public transport are doomed, because it requires Hong Kong- style densities to operate economically: 'A rule of thumb is that rail-based systems require 40,000 people per square kilometre to be viable... Express bus systems need 26,000 per square kilometre.' No source is provided for these claims, which equate to 400 and 260 per hectare respectively, densities that would be impossible to achieve in any Australian environment.

The International Panel on Climate Change seems to agree with Moran on this question. Its fourth Climate Change Assessment Report, released in 2007, has little to say about transport,

reflecting the cautious tone of the report from the IPCC's Transport Working Group. The working group report says: 'Providing public transport systems... and promoting non-motorised transport can contribute to GHG mitigation. However, local conditions determine how much transport can be shifted to less energy intensive modes.' The potential for mode shift is 'strongly influenced by the density and spatial structure of the built environment', but 'densities are decreasing everywhere'. (Kahn-Ribeiro et al, 2007, pp. 326, 367.) The working group's recommendations focus on technological responses to emissions from transport, perhaps unsurprisingly since its coordinating authors were a Brazilian engineer specialising in biofuels and a Japanese researcher working at the Toyota R & D laboratory on 'clean energy vehicles'.

If Moran is correct, then the IPCC working group is right to dismiss transport mode shift as a serious part of the response to global warming. The same is true even if the more modest doubling or tripling of densities implied by the discussion in Melbourne 2030 is needed. Climate change and oil dependence require urgent action, but doubling the density of a large metropolis would take many decades to achieve, and may be politically impossible in a democratic society. The majority of the houses Australians will be living in by 2040 already exist; the built environment changes slowly in aggregate, even if localised change sometimes seems spectacular (see also Dodson & Sipe, 2008, pp. 73-6).

Density-based responses to the environmental problems of transport tend to downplay, or dismiss outright, the possibility that mode shift can occur in response to transport policies. But transport policy can be changed much more rapidly than urban form. Before accepting that improved environmental outcomes require changes in urban form that may be unachievable within a realistic timeframe, policy-makers should carefully scrutinise the evidence supporting these arguments. But this has not been the case: instead, the degree of analytical rigour employed is typified by the extract from Melbourne 2030 cited above, which provides no sources for the density estimates offered for Melbourne, Montreal and Toronto.

X-Ray the data

The density estimates in Melbourne 2030 actually come from the work of Jeff Kenworthy and Peter Newman, based originally at Murdoch University, but now at Curtin. For more than two decades, the Murdoch-Curtin team has assembled data on urban form and transport in cities across the world, with the results being published in three editions: *Cities and Automobile Dependence* (1989); *An International Sourcebook of Automobile Dependence* (1999) and the *Millennium Database for Sustainable Transport* (2001). Each successive edition has incorporated more recent data, but also revisions of earlier data in the light of new information.

Newman and Kenworthy have used their data-sets to compare population densities and transport patterns. The results, expressed in the form of a much-reproduced graph, apparently show a hyperbolic relationship in which car use increases exponentially once densities fall below about 30 persons per hectare. This graph sparked heated debate during the 1990s (reviewed in Banister, 1999, chapter 6 and Mees, 2000, chapter 3), but the relationship has been accepted uncritically by most Australian planners and governments.

Melbourne 2030 cited figures from the 1999 *Sourcebook* even though those from the 2001 *Millennium Database* were available at the time. The omission is significant, because by 2001, Kenworthy and his colleagues had revised their estimate of Toronto's density

substantially downwards, from 41.5 persons per hectare to 25.5. The 1999 figures covered the City of Toronto (formerly the Municipality of Metropolitan Toronto) only, which houses only half the population of the Toronto Census Metropolitan Area. Kenworthy and his colleagues noted this at the time, indicating that data for the larger area had been difficult to obtain (Kenworthy et al, 1999, p. 32). The data released in 2001 rectified this deficiency, and covered the whole CMA.

This problem illustrates the importance of ensuring that density comparisons are made on a consistent and rigorous basis. Failure to do so will produce results that are at best meaningless, and at worst downright misleading.

The problem is not new. More than six decades ago, Ernest Fooks published a little book titled *X-Ray the City!* Ernst Fuchs – 'we changed the spelling', his widow Noemi Fooks told me: 'you can imagine how people pronounced it' – arrived in Melbourne as a refugee from Nazism in 1939. He was the first person in Australia to hold a doctorate in town planning, which he had obtained in Vienna with an investigation of linear cities. Fooks was one of the first lecturers in town planning at RMIT, although he ultimately ended up working as an architect (Townsend, 1998). Fooks wanted to place Australian town planning on an intellectually rigorous footing, and wrote the book to show how this might be done.

The central argument of *X-Ray the City!* is one that still needs to be made in the 21st century. Most reported measurements of urban density are calculated by dividing the population of a municipality or other administrative region by its gross area. 'It is of the utmost importance,' Fooks says, 'to stress the major defect of such figures: THE ARBITRARY NATURE OF URBAN BOUNDARIES' (Fooks, 1946, p. 43; capitalisation in original). Municipal and administrative boundaries rarely correspond to actual urbanised areas. Some cities (e.g. Brisbane) contain large areas of vacant land within their boundaries, while others (e.g. the City of Toronto) occupy only the inner part of the urbanised area. Therefore, more accurate density measures are needed: Fooks proposed a series of them, linked to form a 'density diagram' that could be used to 'X-Ray the city'.

Fooks provided examples to illustrate his main point: 'The artificial character of legal and administrative urban boundaries makes overall density figures meaningless. A study of the two accompanying tables makes this clear' (p. 48). The two tables show self-evidently absurd results, such as Vienna's density being lower than Melbourne's and about the same as Los Angeles', and Detroit having double the density of Zurich.

Interestingly, a decade later, the Technical Committee of the Auckland Regional Planning Authority took Fooks' tables, deleted cities like Vienna and Zurich that might have alerted readers to his real point, and presented the result as 'proof' that Auckland had the world's lowest urban density. This in turn 'proved' that government plans to upgrade the city's rail system should be scrapped and the funds diverted to an extensive motorway-building programme. The prophecy proved self-fulfilling, as Auckland's extensive motorway system and marginal public transport have made it one of the most auto-dependent cities in the world, a problem the city's road planners still attribute to a supposedly world-beating low density (Mees & Dodson, 2007; Mees, 2009, chapter 2).

Fooks' efforts to introduce rigour and consistency into Australasian discussions of density were unsuccessful. Nearly half a century after Fooks' book, Brian McLoughlin (1991) lamented the shallowness of local analysis, arguing that British town planners had established

rigorous definitions of density that could be used for comparative purposes, but were being ignored. McLoughlin would not have been impressed to read Melbourne 2030!

Defining density

The key point Fooks and McLoughlin make is that useful measures of density should be based on the area of urbanised land, not on arbitrary administrative boundaries. The whole urban area should be counted, not just that portion lying with the boundaries of a central municipality: urbanised New York extends far beyond the five boroughs of New York City, into Long Island and even the neighbouring states of Connecticut and New Jersey. Conversely, only urbanised land should be counted when measuring density, so measurements must exclude non-urban land that happens to lie within city boundaries.

Density can be examined in more detail by distinguishing between residential and non-residential land. Using McLoughlin's nomenclature, **Net residential density** is calculated by considering only the residential blocks on which houses are built. **Gross residential density** includes non-residential uses found within residential neighbourhoods, such as local schools and parks. **Overall urban density** includes all other urban uses, such as industrial areas, transport terminals and regional open space.

Different definitions of density will naturally produce different figures. So when comparing the densities of different cities, or parts of cities, it is important to use consistent definitions, count only urbanised land and count all the urbanised land. Most discussions of density by urban planners have failed this test. Countless discussions of metropolitan areas have compared 'densities' of inner and outer municipalities based on the whole area within municipal borders. Since outer municipalities often incorporate large areas of non-urban land, the result always appears to be a steep decline in density with distance from the centre. But this decline is likely to be exaggerated or even completely illusory: Max Neutze's careful analysis of Adelaide three decades ago found that the apparent decline in density was a statistical artefact, with residential densities actually highest on the urban fringe, and overall urban densities roughly constant throughout the metropolis (Neutze, 1981, p. 67).

Newman and Kenworthy expressly attempted to avoid problems of this kind in their multi-city comparison, by using a definition that corresponds to overall urban density in the above discussion. They were successful in most cases, but not all. In some cities, especially in Europe, land use data for complete urbanised areas proved difficult to obtain, and only the central municipality was studied. Because the central municipality is the most densely-populated part of the region, this means the density figures are overstated for all such cities. In the case of the 1999 *International Sourcebook*, this means Amsterdam, Brussels, Frankfurt, Hamburg, Munich, Stockholm and Vienna – the majority of the European cities shown on the famous hyperbola (Kenworthy et al, 1999, pp. 27-32: the 2001 *Database* does not specify how urban boundaries were defined).

A similar problem affected Newman and Kenworthy's 1989 and 1999 density data for Toronto, which as we have seen was confined to the City of Toronto. The resulting overstatement of density was magnified by the fact that the gross residential area was inadvertently used as the basis for calculating density, instead of the overall urban area. This can be seen clearly from the map of urbanised Toronto in the *International Sourcebook*, which shows Toronto and York Universities, two large cemeteries, the main racecourse and numerous parks as non-urban (Kenworthy et al, 1999, p. 375). These deficiencies were

corrected for the third edition of the dataset, the 2001 *Millennium Database*, resulting in a large decline in the density figure reported for Toronto, but nobody in Australia appears to have noticed.

Newman and Kenworthy had little difficulty specifying the densities of cities in the United States, because that country's Census Bureau has been calculating overall urban density figures for some time (see US Census Bureau, 2007, p. A-22). An 'urbanized area' is defined for each metropolitan region, made up by combining adjacent 'census blocks' (the smallest units for which data is collected) with more than 1000 residents per square mile, or 386 per square kilometre, regardless of how many municipal or even state boundaries are crossed. Less-dense census blocks that are surrounded by 'urban' blocks are also included. This generally contains most of the population of the equivalent 'metropolitan statistical area', which covers non-urban as well as urban land. The main exception is free-standing suburbs within the boundaries of the census area, which are counted as separate urbanized areas if sufficiently distant from the main area: for example, San Bernadino is counted separately from Los Angeles, just as Melton would be counted separately from Melbourne.

Newman and Kenworthy used the urbanized area density figures for US cities, but did not use their equivalents for Australian and Canadian cities, possibly because these were hard to locate until recently. Statistics Canada defines 'urban areas' on an almost identical basis to the United States, using a density threshold of 400 per square kilometre (Puderer, 2009, pp. 5-6). The Australian Bureau of Statistics does the same for 'urban centres', although with a threshold of 200 per square kilometre (ABS, 2006, chapter 6), which means that Australian urban densities will be slightly understated relative to the other two countries.

Each country's statistical agency also asks a question in the census about the method of travel to work, in a manner that enables the answers to be compared. While work trips only account for a minority of urban travel, they are the only kind for which this kind of consistent information is available across such a range of cities. Surveys of overall travel are usually conducted locally, in different years, and often with inconsistent methodologies.

Despite the limitations of this census data, it enables a more rigorous comparison of urban densities and transport patterns across the three countries than has been made previously – partly because not all the information was available at the time Newman and Kenworthy collected their data. The Canadian census has only included a question on the method of travel to work since 1996, while the land areas of Canadian urban areas were not published until the 2006 census (the Australian urban centre areas were released for earlier censuses up to 1991, but not released again until the 2006 census).

One difference with Newman and Kenworthy's methodology is made necessary by time and resource constraints. Newman and Kenworthy included all urban areas within the boundaries of the broader statistical regions in their density figures, for example including San Bernadino in Los Angeles and Melton in Melbourne. Because there are so many smaller urbanised areas, the following data is based on the central urban area only, which usually accounts for the great majority of the urban population. This difference makes the density figures for the US and Australia slightly higher than those of Newman and Kenworthy, but is unlikely to significantly affect the rankings of different urban areas.

The results are set out in Table 1, using figures from the most recent census in each country: 2006 in Australia and Canada, 2000 in the United States. Because there are so many

metropolitan areas in the USA, only the largest have been included. The urban areas have been arranged in order of overall urban density, from highest to lowest.

And the winner is…

The results are very different from what might have been expected. Far from being the archetype of sprawl, Los Angeles has the highest density of any urban area in the table, just edging out Toronto and San Francisco, and significantly higher than other Canadian and US cities. LA is considerably denser than all Australian cities, even allowing for the understatement of the Australian figures created by the differing definition of urban areas. By contrast, Portland, Oregon has less than half the density of the City of the Angels, with a lower figure than most Australian cities. And there are other surprises: Boston's density is much lower than Las Vegas or Phoenix, as is Brisbane's.

The US and Australian results are consistent with those reported by Newman and Kenworthy: all three editions of their data-set show Los Angeles having a higher density than any other city in the US or Australia. The big difference comes with the Canadian figures – which, it should be recalled, are compiled on a virtually identical basis to those for US cities. The problem here seems to have been that Newman and Kenworthy's Canadian city densities were calculated on a 'net residential', rather than 'overall urban' basis, as we saw above in the case of Toronto. This made the Canadian densities seem much higher than those in Australia and the United States, when in reality they are much the same.

One thing the results make clear is that high-rise city cores are not good predictors of overall urban densities. New York City does have a high urban density, but its 8 million residents are surrounded by 13 million suburbanites, many of whom live in very spacious surrounds. The City of Los Angeles is less dense than New York City, but its suburbs are considerably more dense than those of the Big Apple. In each case, the suburbs, which house the majority of the population, have the biggest impact on the overall result. Robert Brueggmann points out, in his book *Sprawl*, that the high suburban densities of West Coast US cities are partly due to their dependence on piped water, which prevents the very scattered, 'ex-urban' development found along much of the East Coast (Bruegmann, 2005, pp. 67-8).

Australian cities are more like Los Angeles than New York. Their central regions have lower densities than those of older North American cities, but their suburbs generally have higher densities, thanks to stronger regional land-use planning, which has restricted scattered fringe development. Brisbane, with a weaker tradition of regional planning, has a significantly lower density than any other large Australian urban area.

The densities of Australia, Canadian and US cities are more similar than has generally been believed, and bear little relationship with the amount of high-rise development in their centres. They also show little relationship with public transport use. Los Angeles is three times as dense as Brisbane, but public transport's share of work trips is only a third as high; New York's density is nearly a third lower than San Francisco's, but the mode share for public transport is more than twice as high. Portland, Oregon has a higher public transport mode share than Los Angeles despite its much lower density, but with only 6 per cent of workers using public transport, Portland is less successful than any Australian city.

The US cities, apart from New York, have the lowest rates of public transport use and the Canadians the highest, with Australia in-between. The same national patterns are apparent for

walking rates, which are generally highest where public transport use is highest. Smaller cities tend to have more walking than larger ones; they also tend to have lower densities. Cycling is of negligible importance across all three countries, but a similar pattern applies to that with walking: the Canadian figures are highest, despite the country's inclement weather.

Car usage rates are, naturally, the reverse of the other modes, lowest in Canadian cities and New York; highest in the United States. Again, density is a poor predictor of car usage rates: New York and Ottawa are the only cities where the figure is below 70 per cent, but do not have particularly high densities. When allowance is made for the understatement of Australian figures caused by the different methodology, Ottawa's density is about the same as Melbourne's.

Los Angeles' density of 27.3 persons per hectare is similar to the figure of 28.5 per hectare reported for Copenhagen in Kenworthy and Laube's *Millennium Database*, and higher than Oslo's reported density of 24.0 per hectare. Although comparisons should be made cautiously, as the European figures have been compiled differently, the gap between North America and Europe may not be as great as is generally believed. There is a larger distance in density between LA and the higher-density European cities in the *Sourcebook*, but it should be recalled that most of these figures are over-statements, as they cover only the central municipality not the entire urban area.

Like their North American counterparts, European central cities are surrounded by lower-density suburbs, as the European Environment Agency confirms in its 2006 report *Urban sprawl in Europe*. The same difficulties of regional government that prevented Newman and Kenworthy extracting region-wide density figures have also made it difficult to control land-use beyond central city boundaries. 'European cities have become much less compact' thanks to '[n]ew transport investment, in particular motorway construction'. The report cites Helsinki, Copenhagen and Brussels among its examples of 'sprawled' cities, while Munich, Milan and Bilbao are listed as compact (EEA, 2006, pp. 11, 18, 13). The proposed solutions are improved regional planning and governance, with greater Munich cited as a model. European cities might be grappling with the problem of urban sprawl, but this has not prevented many of them establishing effective, region-wide public transport systems that carry much higher shares of travel than in most US, Canadian and Australian cities (see Mees, 2009).

European cities have been less successful at controlling suburban sprawl than their counterparts across the English Channel, where green belts and strong national policies have worked against extremely low-density scattered growth. As a result, English urban areas probably have higher overall urban densities than most of their continental counterparts, despite having less dense city centres: the English cities are more like Los Angeles, while the Europeans are more like New York or Boston. But public transport in UK cities, except for London, is in serious decline, with mode share figures at the 2001 census similar to those of Australian cities and lower than Canadian cities, despite lower British incomes and car ownership rates (Mees, 2009).

Form or structure?

The mode shares for public transport and walking in US and Canadian cities correspond more closely to the share of economic activity in the Central Business District than they do to density. Urban *structure* appears more important than urban *form*, an argument made three

decades ago in J. Michael Thomson's *Great Cities and Their Traffic*. Thomson (1977, p. 274) suggests that densities as low as 12 people per hectare would be sufficient to support an unsubsidised rail service supported by feeder buses, provided the railway serves a strong centre with a significant share of the region's jobs and activity.

Although census data does not allow direct examination of this question (because census authorities have not adopted a common definition of the CBD), New York has by far the strongest centre of any US city, and this plays a major part in the high rate of public transport use there. Canadian cities have stronger centres than their US counterparts, thanks to historical differences including a greater propensity for the wealthy to reside in the inner city and the absence of a federally-funded urban freeway program.

But Australian cities have stronger CBDs and less extensive freeway networks than their Canadian counterparts, and their inner cities are even more comprehensively gentrified. And Vancouver, which is not the provincial capital and has an awkwardly-sited CBD, has a weaker centre than any other Canadian city, and even than many US cities. A detailed analysis of Canadian journey-to-work data suggests that workers employed in city centres use public transport at similar rates to their Australian counterparts; the biggest difference is the higher public transport usage rates of workers employed in non-central locations (Statistics Canada, 2005, table 3.5).

The fact that mode shares for CBD workers are similar in Australia and Canada, while mode share for suburban workers is different, suggests that some factor other than inner-city population or job density must be at work. This provides further support for the suggestion that transport policy, rather than urban structure or form, is the main factor driving the different outcomes.

Urban structure is important, but it is not an insuperable barrier to change.

Conclusions: the good news

All other things being equal, density does have an impact on transport patterns. But all other things are definitely not equal, and the effect of density is outweighed by other factors unless the differences in density are huge. This suggests both good and bad news.

The bad news is that the compact city is unlikely to solve the problem of automobile dependence, as the increases in density required to significantly change transport patterns on a metropolitan scale are impossible to achieve. 'Smart growth' policies might, after many decades, make Melbourne as dense as Los Angeles is now, Canberra as dense as Las Vegas, or Brisbane as dense as Adelaide, but it is hard to see this producing big shifts away from the car. As the British Royal Commission on Environmental Pollution concluded in its exhaustive 1994 transport inquiry, 'there is no single pattern of land uses that will reduce the need for travel and so reduce the effects of transport on the environment.' (RCEP, 1994, p. 151)

This is not to argue that unplanned urban sprawl should continue to devour farms and forests. Most participants in the compact city debate are opposed to sprawl in the original sense of 'ribbon' development along roads or 'leapfrogging' of housing estates, producing an environment that is 'neither town nor country'. Vigorous critics of the compact city, such as Hugh Stretton and Patrick Troy, are equally critical of unregulated fringe development. Similarly, urbanists on both sides of the debate support clustering suburban activities into

sub-centres instead of allowing them to spread randomly across the landscape. And since there is a demand for higher-density housing, it makes sense to locate it in these centres, or in other places well-served by public transport. Measures of this kind have a range of environmental advantages, including making it easier to provide effective public transport.

The good news is that we don't need impossible increases in density to provide viable alternatives to the car. The relative attractiveness of competing urban transport modes seems to influence mode choice much more than differences in density, and the notion that 400 or even 30 residents per hectare is a minimum density below which public transport cannot be provided is unsupported by evidence. It even looks as if greater usage of public transport might go hand-in-hand with higher levels of walking, which would be excellent news for the environment.

The necessary changes to transport policy are beyond the scope of this paper, but are discussed in Mees (2009). Transport policy can be changed more quickly and cheaply, and with less disruption, than city density, so it might even be possible to make the necessary changes in time to save the planet.

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