

5th Healthy Cities: Working Together to Achieve Liveable Cities

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Table of Contents

Authors	Title	Page
Andrews, F, Henderson-Wilson, C & Townsend, M	Parenting and place: pilot study exploring experiences of women from inner and outer Melbourne suburbs	1
Bajracharya B. & Too L.	Planning and design of master-planned communities for healthy living	12
Christian, H	Building healthy communities: Creating supportive environments to encourage dog walking	26
Cooper, R	Green infrastructure thinking – a lifeline and values system for ‘liveable’ cities	45
Matan, A et al.	Review of Public Health and Productivity benefits from different urban transport and related land use options in Australia	65
Meikle, H	Urban Ecology and the Future of Cities	86
Nichols, D	Reinvigorating 20 th century residential pocket parks for the 21 st century	108
Peerson, A., Leao, S & Elkadi, H	Effects of exposure of traffic noise on health	125
Turner, B & Henryks, J	Cultivation, Consumption and Connection: How to make the most of local food	145
Wang, Y	Cities built on steeply sloped areas in Japan	162
Webb, M	Developing biomimicry in the built environment	174

Parenting and place: pilot study exploring experiences of women from inner and outer Melbourne suburbs

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Abstract

This pilot study explored the views of women from inner-city and outer suburban municipalities on their residential location as a place in which to raise children. Thematic analysis of interviews revealed that, irrespective of location, women had not chosen to reside in their municipality on the basis of child-rearing. However there were key differences between their experiences of raising their children in the two municipalities in relation to the social connections they both expected, and encountered in their local communities, as well as their attitudes towards transport, open space and safety. Findings will help inform the design of a larger scale study comparing families' experiences of raising children in a changing urban environment.

Keywords: parenting, perception, residential location, neighbourhood, social connectedness, qualitative.

Introduction

Choosing where to live is a major life decision, with previous studies showing children are an important consideration in this process (Kim et al., 2005, Green 2009, Andrews, 2010). Historically some neighbourhoods have been perceived to be more appropriate for raising children than others (Mee, 2010), with suburbia portrayed as 'a good place to raise a family' (Cunningham & Jones, 1994 p84), and inner-city areas described as places that 'deprive children of healthy development' (van Vliet, 1981, p459). Recently, this has been challenged both by research suggesting conventional life-course models of housing choices may no longer be appropriate in Australia (Fincher, 2007), and by government policy designed to intensify development in existing inner-city suburbs (Victorian Government, 2008). Whilst residential location can have an impact on child health and development (Brooks-Gunn et al., 1993, Curtis et al., 2004, Edwards, 2005, Sellstrom & Bremberg, 2006), little is known of how Australian parents in inner-city locations experience raising their children compared with those in suburbia. As parents of young children in particular, are the intermediaries between their children and place, it is important to understand these perceptions in order to build healthy communities for families. Hence this was the aim of the current study. Urban intensification is a relatively new phenomenon in Australia, thus this research was undertaken as an exploratory, qualitative descriptive pilot study to identify themes on which to base more extensive targeted research.

Methods

Methods were similar to those employed in a previous study (Andrews, 2010). Participants were recruited from playgroups in one inner-city and one outer suburban municipality with similar middle-class socioeconomic profiles and the same proportion of preschool-aged children residing in the municipality (ABS, 2006). The inner municipality was located 10km or less, and the outer municipality 30km or more, from the Melbourne CBD. Participants were eligible if they had resided at their current address for twelve months or more, had at least one pre-school-aged child (as young children can increase the need for neighbourhood support and services (Witten et al., 2009) and had a disposable income in the median range (between the 30th- 80th percentiles [Hamilton et al., 2007]) so as to focus on families who can exert some choice, within limitations, on their residential location.

Participants were interviewed using a guide consisting of open-ended questions. These included: questions about choice of residential location and ideals, experiences of neighbourhood (e.g. services, transport and open space), and neighbours. All interview material was recorded and transcribed. Data were analysed using a qualitative descriptive approach (Sandelowski 2000) involving data immersion, coding, development of themes (Cohen et al., 2000, Creswell, 2009) and identifying exemplary statements (Cohen et al. 2000). This project was approved by the Deakin University Human Ethics Committee.

Findings and discussion

Ten women participated: five from the inner, and five from the outer municipalities. Four of the inner-city, and all of the outer suburban women, were married. One woman was a full-time student; the remainder were employed part-time or were at home full-time. All the women were born in Australia. All the women had one or two children aged five years or under living with them, living in a house (as opposed to an apartment), with only one woman (inner-city) renting her home.

Three main themes were identified from the interview data: children and residential location, social connectedness and attitudes to facilities and services. Pseudonyms have been used in this paper to protect anonymity.

Children and residential location

Unlike traditional models of housing choices where middle-income families in the child-rearing stage of the life-cycle tended to move out towards the suburbs for ownership of a relatively new home (Short, 1978, Forster, 2004), none of the women in this study had chosen to reside in their municipality as a result of child-rearing.

All the women in the inner-city had resided in the area prior to having children because of proximity to work or study. For example Helen said:

"I actually moved here about 15 years ago as a student wanting to be close to the city because it was handy for university and things like that. So I guess through that and living in share houses where I got to know the area ... well I guess I just liked the area and had become familiar with it. So I guess it was less a direct choice about my family needs, than my decision as a single person to live here."

However, whilst child-rearing did not initiate relocation amongst these women, experiences of place were not static, with Helen explaining:

"It's the experience of sort of 'discovering' where I have been living for the last ten years. And all over again, because I suddenly had different needs."

Thus child-rearing was associated with a redefining of existing places rather than searching for new places to accommodate this stage of the life-cycle.

For women from the outer Melbourne municipality, growing up or having a spouse grow up in the area was their key reason for choice of residential location. Zoe explained:

"I come from the country; when I met my husband he lived in this area so I naturally assumed this was the better side of town. So I'm happy here, it has a very country feel, it feels like home."

These families did not move into the outer-suburban area at the pre-child or child-bearing stages as predicted by the life-cycle model (Short, 1978, Forster, 2004) demonstrating that not all outer suburbs are 'new' suburbs but may also now be home to several generations of a family.

Social connectedness

The extent to which parents feel connected to their neighbourhoods has been shown to influence child health and development outcomes (Leventhal & Brooks-Gunn, 2000, Xue et al., 2005, Edwards & Bromfield, 2009). A key difference between the experiences of women raising their children in the two municipalities was of the social connections they both expected and encountered in their local communities.

Women from the inner-city expected strong social connections in their immediate neighbourhood. This was evident when asked about what makes a healthy place in which to raise children, where all inner-city women spoke of having good neighbours as their top priority.

Helen summed this up saying:

"I guess it's what sort of connections you make with your community really...if it felt like an unfriendly neighbourhood that would be something that would make you move pretty quick."

These inner-city women also spoke at length about positive experiences of their neighbours in supporting them to raise their children. These were not restricted to people their own age or class backgrounds. Deb highlighted this, saying:

"There is one family in particular that lives two doors down from me ...They have five children. Lily is part of their family ... if I ever need someone to quickly look after her it's no problem, she just goes down there and she loves it, you know, she's number six child!... And in the houses directly across the street, one older lady, every time she cooks, she always cooks more and brings it over for Lily and me. So they all like helping me out. Not that I need any help that way, but it's lovely that someone does that for you."

In contrast, women from the outer municipality had not experienced support from their immediate neighbours in raising their children. For example Michaela said:

"Forty of fifty years ago it used to be that you played with the kids next door but I've got no-one to let the kids go and play and leave them with."

Women particularly commented on the diversity of neighbours' ages being a negative aspect of their immediate neighbourhoods. With Michaela going on to say:

"All the kids are older or have moved on, and there are just grumpy old people."

However, women in the outer municipality were not socially-unconnected, with several women describing the support they received from friends outside their immediate local neighbourhood, or how being part of organised groups helped them in raising their children. Zoe in recognising her lack of support from her immediate neighbours said:

"I guess that is why it's really handy; the health centre getting mothers' groups together, it's a real support."

Williams et al., (2007) in their work comparing perceptions of traditional and master-planned communities described how more established suburbs were associated with stable long-lived communities with older people more likely to know each other, encounter diverse neighbours and offer deeper forms of social support. Whilst the differences in the current study could be explained by these differences in 'historical sediment' (Williams et al., 2007) this is not the only explanation. The women in the

current study did not reside in new master-planned communities referred to in the work by Williams and colleagues. In addition, when originally asked about their ideals for a healthy place in which to raise a family, unlike women from the inner-city, women from the outer municipality did not identify relationships with neighbours as an ideal, instead citing safety, having a backyard and good access to shops as their priorities. This may reflect their negative experiences of neighbours described above; however, it may also reflect an intrinsic difference in values around the concept of neighbourhood between the women in the two locations. This latter explanation is also supported by women's experiences of facilities and services in their communities described below.

Attitudes towards services and facilities

All the women in this study spoke of the importance of having access to good quality services and facilities in their local neighbourhoods in helping them to raise their children. In the case of health care services and child care, women from both municipalities had similar experiences; however, there were some distinct differences in their experiences of transport and open space.

All the women in the inner-city spoke of using a wide range of forms of transport with their children. For example, when asked about accessing local services with her children Lisa said:

"Oh yeah we walk and we take the children and go on our bikes."

Whilst Alice, who had no access to a car during the day, talked not only of public transport as a means of getting around with her son, but also emphasised the importance of the social aspects of this mode of transport:

"He really enjoys it...Lots of things to see and people to talk to."

In contrast, whilst women from the outer-suburban municipality acknowledged their suburbs were served by train and bus services, all said they rarely used them. The main reason for not using public transport was the perceived convenience of travelling by car, rather than limited public transport. For example Sue said of using public transport:

"It's a fun thing. We have to think about it a day or two in advance, that maybe we'll take the bus or train just to the park. It's a sort of play thing. It's not a necessity."

Previous studies on public transport usage by families in outer suburban areas has focussed on the difficulties in accessing services as a barrier to usage however, the current findings support the need to also consider the social theory of travel behaviour (Baslington 2008) in future studies on public transport usage by families.

Different attitudes between inner and outer suburban women were also seen with regards to playgrounds and parks. Whilst quality open space was seen as a key aspect of a healthy place for raising children by all women, and women were generally satisfied with the amount of parks/playgrounds, inner-city women explained that this was less about the facilities within these places, and more about the social connections they offered. For example, Alice said:

“There are always people about... if you sat down at any time, there’s people there. It’s very friendly. Some of the playground equipment is a bit old... but I don’t think it really matters, ‘cos kids do other stuff really.”

Deb went on to highlight how the sense of community ownership and responsibility for her local park made it a valuable asset for families:

“Everyone takes ownership for it, so you know we’re all down there, no one litters, if your dogs are down there everyone has a dog-poo bag and we all look after it because we all use it. It’s a very popular area.”

Women from the outer municipality did not share inner-city women’s experiences of open space as a place of social connectedness. Instead, their experiences revolved around the facilities in the open spaces. In talking about her local park, Rachel said:

It’s a swing and a slide and that’s it. We’d probably use it more if it was bigger and had more grass and was a bit more attractive.”

Unlike inner-city women, outer suburban women did not experience a sense of community ownership of open spaces, with several women voicing concerns about the safety of their local parks. Drug use and discarded syringes were particularly concerning. Sue said of a local park:

“I won’t let Joe go in the sandpit. I don’t like the sandpit at all... there’s all sorts of stuff in it. The park has video-surveillance but I don’t know how maintained that is or whether it’s on.”

Zoe spoke more generally, highlighting how her views on neighbourhood social connectedness and safety influenced her parenting practices:

“In today’s society it’s become so protective you just don’t venture outside your front door without thinking twice. Everyone’s got play things in their backyards, no-one plays in the street like they used to.”

These findings are supported by the work of Veitch et al (2006) who reported that parental concerns about safety was the most frequently reported factor influencing where children played across a range of Melbourne suburbs.

Women from the inner-city had the opposite experience of safety. Deb from the inner-city summed up her neighbourhood highlighting the links between social connectedness and safety:

“It’s great, it’s safe – I feel safe and I’m sure my daughter does ‘cos she knows the kids in the street and all around the block. They’ve all grown up together. They’re all safe because they all know everyone. It’s like a little community.”

In summary, findings in relation to social connectedness and attitudes to services/facilities not only challenge some of the negative stereotypical views on raising children in the inner-city, but also raise the possibility of women in different locations having different ideals (as well as experiences) of neighbourhood and social connectedness. Further research is required to explore how these differences arise.

Conclusion

Australian cities are undergoing a period of urban intensification as the population grows but land is in limited supply, which is challenging accepted approaches to housing families. This exploratory study provided a comparison of the experiences of women raising children in a more traditional family-orientated outer municipality, with women's experiences of raising children in an inner-city location. Whilst this is a small, pilot study carried out at one point in time and is not generalisable to the wider population, it identifies alternative experiences to the life-cycle model of resident location. It also identifies differences in the ways women expected and experienced social connectedness in their communities, and their differences in attitudes towards transport, open space and safety. These provide an important starting point to build larger, longitudinal studies to explore the relationship between parenting and place in these different communities. Fincher (2007) argues that planning in inner-Melbourne is largely developer-driven and often not inclusive of families with children. Research that incorporates parents' perspectives of their residential location could assist in the development of much-needed policy aimed at designing communities to meet the differing aspirations of families, and foster a healthy environment in which to raise children.

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Planning and design of master-planned communities for healthy living

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Abstract

Due to growing health concerns linked to inactive living, a number of new master-planned communities in South East Queensland are creating supportive environments for physical activities. Varsity Lakes in Gold Coast is an example of such community which provides both infrastructures and programs to encourage active living. The objective of the paper is to examine the relationship between built environment and healthy communities through a review of current literature. Synthesising these findings, a conceptual framework is developed for supporting active and healthy living in master-planned communities. The three key factors are 1) place; 2) program and 3) partnership. This framework is then applied to Varsity Lakes as a case study area for validation. The paper will also identify key challenges and opportunities Varsity Lakes face in its role in promoting active and healthy living and draw implications for the planning of future master-planned communities.

Keywords: Active, Healthy Living, Place, Program, Partnership

Introduction

With increasing demand for housing in large metropolitan regions, private developers are building new master-planned communities in the fringe of the cities. Unlike conventional housing subdivisions, master-planned communities are large scale integrated housing developments with provision of diversity of housing, shopping, open spaces and recreation facilities (McGuirk and Dowling, 2007; Minnery and Bajracharya, 1997; Schmitz and Bookout, 1998). The developers provide a range of community facilities such as parks, walking trails to attract residents to the community. The developers also create opportunities for social interaction through organised activities and programs for special groups such as parents of young children, young children and the elderly.

While master-planned developments are gaining popularity, there is also an increasing focus on promoting healthy and active communities by both academic and government institutions. During the mid-eighties, Drs Len Duhl and Trevor Hancock first inspired the “Healthy Communities Movement” through the World Health Organization’s initiative on Healthy Cities. Since then, private property developers have also caught on to this and created master-planned townships that incorporated promoting healthy and active living as a design objective. As such, the objective of the paper is to examine the emerging role of master-planned communities in promoting active and healthy living. To do this, the paper will first review the literature on the relationship between built environment and healthy communities in order to develop a conceptual framework for analysis. The next

section then introduces Varsity Lakes master-planned community and its role in promoting active and healthy living based on three critical themes: 1) provision of supportive built environment and infrastructure (place factor); 2) development of recreational programs (program factor); and 3) governance structures (partnership factor). Following this, the paper will analyse the case study to identify some of the key challenges Varsity Lakes face and draw lessons for future master-planned communities.

Link Between Built Environment and Healthy Communities

There is a growing body of literature which examines the links between built environment and health (e.g., Frank *et al.*, 2003; Frank. *et. al.*, 2006; Sallis, Millstein and Carlson, 2011; Giles-Corti and Donovan 2003). Frank *et. al.* (2003) argued that the design of built environment can play an important role on physical activities by exacerbating or mitigating physical and mental well-being outcomes among people. In another study, Frank *et. al.* (2006) found that single use, low density developments with disconnected street networks can result in reduced walking and transit use which in turn adversely affect health by limiting physical activity. According to Sallis *et al.* (2011), built environment attributes such as mixed land use, street connectivity, residential density, pedestrian infrastructure, aesthetics and access to recreational facilities can enhance physical activity in a community. The design of built environment can also contribute to social capital by providing opportunities for social interaction and use of shared spaces which in turn can have positive effect on health (Eicher and Kawachi, 2011). Similarly, Giles-Corti and Donovan (1982) opined that there needs to be supportive social and physical environment for walking (such as provision of attractive open spaces) as well as strategies to influence and encourage individuals to walk in small groups.

In Australia, various levels of government have taken the initiative to provide guidelines for developing supportive environments for physical activity and healthy eating (e.g., Heart Foundation, 2009; Queensland Government and Heart Foundation, 2010). NSW Premier's Council for Active Living has also identified five principles for active living (Lette and Wiggins, 2010). They are: walkability and connectivity, active travel alternatives, legibility, quality public domain, and social interaction and inclusion. Similarly, professional institutions such as The Planning Institute of Australia's *Healthy Places and Spaces* has released a national guide identifying ten principles for designing the built environment for healthy living. These include active transport, aesthetics, connectivity, environment for all people, mixed density, mixed land use, parks and open spaces, safety and surveillance, and social inclusion (Planning Institute of Australia, 2009).

While the above elements represent space characteristics, the principle of social interaction and inclusion is the *raison d'etre* for those spaces given that we are all social being to varying extent. To achieve social interaction and inclusion,

recreational facilities and infrastructure are insufficient to encourage active usage; programs and organised group initiatives are equally important (Carlson, 2011). The NSW Premier's Council for Active Living report suggested a socio-ecological approach to health and this includes educational programs to promote healthy lifestyles. The educational campaigns focus on increasing the individual's knowledge so that they can make choices to live an active lifestyle by encouraging attitudes and skills which can be applied to local opportunities for sport and recreation.

In addition to the importance of spatial characteristics and organised programs to promote healthy living, it has also been widely acknowledged that an integrated approach is necessary to build active and healthy communities (e.g., Srinivasan et al., 2003). Researchers have argued that a collaborative approach is necessary for building healthy and sustainable communities. Srinivasan et al. (2003) noted that *"creating communities that are conscious of environmental health concerns require partnerships and collaborations among policy makers, governments, researchers, communities, and health specialists with interdisciplinary perspectives"*. Others have highlighted the importance of community participation and partnerships in promoting active and healthy living (Mitchell and Shortell, 2000; Minkler, 2000).

From the broad review of literature above, three key themes emerge as most relevant to promoting active and healthy lifestyles within communities. These are:

- 1) Provision of supportive built environment and infrastructure, i.e., Place factor
- 2) Initiatives for social interaction and inclusion, i.e., Program factor
- 3) Governance and management, i.e., Partnership factor

In the following section we use these three key themes to serve as a framework to evaluate Varsity Lakes' role in promoting active and healthy living within its community.

A Case Study of Varsity Lakes

Varsity Lakes is one of the major master-planned communities in South East Queensland (other major communities in SEQ include North Lakes, Greater Springfield, Forest Lake – see Figure 1). It is located in Gold Coast and is in proximity to Bond University, golf courses, beaches, shopping centres, and a number of canal residential estates. Varsity Lakes has a diverse population mix including empty nesters, professional couples, mature-age-groups, students, and families due to its variety in built form and provision of business parks and amenities. Started in 2002 by developer Delfin Lend Lease, it covers an area of 343 hectares and contains a range of residential, mixed use, community and business land uses, focused along the foreshore of Lake Orr and a range of open space areas (Delfin Lend Lease, 2010).



Figure 1: Location of Varsity Lakes in South East Queensland

Varsity Lakes has a current population of close to 9,000 residents and comprises a number recreational facilities including the 80-hectare Lake Orr, 56 hectares dedicated to open space, 20 kilometres of walking and bike trails, and is located close to the 18-hole championship Robina Woods Golf Course (Delfin Lend Lease, 2010).

The paper will use the following integrated framework to analyse Varsity Lakes in terms of its active living facilities (place), initiatives (program), and governance structure (partnership) in promoting a healthy community (Figure 2).

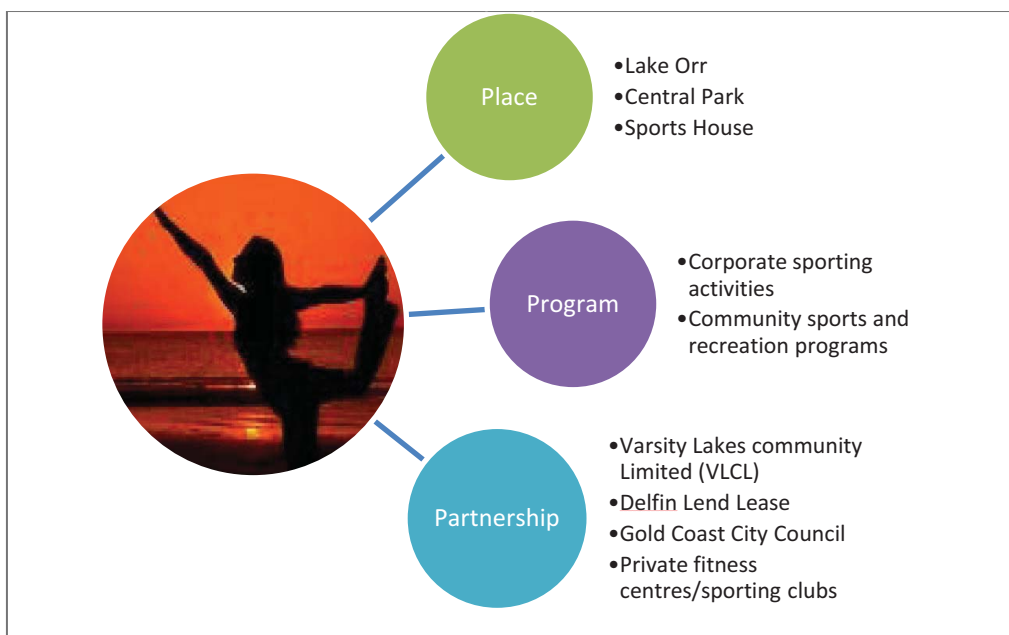


Figure 2: Framework for Active Living in Varsity Lakes

Place Factor

There are three key public spaces in Varsity Lakes which are designed to promote active and healthy living. They are Lake Orr, Central Park, and Sports House (see Figure 3).

Lake Orr is one of the major landmarks in the area providing residents of Varsity Lakes and its surrounding areas the opportunity to participate in on-water activities. It is said that in excess of 10,000 people currently use Lake Orr on an annual basis for various events such as regattas and events. More specifically, the lake is currently used by Varsity College for its sailing and rowing programs. Lake Orr is an important public realm for walking and informal recreational activities that has been designed to include a public boardwalk around its perimeter

The second important public space for active and healthy living is the central oval (Central Park). The park provides a venue for a number of important events such as the annual Gold Coast Pet and Animal Expo, Christmas Carols, and school fetes. This is also an important venue for formal sports and recreation activities such as basketball, netball, cricket, as well as for events associated with Varsity College which uses the park for its school sporting activities. Varsity Lakes Sports and Arts Centre adjoins Central Park to complement the park's activities.

The third key facility is the recently completed Sports House fronting the Lake Orr, which acts as the sport and recreation hub for Varsity Lakes and its surrounding areas. It has community meeting spaces, watercraft storage and training areas, as well as fitness and recreation programs. It also has office space for community and sports-based businesses. There is a focus on water-based activities enabling community groups and clubs to easily access the 80 hectares of Lake Orr, along with its 12km of paddling routes. The venue provides a launch point for canoeing, kayaking, sailing, dragon boating and recreational crafting.

Besides these three major public spaces, there is also private provision of health and fitness facilities within the apartment complexes for exclusive use of the residents. Some of them include swimming pools and gyms within these developments.

	
Lake Orr in the foreground is a key open space for active living in Varsity lakes	Public walkway around Lake Orr is popular walking area for residents
	
Central Park has sporting facilities such as basket ball courts, ovals for use by local people	Sports House supports many water based sporting activities such as rowing, sailing, kayaking

Figure 3: Key places and amenities for active living in Varsity Lake are Lake Orr (and walkways around it), Central Park and Sports House

b) Program Factor

Varsity Lakes has a number of events, services and programs organised by community, council and private corporations in relation to health and wellbeing. Events include sporting activities such as kayaking, sailing as well as recreational activities such as art, cooking, self-defence and fishing classes. Other activities are movie nights, Christmas carols in the park and seasonal festivals. The Sports House runs Karate classes as well as water sports activities for the community.

Informal special interest groups such as walking groups, running groups and stroller groups have also emerged in Varsity Lakes. Many of the sports and recreational programs are run in partnership with local private businesses as well as public sector such as Gold Coast City Council's *active and healthy program*. Public spaces have been used for many events and programs for example, *Varsity Lakeside run fun* was recently organised around the lake with fitness testing, treasure hunts and face-painting. Involvement of local music identities was sought to support the event.

An *on-line community portal* (Varsity Lakes on-line) was established by the developer and managed by the community to provide up-to-date information on community events and community groups among other things. The use of public spaces for community events provide opportunities for social interaction among different groups within the master-planned community and neighbouring areas thus strengthening the social capital of Varsity Lakes.

c) Partnership Factor

A community organisation, Varsity Lakes Community Limited (VLCL) currently plays an important role in promoting active and healthy living in the area. It was set up as a not-for-profit company by Delfin Lendlease in 2005 to take over management and governance functions once the developer leaves the community, marking the transition from a private to community governance of the master-planned community. Some of the objectives of this company are: 1) to provide vision and leadership; 2) to identify and develop community, business and innovation opportunities; 3) to co-ordinate and develop relationships; 4) to play active role in promotion and advocacy; 5) to provide governance and resources ; and 6) to provide a central point of contact for community matters”¹

The company is a membership based organisation with a volunteer Board of Directors representing key membership categories of residential, commercial, community groups and education (Bajracharya and Khan 2010). VLCL assumes the role of the owner and manager of community facilities such as the Sports House. It is designed to act as a peak body representing the major groups, serving as the overarching custodian to provide direction and support to groups.

Sports House is a joint venture between Delfin Lend Lease, Gold Coast City Council and Varsity Lakes Community Limited (VLCL). It is owned by Gold Coast City Council and managed by VLCL. For funding Sports House, VLCL sought to raise \$300,000 to build this community meeting and craft storage facility. To assist in achieving this fundraising target, VLCL registered the Sports House project with the Australian Sports Foundation Ltd (ASF). The fact that Sports House is managed by Varsity Lakes Community Limited ensures that it will be run by the community and for the community (Sports House at Varsity Lakes, undated).

¹ Quoted from <http://www.varsitylakesonline.com.au/Varsity-Lakes-Community-Limited/default.aspx>

There is also a number of fitness centres and sporting clubs providing support for active living in Varsity Lakes. Some of them work closely with the local council and VLCL to organise health and fitness related events in the area. One example is the annual Children and Health Expo which is held in the Central Park in collaboration with range of public, private and community stakeholders (Figure 4).



Figure 4: Collaboration between the Council, community and private sector is the key to promoting active and healthy living

Lastly, Varsity Lakes is one of the few master-planned communities where a full time recreational officer has been employed to promote active and healthy programs.

CASE ANALYSIS: CHALLENGES/OPPORTUNITIES

Varsity Lakes is an example of a master-planned community, which has taken important steps in developing an active and healthy community in terms of place, program and partnership factors. The following discussion will evaluate the effectiveness of Varsity Lakes based on these three factors in developing an active and healthy community.

Place Performance

Public open spaces such as Lake Orr and Central Park as well as the Sports House building are some of the key *places* used for active and healthy programs. The Boardwalk around Lake Orr is a major asset of the Varsity Lakes in terms of

promoting walkability in the area. However, certain sections of the boardwalk are not open to public and are restricted to private users of the apartment complex fronting boardwalk (Figure 5). These restrictions on public access to lake can constrain active and healthy living in the community.



Figure 5: Cordoning off part of boardwalk for private use limits public access for walkability around Lake Orr

There is also potential for improving the walkways and bikeways in the Varsity Lakes to promote active transport. Pedestrian walkways can be made safer by minimising pedestrian/vehicle conflict in some parts of Varsity Lakes (such as near Market Square). To make parks and walkways more conducive to outdoor physical activities, greater considerations need to be given to issues such as safety, shade and visual amenities.

Low density housing in the outskirts of Varsity Lakes is not well connected with the Market Square which is the major hub for shops, restaurants and offices in terms of active transport such as walking, cycling and public transport. While there has been an attempt to mix densities and land uses within Varsity Lakes through mixed use developments and Small Offices/Home Offices (SOHO) around Market Square, more research need to be conducted to examine whether they have been able to promote active transport and healthy living.

There is also an opportunity to improve linkages with activity centres outside Varsity Lakes to enhance accessibility and promote greater physical activity. By linking Varsity Lakes to parks and open spaces across the city as well as to beaches and foreshore pedestrian and cycle networks, there is potential to use council-wide active and healthy programs and amenities.

In essence, Varsity Lakes has in general performed well in terms of the physical place factor in promoting active and healthy living. Apart from public open space, it also has purpose-built and designed facilities such as the Sports House, bikeways

and mixed-use developments that adhere to the urban design and planning principles prescribed in the current literature. However, physical infrastructure alone does not ensure active usage of these amenities. The PIA guidelines suggest that connectivity and attention to ensuring the safety of these public spaces are needed to encourage their utilisation.

Program Performance

Extant literature has indicated that the provision of physical spaces and places alone do not make people active. Within Varsity Lakes, there have been concerted efforts to develop a number of sports and recreational programs within the community thus highlighting the importance of *program* factor. However, there are also some potential issues with the active living initiatives in Varsity Lakes. For example, there seems to be a narrow focus on water-based sporting activities alone in Sports House. Further study is needed to identify to what extent the sports and recreation activities reach the wider community group who do not necessarily have an interest in water-based sports. There is potential for providing non-water based sporting activities to cater to the needs of the wider community.

Although PIA's national guide in promoting healthy space and places suggests the need to provide an environment for all people, Varsity Lakes' sports and recreation activities seem to have a stronger focus on able-bodied people. In this regard, developing programs for greater social inclusion and interaction is an area for improvement within Varsity Lakes. Perhaps, a promotion of beginners programs to equip the less adventurous and physically-abled with basic skills is a good way to reaching out to the group who are less inclined to water sports.

Partnership Performance

Lastly, the establishment of Varsity Lakes Community Limited (VLCL) to manage the Sports House and other active living initiatives is an example of partnership factor at work to promote active living. The shared approach between VLCL, council and private sector to organise events and programs demonstrates the importance of collaboration and engagement for the programs to become more viable and participatory. The employment of a full time recreational officer to develop and promote active and healthy programs in Varsity Lakes further demonstrates VLCL's commitment to active and healthy living.

In this regard, Varsity Lakes has been effective in ensuring a collaborative approach (Srinivasan et al., 2003) in building healthy and sustainable communities. However, funding and its allocation is a key consideration in ensuring a sustainable and viable partnership structure. VLCL is at its initial stage in terms of standing on its own feet to run programs and activities to enhance the social capital as well as to promote active and healthy living in the community. With limited resources, it has to develop partnership with other stakeholders, both public and private, to fund programs, engage with the community while remaining viable and sustainable as an entity.

Conclusion

Ageing population and obesity in the developed world has become the twin engine fuelling research interests in healthy and active living. As such, this paper has examined the relationship between master-planned community and healthy living. To do this, a conceptual framework focussing on place, programs and partnership has been developed and applied to Varsity Lakes as a case study. The analysis has demonstrated the relevance and applicability of the conceptual framework developed and identified the challenges and opportunities for Varsity Lakes in promoting healthy living within her community. To this end, this study has laid the foundation upon which future research can be based to refine the framework and test its robustness by applying it to other master-planned communities.

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**Building healthy communities:
Creating supportive environments to encourage dog walking**

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**Building healthy communities: Creating supportive environments to
encourage dog walking**

Abstract

Almost 40% of Australian households own a dog. A growing body of evidence suggests that dog owners experience improved physical, mental and emotional health compared with non-owners. Dog owners improved health status may in part be explained by the increased walking facilitated by dog ownership.

A number of urban factors are important for supporting owners to walk with their dog. Access to a local park with dog supportive features such as dog litter bags and bins, is associated with regularly walking with a dog. Dog owners are attracted to attributes of parks that are equally valued by other park users. This highlights the need for public open space planning to accommodate different community and user groups.

Planners, developers and government may not perceive that they have an important role in creating supportive environments for dog walking, however, such initiatives are likely to result in a number of broad community benefits.

Keywords: dog, physical activity, policy environment, public open space

Introduction

This paper examines how the health status of communities can be improved through encouraging and supporting people to be physically active with their dog. The paper begins with an overview of why physical activity is an important ingredient in healthy communities and then summarises the research to date on the relationship between dog ownership and physical activity. The paper outlines dog-owner and physical and policy environment barriers and motivators to owners walking with their dog. The paper then introduces intervention research trialling different strategies for increasing community levels of dog walking and concludes with the importance and features of supportive physical and policy environments for dog walking.

Overall, this paper aims to:

1. Confirm the importance of physical activity as an important feature of healthy communities
2. Overview the evidence of the benefits of dog ownership and dog walking to levels of physical activity
3. Review the barriers and motivators for people walking with their dog
4. Introduce intervention research aimed at identifying strategies for increasing community levels of dog walking
5. Outline the importance of supportive physical and policy environments for physical activity and dog walking and identify key features of these environments

Physical activity is an important public health issue

In the Western world, physical activity is on the decline and sedentary lifestyles are becoming more common (World Health Organization 2004). Physical inactivity is a major lifestyle risk factor for chronic diseases such as heart disease, stroke, type II diabetes, depression and some cancers (Bauman 2004, Blair et al. 1989, Brown et al. 2005, US Department of Health and Human Services 1996). Moreover, physical inactivity is second only to tobacco smoking as leading risk factor for the burden of disease and disability from all causes in Australia (Mathers et al. 1999).

In Australia alone, at least 2.5 million people are classified as obese (1 in 4 male and 1 in 5 female adults), with another 4.9 million overweight (Australian Institute of Health and Welfare 2011b). Importantly, over 70% (69% of males and 76% of females) do not get enough physical activity to incur health benefit (Australian Institute of Health and Welfare 2011a). The current Australian national recommendations for physical activity are 30 minutes per day of light-moderate physical activity on five or more days of the week (150mins/week) or 60 minutes of vigorous intensity physical activity per week (Commonwealth Department of Health and Aged Care 1999).

The well established association between physical inactivity and chronic disease combined, with the high prevalence of physical inactivity, highlights the need for new and better methods to increase population levels of physical activity. One strategy

that has not received serious attention but which lies right at our feet is the physical activity facilitated by owning a dog.

Physical activity and dog ownership

Sixty three percent of Australian households own a pet, with 38% owning a dog (BIS Shrapnel Pty Limited & Australian Companion Animal Council 2006). A wealth of studies investigating the value of pet ownership have demonstrated the accompanying psychological, physical and emotional health benefits (Jennings 1997, McNicholas et al. 2005, Virues-Ortega & Buela-Casal 2006, Wells 2007, Wood & Giles-Corti 2005). For example, pet ownership is associated with better cardiovascular health (Anderson et al. 1992, Friedmann et al. 1980, Friedmann et al. 2003), fewer annual visits to the doctor (Headey & Grabka 2007) and lower levels of loneliness, stress and depression (Garritty et al. 1989, Katcher 1982, Stallones et al. 1991). One of the key mechanisms that may explain pet (dog) owners improved health status may be the increased physical activity facilitated by owning and walking with a dog (Anderson et al. 1992, Bauman et al. 2001, Raina et al. 1999, Serpell 1991).

Emerging evidence shows that dog ownership is associated with increased levels of walking, physical activity (Bauman et al. 2001, Brown & Rhodes 2006, Cutt et al. 2008c, Dembicki & Anderson 1996, Schofield et al. 2005, Serpell 1991, Thorpe et al. 2006a) and increased likelihood of meeting the recommended level of physical activity (Cutt et al. 2008c, Moudon et al. 2007, Schofield et al. 2005, Thorpe et al. 2006b). Recent Western Australian research has unearthed the potential of dog walking as a source of daily physical activity (Christian (nee Cutt) et al. 2010, Cutt et al. 2008a, Cutt et al. 2008c, Cutt et al. 2008e). The Dogs and Physical Activity (DAPA) study sought to examine the relationship between dog ownership and physical activity, in particular walking. It used an ecological model to examine the socio-demographic, intrapersonal, social environmental, physical environmental and policy-related factors affecting dog owners walking with their dog (Cutt et al. 2008b). The sample included participants (n=1813) taking part in the RESIDential Environments (RESIDE) study. RESIDE is a 5-year longitudinal study evaluating the impact of a state-government sub-division code in Perth, Western Australia. Details of the RESIDE study recruitment and design are described elsewhere (Giles-Corti et al. 2008).

The DAPA study found that dog owners did significantly more minutes of walking (150 vs. 111) and physical activity (322 vs. 267) per week than non-owners (Cutt et al. 2008c). The same study found that dog owners were 60% more likely to achieve the recommended level of physical activity and walking than non-owners (Cutt et al. 2008c). Importantly, these results remained the same even after controlling for socio-demographic, intrapersonal and physical and social environmental differences between dog owners and non-owners (Cutt et al. 2008c).

However, while the literature supports the principle that dog owners are more physically active than non-owners, it appears that dog ownership does not in itself facilitate an increase in physical activity for all owners. In fact, up to 60% of dog owners report no dog-related physical activity (Bauman et al. 2001, Schofield et al. 2005). Findings from the DAPA study show that while 45% of dog owners regularly

walk with their dog (≥ 90 mins of dog walking/week) (mean: 193; SD: 113), 32% only occasionally walk with their dog (mean: 48; SD: 19) and 23% undertake no walking at all with their dog (Christian (nee Cutt) et al. 2010, Cutt et al. 2008a). Tapping into the large proportion of dog owners who do not walk with their dog or do so only occasionally, and introducing strategies aimed at increasing their dog walking activities, would result in a positive increase in community levels of physical activity, health and well-being. For example, in 2001 it was estimated that if all dog owners in Australia walked their dog the direct healthcare cost savings could amount to \$175 million per year (based on 2000 costs of illness attributable to physical inactivity) (Bauman et al. 2001).

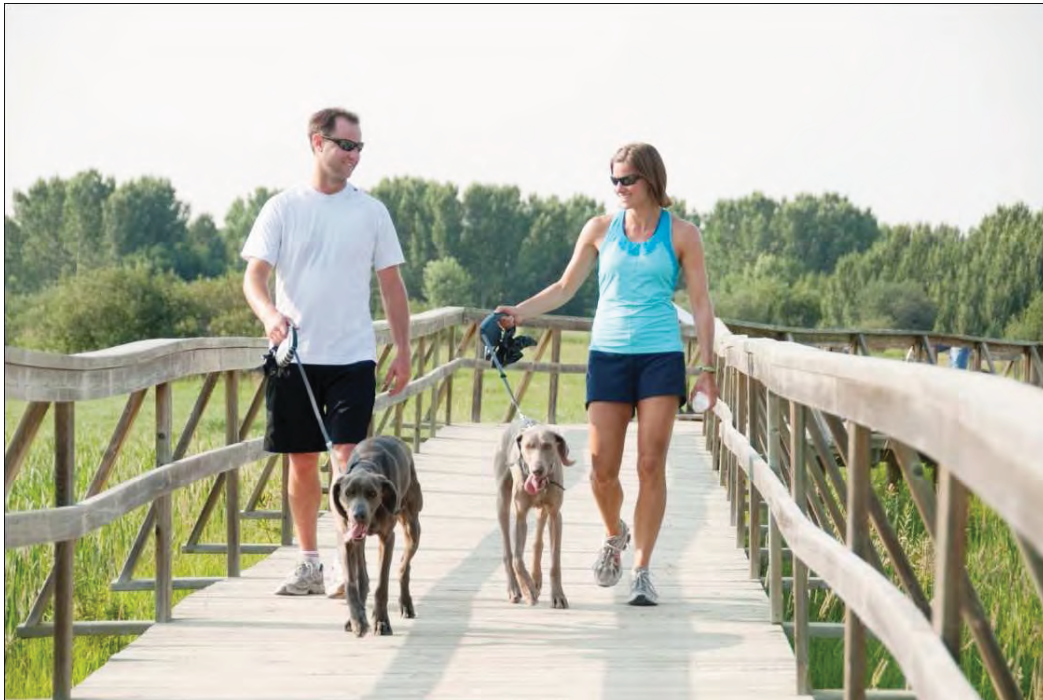


Figure 1. Physical activity benefits of dog ownership - dog walking (Source: Petcare Information and Advisory Service)

Factors affecting people walking with their dog

Investigation of the perceived and actual barriers and motivators for walking with a dog is important for the development of strategies aimed at increasing the level of dog walking and the proportion of the community who are sufficiently active. A number of key dog-owner related and environment factors have been identified as important for whether people walk with their dog and the amount of dog walking they undertake.

Dog-owner related factors

Dogs are unique motivators and provide important social support for walking (Ball et al. 2001, Christian (nee Cutt) et al. 2010, Cutt et al. 2008a, Cutt et al. 2008d). Unlike family members or friends who may be either busy or unmotivated dogs are

always ready and eager to run out the door and go for a walk. Perceived social support and motivation provided by a dog to walk has been shown to be positively associated with regularly walking with a dog (Christian (nee Cutt) et al. 2010). This is also one of the main factors associated with not walking with a dog (Cutt et al. 2008a). These results suggest that the perceived level of social support and motivation provided by a dog to walk are important factors to consider in encouraging the uptake, as well as the frequency or regularity of dog walking.

Sedentary dog owners also perceive that dog-specific barriers (e.g., difficulty of walking two dogs – as opposed to one, unfriendly or difficult to control dog, fear of other people's dogs, dog owners not picking up after their dogs, and unavailability of dog litter bags and bins) are more likely to discourage them walking with their dog (Cutt et al. 2008a). Owners who do not walk with their dog are less likely to have a positive subjective norm about dog walking (Cutt et al. 2008a). Subjective norm measures the normative beliefs of significant others (other dog owners, family and Veterinarians) in regards to walking with a dog daily (Cutt et al. 2008b). Strategies aimed at increasing social pressure from well-respected significant others including vets, other family members or other dog owners may aid in encouraging irregular dog walkers to engage in regular dog walking behaviour (Sheth & Frazier 1982).

Supportive physical and policy environment

The DAPA study also identified that increased access to a neighbourhood park with dog-supportive infrastructure (e.g., dog litter bags and bins, dog-related signage) was positively associated with regularly walking with a dog (Christian (nee Cutt) et al. 2010). Moreover, focus groups with Western Australian local government employees identified a number of positive and negative issues related to residents walking with their dogs in public (Cutt et al. 2006). Group discussions and in-depth interviews were conducted with key personnel (n=44) from local government authorities (LGA) across metropolitan Perth, Western Australia. Local government employees perceived that an increase in the number of people walking with their dog could result in a decrease in dog-related problems such as barking and an increase in knowledge of and compliance with local laws.

"I think if they were exercised at least once or even twice a day...It's very rare that we get noise complaints from people that we know or find out that do regularly exercise their dogs." (Interview 7; male; ranger)

"It is a social group for them and they talk to each other and with humour they will say 'don't let your dog do this or don't let them do that' and there are a couple of people down there who are called the 'sheriffs'. So through humour and a sense of place and belonging to this community they uphold those informal rules that they have set." (Interview 5; female; ranger)

Local government employees also discussed community benefits of dog walking such as increased sense of community and social capital (Wood & Giles-Corti 2005) and, deterrence of local crime.

"I think it (dog walking) forms one of our strategic plans, community well being, as well as providing the social context. The social hubs, and reserves

and parks play a big part in that. Our LGA currently has three dog training or clubs on our reserves and I think that's integral to community development.” (Interview 8; female; community development)

“I think it would be very beneficial if we had more people on the street. While there is a downside as far as enforcement, there are upsides in regard to neighbourhood watch. People being out on the streets, crime prevention, communities coming together and being exposed to each other, neighbours talking, dogs bring down barriers. It's the same as being a mother with kids at school.” (Interview 5; female; ranger)

Finally, local government-related factors perceived to be important for encouraging people to walk with their dog included access to well-designed and high quality parks with off-leash areas and dog litter bags and bins (Cutt et al. 2006).

“A dog owner wants the same facilities as a non-dog owner. So if they are going to take their dog to the park they may wish to combine it as a family outing and take their dog. If it is an exercise area they think ‘well that’s even better’ because the dog can run around and play and they can still enjoy nice surroundings.” (Interview 2; female; ranger)

“It needs to be pleasant to go walking in the first place. Otherwise you put the dog in the car and drive somewhere else.” (Interview 13; female; town planner)

“You need the dog poop bags. You also need the proper receptacle to put them in and I personally need more than one of two of these scattered around the area.” (Interview 2; female; ranger)

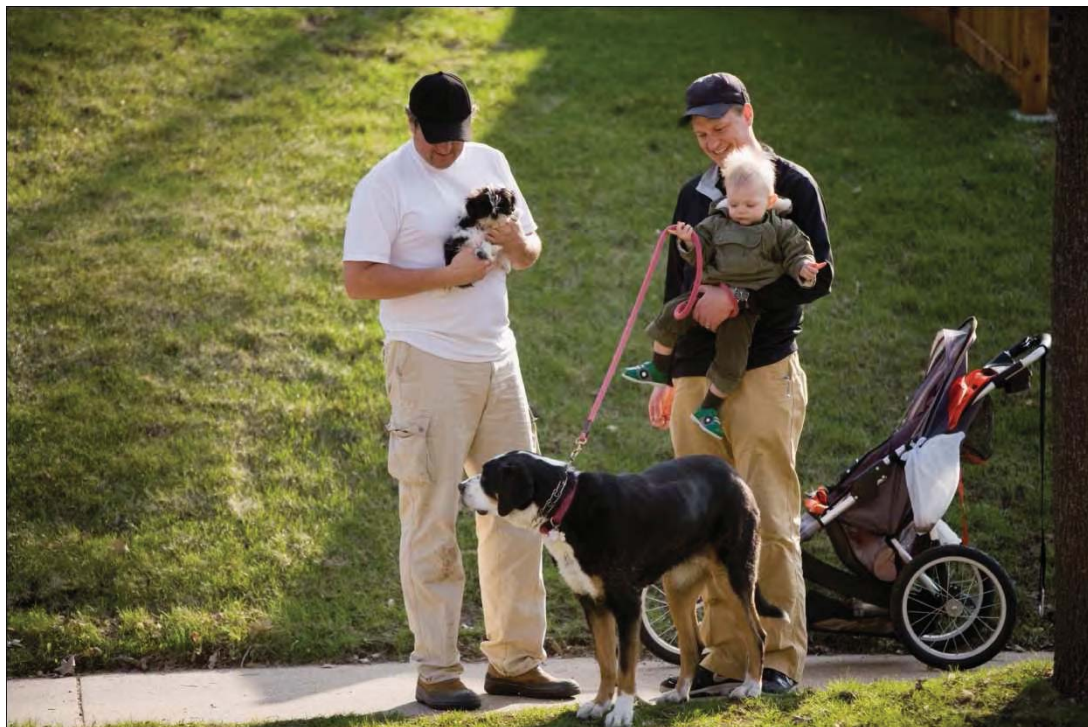


Figure 2. Community benefits of dog walking - social capital and sense of community
(Source: Petcare Information and Advisory Service)

Strategies for increasing levels of dog walking

Social support based interventions in community settings have been proven to be effective at increasing physical activity (Kahn et al. 2002). Along with family and friends, walking with a dog is considered to be an important form of social support for walking (Ball et al. 2001, Christian (nee Cutt) et al. 2010, Cutt et al. 2008a, Cutt et al. 2008d). Dogs provide not only a regular impetus for owners to exercise but also motivation to exercise for longer periods of time (Friedmann & Thomas 1985, Hartig et al. 1991, Messent 1983).

Given the widespread attachment of owners to their dogs, programs that promote the love that dogs have for going 'walkies' might also encourage owners to begin walking, if only for the sake of their dog. Owners may be motivated to walk with their dog because they acknowledge the benefits of improved health of their dog and the associated decreased veterinary costs. Furthermore, owners might be encouraged to begin walking with their dog because it's inexpensive, cheap and easy to do.

Previous research has shown that owners are *three times less likely* to walk with their dog if they don't feel pressure from family, other dog owners or their veterinarian to provide their dog with daily exercise (Cutt et al. 2008a). Physician advice to engage in physical activity has shown promise in intervention studies both overseas and in Australia (Armit et al. 2009, Eden et al. 2002, Elley et al. 2003, Morgan 2005, Petrella & Lattanzio 2002). The merit of programs such as Lifescripts (Department of Health and Ageing 2009) lies with the delivery of physical activity advice to patients by credible service providers (Armit et al. 2009). According to an American led Gallup poll (Gallop News Service 2006) that ranked ethical and honest occupations, medical doctors were considered to rank fourth highest with veterinarians ranking third. Thus the involvement of a legitimate and trusted authority such as a local veterinarian may be important for assisting dog owners to increase the amount of walking they do with their dog. Moreover, dog owners may be more willing to comply with the veterinarian's dog walking advice if they consider it to be appropriate or normative behaviour. Furthermore, a greater consistency between beliefs, attitudes and behaviour may be obtained if dog owners make a verbal or written commitment to follow their veterinarian's advice to walk their dog (Donovan & Henley 2003). With this in mind, intervention strategies aimed at increasing social pressure from well respected peers (i.e., veterinarians) might help to encourage dog owners to have a more positive attitude towards walking with their dog (Sheth & Frazier 1982).

Using the findings from previous research a community-based health intervention was developed. The Pooches and Walking Study (PAWS) has been developed to translate prior research results into an intervention that can help increase community levels of dog walking which in turn, can lead to an increase in physical activity among dog owners.

Intervention research - PAWS (Pooches And Walking Study)

The PAWS study addresses a number of high priority issues including physical inactivity and overweight and obesity. The aim of this study is to test the efficacy of three minimal intervention strategies (veterinarian advice, dog and owner pedometer, and standard physical activity brochure) aimed at increasing community levels of dog walking. The study targets veterinary clinics as a setting to reach a significant proportion of dog owners. Dog owners who do little or no walking with their dog will be invited to take part in the study when Veterinary Clinics send dog owners an annual reminder letter to notify them that their dog due is due for a check-up. Overall, 675 dog owners will be recruited to take part (225 per intervention group). Participants will be surveyed at baseline (prior to receiving the minimal intervention) and then one and three months post intervention. PAWS study design is based on the GP-setting intervention model which has been shown to be an effective intervention for increasing physical activity over the short to medium term (Eden et al. 2002).



Figure 3. PAWS dog pedometer intervention strategy (Source: PAWS Project Coordinator - Claire Lauritsen)

Significance of study

The current study is the first Australian based evidence to provide direction in terms of the best strategies that will increase community dog walking levels. The study seeks to provide specific evidence on a number of key fronts. Firstly, it will provide important information to help guide future health promotion programs by determining the best way to disseminate campaign messages on dog walking and physical activity. Secondly, it will provide information for practitioners looking to deliver community physical activity strategies with the best chance of success in regards to cost and reach.

Considering a large proportion of Australian households own a dog and about half of all dog owners do little (32%) or no (23%) walking with their dog, this intervention has the ability to reach a large proportion of the community and the potential to significantly increase the proportion of the Western Australian community who are sufficiently active. It is likely that the effects of this minimal intervention study will not be limited to study participants alone since the majority of dog owners have children and most children are actively involved in taking care of the family dog (e.g., feeding, grooming, exercising/playing).

The study will also yield broader findings relevant to the transferability of minimal intervention strategies as applied to different settings and health professional groups. It is anticipated that this study will provide knowledge and best practice on how to encourage inactive dog owners to begin walking with their dog and support occasional dog walkers to do more walking with their dog.



Figure 4. Features of supportive physical environments for dog walking (Source: Petcare Information and Advisory Service)

Supportive environments for physical activity and dog walking

While there is ample opportunity for scope in terms of delivering higher levels of physical activity across the broader population by introducing such health interventions to dog walkers, unless the policy and built environment is supportive of such behaviour, the deliverables will not be successfully met. The social-ecological model of human behaviour emphasises an interaction between the individual and the social and physical environment and the need to focus on the 'person-environment fit' (Stokols 1996). Thus programs that incorporate strategies aimed at creating more supportive policy and physical environments for dog walking are likely to have greater reach and effect than interventions targeted at the individual level alone (Sallis et al. 1998). The influence of the physical and policy environment on dog walking and physical activity behaviour and its interaction with the social environment, socio-demographic and individual dog-owner related factors is shown in Figure 5.

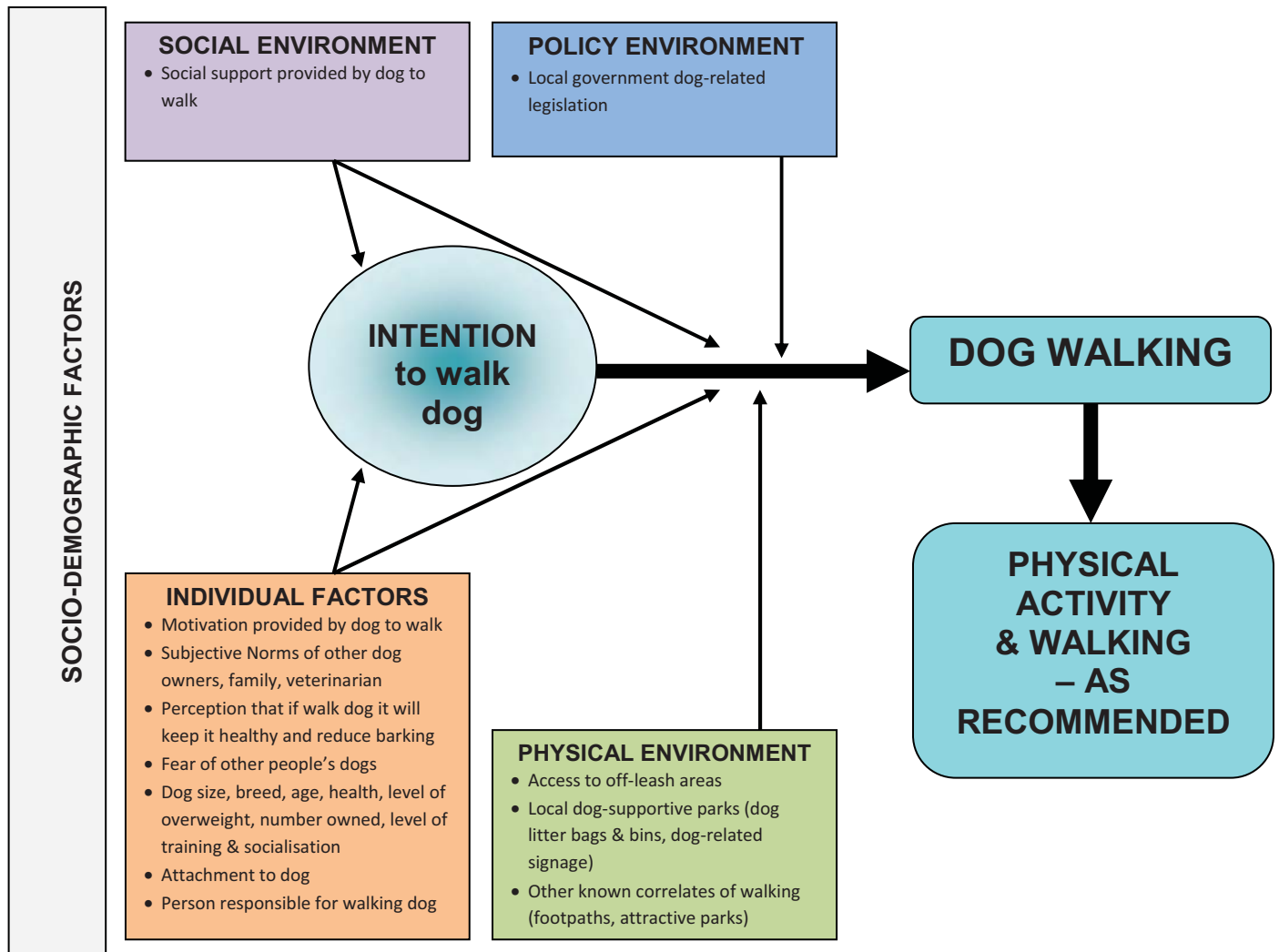


Figure 5. Model of the relationship between dog ownership and physical activity (Adapted from Cutt, H., Giles-Corti, B., Knuiman, M. & Pikora, T. 2008. Physical activity behavior of dog owners: Development and reliability of the Dogs And Physical Activity (DAPA) tool. *Journal of Physical Activity and Health*, vol. 5, no. Supp1, pp. 73-89.)

Consistent with studies investigating supportive physical environments for physical activity in general, the DAPA study found that access to a neighbourhood park with dog supportive infrastructure was associated with regular dog walking (Christian (nee Cutt) et al. 2010). Dog supportive infrastructure encourages the presence of dogs and their owners in parks and includes items such as litter bags and dog-related signage. Moreover, focus groups with dog owners identified that a perceived lack of accessible public open space and dog specific exercise areas as major barriers to dog owners walking with their dog (Cutt et al. 2008d).



Figure 6. Attractive neighbourhood park with dog supportive infrastructure (dog litter bags and bins and appropriate dog-related signage) (Source: H. Cutt for the DAPA study)

Programs such as PAWS cannot stand alone in an environment that does not facilitate socially responsible dog walking behaviour. For example, if it is difficult to transport a dog to an off leash park due to pet bans in public transport, or to a cafe where dogs are not allowed to sit at an outside table, the capacity to get the most leverage from such health promotion interventions will be minimised. The local policy environment can directly positively influence owners walking with their dog through careful consideration of sensible pet permissibility regulations.

The local policy environment directly influences owners walking with their dog, with regulations about where dogs are allowed in public as well as the times of day dogs are allowed to be present in certain public places such as dog beaches. The local policy environment also indirectly influences owners walking with their dog through its influence over the local physical environment. The needs of dog owners are often neglected in the allocation and design of parks. In the DAPA study, no dog owners had access to a sign-posted off-leash area within their neighbourhood (Christian (nee Cutt) et al. 2010). Furthermore, dog owners are attracted to attributes of parks that are equally valued by other park users and this highlights the need for park planning to acknowledge and accommodate multiple users.

Planners, developers and government may not perceive that they have an important role in creating supportive environments for dog walking, however, such initiatives are likely to result in a number of broad community benefits such as a reduction in dog-related problems (e.g., barking and roaming), increased compliance with local dog-related laws, creation of social norms around appropriate behaviour for dogs and owners in public places, increased sense of community and social capital and deterrence of local crime. For example, regular dog exercise can improve the physical health and socialisation of dogs and prevent behavioural problems such as barking (Petcare Information & Advisory Service 2010, Seksel 2004, Ruolf 2010).

The provision of a supportive environment is likely to encourage regular dog walking and may also assist in reducing local government dog-related problems such as barking or roaming dogs. Furthermore, local dog walking groups may assist councils by improving awareness and compliance with local dog-related laws (Wood 2009). In the DAPA study, both local government employees and dog owners expressed the view that, through peer pressure and the creation of social norms, dog owners felt they needed to look after and protect their local parks and persuaded other dog owners to do the same. Most local governments that were interviewed appreciated the help of 'responsible' dog owners self-policing their local parks. These results imply that when local governments are planning for dogs in the community it will be important for them to acknowledge, foster and use the resource of responsible dog walking owners to their advantage.

It is important that governments acknowledge the importance of planning for dogs in the community particularly if dog ownership and dog walking become more important over time. Technological advances, a faster pace of living and more sedentary lifestyles are negatively impacting our health, eroding our social fabric and severing community ties. Taking the dog for a daily walk provides opportunities to meet other local dog owners and park users. Dogs, like babies, are social facilitators and provide the opportunity for owners and non-owners to talk and get to know each other. Studies support the notion that taking a dog for a walk 'leads' to more contact and conversations with other people than walking alone (Messent 1985, Rogers et al. 1993) and this likely facilitates the creation of social capital and sense of community (Jackson 2005, Wood & Giles-Corti 2005).

Conclusion

Dog owners experience improved health status compared with non-owners. Dog ownership is associated with increased levels of walking, physical activity and increased likelihood of meeting the recommended level of physical activity for health benefit. The PAWS study was developed to translate findings from prior research into an intervention that can help increase community levels of dog walking which in turn, can lead to an increase in physical activity among dog owners (who represent a significant proportion of Australian households). Programs that incorporate strategies aimed at creating more supportive policy and physical environments for dog walking are likely to have greater reach and effect than interventions targeted at the individual level alone. A number of urban factors are important for supporting owners to walk with their dog. Dog owners' who have access to a local park with dog supportive features such as dog litter bags and bins, are more likely to regularly walk with their dog. Moreover, dog owners are attracted to attributes of parks that are equally valued by other park users. This highlights the need for public open space planning to acknowledge and accommodate different community groups.

While the provision of a supportive policy and physical environment for people walking with their dogs provides a number of important individual and community benefits, local governments will continue to be challenged on how to best manage the dog-related concerns of local residents with the individual and community benefits of dog ownership. Overall, a sensible policy infrastructure that accepts the

valuable role that dog ownership and dog walking can play in increasing physical activity levels is required.

The potential importance and prevalence of dog ownership within the community may increase over time as the population ages, people choose not to have children or have them later in life, and mental health problems associated with social isolation and poor community ties increase. Planners, developers, local government and the community need to take action and plan and provide for dog owners now and into the future.

Acknowledgements

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Green infrastructure thinking – a lifeline and values system for ‘liveable’ cities

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Green infrastructure thinking – a lifeline and values system for ‘liveable’ cities

ABSTRACT

Governments 'value' personal and environmental health but debate the level and priority of their provision. 'The Market' cannot make these decisions as our economies built on trading cannot deal with these often intangible elements unless they can be priced. The risks of non-provision remain unassessed. In this paper a landscape architect reflects on this thought against a back-drop of personal experience in the context of the last 20 years of planning, design and construction of new urban areas between Geelong and Melbourne, some of the most rapidly developed areas in Australia.

This period of valuing liveability began with the 'Rio Earth Summit' and the Australian Government's 'Building Better Cities' initiative: it closes with the UN 'Economics of Ecosystems and Biodiversity' and the Australian Government's 'Urban Design Protocol'. Lessons learned and opportunities lost are extrapolated into the future promised by the conference themes of 'health', 'working together' and 'liveable cities', a future in which hitherto abstract environmental and cultural values will be translated into dollar values on our national balance sheets.

There has indeed been a reawakening to the truth that the health of our communities remains firmly tethered to the networked environmental and cultural qualities that support them. The UN calculates that an annual outlay of \$45bn on environmental conservation will yield \$4tr to \$5tr annual benefits. Multi-disciplinary collaborations have provided city building solutions of unquestioned and measurable value.

However, our governance systems are ill-equipped to promote, measure and integrate the simultaneously realised values of mental and physical health, water quality, habitat, carbon, climate change adaptation and others. Pioneer governments are turning to the concept of Green Infrastructure thinking – to what extent does it provide the 21st Century with the framework of thinking to redress problems and confront the complexity of measuring and managing these often obscure yet essential values?

KEYWORDS

Healthy cities, Green Infrastructure; landscape architecture; ecosystem services.

INTRODUCTION – THE RISE AND FALL OF MELBOURNE?

Urban areas have existed for thousands of years, remaining tethered to their environments until ‘freed’ by relatively recent industrialisation. It was soon apparent that the values of cities as centres of wealth creation and innovation were being realised at an unacceptable cost to many of their inhabitants. Remedies for this focused entirely on improved human health (rather than natural environmental health) and symbolic of this response was the 1847 opening of the world’s first publicly funded urban park in Birkenhead, England, a park ‘for a new kind of client’, the public (Tate 2001). This park proved to be a model for Central Park New York and many others.

Also in 1847 the then only twelve years old Melbourne was declared a ‘City’ by Queen Victoria. The following 1851 gold rush helped fuel the remarkably fast development of the city in times of a relatively enlightened approach to urban human welfare. For example, by 1897 Melbourne’s mains sewage system had become fully operational, linked to what is now the Werribee Western Treatment Plant, roughly equidistant from the centres of Melbourne and the City of Greater Geelong and at 10,850ha one of the world’s biggest.

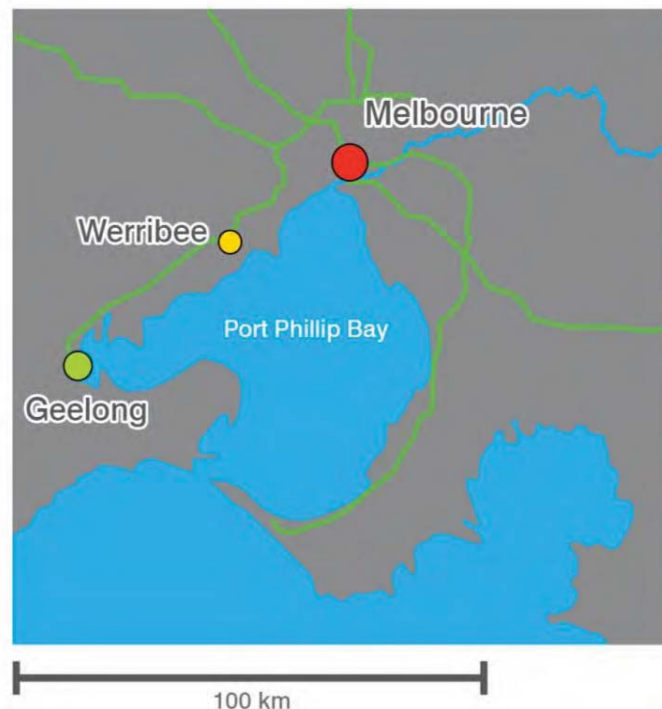


Figure 1: Werribee

Werribee is now in the fast growing local government municipality of the City of Wyndham. Long the butt of 'sewer' humour associated with its nevertheless commendable role in urban health, it is a Principal Town Centre at the hub of one of Australia's key examples of the world's 21st century urban growth phenomena, in local planning terms, the Melbourne West Growth Corridor (GAA 2011a) (Figure 1). However, despite our 20 years of planning and designing this new urban growth amid opportunities to learn from the past, the City of Wyndham considers its *'communities are suffering an epidemic of obesity and diabetes: a factor in this is previous generations of poor environmental design for public health outcomes. Car dependence, poor walkability, inadequate public transport options, limited sporting and recreational infrastructure and lack of access to and availability of nutritious and affordable foods exacerbate preventable health conditions'* (Wyndham City Council 2011). Furthermore:

- In 2001, Diabetes Australia estimated that 1,742 people in Wyndham had diabetes (2% of the population). By 2008, this figure had grown to 4,126 people (3.1% of the population). An estimated 6.5 new cases of diabetes are diagnosed every week in Wyndham;
- In 2008, 58.3% of Wyndham males and 47.8% of females were overweight or obese, furthermore, the male obesity rate is significantly higher than the average across Victoria (23.9% in comparison to 17.3% across Victoria);
- The Victorian Population Health Survey (2008) also estimated that 57.1% of Wyndham residents did not meet either the fruit or vegetable guidelines for recommended consumption, in comparison to 47.7% across metropolitan Melbourne.

(Wyndham City Council 2011).

This is an alarming situation. Melbourne's fringe urbanisation has been justified as a necessary process for community betterment despite negative impacts on our natural environment. Given the complex dynamics of city building, is this a temporary condition? Wyndham believes not and is concerned that the situation may worsen due to small lots / big houses reducing private open space and 'limited' ability to compensate by funding public works, noting that *'In the years to 2040, Council and the State will need to build basic infrastructure in Wyndham valued at a total of \$1.3-1.6 billion (including \$200 to \$300 million for outdoor sports)* (Wyndham City Council 2011).

Wyndham also fears that strategic planning for the next growth phase lacks commitment to planning for health – for example, in terms of linked walkable / cycleable communities, *'Unfortunately the..... Regional Rail Link, appears unlikely to contain the specified number of crossings due to costs associated with grade*

separation, with sections of up to 5k through urban areas with no rail crossings – either at grade or grade separated’ (Wyndham City Council 2011).

However, demand for outdoor organised recreation continues to rise (Wyndham City Council 2009) and the relationship of health to environment is well accepted at the highest government level (Australian Government 2011a).

HOW DO WE VALUE OUR CITY?

‘Valued’ in the sense quoted by Wyndham means *construction cost*. If our new cities are unhealthy should the problem be discussed in terms of construction cost or is it really about the cost of non-provision or is it a problem of process, the ‘environmental design’ process that Wyndham considers to be ‘poor’?

Our politico-economic system is such that ‘value’ is a very frequently used word. Whereas ‘value’ in city-building terms can refer to the worthiness and relative status of a proposition or element, modern usage has defaulted to ‘value’ translated into the absolute monetary or exchange units that seem to strengthen the credibility of planning and design decisions. The other meaning of ‘value’ as moral principal and accepted behaviour also remains most relevant to our approach to human and environmental health.

This paper does not intend to present an enhanced financial model for the creation of new, healthy urban growth areas. The Schedule 1 ‘values’ below concern orders of costs and cash flows that are of relevance but necessarily use incompatible units, complicating the ‘valuation’ of our urban environment and the measurement of its success.

These values not only reflect the considerable flows of capital involved in building up the marketable value of our urban land but also the range of units in which values can be expressed. The costs of providing basic, local green space appear relatively modest and there appears to be economic as well as health justifications for Wyndham’s concern about non-provision of rail crossing points

Of course there are infrastructure costs, direct taxes and other costs involved in creating new urban areas, but the sobering figure is the rising liability of the ‘ill health’ that we may be creating and the fog that surrounds the valuation and costing of ‘healthy environments’.

Expenditure on health in Australia increased from \$72.2 billion in 1999–00 to \$121.4 billion in 2009–10. At the same time, Australia’s gross domestic product (GDP) increased from \$951.0 billion to \$1,284.8 billion, so in 10 years health expenditure as a proportion of GDP has *risen* from 7.9% in 1999–00 to 9.4% of GDP in 2009–10 (AIHW 2011). There are many ways to interpret these figures. In the context of new

urban areas that attract younger populations there may be arguments to suggest lower than average per capita health costs, but on the other hand figures for the City of Wyndham suggest poorer average health and therefore higher costs.

SCHEDULE 1

\$/ha value	item
25,000	Market value of unzoned growth area farm land ¹
365,000	Market value of growth area farmland rezoned for urban development ²
3,250,000	Market value of new houses and lots in growth areas ³
83,250	Construction / land cost, new street, local park / open space landscape works ⁴
1,180,000	Construction cost for a new 'Regional' sporting facility ⁵
19,200	Cost of a new 'Regional' sporting facility over the catchment it serves ⁶
178,000	Recurrent annual health goods and services costs for residents ⁷

Cost : benefit	
1 : 1.9	Provision of suburban road / rail grade separation ⁸

\$ / tN	
80	Cost of urban storm water discharge above Best Practice targets ⁹

\$/ha value	
Variable	Cost of offsetting native vegetation removed for urban development ¹⁰

¹ (GAA 2009), based on the average of the reported \$15,000 to \$35,000 value per hectare

² (GAA 2009), based on an average of the reported \$225,000 to \$450,000 value per hectare

³ New house and land sale cost at a conservative \$250,000 at an average of 13 lots per hectare

⁴ New public landscape and open space construction cost at an industry rate of \$5,000 per residential lot, 13 lots per hectare, plus the cost of 5% open space land contribution (5% of \$365,000), excluding private areas

⁵ Saltwater Reserve Regional sports facility, Point Cook, 22ha area, \$26M cost: 3 pavilions, AFL ovals, cricket, soccer, tennis, basketball and other facilities (Source: Wyndham City Council)

⁶ Saltwater Reserve Regional sports facility expressed at the recommended rate of 0.5ha Regional Active space per 1,000 residents (GAA 2011b), caters for 44,000 residents, i.e. an urban area of 1353 ha at an average 32.5 residents / ha.

⁷ (AIHW 2011), based on a the reported national average health goods and services cost of \$5,479 per Australian in 2009-10, at 2.5 residents per house, 13 houses per hectare

⁸ CPG unpublished study, using recognised State government valuation techniques, infrastructure costs in the order of \$50M, a wide range of benefits including reduced congestion / vehicle emissions / accidents and associated social costs, urban consolidation and business efficiency benefits and the amenity values of a more appropriately provisioned and vibrant public environment.

⁹ (Melbourne Water 2006) approximate price

¹⁰ (DNRE 2002) costs vary with complexity of offset revegetation

'PREVIOUS GENERATIONS OF POOR ENVIRONMENTAL DESIGN' – THE LAST 20 YEARS

Could we have done better?

Melbourne's strategic urban policy through the 1990's to the present continued to provide 'greenfield' corridors of new land for outward growth and to also designate certain urban centres as nuclei for urban renewal and consolidation. Draft Growth Area Framework Plans for Melbourne's next cycle of outward growth were released in November 2011 (GAA 2011a).

In the context of the last 20 years, The Werribee North Concept Plan (Wyndham City Council 1996) provides a relevant example (Figure 2).



Figure 2: The Werribee North Concept Plan area (based on Melway map)

The Plan consolidated work for the Werribee Growth Area Plan of 1990 and confirmed the allocation of a 1,860ha agricultural area for an expected 30 years urban development catering for 55,000 people. Water supply and drainage (signs of public health) have exerted a visible influence on the design of the urban area. The Concept Plan proposed that development would need a high level, pumped potable water storage facility in the site on Cowies Hill, one of the few hills around. It also noted the flat and flood prone nature of the land, the need for space for 50 metres wide floodways and extensive 'stormwater retention and treatment, a potential constraint'.

The Concept Plan also noted:

- *'The need to provide a broad range of recreational facilities'*
- *The 'need to ensure the provision of an adequate open space network utilizing the natural features, particularly water courses and wetlands'*
- *'Minimum requirements for open space will be 5% of unencumbered developable land'*
- *'All residential land should be within a 500 metre radius of an open space reserve of at least one hectare'*
- *Ratios of open space provision – for example 1 football / cricket oval per 5,000 population*
- *'co-location....of at least 2 active recreation facilities to the one site*
- *'No residential area should be further than 2 kilometres from an active open space facility'*
- *'Linkages between major open space areas and linear reserves'*

The Wyndham Recreation Policy (Wyndham 1997a) followed, with a Recreation Plan (Wyndham 1997b) and a study of open space provisions in new areas (Wyndham 1997c). Outline Development Plans followed for various sectors. The landscape architect's site analysis for the Cowie's Hill ODP noted that a 'degraded waterway/channel traverses the site' with 'opportunity to remodel the existing channel and incorporate it into a linear open space' (Coomes 2001). Further urban design confirmed the need for a 5.0ha wetland / retarding area at the lowest point of the area, within an overall 8.7ha of 'encumbered land' (subject to inundation) (Tract *et al* 2003).

Successive levels of planning produced a thoughtful urban layout based on the above and in which stormwater management was integrated with urban open space, providing a linear space incorporating or leading to more structured open spaces and treed streets.

Community and environmental health was implied but neither mentioned nor measured in the Concept Plan. The parameters used to define and quantify open space and recreation are similar to those used all over Melbourne during the last 20 years. In an era that began with Agenda 21 and Building Better Cities there was

indeed very little formal enhancement of simplistic measures that determined urban health: ratios of ovals to population or of 'unencumbered' open space as a percentage of total area. Perhaps the biggest influence was New Urbanism, which revived the more complex notion of building *communities* rather than *housing estates* (Katz 1994), thereby focusing on human wellbeing.

DO WE VALUE A HEALTHY ENVIRONMENT?

With notable exceptions (Haney 2010) (White 2011), it was not until the second half of the twentieth century that world concern for human urban wellbeing matured into complementary understanding of environmental welfare.

Rachel Carson's 'Silent Spring' (Carson 1962) is an often cited milestone. Landscape architect Ian McHarg drew close to setting a new value system, one based on the '*natural systems*' of his 'Design with Nature' (McHarg 1967). With great prescience he warned that '*we must abandon the value system of our inheritance which has so grossly misled us. We must see nature as process within which man exists*' (Smithsonian Institution 1968). The oil shocked 1970's generated environmental facts and figures. 'The Limits to Growth' (Meadows *et al* 1972) exemplified a concern to quantify, rather than value, finite resources and pollution. The study of 'ecosystem services,' the renewable 'free' goods and services provided by nature, began to provide a broadening context and language for the valuation of the environment.

In the 1980's Australians, more than others, were alerted to both the health and economic cost of human induced environmental change – the so called 'hole' in the southern hemisphere ozone layer. The subsequent Vienna Convention (1985) and Montreal Protocol (1987) led to reassurance that long term health and environmental problems can be addressed by co-ordinated action by international and local communities.

Twenty years ago, the world formalised its commitment to and understanding of inter-linked environmental, economic and social sustainability. The 1992 United Nations Rio 'Earth Summit' Declaration on Environment and Development, led to the 'Agenda 21' action plan for environmental development into the 21st century. That year the Australian Commonwealth Government launched its 'Building Better Cities', the first national, co-ordinated look at the contemporary values we must apply to our settlements.

So, yes, twenty years ago there was a heightened but incomplete appreciation of what the environment is worth to us and international and local commitment to safeguard this worth for future generations. Melbourne's local environmental literature of that time appears surprisingly topical today (Pears 1992) and includes

not only discussion of greenhouse emissions, but also of social issues ranging from reclaiming streets for people to affordable housing. What have we learned since?

ENVIRONMENTAL HEALTH - WATER

In contrast to human health issues, the mandatory expectations placed on the storm water drainage infrastructure in Melbourne's urban areas have changed radically and rapidly during the last 20 years. In setting a framework for enforcement of 'Best Practice' Melbourne Water introduced 'offset contributions', to be made if targets were not met, and used the language of the market place by stating that 'Nitrogen has been selected as the common currency' for the contribution (Melbourne Water 2006).

Here, long before the debate on the Carbon Tax, we have one of the earliest and most literal translations of environmental quality into monetary value – a 'charge', if you like, on Nitrogen as an indicator of pollution. Also in 2006 the Victoria Planning Provisions were revised (Clause 56 – Residential Subdivisions) to strengthen the requirement for best practice integrated water management as part of building sustainable communities.



Figure 3: Werribee North – WSUD and multi-functional open spaces, Reflections Estate, Tarneit

Leveraging off the commercial and social appeal of the associated drainage works and a public focus on water issues due to a long drought, this legislation has led to continuing support for the accommodation of elements of the WSUD treatment train at regional down to street scale in the planning of Melbourne's urban form and new growth (GAA 2011c) (Figure 3).

ENVIRONMENTAL HEALTH - HABITAT

Again, and in contrast to human health issues, mandatory expectations have been placed on Victoria's native habitat treatment.

Victoria's 'Native Vegetation Management – A Framework for Action' which introduced the 'Net Gain' concept (DNRE 2002) and sought to be 'a strategic, whole of landscape approach'.

This legislation places values on ecology to encourage retention and incorporation into the urban area. To do so, values have been exchanged into a new 'currency', the 'Habitat Hectare'. Victoria has been mapped to define the Ecological Vegetation Classes (EVC), or communities that, unhindered, would theoretically occur at any given place: vegetation is valued in terms of its degree of intactness compared to the relevant EVC. For example, a hectare of woodland that through damage or other reasons is only half the ecological quality of what is theoretically possible achieves a value of 0.5 Habitat Hectares.

As a result, urban design processes have for some time been conducted with a heightened awareness of ecological issues, but there is still an impression that desired urban layouts can be purchased, forfeiting unrecognised habitat values. The legislation outlines 3 steps: avoidance of damage; mitigation of damage; and offsetting damage if unavoidable. In practice the difficulty of revegetation and the maintenance of an ecological community to mature values are not properly emphasised. Care is needed in according market values to the environment.

This concern about the complexities of environmental balance sheets was highlighted by the Greens party in objecting to further formal expansion of Melbourne's growth areas. As part of the expansion the Victorian State government intends to acquire 15,000ha of grasslands on the edge of Melbourne to offset the loss of 6,900ha within the growth area, interpreted by the State Greens Party as '*In return for the guaranteed, irreversible destruction of high quality grasslands we are going to get a statement of intent to purchase other land and manage it*' (Hansard 2010).

HEALTH AND WELL-BEING VALUES

Are we as clear on our health and wellbeing values as we are on some of our natural environmental values?

It must be noted that the Werribee North example developed at a time when the value of parks and nature in relation to health and wellbeing improvement had been

supported by the 1986 Ottawa Charter for Health Promotion and reaffirmed by the Jakarta Declaration in 1997 (both promoted by the World Health Organization).

Maller *et al* (2008) provides a comprehensive literature review of health benefits of contact with nature in a park setting, including figures relevant to the period in which Wyndham North was developed. Maller records that in 1998 cardio-vascular disease accounted for approximately 40% of deaths with annual costs to the health system at AUD\$3.7 billion. In 1993-94 mental disorders absorbed 8.3% of Australia's total annual health system expenditure (AUD\$2.58 billion). These figures are not presented as conclusive, rather to suggest potential quantities and units for another way of evaluating our environment.

It is true that Government concern has grown since the 1990's. In 2010 the State Government Parks Victoria was a key partner of the Melbourne Healthy Parks Healthy People Congress which focused on the values of open space for physical and mental health and for the resilience of our communities. In 2011 the Environment and Planning References Committee of the State Parliament undertook an 'Inquiry into the relationship between Environmental Design and Public Health'. (Parliament of Victoria 2011): the report is due in May 2012. Also in 2011 the Victorian Competition and Efficiency Commission acknowledged the importance of liveability and the environment to the State's competitiveness (VCEC 2011).

This focus on design, open space and health lacks supporting empirical guidance for urban form and quantity, despite its provision being central to local government governance obligations. Degrees of accessibility and standard ratios of active recreation facilities to population remain the few usable parameters.

Unconvinced of our progress, AMA (Victoria) has recently expressed the view that *'The challenge for government is to design communities in a way that promotes physical and mental well-being'* (Australian Medical Association 2011).

Similarly, Parks Victoria (Parks Victoria 2011) has recently commented that *'In relation to new growth areas, integration of the principles of Healthy Parks Healthy People into current planning and development is limited and could be improved, in particular integrating public and private partnership around open space provision. There are opportunities to increase partnerships with private land developers'*.

Wyndham has recommended that the State Planning Policy Framework be amended to include a Clause 'Planning for Health' and the Precinct Structure Planning Guidelines be amended to include a new section within Clause 56.03 called *'Designing for Health'*. This is a logical extension of the current Clause 56, which since introduction in 2006 has facilitated improved discussion of urban and

environmental design. However, we would still be left with a 'performance based' tool, rather than a direct aid to informing the planning and design process.

In Wyndham, many significant developers are now focused keenly on providing designs that facilitate and accelerate the formation of 'communities' in newly constructed areas. The GAA (GAA 2011b) uses the term 'Integrated Open Space Networks' to encourage the realization of multiple values from open spaces. However, planning requirements and local authority recreation and open space strategies do not challenge the traditional 5% open space contribution and rarely consider how 21st century needs for multi-functional urban environments should be met. The content of much new open space development remains discretionary. Sport is vital to our communities but we will need to manage other overlapping values, including human health, as clearly as we measure our cricket ovals. A new spatial planning and values system is needed.

AN URBAN VALUES SYSTEM – ECOSYSTEM SERVICES

Ecosystem services are the 'free goods' provided by the environment, reductions in which compromise human welfare. The notion of 'ecosystem services' is not new but the attention now being given to them is.

'Services' are extensive and can be summarised as; 'Supporting' (nutrient recycling, oxygenation, soil formation); 'Provisioning' (food, fuel, fibre, water); 'Regulating' (climate, water quality, flood mitigation) and 'Cultural' (education, recreation, aesthetic services). These services are in poor shape – most concerning, given the acknowledged bond between human health and wellbeing and ecosystem services,

In 2005 the United Nations cautioned that '60%....of the ecosystem services evaluated are being degraded or used unsustainably' (MEAB 2005). In 2010 the UN The Economics of Ecosystems and Biodiversity (TEEB 2010) concluded that \$45 billion per annum expenditure on environmental conservation will yield \$4trillion to \$5 trillion benefit per annum from ecosystems services. The UN study also prompted this discussion between an economist and an ecologist:

'What you buy and sell is stuff that is able to be identified, privately owned and marketed. A market does not sell a public good. Pigs will fly before markets trade public goods. The only way you can get a public good into the marketplace is to first create a private liability or private asset' (Pavan Sukhdev, former Deutsche Bank economist and head of the groundbreaking TEEB - (Levitt, 2010).

This exchange between an economist and an ecologist about how to value of our 'free' natural environment is a sign of the times in which we live, times in which we increasingly have to translate 'values' into absolute monetary or exchange units in an attempt to make choices and understand the costs of not doing something.

Furthermore, we have then to ensure systems or persons are accountable for these values. Despite unprecedented access to data on the value of our environment, our urban areas remain disconnected from it, partly by force of habit but also because these values are expressed in non-interchangeable units and we simply have no integrated system of evaluation.

Governments are therefore taking stock of their environmental values. The UK Government has studied its ecosystem values in entirety and this includes 'Health Values from Ecosystems' (UK NEA 2011) and the The European Commission is developing an EU-wide strategy.

In Australia, there is again a focus on national urban policy '*for a productive, sustainable and liveable future*' (Infrastructure Australia 2011). This has led to the National Urban Design Protocol that includes consideration of human health (Australian Government 2011b).

Talk of overseas and high level initiatives may seem disconnected from the current issues faced by our local planning and design system, but it is clear that:

- We need to understand the true values of multiple, overlapping qualities relevant to the human and environmental health of our cities
- In many cases these values have to date been obscure and impossible to compare and prioritise
- Our cities are being called upon to be more resilient to and aware of change.

GREEN INFRASTRUCTURE – A SPATIAL VALUES AND PLANNING TOOL

Local and global thinking is at a point where the values of the environment are being actively defined. Urban planning and design needs some form of consolidated open space accounting that applies these values to A spatial framework. 'Green Infrastructure' thinking could provide a settlement-orientated multi-layered framework suited to collaborative urban planning and to the applications of ecosystems services values to both create and to monitor urban areas.

Green Infrastructure as a term and concept is in use in government and the broader market (AILA 2009). The term has been in use in North America for some time, with reference to catchment management and water quality. Its significance as a resource and values management tool is recognised by Standards Australia in its recent *Draft Climate Change Adaptation for Settlement and Infrastructure* (SA 2011). The State of South Australia has announced a 'green infrastructure vision' for the realisation of the State's economic, environmental, social and cultural sustainability.

The power of the Green Infrastructure approach lies in its ability to assist the classification and maximisation of the multiple environmental functions actually or

potentially fulfilled by spaces and built elements. Multifunctionality, connectivity and integration are stressed – that is, the co-ordination and interaction of different natural and human functions or activities on the same piece of land.

‘The aim is to increase the quality of natural capital rather than concentrate solely on the quantity of natural capital’ (Davies *et al* 2006). Unlike traditional, ‘grey’ infrastructure (such as roads and power lines), green infrastructure is often hard to visualise: the ‘grey-green continuum’ of thinking suggested by Davies assists in conceptualising an approach to managing current assets and planning for their future (Figure 4).

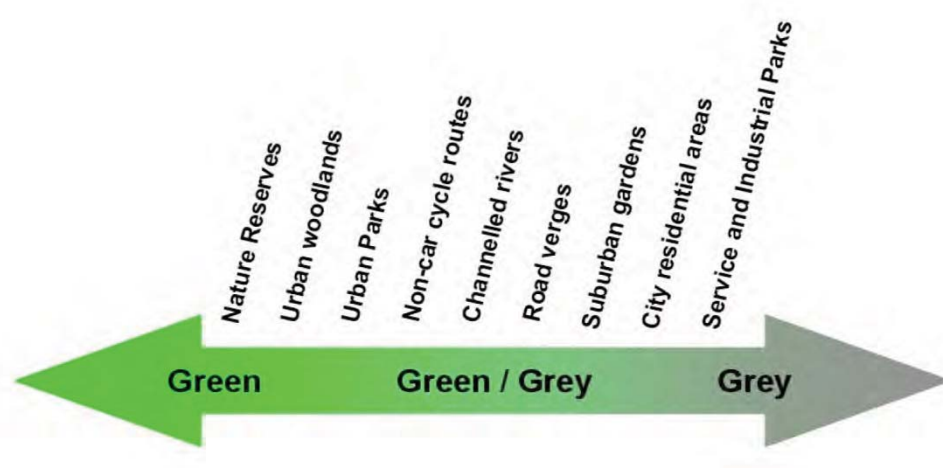


Figure 4, A green to grey continuum (after Davies *et al*, 2006).

Figure 5 (after Davies *et al*, 2006) provides a glimpse of how places with positive environmental contributions (‘green’) can be ascribed GIS values, mapped and further categorised. The scale and detail illustrated here is irrelevant and could be regional or local, values could describe multiple urban water cycle issues, habitat, human health, potential carbon sequestration or whatever is required. Conventions are adjustable and political boundaries can be downplayed to see the ‘big picture’. For example, many Melbourne municipalities have ‘2020’ or ‘2030’ environmental strategies based on common concerns, but without a common basis for comparison their effect is reduced. Review, testing of strategies, introduction of changed or refreshed data is facilitated. As Standards Australia has reminded us (SA, 2011), green space and Green Infrastructure should be part of the climate change risk assessment and management related to our settlements and infrastructure.

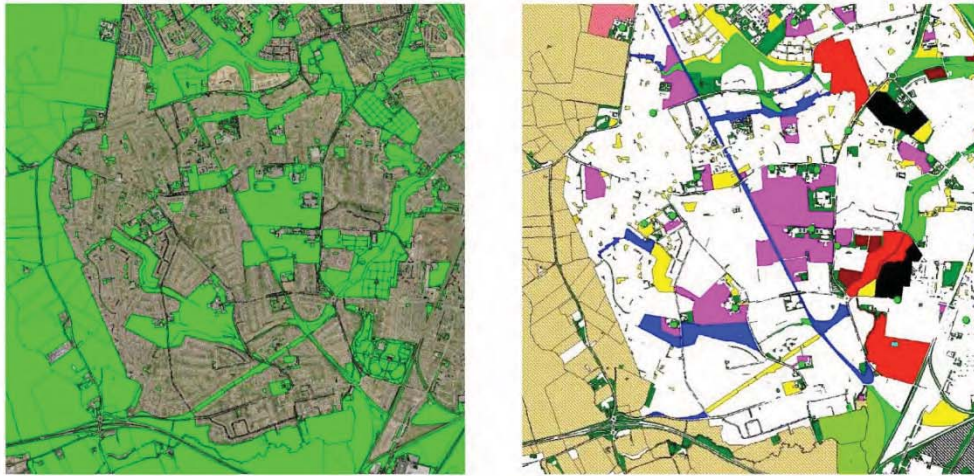


Figure 5. Green Infrastructure mapping on a scale equivalent to the Werribee North Concept Plan area – an example (after Davies et al 2006)

Increasing population densities lead to less open space per head (VEAC 2011) and more competition for the use of other public spaces such as road reserves. We also anticipate the intensified use of these same communal, often accidental spaces in our existing and new urban areas. Future open space will need to satisfy increasing demands to support the urban water cycle, maintain health, combat urban ‘heat island’ effects, sequester carbon, provide bio-engineering contributions, produce oxygen and food, and respond to strategies for climate change adaptation. The costs of providing and provisioning open space appear clear and accepted – issues of definition of and priorities for their function remain (Cooper 2010).

WHAT HEALTH VALUES SHOULD OUR GREEN INFRASTRUCTURE CONSIDER?

Much more work is needed to answer this question in a way useful to the long term planning and design process.

This paper has considered obesity, diabetes, dietary statistics and mental health: in so far as these statistics are related to local planning and design, they are reflections of decisions taken some time ago and therefore in need of careful interpretation.

Less easily measured, the continuing integration of urban and transport planning is expected to provide the health benefits of public transport provision combined with ‘active’ transport (walking and cycling) empowerment. Quantitative evidence of

effects is either patchy or is anecdotal. The same comment could be made about the encouragement that accessible green space and formal recreation facilities give to healthy living (Australian Government 2011a).

Meanwhile, we measure the nitrogen in our water, the flora / fauna in our habitats, the carbon in our emissions and the temperature of the air with great precision and in ways now understood by '*the market*'. The same should apply to health.

Indeed, the UK National Ecosystem Assessment (UK NEA 2011) commented in relation to health that '*Future research needs to address the issue of causality to convince policy makers of the health benefits derived from exposure to nature... . Therefore, existing measures need to be integrated within longitudinal population studies*' The study went on to suggest data gathering by: physiological and questionnaire based methods for assessing physical health; studies of Body Mass Index , Waist to Hip Ratio , blood pressure, cortisol; and questionnaire-based methods for establishing connectedness to nature.

It appears that to have the usable health parameters we need for urban planning and design we must:

- Collect much more data and undertake longitudinal studies
- Group data into a range of composite key indicators of urban health
- Look for ways of expressing these indicators alongside other environmental indicators in terms understood by the markets and the '*policy makers*' (cost, risk, yield) and the planners and designers (spatial and temporal relationships).

CONCLUSIONS

There are clear indications that the designs of our new urban areas are encouraging ill health. Concerns documented by Wyndham City Council, in charge of one of Australia's fastest growing areas, appear to be justified criticism of the unintended outcomes of the last 20 years of local planning and design. Other critics include the AMA (Australian Medical Association (Victoria 2011) and Parks Victoria (Parks Victoria 2011), collectively charged with significant human and environmental health responsibilities. There is also cause to query why we have made more effort to quantify natural environmental parameters than we have to measure urban human health in ways intelligible to our planning and design processes.

We began by looking at Birkenhead Park. Joseph Paxton, its creator, was a horticulturist-engineer-building designer, an eclectic, self contained person, symbolic of his times. The later divergence of skills into proudly separate 'professions', the municipally funded engineer, health worker, educator and others, helped to preserve our 19th century cities, but created a false sense of what independent values were

important for their survival. The success of the multi-functional approach of Green Infrastructure thinking is symbolic of the return to a more integrated view of urban values, one that better responds to contemporary needs for survival.

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Review of public health and productivity benefits from different urban transport and related land use options in Australia.

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Abstract

The relationship between public health, urban forms and transportation options in Australia is examined through a review aimed at determining possible health indicators to be used in assessing future land use and transportation scenarios. The health benefits, and subsequent economic benefits of walkable, transit orientated urban forms are well established and are measurable. Important health indicators include vehicle miles travelled, access to public transport, access to green areas, transportation related air pollution levels, transportation related noise levels, density and mixed land use. A comparison between a high walkability urban environment and a low walkability urban environment identifies various infrastructure, transportation greenhouse gas emissions and health costs. From this it is determined that infrastructure and transport costs dominate, health costs are relatively small and that health-related productivity gains associated with highly walkable urban areas are substantial. This review provides health and economic rationale for developing urban forms geared towards active travel.

Keywords: *public health, active transport, urban form, pollution, productivity.*

Introduction

The relationship between public health, urban forms and transportation options is now the subject of significant research. Much of this research focuses on the urban attributes, such as transport and urban form that can encourage human health building on a long tradition in the health profession that stressed health outcomes from town planning (Broadbent, 1990; Newman & Hogan, 1981; WHO, Canadian Public Health Association, & Health and Welfare Canada, 1986). Many studies support that car dependent urban forms have led to the creation of obesogenic environments increasing the health burden (Ewing et al. 2003; Frank et al. 2004; Trubka et al. 2010). Furthermore, rising temperatures, increasing extreme weather and poor air quality related to climate change, urban heat island effects and transport-related air pollution are a major public health concern for cities, and are predicted to place an increasing health burden on urban populations (Harlan & Ruddell, 2011). There is much overlap between policies aimed at mitigating climate change and those that would increase active travel (Harlan & Ruddell, 2011; Hoorweg, et al., 2011; Kent et al., 2011; WHO, 2011b). Additionally, there are strong financial justifications to include health costs in appraisals of developments (Trubka et al., 2010) along with a growing cultural shift to more sustainable urban lifestyles, a reduction in car use and increasing competition between cities to attract educated residents and economic development (Brookings Institution Metropolitan Program, 2008; Florida, 2002; Newman & Kenworthy, 2011; Newman & Newman, 2006).

This paper first looks at the relationship between public health, urban forms and transport options as found through the literature, discussing potential health outcomes related to urban form and transport. The paper then identifies studies that discuss the potential economic impacts of urban form and transport choices. Lastly, the result of a comparison between a high walkability urban environment and a low walkability urban environment is presented. This comparison identifies various infrastructure, transportation greenhouse gas emissions and health costs. This review is the first stage of a project looking at developing potential human health impacts of future urban development scenarios able to be modelled to determine the consequences of urban transport and land use policies on human health under various climate change scenarios. This review does not investigate socio-economic factors, access to employment, health care, education or other land uses which can also influence urban transport choices as these are beyond the scope of the paper.

Background

The relationship between public health, urban forms and transportation options is now the subject of significant research. Much of this research focuses on the urban attributes, such as transport and urban form that can encourage human health. It is

now commonly accepted that the conventional model for residential developments located in greenfield sites that have been prolific in Australian cities since World War II have resulted in car-dependent locations and inactive travel (Ewing & Cervero, 2010; Jackson, 2003; Newman & Kenworthy, 1999; Saelens & Handy, 2008; Saelens et al., 2003). These neighbourhoods are generally characterised by low population densities, poor accessibility and connectivity and a lack of services within walkable distances, resulting in low levels of active transport. Growing evidence links these areas to obesity and other chronic illnesses (Giles-Corti, 2006; Giles-Corti et al., 2012; Jackson & Sinclair, 2011; Kent et al., 2011; Sturm & Cohen, 2004).

A large current stream of research is looking at the carbon impacts of land use decisions. It has been determined that people living in dense urban centres can emit half the amount of greenhouse gases (GHGs) than those living in suburban areas (Hoornweg et al., 2011). Importantly however, is the link between policies to reduce GHG emissions and policies to increase health. Policies suggested to reduce GHG emissions often also have health benefits including increasing public transport use and access, discouraging car use, reducing trip lengths through mixed use zoning and compact urban forms, supporting non-motorised traffic modes through traffic calming and bike lanes, and reducing the heat island effect (Kent et al. 2011; Hoornweg et al., 2011; WHO, 2011b).

Australia now has one of the highest obesity rates in the world ranking 21st in the world and third among all English-speaking countries (Forbes, 2007), with much of Australia's adult population not getting enough physical activity to remain healthy. The cost of inactivity in Australia was estimated by Medibank Private to be \$13.8 billion a year with residents living in cities generally more physically active than those living outside of major cities (Australian Government, 2011, p.175). It is estimated that 1.5-3.0% of total direct healthcare costs are related to inactivity in developed countries (Oldridge, 2008). The National Physical Activity Guidelines for Australians recommends that people should engage in 30 minutes of physical activity per day over 5 days of the week in order to be healthy and to be considered physically active. Some of this could be met by increasing the amount of active transport and incidental walking (Trubka et al., 2010).

Walking and cycling are widely recognised as the healthiest ways to get around our cities for both public and environmental health (Hoornwe et al., 2011; Huy et al., 2008; Newman & Kenworthy, 1999; Pucher & Buehler, 2010). Direct and indirect benefits of walking include increasing physical activity and the reduction of air pollution, road-based stormwater and noise pollution through the reduction in the use of automobiles (Newman & Kenworthy, 1999; Pucher & Buehler, 2010). However, it has also been identified that pedestrians and cyclists can also be exposed to high levels of air pollution in certain urban microenvironments such as busy street canyon (Kaur et al., 2007).

Urban form, transportation and human health

This section examines the relationships between human health, built forms and transportation options. From the literature, the urban form structures that can relate to or indicate increased physical activity and health (and which often overlap in their ability to help create walkability) are density of urban form, accessibility, particularly the number of intersections per area, compactness, diversity of land use, amount of time spent in a car or vehicle kilometres travelled (VKT), proximity to public transport, access to public space, particularly green space, and the presence of appropriate active transport infrastructure (Ewing & Cervero, 2010; Forsyth & Krizek, 2010; Guo, 2009; Handy et al., 2005; Jackson, 2003; Larco et al., 2011; Saelens & Handy, 2008; Saelens et al., 2003; Soltani, 2006). Furthermore, transport related air pollution, noise pollution and accident levels are also potential important indicators able to be modelled. All of these elements relate to minimising the need and distances required to travel for everyday services and activities, and residents of these types of areas have been found to be more active (Frank et al., 2005), especially where these features are combined and act in synergy (Saelens et al., 2003). These features overlap and work together in ways that is yet to be completely understood. This section highlights some of the key findings or measures around these urban form and transport indicators.

Urban density and human health

The links between human health and urban density are a particularly important potential indicator. People that live in higher density, mixed use neighbourhoods have been found to have lower rates of obesity than those that live in lower density residential areas, although this result is mixed in the literature. Appropriate levels of density and mixed land use are required to encourage active travel and public transport (Giles-Corti et al., 2012), presumably because distances for travel become less. Cross-sectional research indicates that people that live in higher density, mixed use neighbourhoods have lower rates of obesity than those that live in lower density residential areas, however longitudinal studies show mixed results (Berry et al. 2010). Wilson et al. (2012) in a survey of areas in Brisbane found that residents that lived in the densest neighbourhoods were 80% more likely to walk between 1 and 60 minutes weekly, and more than twice as likely to walk more than 150 minutes. Sturm and Cohen (2004) found that a difference in their sprawl index of 100 points (the difference between a very sprawling area and an inner city) was associated with about 200 fewer chronic medical problems per 1000 persons. In their research Newman and Kenworthy (1999; 2006) found that 35 people and jobs per hectare (referred to as 'activity density') was the threshold density for decreased car dependence and beyond that, travel by car lessens and active travel and public transport use begin to increase.

Importantly however, increased urban density is related to increased levels of walking but not necessarily to increases in levels of walking for physical activity or for leisure (Forsyth et al., 2009; 2009). The relationship between density and walking, in particular, relates to issues of self-selection of residential locations based on

preference, i.e. people that prefer a highly walkable neighbourhood and live in one walk and people that are not interested in walking don't regardless of the walkability of their neighbourhood (Berry et al., 2010; Frank et al., 2007). These studies imply that it takes more than simply increasing density to increase activity levels, although the reverse is more likely, that low density levels lead to less walking as the distances and time required for travel mean that a motor vehicle is used for most transport (Newman & Kenworthy, 1999). Furthermore, a quasi-longitudinal study from Northern California (Handy et al., 2005) determined that people who move to a more walkable area began over the course of a year to adapt their travel behaviours accordingly. The links between personal preferences, density and levels of walking are clearly difficult to measure. The link between public transport use and density is a little easier to determine with public transport ridership found to increase steadily as residential density increases, along with other measures to restrict car use (Lee et al., 2009).

Accessibility, compactness, mixed land use and human health

Active commuting is clearly related to proximity and availability of public transport and to the distances between residences, services, commercial activities (particularly local stores) and employment locations (Ewing & Cervero, 2010). Compactness is now a widely accepted planning policy in Europe, Australia and the United States (U.S.). A tighter urban grain enables cities to maintain continuity within a small area and to be easily accessible on foot and by bicycle. A sustainable city needs to be compact and compactness has been shown to influence travel choices and to result in lower GHG emissions than sprawling cities (Cervero & Kockelman, 1997; Dulal et al., 2011; Kenworthy, 2006).

Permeability, particularly as measured by intersection density, is positively correlated to levels of walking (Baran et al., 2008; Ewing & Cervero, 2010; Kerr et al., 2007; Montgomery, 1998; Saelens & Handy, 2008; Saelens et al., 2003; Papas et al., 2007; Parks & Schofer, 2006). Residents that live in neighbourhoods with greater connectivity have been found to be 80% more likely to walk between 1 and 60 minutes per week or more than 150 minutes per week, than residents that lived in less connected areas (Wilson et al., 2012). Furthermore, the presence of footpaths have been strongly linked to improved human health, particularly due to the increase in active transport and to a reduction in vehicle miles travelled (Reed et al., 2006; Sallis et al., 2009) and, therefore, to a reduction in GHG and air pollutant emissions (Frank et al., 2011; Sciara et al., 2011). In New York, the creation of a pedestrian-only plaza at Times Square was found to have resulted in substantially reduced levels of Nitrogen dioxide (NO₂), thereby reducing pedestrian exposure to vehicle pollution (New York City Department of Health and Mental Hygiene, 2011). A study in Brisbane found that residents living in areas with off-road cycleways, used as walkways, were found to be 69% more likely to walk for more than 150 minutes for transport per week (Wilson et al., 2012). However, a Perth based study found that if greater connectivity is not associated with density and public transport access then

walking does not increase much due to the lack of destinations reachable by foot (Falconer et al., 2010).

The link between mixed land use and physical activity has also been established (Sallis et al., 2011). Increasing the land use mix has a strong association with a reduction in obesity (Frank et al., 2004). This is because the distances required to travel become less. Frank et al. (2004) conclude that each quartile increase in mixed land use results in a 12.2% reduction in the likelihood of obesity across different genders and ethnicities.

Car use and human health

There is a strong link between car use, usually measured in VKT, and obesity levels (Frank et al., 2004; Grabow, et al., 2011; Lindsay, Macmillan and Woodward, 2011). Frank et al. (2004) determined through their analysis in Atlanta that each additional hour spent in a car per day was associated with an increase of 6% in the likelihood of obesity and that each additional kilometre (km) walked per day was associated with a 4.8% reduction in the likelihood of obesity. Furthermore, the relationship between obesity and active travel is an inverse one. Countries that have high levels of active transport, such as The Netherlands and Denmark, have lower levels of obesity, while countries with low levels of active transport, such as the U.S. and Australia, have higher rates of obesity (Pucher & Buehler, 2010).

Public transport use and human health

People who use public transport have been found to be more physically active than those that drive (Frank et al., 2010; Litman, 2010; MacDonald et al., 2010; Wilson et al., 2012) and less likely to be obese (MacDonald et al., 2010). The link between active transport and public transport is particularly important with the modes being integrated and complementary (Agrawal et al., 2008; Gehl, 2010; Newman & Kenworthy, 1999, 2006; Pucher & Buehler, 2010). The U.S. Active Living Research Program (2009) found that 29% of people who use public transport were physically active for 30 or more minutes per day, due primarily to walking to and from public transport stops. In addition, they found that public transport users compared to car users walked 30% more steps per day and spent 8.3 more minutes walking per day. The New York City Department of Health and Mental Hygiene (2011) determined that New York residents who commuted via public transport got almost half an hour more physical activity per day than those who commuted via automobile or taxi. Litman in his meta-analysis determined that on average public transport users spent a median of 19 minutes walking per day (Besser & Dannenberg 2005; Weinstein & Schimek 2005 as cited in Litman, 2010). Wilson et al. (2012) determine that residents living close to public transport are 72% more likely to walk between 1 and 60 minutes per week.

Access to green space and human health

Access to nature plays an important part in the health and productivity of people (Beatley, 2011). People with access to green space within close proximity of their residences perceive their health to be greater than those who do not have easy access to green space and to feel less lonely (Maas et al., 2009). Access to open space is also associated with recreational walking. Adults were found to be more likely to walk 150 minutes or more per week if they lived within 1.6 km of a large and attractive open space (Sugiyama et al., 2010). Guo researching commuter's path choice from public transport stations to work places in downtown Boston determined that commuters were more likely to choose routes that passed through a central public park even if the route was longer (Guo, 2009). Evidence also indicates that living close to places for physical recreation makes people much more likely to use them (Kent et al., 2011), indicating that it is not the size of the green space so much as the location.

There is a growing body of research, summarised in Loftness and Snyder (2008), that determines that views of nature and proximity to windows are linked to "reduced length[s] of stay after surgery, reduced sick building syndrome (SBS), increased performance at task, and overall improved emotional health" (p.120). However, they stress that it is unclear whether the improvement in health and performance is due to the effect of the views, the daylight, the increased air flow or to the increased control of temperature and lighting (which often accompanies being close to a window). Access to natural daylight (particularly time of day lighting) and access to outside air in particular has been found to have a positive impact on health (Loftness & Snyder, 2008; Seppanen & Fisk, 2002; Ulrich, 2008). Carnegie Mellon University reveals that "natural ventilation and mixed-mode conditioning systems can provide 47-79% HVAC [heating, ventilation and air conditioning] energy savings, 0.3-3.6% health cost savings, and 0.2-18% productivity gains, for an average return on investment of 120%" (Loftness & Snyder, 2008, p.125).

Traffic intensity, air pollution, noise pollution and human health

Traffic intensity is associated positively with noise, stress (tension) and air pollution, and negatively with levels of social interaction, territorial extent, awareness of the street environment, and both perceived and actual safety (Hart et al., 2011; Kelly et al., 2012; Mindell et al., 2011; Sugiyama et al., 2010). Environmental noise can seriously harm human health, and interfere with sleep and daily activities reducing performance at school and work. Road traffic noise has been associated with hypertension, increased stress and disturbed sleep (Jarup et al., 2007; Bodin et al., 2009). WHO (2011a) reported that at least one million healthy life years are lost every year from traffic-related noise in the western part of Europe, mainly due to sleep disturbance and annoyance related to road transport noise. However, it is difficult to separate the health effects of road transport-related noise and air pollution because of the strong spatio-temporal co-variation of certain air pollutants with noise in urban areas (Weber & Litschke 2008; Weber 2009). Both road transport noise and air pollution are often higher at busy street junctions where vehicles brake and

accelerate due to traffic lights and congestion (Barnett et al., 2011; Vardoulakis et al., 2011). However, in a study looking at the combined effects of road transport (de Kluizenaar et al., 2007), noise was found to be still associated with hypertension (in the 45-55 years old group) after adjustment for air pollution. Although the additional health cost of road transport-related noise has not been fully quantified in Australia, it is likely to be substantial.

Road transport accounts for a large proportion of total air pollutant emissions in Australian cities. Motor vehicle engine design, end-of-pipe emission control technologies (e.g. three-way catalytic converters) and improved fuels (e.g. unleaded and low benzene content petrol) have all contributed to reduced atmospheric emissions from cars. As a result, exposure to certain road transport-related toxic pollutants, such as lead, benzene and carbon monoxide (CO), has substantially decreased in developed countries in the last twenty years (Cowie et al., 1997). However, the ever increasing volume of private cars, the trend towards larger and heavier cars, and the expanding VKT in urban areas have eroded the environment gains from technological improvements in this sector.

The adverse health effects of airborne particulate matter have been well-characterised in several epidemiological studies focusing on short- and long-term exposure effects of different particle size fractions. For example, the large American Cancer Society (Pope et al., 1995; Pope et al., 2002) and the Harvard Six Cities (Dockery et al., 1993) cohort studies have reported a strong association between annual concentrations of particles of less than 2.5 micrometre (PM_{2.5}) and mortality in U.S. cities, with more recent European studies broadly confirming this association (COMEAP 2009). In addition, a large number of time-series studies have shown an association between particles of less than 10 micrometre (PM₁₀) (and other pollutants) and daily mortality in North America, Europe and Asia (Katsouyanni et al., 1996; Wong et al., 2008; Bell et al., 2005). The transferability of these studies carried out in other continents can be assessed by reviewing the findings of local epidemiological studies. To this end, we carried out a systematic review of studies focusing on transport-related air pollution in Australian cities.

The systematic review identified sixteen air pollution epidemiology studies carried out in Australia. Their findings, broadly consistent with those from large epidemiological studies conducted in North America and Europe, show: (a) positive association between particulate matter (PM) and daily mortality and respiratory hospital admissions (Simpson et al., 2000; Simpson et al., 2005; Simpson et al., 1997; Morgan et al., 1998a; Chen et al., 2007), (b) positive association between ozone (O₃) and daily mortality and respiratory hospital admissions (Simpson et al., 1997; Petroschevsky et al., 2001), (c) positive associations between NO₂ and daily hospital admissions (although this may reflect the impact of PM) (Morgan et al., 1998b; Barnett et al., 2006), (d) positive association between exposure to road transport-related air pollution and daily emergency department attendances for childhood asthma (Cook et al., 2011; Pereira et al., 2010; Rennick and Jarman 1992;

Jalaludin et al., 2000), (d) suggestive evidence of positive association between exposure to road transport-related air pollution and negative birth outcomes (Barnett et al., 2011; Mannes et al., 2005; Jalaludin et al., 2007; Pereira et al., 2011). These studies highlight the negative impact of transport air pollution on human health indicating that this is an important indicator to model.

Many studies use the distance from major roads as an indicator of potential exposure to road transport-related air pollution when modelling the impact. A recent report of the U.S. Health Effects Institute (HEI 2010) summarising evidence from a wide range of field studies, identified an exposure zone (up to 300-500m from a major road) as the area mostly affected by road transport-related emissions. This is consistent with studies carried out in Australian cities (Barnett et al., 2011; Hitchins et al., 2000; Cheng et al., 2010). Traffic management interventions (e.g. parking and stopping restrictions, redistribution of road space, park and ride schemes) are likely to have a positive impact on reducing potential exposure to road transport-related emissions and on population exposure levels within this zone (Vardoulakis et al., 2008). Broader scale interventions, such as improved fuel and vehicle engine technologies, are expected to reduce potential exposure to road transport-related emissions at a much wider area.

Traffic accidents and human health

Results of studies that determine the rates of pedestrian and cyclist accidents that result from urban form changes are mixed. Woodcock et al. (2009) modelled the changes in transport use towards increasing physical activity using a linear relationship between distance travelled by pedestrians and motor vehicles and risk of injury. They assumed that a doubling in the distance walked resulted in a doubling in the risk of injury. They also assumed that if the distance driven was halved the risk of injury to pedestrians was halved. Other research, however, reveals that the relationship between the numbers of people walking or bicycling and the amount of accidents with motorists is not linear (Litman, 2010). Pucher and Buehler (2010) maintain that injury and fatality rates per trip and per km decrease dramatically as cycling and walking rates increase. Furthermore, they determine that countries with low levels of walking and cycling have higher fatality and accident rates than countries with high levels of bicycling and walking. From this finding, they conclude that increasing levels of walking and cycling in Australian cities could result in less cycling accidents, especially if the increase coincided with a coordination of infrastructure and policies aimed at enabling safe and convenient active travel.

Perception of an area and human health

The ability of the urban form to be conducive to active transport is not purely related to an area's physical attributes but is also related to the perception of the area as being walkable. Areas that are perceived as walkable have been found to result in increased levels of health (Eisenstein et al., 2011). Gebel et al. (2011) determined

that residents of areas that are objectively measured as walkable that perceive their area as having low walkability have significantly lower levels of walking for transport than residents whose perceptions matched that of the objective measures, perhaps due to safety issues. A before-and-after study of improvements to an area, including the implementation of a light rail line (LRT), showed that more-positive perceptions of an area resulted in an average of a -0.36 lower Body Mass Index (BMI), 15% lower odds of obesity, 9% higher odds of meeting weekly recommended physical activity (RPA) levels through walking and 11% higher odds of meeting RPA levels through vigorous exercise (regardless of whether the person used the LRT line) (MacDonald et al., 2010).

Economic value improved through healthy environments and active transport

The research that looks at the health costs of different urban forms is very limited. Much of this lack of literature is due to the complexity of the calculations needed and the large number of assumptions that have to be built into such calculations. There are a few studies that quantify the health from reduced air pollution and increased physical activity and monetary benefits of replacing short car trips with a bicycle trips. This section presents the results of these studies.

The health (from reduced air pollution and increased physical activity) and monetary benefits of replacing 50% of short car trips (those <4 kms one-way) with a bicycle trip, equating to a 10% reduction in VKT, was quantified by Grabow, et al. (2011) for 11 Midwestern urban areas in the U.S. with a combined population of 31.3 million people. The estimated results of this change in travel behaviour was a mortality decline of 1,100 deaths per year and a combined benefit of improved air quality and increased physical activity resulting in a net health benefit of over \$US7 billion per year, equating to approximately 2.5% of the health care costs of the region. A study in New Zealand by Lindsay, Macmillan and Woodward (2011) determined that a shift of 5% of VKT to cycling would reduce vehicle travel by approximately 223 million kms each year, saving about 22 million litres of fuel and reducing transport-related GHG emissions by 0.4%. Furthermore, they determined that the 5% reduction in VKT would result in 116 fewer deaths per year due to increased physical activity, six fewer deaths due to local air pollution from vehicle emissions and 5 more cyclist deaths due to road accidents. They concluded that the combined savings from air pollution and avoided deaths would be NZ\$200 million per year. Stokes, MacDonald and Ridgeway (2008) developed a model to quantify public health benefits of a new light rail transit system in Charlotte, North Carolina. Using estimates of future riders, the effects of public transport on physical activity and obesity rates, they estimate future public health cost savings determining a cumulative public health cost savings of \$12.6 million over nine years. Rabl and de Nazelle (2012) calculate the health benefits from switching to cycling from driving as 1300 Euro (€) per year for a cycling commute of 5km (one way) 5 days per week, 46 weeks per year. Furthermore in a city of plus 500,000 people the value of the associated reduction in air pollution is 30€ per year. These studies show that the health savings are substantial and when

combined with the health outcomes have implications that are not yet fully understood or accounted for.

Several studies have attempted to estimate the cost of air pollution in high income countries. The health cost of ambient air pollution in the Greater Metropolitan Region (GMR) of Sydney was reported in a study published by the NSW Department of Environment and Conservation (DEC 2005). Using PM_{10} as an indicator, this study estimated the cost of air pollution to be between \$1.66 billion and \$15.21 billion per annum (if the health impacts of PM_{10} are estimated without a threshold), including the cost of life lost, the cost of illness and the cost of productivity losses. Given the contribution of motor vehicles to the total anthropogenic PM_{10} emissions in the Sydney region, the annual health cost of road transport-related PM_{10} in the GMR of Sydney was estimated to be between \$105 million and \$990 million. It should be noted that this is a conservative estimate since air pollution from motor vehicles is emitted close to the ground in densely populated areas (where many people are exposed) and is therefore likely to have a disproportionately large impact on population health compared to other emission sources. Amoako et al. (2003) estimated a substantially higher health cost of motor vehicles emissions in Sydney (between \$496 million and \$4.7 billion per year).

Comparison between a high walkability urban environment and a low walkability urban environment

Some urban form types fit the requirements for an active transport lifestyle as set out above. A comparison between a 'high walkability urban environment' and a 'low walkability urban environment' is made (see Chart 1) building on prior work by Trubka et al. (2010) to demonstrate the kind of monetary value associated with both kinds of urban form and associated lifestyles.

Trubka et al. (2010) examined the health and productivity costs of different urban development forms using a cost-of-illness approach. To do these calculations, Trubka et al. (2010) estimated that Australia's indirect health cost of physical inactivity due to car dependence would be \$AU1.78 billion. This would make the total cost of inactivity \$3.82 billion, and the total value of all Australian adults meeting recommended activity levels \$6.1 billion. Furthermore, they found that productivity increased by 6% when walking increased due to urban form improvements. This increase in productivity was from the enhanced physical and mental wellbeing due to increased walking.

From these calculations, a comparison between a 'high walkability urban environment' modelled on a Transit Oriented Development (TOD) to a 'low walkability urban environment' modelled on a conventional low-density suburban development, both of 1000 dwellings, was made. Using the Australian weekly earnings average of \$AU1165.40 as the baseline level of productivity, Trubka et al. (2010) calculate that an average development of 1000 dwellings with an average of

1.83 adults of over 18, a reduction in absenteeism would accrue “an annual average of \$489.47 per person” per year and an increase in productivity would result in an additional \$3,468.23 per person per year in benefit (p.8). For an urban development of 1000 dwellings structured towards active-travel “where 19% more of the population meets their minimum physical activity requirements, these values surge to \$170,420 and \$1,207,550 per annum respectively, with a total annual health benefit of \$1,377,970” (Trubka et al, 2010, p.8). They pursue this further for a 50-year development time span using rates of increase of 3%, to discover that the total value would be “\$4,384,900 and \$31,070,000 for absenteeism and presenteeism respectively” for a total of \$35,454,900 for the productivity-related health benefits (p.8). These are substantial economic benefits from having an urban form geared towards active travel. They considerably outweigh the savings due to increased physical activity and reduced health cost reductions from active travel.

Chart 1 first provides a summary of transport and land use characteristics and then provides infrastructure costs, transportation costs, greenhouse gas emissions costs, and health costs related to activity levels. The calculations, from Trubka et al. (2010), for health are done by placing a value on an hour of moderate intensity activity per person, looking at adult Australians (approximately 15.4 million people in 2006), 1.83 people per dwelling, 30 minutes of moderate activity per day and 19% more walking in walkable neighbourhoods and cycling trips as 21% of walking trips. The estimated savings benefit due to increased physical activity levels in an active travel neighbourhood was calculated for a development of 1000 dwellings as:

Walking at 45,263 hours x \$3.02/hr = \$136,694

Cycling at 9,505 hours x \$3.02/hr = \$28,706.

Total \$164,399

Chart 1 shows that when comparing the difference between high walkability urban environments and low walkability urban environments:

1. Infrastructure (regional power, water, sewer, and social infrastructure) and transport costs (mainly time and congestion costs) dominate and should be seen as a rational basis for changing our priorities towards more walkable urban environments. It should not need any other rationale.
2. Greenhouse gas emission costs are small unless social costs are considered, and then they become substantial but still lower than the infrastructure and transport costs. They are cumulative however and will become more important in future.
3. Health costs are very small if considered to be those related to sickness but health-related productivity gains are substantial and should be the focus of the extra rationale for changing our urban form and transport priorities. They are also additive to the other costs and together provide a powerful rationale for making more walkable urban environments.

Chart 2 provides a list of the functions and sources used to compile the table.

Conclusion

This review has attempted to investigate some of the urban form characteristics that can be measured when looking at health impacts of different urban transport and related land use form types, determining that the health benefits, and subsequent economic benefits, of walkable, transit orientated urban form have been well established and are measurable. This review has provided the first stage of a project looking at modelling the health impacts of urban form and transportation options (with an emphasis on Australia) identifying that density and mixed land use, vehicle miles travelled, access to public transport, access to green areas, transportation related air pollution levels, transportation related noise levels, are all measureable and important. Developing indicators to predict the safety for pedestrian and cycling from different urban forms is obviously very dependent on other measures than just simply looking at possible increases in distance travelled by those modes.

The economic impacts of transport and land use decisions can be determined. The comparison between a high walkability urban environment and a low walkability urban environment identified that infrastructure and transport costs dominate. Greenhouse gas emission costs are small unless the social costs are considered, and then they become substantial but still lower than the infrastructure and transport costs, though they are cumulative and will become more important in future. The health costs are relatively small if considered to be those related to sickness however health-related productivity gains that are associated with highly walkable urban areas are substantial. Increased productivity considerably outweighs the savings of increased physical activity and reduced health cost reductions from active travel alone. Furthermore these productivity gains are additive to the other costs and together all of these costs provide a powerful economic rationale for developing urban forms geared towards active travel.

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	High Walkability Urban Environment (HWUE)	Low Walkability Urban Environment (LWUE)	Difference
Per person per year			
Transport and Land use Characteristics			
NOTE: Typical characteristics for an Australian City.			
VKT per person per day	3-13 km	20-35 km	
Car trips per person per day	2.32	3.39	
Transit trips per person per day	0.56	0.165	
Transit accessibility	more than 80% w >15min service	less than 15% w >15min service	
Walk/Cycle trips per person per day	2.115	0.945	
Distance to CBD	less than 10 km	more than 40 km	
GhG per capita daily (CO2 -e)	0 to 4 Kg	8 up to 10 Kg	
Activity density	> 35	< 20	
Infrastructure Costs			
Roads	\$5,086.56	\$30,378.88	\$25,292.32
Water and Sewerage	\$14,747.62	\$22,377.46	\$7,629.84
Telecommunications	\$2,576.11	\$3,711.85	\$1,135.74
Electricity	\$4,082.12	\$9,696.51	\$5,614.39
Gas		\$3,690.84	\$3,690.84
Fire and Ambulance		\$302.51	\$302.51
Police		\$388.42	\$388.42
Education	\$3,895.46	\$33,147.27	\$29,251.81
Health (Hospitals, etc.)	\$20,114.87	\$32,347.33	\$12,232.46
Total Infrastructure	\$50,502.74	\$136,041.07	\$85,538.33
Transport Costs			
Transport and Travel Time	\$206,542.06	\$342,598.10	\$136,056.04
Roads and Parking	\$46,937.54	\$154,826.10	\$107,888.56
Externalities	\$2,219.88	\$9,705.38	\$7,485.50
Total Transport	\$255,699.48	\$507,129.58	\$251,430.10
Greenhouse Gas Emissions Cost			
Offset Cost (\$25/t)	\$2,500.00	\$5,400.00	\$2,900.00
Social Cost (\$215/t)	\$21,500.00	\$46,440.00	\$24,940.00
(NB. not included in total)			
Total Greenhouse	\$2,500.00	\$5,400.00	\$2,900.00
Physical Activity Costs			
Inactivity costs*		\$4,229.95	\$4,229.95
Productivity Loss		\$34,454.90	\$34,454.90
Total Activity Costs		\$38,684.85	\$38,684.85
Total (excluding social cost)	\$308,702.22	\$687,255.50	\$378,553.28

*Includes social costs and direct and indirect costs and obesity costs.

Chart 1 – Comparison between a high walkability urban environment and a low walkability urban environment in Australia (costs in \$AUS). Source: Authors building on Trubka et al., 2010.

Functions and sources used in establishing the costs.	
Transport and Land use Characteristics	
VKT per person	Extrapolated from Chandra (2005) using ‘Total Car Energy Use’, ‘Total GHG’, ‘Per Capita GHG’, and ‘Population’ to determine a Daily Total VKT and then a ‘Daily Per Capita VKT’.
Car trips per person per day	Based on Melbourne. Source: Kenworthy and Newman (2000).
Transit trips per person per day	Based on Melbourne. Source: Kenworthy and Newman (2000). US Active Living Research Program (2009) 29% of people who use public transport were physically active for 30 + minutes per day, due primarily to walking to and from transit stops and transit users compared to car users walked 30 % more steps per day and spent 8.3 more minutes walking per day.
Transit accessibility	Transit accessibility relates to the proportion of land within an urbanised area that is within 400m of a full-service bus or tram, or within 800m of a train station. ‘Full-service’ is defined as a route operating seven days a week with at least four services per hour on weekdays and Saturdays during the day and two services per hour on Sundays and holidays.
Walk/Cycle trips per person per day	Based on Melbourne. Source: Kenworthy and Newman (2000).
Density	Walkable areas had + 30 mins exercise per week.
Distance to CBD	
GHG per capita daily (CO2 -e)	$Y = [0.073 (\text{Distance to CBD}) - 0.25 (\text{Transit accessibility}) + 4.35]$
Activity density	Jobs plus residences. Frank et al. (2004) conclude that each quartile increase in mixed land use results in a 12.2% reduction in the likelihood of obesity across different genders and ethnicities.
Intersection density	Permeable=250 intersections within one square mile
Infrastructure Costs	
Roads	ABS (2008) and WAPC (2001)- weighted inflation rate from the Consumer, Producer and Labour Price Indices. WAPC (2001) comparative costs.
Water and Sewerage	
Telecommunications	
Electricity	
Gas	
Fire and Ambulance	
Police	
Education	
Health (Hospitals, etc.)	
Transport Costs	
Transport and Travel Time	Newman and Kenworthy, 1999- weighted inflation rate from the Consumer, Producer and Labour Price Indices, where possible.
Roads and Parking	
Externalities	
Greenhouse Gas Emissions Cost	
Offset Cost (\$25/t)	2007. $\text{GHG} = (365 \text{ days/yr})(\text{price/kg CO}_2\text{-e}) (\text{No. of dwellings})(\text{Inhabitants/dwelling}) (0.073x - 0.25z + 4.35)$
Social Cost (\$215/t)	UK Government Economic Service \$175 in 2000, = \$217 in 2007
Physical Activity Costs	

Healthcare Costs Obesity (inactivity)	Direct: \$1.5 billion (Econtech, 2007) = cost of inactivity. 54.2 % of Australia's over 18 population is inactive. Therefore \$2.8 billion is the cost associated with an inactive population. Indirect: Health Canada's Economic Burden of Illness (1993) appropriates 54.3 % of the total cost of illness to indirect health = Estimate Australia's indirect cost of inactivity at \$1.78 billion, the total cost of inactivity at \$3.28 billion.
Productivity Loss	2.1 day reduction in workdays lost due to illness, stress, or waning workplace satisfaction (absenteeism) and 6.2% increased ability for employees to focus on tasks and maintain focus for longer periods of time (presenteeism or on-the-job productivity) based on averages from Shephard (1992) and Lechner and de Vries (1997). Using Australian weekly earnings average of \$AU1165.40 as the baseline level of productivity, and an average development of 1000 dwelling with an average of 1.83 adults of over 18.

Chart 2 – Functions and sources used in establishing the costs in the comparison between a high walkability urban environment and a low walkability urban environment in Australia. Source: Compiled by the Authors.

Urban Ecology and the Future of Cities

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Urban Ecology and the Future of Cities

Abstract: The role of ecology in a sustainable future is prominent in the media, academic writing and political decisions; as such environmental pressures, as well as economic, social and political, increasingly influence planning for the future. This paper looks at how this translates into the process for planning future cities – highlighting gaps in knowledge and issues of implementation. It draws on interdisciplinary sources to explore three main elements of the debate: What is urban ecology and why is it important to sustainable cities?; What gaps are there in the ecological knowledge of planners and policy makers and why are there gaps?; and How can urban ecology be integrated into the planning of future sustainable cities?. This paper does not aim to provide a definitive answer to the problem; rather it addresses the first two areas and identifies potential directions for the third. It takes Australia, as national, Victoria, as regional and Geelong, as local, points of reference.

Keywords: *Urban ecology; Biodiversity; Future cities; Sustainable development; Urban planning*

Introduction

Political, social, economic and environmental pressures are increasingly influencing planning for the future. Sustainable cities and environmentally sensitive urban development are the focus of many academic and practitioner reviews, where the gaps in the knowledge between urban design and planning and the principles that govern natural ecology are often highlighted. Existing policies and new legislation refer to the need to integrate ecology into the decision process, and strategy and vision documents have increasing input from environmental sources. But to what extent does the theory that this knowledge is integral to planning for the future penetrate into Australian practice of decision making and urbanization; and if it does not, why not?

Urban areas are fundamental to economic, social, cultural and spiritual enrichment. However, increased urbanization almost always exploits natural resources and damages the natural environment in an unsustainable way. This is of global concern as urban settlements currently house 51% of the world's population, with the trend indicating that this will continue to increase (Figure 1: World Bank data, <http://data.worldbank.org>); in Australia the urban population is 89% and rising.

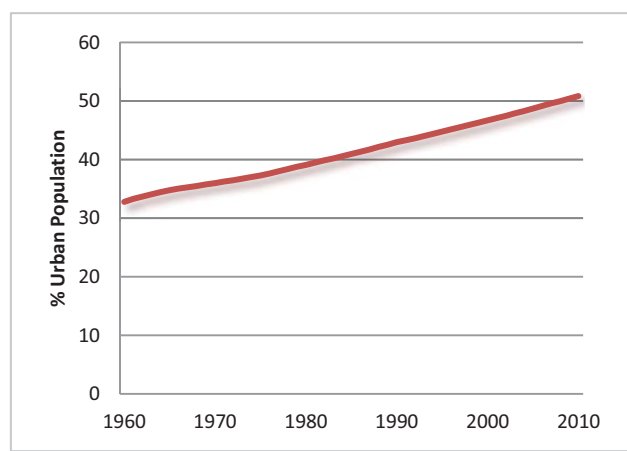


Figure 1: Global urban population growth 1960 – 2010; compiled from World Bank Data

Consequently the management of existing and proposed urban areas is an increasingly important issue, and the transformation of cities to sustainable entities requires the cooperation of all levels of government, the business sector (including planners and designers), community groups and residents. Improving the sustainability of cities will not only benefit the local inhabitants, but also contribute to improving the global situation – both environmentally and economically. Australia's per capita ecological footprint¹ c.2007 was (and continues to be) one of the largest in the world, in the world top ten – 6.9gha (Global Footprint Network, 2010; figure 2). Without stabilizing the ecological footprint there will come a point, in the not too distant future, when the demand will outstrip the biocapacity.

¹ A country's ecological footprint is a standardized measure of the human demand placed on the Earth's ecosystems. It represents the region of biological productivity necessary to supply the resources a human population consumes, and to assimilate the associated waste. It calculates the contrast between demand for natural capital and the planet's ecological capacity to regenerate.

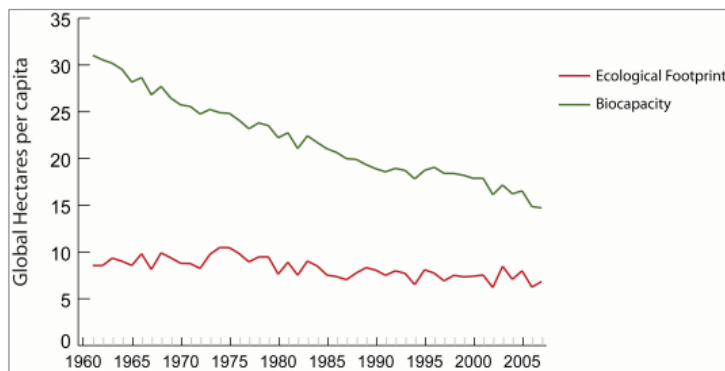


Figure 2: Per-person resource demand (Ecological Footprint) and resource supply (Biocapacity) in Australia since 1961

Urban areas accommodate not only humans, but a myriad of diverse biota and abiota – they are highly human-influenced biomes (see terms below).

Maintenance of this ecology is essential not only for the recognised value to residents as recreational areas and for

enhanced property prices (Tryäinen, 1997), but also its intrinsic value (Niemelä, 1999a); all living creatures, including humans, require the life support systems which are maintained and created by biodiversity (for example oxygen, water and food sources). The diversity of the activities conducted by human users of urban areas can create and maintain a wide variety of habitats and biodiversity, with urban landscapes potentially hosting rare and threatened species (Shepherd, 1994; Eversham *et al*, 1996); at the same time, increased destruction of ‘green’ areas through urbanization and development can destroy much of the biodiversity. In Australia, more than 1,700 species and ecological communities are under threat or at risk of extinction (DSEWRaC, 2010). This is only the tip of the iceberg, for every known species that is placed on the ‘at risk’ register there are many more that are affected by destruction of habitats and other threats. In order to maintain urban biodiversity and counteract the effects of urban growth, while presenting a sustainable ‘future city’, it is essential that there is integration of ecological knowledge into urban planning (for example: Niemelä, 1999a; Hokkanen & Kojo, 2003).

A review of urban planning policy and ‘vision’ documents confirms the conclusions of academic literature: that there is a gap in the knowledge available on urban specific ecology, more importantly, perhaps, there is also poor dissemination of the information that is available among environmentalists, planners and decision makers. And, where this information is available and presented, it may not be in an accessible or complete form and that can lead to it being downplayed or ultimately disregarded in the planning process. The political nature of the planning process is also evident, where pressure from media attention, local community, homeowners and voters influences (to an extent at least) the decisions made (for example: Budhya & Benjamin, 2000; Yli-Pelkonen, 2008).

There is an abundance of academic and policy literature surrounding this topic (and variations on it) dating back over two decades and a commitment to ecological sustainability is embedded in national and international policy. However, even with extensively articulated plans for the management and maintenance of biodiversity in most of Australia’s (and international) policy/resource plans, these commitments have not stopped the decline in biodiversity. It should be noted that many of these

‘umbrella’ policies are related to regional or national biodiversity; there is often not specific mention of the preservation or control of urban biodiversity. This paper highlights three areas that need to be explored further:

- What is urban ecology and why is it important to sustainable ‘future’ cities?
- What ecological gaps are missing in the knowledge of urban planners and why do these gaps exist?
- How can we begin to bridge these gaps?

This paper aims to answer the first two, and to propose some preliminary ideas for the third.

What is urban ecology and why is it important?

Terms and Concepts

One aim of this paper is to bridge the gap between scientific and practitioner knowledge bases and disciplines. It is important that academics, practitioners and decision makers are able to explore the material presented here with common understanding. The following definitions, however, are necessarily simplified and in no way aim to cover every scientific or practitioner application.

Urban Ecology

The first question posed in this paper is ‘what is urban ecology?’ And, for that matter, what do we actually mean by ecology as a general term? In order to define this concept it is first necessary to clarify the constituent words – ‘urban’ and ‘ecology’.

The term ‘urban’ is used differently by social and natural scientists (and possibly academics and practitioners). In this context ‘urban’ is taken as a specific category of human community, comprising residential, industrial and commercial districts, a relatively high density of people and varied activity. This broad definition, as used mainly by ecologists, is well suited to a study of urban ecology, it being difficult to define strict boundaries around urban areas (Niemelä, 1999b). Parallels are drawn here to Forman and Godron (1986) who divide landscapes into five broad categories – spanning the continuum from pristine natural areas to urban centres that have been highly modified by humans (Figure 3). Despite the obvious differences between these categories there are no definite boundaries between them; there is overlap between the zones and patches of other types may occur in any of these areas (Forman and Godron, 1986). For example, due to urban spread, including daily commuting for work, areas which were traditionally understood to be rural are touched by a so-called ‘urban lifestyle’, and as such it is difficult to draw a sharp boundary between rural and urban areas.

Pristine natural landscapes	Managed landscape	Cultivated landscapes	Sub-urban landscape	Urban landscape
Natural landscapes support a matrix of mostly unplanted and unmanaged native biota	Consists of largely planted and/or managed native or non-native species	A matrix of agricultural land that can either be crop or grazing land	Low to moderate density housing, yards, open spaces and roads	This represents the most intense human influence; a matrix dominated by high-density residential and commercial building, roads and other paved surfaces

Figure 3: Urban-to-rural continuum (Forman and Godron, 1986); Adapted from Niemelä, 1999a, p.120-1

For the purposes of this paper, the concept of ‘ecology’ uses a combination of definitions, drawn from scientific sources and acknowledging or incorporating three different meanings as put forward by Haila and Levins (1992); shown in Figure 4, below.

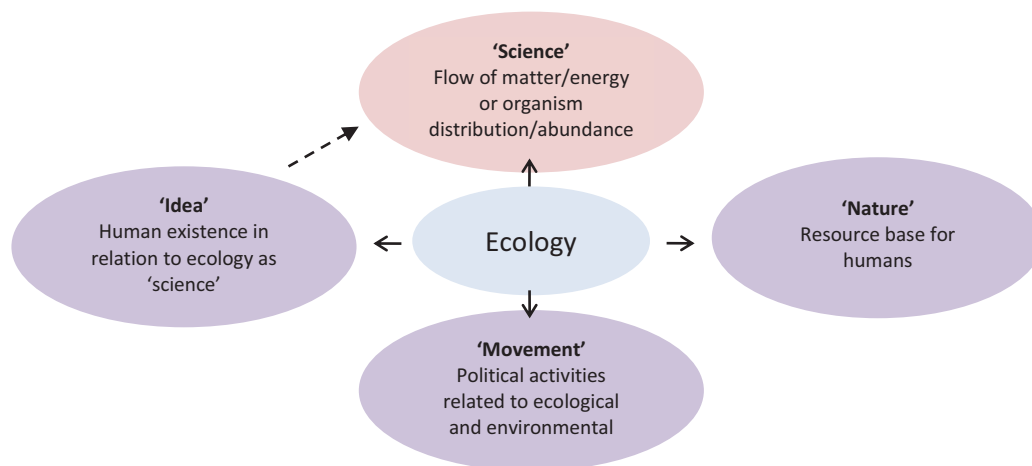


Figure 4: Four distinctions of ecology; Adapted from Niemelä, 1999a

It is important to note that ecology is often seen by those who are not ecologists to be linked more closely to the other three concepts than to the science-oriented definition (Niemelä, 1999a). This makes integration of ‘ecology the science’ into planning for sustainable future cities a potential challenge (Trepl, 1995). From a scientific perspective, ecology can be seen as an all-embracing term – it relates to biodiversity (the total variety of life on earth), biomes (regions of the Earth’s surface

which contain a typical or ‘major’ ecosystem), biotopes (generally small areas of homogenous environmental conditions), species and genetics. Ecology is not static; it is adaptive and changeable. It can be increased by evolutionary processes and genetic change, or reduced by various threats including human interaction and climate change. This paper adds to this definition by encompassing ‘environmental information’ (Yli-Pelkonen and Niemelä, 2005) where not only are the above features taken into account, but also the physical characteristics of soil, land-density, water-balance etc. There is also scope, and need, for contributions by local residents and nature enthusiasts – termed ‘common ecological knowledge’ by Yli-Pelkonen and Niemelä (2005).

With these definitions in mind we define ‘urban ecology’ as used in this paper (figure 5) as the study of ecological, environmental and common ecological knowledge within cities and towns; for planning purposes, elements of social sciences (Pickett *et al*, 1997a; Niemelä, 1999b; Grimm *et al*, 2000; Kinzig and Grove, 2001) and urban planning or political approaches (Sukopp, 1998) are also included.

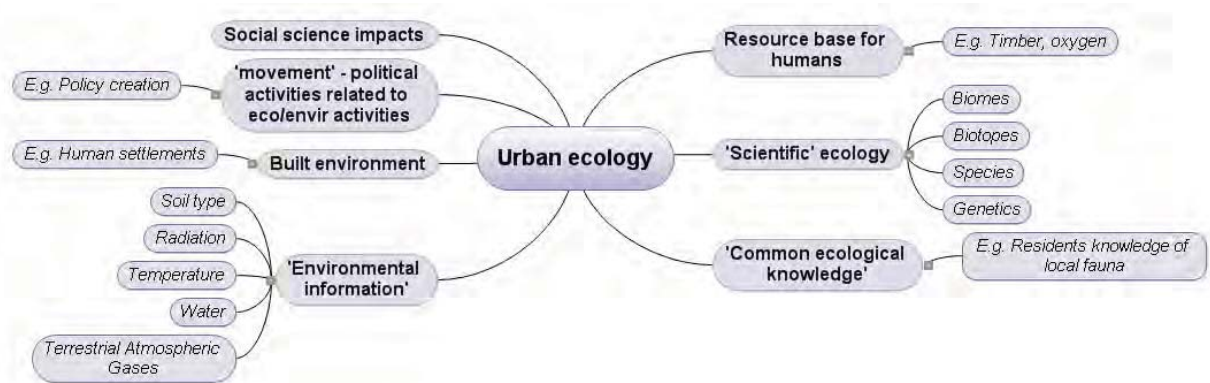


Figure 5: An encompassing definition of urban ecology as used in this paper

Sustainable development

The term sustainable development has become widely used in relation to planning for the future; for this paper the definition from the World Commission on Environment and Development (WCED, 1987) is used: *‘a development that meets the needs of the present generation without compromising the needs of future generations’*. This succinct definition summarises what should be an essential element of the planning process – that it is not possible to achieve ecologically sustainable development without ensuring that it is also socially sustainable and, importantly, the converse is also true (Redclift, 1993). As used here, sustainability is seen as the end goal in a process for improved urban development, including integration of urban ecological, social and socio-economic factors.

Importance of urban biodiversity

Natural environments enrich culture, sport and recreation, artistic and spiritual well-being, and also have direct financial implications. This is shown particularly in the increase in property values by the addition of green spaces and recreation areas (Vadruff *et al*, 1995; Tyrväinen, 1997; Bolund & Hunhammar, 1999; Niemelä, 1999a; Lankinen & Sairinen, 2000; Korpela *et al*, 2001; Adams, 2005; Yli-Pelkonen & Niemelä, 2005; and Yli-Pelkonen, 2008). Biodiversity is important not only for human users, but also for the intrinsic value of the biota and abiota. Australian biodiversity developed/ evolved in isolation over many years, leading to the formation of one of the most biologically diverse places on the planet. Australia is estimated to be home to around 560,000 species, many of which do not exist anywhere else, for example 87% of its mammal species and 92% of its higher plants. This diversity feeds back into positive implications for human users, for example through increased tourism on the Great Barrier Reef.

What gaps are there in the ecological knowledge of urban planners and why do these gaps exist?

The above section addresses the first key theme of this paper, exploring the definitions of urban ecology and related terms and concepts; it also explains the importance of these to planning for a sustainable future of urban areas. This section answers the second theme of gaps in the knowledge of planners and policy makers – exploring what forms these gaps take, and why. The scope of this paper is such that only a selection of Australian literature is reviewed, focused on the Victoria region, it is noted however that many policy and educational documents, nationally and internationally, contain a degree of consistency in the information being presented and the stated purposes – this is partially due to the constraints of the umbrella government policies (such as the Biodiversity and Geological Conservation – Statutory Obligations and their Impact Within the Planning System, UK Office of Deputy Prime Minister, 2005; or the Environment Effects Act 1978, Victoria, Australia).

Current planning practice

To review planning processes on a global scale would constitute a paper in its own right; it is not the aim to conduct this review here, however, in looking at the integration of ecology into planning for future sustainable cities it would be foolish not to mention at the very least a small sample of planning processes to clarify the actual process of integrating ecology in the decision making system. The sample was taken

from several cities both analogues and larger cities than Geelong, from the USA, Canada, Asia, South Africa and the UK².

What gaps exist in the ecological knowledge of planners and policy makers?

There are several suggestions in the literature as to what needs to be explored in the knowledge of urban biodiversity but, for the purposes of this discussion, there are two which we suggest are requirements for contributing to successful planning of sustainable future cities – What ecology exists in cities? and What ecological processes are important in urban biomes? As this is not a scientific paper on the ecology of urban areas this will not be answered fully here; what is addressed,

however, is why this information is important to planning and design.

It is important that there is a focus on a better understanding of ecology in urban areas (Niemelä, 1999a) and generating summaries of urban areas by species type, age of species etc. Allowing this information to be widely available would clear the way for comparative studies of urban areas and for increasing

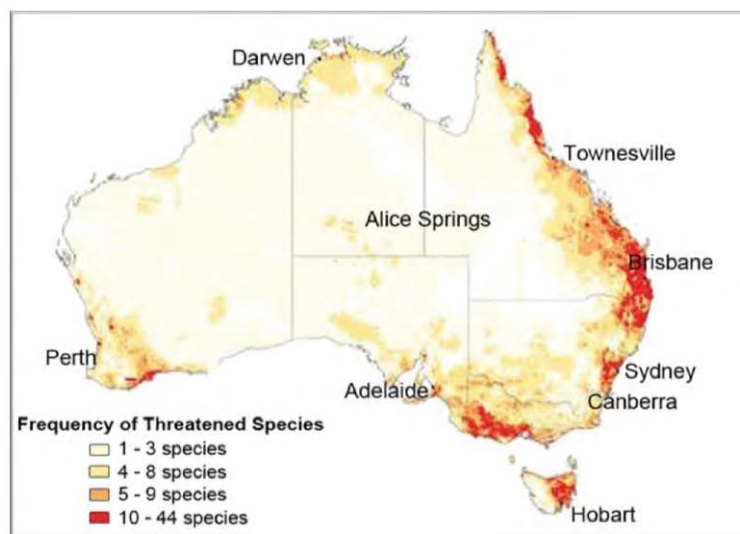


Figure 6: Distribution of species listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999.

community engagement (essential in any move towards sustainability). The question of the importance of what nature exists in cities is explored further by Shephard (1994), Eversham *et al* (1996), Niemelä (1999a) and Yli-Pelkonen & Niemelä (2005). Knowledge of what exists in areas designated for development or increased urbanization becomes especially important when remembering that more than 1,700 species and ecological communities in Australia are at risk of extinction (DSEWPoC, 2010), with urban areas known to be home to some of these. Looking at Figure 6, it can be seen that the highest concentrations of endangered species/ecosystems are located around the most urbanised areas and regions of highest population i.e. Melbourne, Sydney and Brisbane. In each of these areas there are 10-44 species listed as threatened under the Environment Protection and Biodiversity Conservation Act (1999) – but, although statistics state that these areas are prevalent with biodiversity, there is no readily accessible databank on the urban ecology of these

² Planning policy and urban growth strategies reviewed from Australia – Victoria (regional planning), Geelong (local planning); UK – Liverpool, Southampton; USA – Baltimore (MD), Bellingham (Washington), Washington (DC); Canada – Kingston (Ontario); Malaysia - Kuching (Sarawak); and South Africa – Port Elizabeth, Cape Town. Links to the original documents are provided in the bibliography section. Chosen using the criteria – proximity to a waterfront and major urban area, university presence, and where possible having similar demographics.

areas. National urban biodiversity accounting has the capacity to play an important role in exploring how much biodiversity exists and how it is faring. Australia's Biodiversity Conservation Strategy (ABCS) 2010-2030 notes that these accounts could support public policy and education, as well as increasing public awareness and backing for conservation strategies. Not only is this data important to planning and urbanization, but by having accurate data it would be possible to ensure that the intrinsic value of urban (and national) ecology is reflected in a realistic fashion alongside social and other national indicators – therefore providing a more comprehensive picture of Australian biodiversity.

Once it is known exactly what exists in urban areas, it will be possible to explore the key processes in maintaining and creating these biomes/biotopes (Trepl, 1995; Rebele, 1999; Niemelä, 1999a; and Yli-Pelkonen and Niemelä, 2005). With this knowledge of *what* and *how* urban biodiversity exists it would be easier and more practical to approach the question of how to maintain this diversity and as such what processes need to be put into place to assure the survival of urban ecologies. Recognising that knowledge is limited should not mean action to prevent biodiversity degradation is postponed, rather that a precautionary principle should be adopted, as discussed in the ABCS – where it is suggested that the precautionary principle be adopted while employing an adaptive management approach based on practical experience and new scientific research.

Exploring the cause of these gaps

We have explored the gaps in knowledge of urban biodiversity, which in themselves would make it hard to integrate ecology into the planning process; but academic research also suggests that not only is the information not available, but where it exists there may not be adequate tools for integrating biodiversity and ecological information into the system (Maijala, 2000). When information is presented to planners or decision makers it often contains substantial scientific jargon that potentially cause the information not to be readily accessible to a lay-person and none but the most dedicated of planners or decision makers will work their way through the documents to glean the relevant information.

Following on from this, current inclusion of ecological knowledge into planning and management tends to be weak and political (e.g. Douglas, 1992; Sukopp & Numata, 1995; Niemelä, 1999a; Tonn *et al*, 2000; Yli-Pelkonen & Niemelä, 2005; and Yli-Pelkonen & Niemelä, 2006). The information is perceived to be used more when it is of use to the local body making the decisions - 'ecological information becomes more important if there are significant conservation values connected to a plan area, contacts and appeals from plan participants, strong media attention or if a decision maker focuses more on the issue due to personal interests and values' (Yli-Pelkonen, 2008). The same is also true, potentially, of planners and designers – historically there has been a tendency to promote the development of cities at whatever cost to ecosystems. In order to expand or create cities humans have

cleared rainforests, levelled mountains, destroyed habitats, and polluted rivers and the even the air we breathe (Campbell, 1996).

There are some basic [divergent] properties of planning (shown in figure 7) which in themselves need to be confronted in order to move forward to a sustainable future where urban ecology is integrated into the planning process. It is interesting to note the triangle of conflicting goals for planning as put forward by Campbell (1996) continues to be relevant over two decades later.

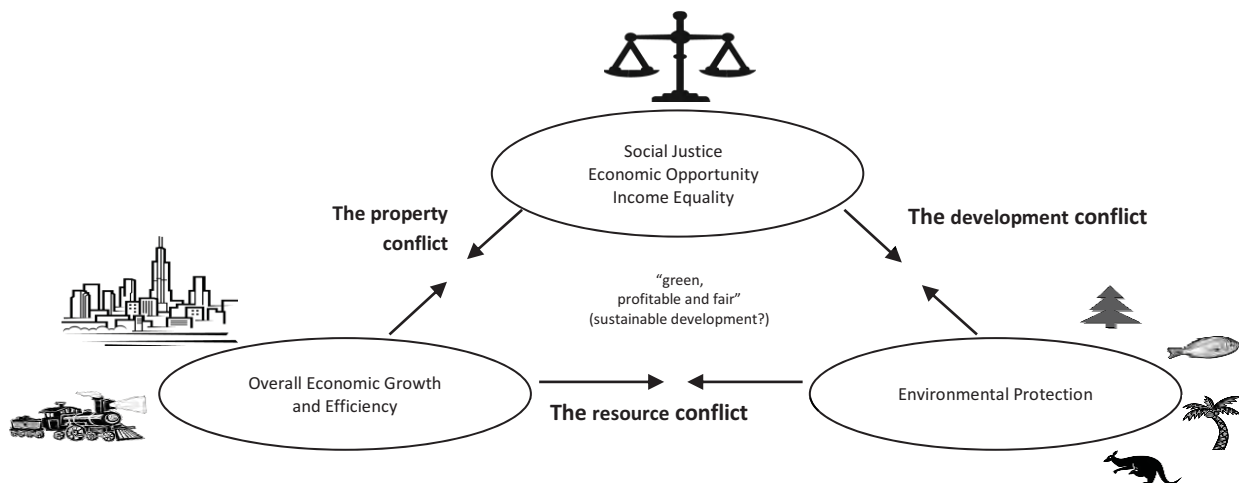


Figure 7: The triangle of goals and conflicts for planning; Campbell, 1996

The property conflict

The first conflict – between economic growth and equity – comes from competing land use agendas, such as between landlords and tenants or potentially local government and residents. The growth-equity conflict is further complicated by its resistant and symbiotic relationship - for example land or housing is defined by a capitalist, democratic society as a private commodity, but simultaneously requires government intervention for aspects such as zoning or public housing. Foglesong termed this the ‘property contradiction’ (1986). In this instance the conflict defines the boundary between private interest and public good. Industrialists must curb their tendency towards profit driven agendas to ensure that the labour pool is sufficiently well paid to ‘reproduce’ itself – the subsistence wage. In the Geelong region of Victoria, Australia – the population (currently recorded at 290,000) is growing at an annual rate of 1.7% (G21 – Regional Growth Plan, 2011); the strategically identified urban growth area currently has the potential to accommodate an additional 158,500 residents – meaning there is a notional shortfall of land to house the additional 45,000-51,000 people based on the existing development plans. The property conflict becomes evident in the debates on housing affordability and lack of rental stock; limited housing choice exists, with the current market dominated by single detached dwellings (91% of housing stock) and high housing costs of the predominant coastal areas.

The resource conflict

The conflict for natural resources is similar to that of the property conflict – for example business resists regulation but society requires it to conserve resources for present and future generations. The essence of this conflict lies in the tension between the economic utility in industry and the ecological utility in the natural environment. Cambell states that there does not appear to be a single, universal economic-ecological conflict underlying all disputes, that these are specific to different areas, times and situations. This conflict is similar again to the property conflict, in that industry needs to curb its tendency towards profit driven agendas in order to ensure, for example, that enough of the forest remains to reproduce itself – sustained yield. The conflict is further influenced by the differing views of how far the forests can be exploited while remaining sustainable. This can be seen in the G21 debate on the cost of developing Greenfield sites in the Geelong region versus the cost of consolidating urban areas where there is a significant difference in associated cost (G21 – Regional Growth Plan, 2011).

In both the property and resource conflict industry must leave enough of the exploited resource to ensure the continued future delivery, regardless of whether this resource is human or natural. Of course this also opens the way for discussion on how much is enough, however, the fact remains that, when taken in the context of planning and ecology, a conflict is apparent between allowing for urban growth while maintaining the balance with natural resources and health of the workforce.

The development conflict

The final axis, the development conflict is the most subtle, sitting between the poles of social equity and preservation of environmental concerns. If we are saying that the property conflict is characterised by the economy's ambivalent interest in providing, at the very least, a subsistence existence for the labour force; and the nature conflict by the economy's, again ambivalent, interest in maintaining sustainable conditions for the natural environment; then the development conflict is characterised by the difficulty in doing both of these at the same time. This is potentially the most challenging of the conflicts for sustainable development. For example, in Geelong (as in many urban areas) there are direct implications for the potential Greenfields area based on the extent of the urban growth and consolidation.

The quest for sustainable growth

These three paths of conflict correlate to the three pillars of sustainability – social equity (people), economic health (prosperity) and environmental stewardship (planet). So is the quest for sustainable growth an oxymoron? In his paper presented at this conference last year, Dr Geoff Edwards (2011) presented a rather harsh truth

– that an opportunity was missed in the 1970s to change the trajectory of this conflict between growth and biocapacity. While agreeing that there is conflict between the draining of resources and the ever increasing urban growth, it should be possible, if not to arrest the negative consequences, at the very least to slow the effects to a point where the ecological balance has a fighting chance of some degree of regeneration. Edwards argues that Western society resisted the opportunity to change in the past and continues to ignore the advice of experts in this field – unfortunately this would seem to be the case. In reviewing the literature it appears that while academics and practitioners alike are in agreement that there is an issue, and that we should as individuals and a world community be acting on the problems, this is not filtering into the actual practice of planning for the future. Why is that?

Well, it would seem that there are two main issues – first there is a lack of specific knowledge on urban ecology which would support or counter proposed developments, and second there continues to be a conflict between urban growth, planning and biocapacity which makes it difficult for knowledge to be used in any constructive way.

How can we begin to bridge these gaps?

Having addressed the first two themes set out at the start of this paper we now tackle the third – looking at ways in which gaps can be bridged.

An interdisciplinary approach

As seen in the definitions provided earlier in this paper, the information regarding urban ecology/biodiversity/ecosystems etc. can become highly scientific and detailed. Is this always necessary and is it possible for the non-scientific community to take ecology into account for every proposed development? Planning for the future, for sustainable cities, necessitates an integrated approach – where interdisciplinary knowledge is collated and organised into the system, allowing planners and decision makers to have access to relevant information in a timely and comprehensive manner without the need for formal scientific training to understand the key facts. This interdisciplinary research needs to incorporate natural and social sciences, as well as an awareness of planning legislation and policy (Sukopp & Wittig, 1993; Picket *et al*, 1997a/b; Niemelä, 1999a; McIntyre *et al*, 2000; Kinzig & Grove, 2001; Devuyst *et al*, 2001; Ehrlich, 2002; Yli-Pelkonen & Niemelä, 2005; and Tonn, English and Travis, 2010).

Using up to date information and tools

One of the biggest problems for developers, planners and policy makers appears to be the lack of up-to-date and accurate information. It is no use to anyone if the information used in planning for the future contains only information from the past;

ecology by its very nature evolves and develops, the needs of the biome adapt and the individual species within it can also to an extent adapt. While a firm basis in past trends and prior knowledge needs to be available and utilised, it is also essential that up-to-date information is collected and disseminated so that, for example, development is not postponed on the basis of a species of bird that no longer resides in an area or a plant that has already been lost.

There are tools available for assessing developments – such as the Environmental Impact Assessments where decision makers consider the subsequent environmental impacts when deciding on viability of a proposed development. The International Association for Impact Assessment (IAIA) defines an environmental impact assessment (EIA) as ‘the process of identifying, predicting, evaluating and mitigating the biophysical, social, and other relevant effects of development proposals prior to major decisions being taken and commitments made’ (IAIA, 1999). The EIA process in Victoria is linked to the Environment Effects Act 1978 and the Ministerial Guidelines for Assessment of Environmental Effects. EIAs are unique in that they require decision makers to account for environmental values in their assessment and to justify decisions in light of detailed environmental studies and public comments on the potential environmental impacts of the proposal (Holder, 2004). The ABCS notes that it is important to ‘integrate biodiversity into planning instruments by implementing a decision-making hierarchy for biodiversity management: the first aim is to avoid loss; if that is not possible then aim to minimise loss; if that is not possible then impacts should be managed to maintain ecosystem functions including where feasible through the use of offsets’ (ABCS, 2010-2030).

Use of available software

Many of the current suggested approaches are very computer focused – they work towards increasing the use of available information; but do not necessarily allow for exploring what information is actually needed or in fact to explore in what way this information needs to be presented in order for this to be a useful commodity? Examples of these packages are UrbanSim (an urban simulation system where reference is made to the interaction of many decision making actors within the urban markets for land, housing, non-residential space and transportation), GIS (a geographic information system used to collect, store, manipulate, scrutinize, collate and present geographically referenced data) or Biotope mapping (a method for assessing the occurrence of various habitat types and the associated species in an urban landscape). This is in no way a full list of available software, they are mentioned here simply to highlight the fact that there are available and possibly under-developed resources.

Information dissemination

Freire (2002) points out, ‘without dialogue there is no communication, and without communication there can be no true education’ (p93) – this is the same for ecologists and planners; unless there is a dialogue between the disciplines there can

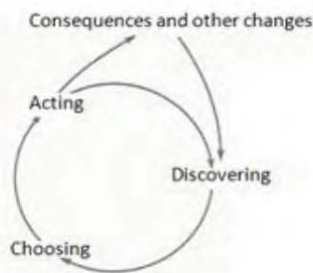
be no true learning and development. More importantly, perhaps, is the standard of the dialogue between these disciplines, if the communication is too scientific it will alienate certain sectors, too basic and others will not be interested. Information needs to travel between the sectors in a systematic and comprehensive way to be of any use. This information needs to be shared from both sides, in a transparent way – for example where planners/and policy makers highlight changing legislation, and ecologists explore new species found/ and their relative importance. Knowledge that is not applied or disseminated is, to an extent, wasted.

Education and ongoing training

The education system, on an international scale, provides the perfect vehicle for ensuring that current and future generations are aware of their ecological responsibility and, particularly in courses relating to training future planners, ensuring that development without regard for nature does not continue. The ABCS notes the importance of integrating biodiversity into everyday lives so that it becomes everyone's business – this is an opportunity for all education providers to begin the process by implementing knowledge on ecology into general learning (not only at a higher education level). Edwards (2011) also notes that no one should graduate without having had scholarly exposure to each of ecological science; history or sociology or public policy; and systems dynamics'. This is important for many reasons, not least because as individuals we all have the responsibility for helping to alleviate stress on the eco-system and reduce our personal ecological footprint; but also because with all aspects of future society being linked with biocapacity it is essential that our future policy makers, industry leaders and populations as a whole have an awareness and understanding of basic ecology.

Stacey (2003) expands on Senge's (1990) two systems for learning which, while not directly linked to ecology, provides an interdisciplinary approach to planning for the future which would be interesting to explore further - the concept of single and double loop learning. These processes are linked to organisational achievement – but what if we translate them into planning for sustainable future cities? The basic concept of the learning models is that they allow organisations to learn and develop or maintain a stable environment (but with little or no innovation or learning). Single loop learning, as seen in Figure 8, is the process by which organisations (or in this case planners and policy makers) review and learn from the actions they have taken; this in itself sustains group learning and enables them to move towards the realisation of a shared goal or vision. This is a simple act' and react' culture, which Strichman *et al* (2007) found hindered organisational growth and knowledge development. Double-loop learning also places importance on learning from actions, but this coincides with a process of questioning assumptions; forming a revolutionary and destabilising process whereby organisational learning and innovation are supported. This could be a very useful tool in planning, where not only are assumptions reviewed and acted on, but they are also challenged and questioned.

Single loop learning



Double loop learning

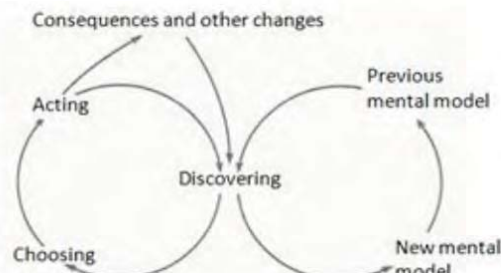


Figure 8: Single and double-loop learning, Senge 1990, as cited in Stacey 2003

Current planning and design practice seems to fit single loop learning, but in developing a new model for sustainable planning and design it would be interesting to see if old assumptions could be tested – for example exploring the potential for developing up rather than out. While this may not always be practical it does question the assumption that increased urbanization requires an outward spread. Another example could be made of the use of urban agriculture, where Smit *et al* (2001) note that there is considerable potential to expand urban agriculture around and within the densely built-up core of urban areas; an example of this is seen in Europe, where Italy leads the so-called slowfood movement, a positive reaction against fast food. This movement promotes a grow it, cook it, eat it slowly approach — for the good of the family, community, and globe” (ibid). This again questions assumptions: agriculture needs to be separated from urban living.

Summary

Maintaining urban biodiversity through the integration of ecological knowledge and urban planning is essential for the development of ecologically sound sustainable cities. It is important to integrate ecological and biodiversity knowledge into the planning process. Urbanisation and future developments threaten to encroach further and further into the green belts and destroy urban biodiversity in the need to take more space for ever-expanding urban growth.

We have the capacity and responsibility for exploring ways in which humans can live in environments without destroying them or the diversity which depends on them. Society operates within a complex of mixed views and values – it is not always easy to align the values placed on urban biodiversity and the environment as a whole into society and the systems that regulate it.

For planning to become linked to ecology and a sustainable future city it needs to alter the old ways of viewing nature and create new ways of thinking. This could be done by using double loop learning – questioning old assumptions and allowing for an iterative process of learning. Knowledge of ecology (both urban specific and in

general) needs to be incorporated fully into the education system, with proper dissemination of information in all sectors of society, but especially in the planning process.

As a species we are intrinsically adaptable; humans have the capacity to learn and to develop, and ecology has a degree of regeneration capabilities. There are issues, and the current situation is unsustainable. But does this mean that all hope is lost? No. At the moment there is not enough specific data being used to assess the extent to which urban areas can drain, maintain or develop biomes. There is still scope for humans as a species to sit up and take note of the stress being placed on the ecosystem – and by hosting conferences such as these, bringing a variety of related subjects to press we, as academic and practitioners, can continue to try and push for change. So, is the ecosystem in danger from urbanization? Potentially. But is this a manageable situation? Almost certainly.

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Reinvigorating 20th century residential pocket parks for the 21st century

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Abstract

The internal reserve is a small park hidden within the interior of residential blocks and intended in the early 20th century as an amenity for the immediate neighbourhood. Lack of use and understanding saw them fall from favour, but they endure even today into some contemporary master planned communities. In an understated but practical way, they implemented the early planning movement's aspirations for healthy communities. But they rarely reached their potential, causing maintenance and management headaches and coming to be seen as unsafe spaces. In many instances, they were sold off by local authorities for infill redevelopment or subsumed within surrounding house allotments. The contemporary rationale for healthy communities planning offers the opportunity to rethink the future of remaining spaces which remain underutilized and unloved backlands. Historic and recent community initiatives in Australia and overseas showcase a spectrum of possibilities connecting local concerns with global imperatives of sustainability, community empowerment and food security.

Keywords: *open space, community, residential planning, urban form*

Introduction

This paper addresses the issues and opportunities posed by planned internal reserves, mostly the legacy of town planning ‘on garden city lines’ from the 1910s and 1920s. Our primary focus is on community gardens and the production of fresh food but an array of renewal possibilities depending on site and context present. In examining this we specifically use the example of the ‘Tuppal Reserve’, first planned by Walter Burley Griffin, and the East Keilor Sustainability Street Community Garden, now located within it. While the community garden at a very local scale strongly addresses current concerns about healthy activity for young and old, we also acknowledge that examples such as this are just one reworking of redundant internal reserve spaces for new concerns. A key question for us is what differentiates estate designers creating such spaces, and home purchasers of the early 21st century attracted to these enclosed parks, from those of a century before?

Tuppal Reserve, East Keilor

Unassumingly but powerfully, in a corner of outer suburban Melbourne rendered something of an island by freeways and arterial roads, and on a hitherto largely forgotten barren tract of land designated for community use as long ago as the 1920s, a gentle revolution has taken place in the last decade. It is all about transforming space long regarded as wasteland into a much more productive land use and in turn transforming the neighbourhood surrounding it.

One rainy May afternoon this year, during one of the East Keilor Sustainability Street Community Garden’s three annual open days, small groups of people wander through the fifty plots hidden from street view discussing pragmatic aspects of small-scale agricultural practice – from the self-seeding of broccoli to the healthy production of tomatoes. The event is less successful than organisers had hoped – rain certainly didn’t help – but the chief purpose of an open day, the drawing in of visitors from the surrounding neighbourhood, was achieved as always. The reserve’s two walkways are fenced at one end, gated at the other; access, therefore, is a rare privilege for non-members and it is only by traversing the path into the reserve that its full import is revealed. Once inside, new visitors are invariably amazed (Figure 1)



Figure 1 – Tuppal Reserve, May 2012 (Photographs M. Schoen)

Hundreds of these interior block parks exist in early 'town-planned' residential estates across Australia, concealed from roads and usually ignored by both residents and councils alike. They are the legacy of an earlier round of urban reform when idealistic planners sought to deliver amenities for the local community. They have had their ups but mostly downs, and only now is their immanent potential as spaces promoting healthy community living in the fullest sense of that term truly being realised. Sharing the stories will advance that process, not only in Melbourne or even Australia but world-wide.

The design of Tuppal Reserve originated in the office of Walter Burley Griffin, and thus its conceptual origins lie in an idealistic embrace of landscape architecture, active living, community solidarity, and nature conservation. An overriding concern was how the nascent field of urban planning could assist in the 'correct' development of America's – and later, Australia's – relentless metropolitan expansion.

Walter had met his wife Marion working in the architectural offices of Frank Lloyd Wright in Chicago. They relocated to Australia shortly before the First World War as competition winners in the Federal Capital Competition and worked on the design of Canberra for seven years, until 1920, when after years of acrimony and subterfuge from resentful bureaucrats, Walter resigned from the project. His contract in those early years of their Australian sojourn allowed him to work on other design projects for half of the week and during this time they designed at least five suburban projects in Melbourne and one in Sydney, all featuring internal reserves which they tended to label as 'playgrounds' but were dedicated regardless to the imagination and needs of the local community.

In the mid-1920s, the Griffins moved from Melbourne to Sydney, where they lived at Castlecrag, in a house *and* suburb of their own design. A few years later they created their final plan for a suburb, the first section of which was known as the City View estate, later incorporated into the larger Milleara Estate in Keilor. Here, in a development proclaimed by developer Henry Scott as equal to the world's best, the Griffins dedicated a quarter of the available land to open space, comprising 'parks, playgrounds and wading pools.'¹

Yet despite Scott's enthusiasm only Milleara's skeleton weathered the Great Depression. Its atypical elliptical roads and elegant 'viewpoints' – the estate is on the eastern edge of a plateau – remained largely undeveloped for nearly forty years. As is so often the case, by the time the residential land market had caught up with the Griffins' miracle estate and houses were actually being built there, the original designers and promoters were long gone and their guiding ideals with them. When residents finally started arriving in numbers in the 1960s, building the first homes on allotments pegged out for close on half a century, they discovered that in many cases small empty spaces existed within their suburban blocks. These were the archetypal internal reserves envisaged by the Griffins. They did not come with instruction manuals.

The Griffins' original scheme called for specific uses for both the enclosed and street frontage open space; most of these were geared towards use by children, under the supervision of mothers or other adults, but there were also suggestions for tennis courts and similar recreation pursuits.

The Tuppal Reserve is the northernmost of the spaces in Milleara, within a block bounded by Tuppal Place and Borval and Moyangul Drives. It has had a chequered history. For decades, it was essentially empty space. When building began in the 1960s-70s the area was host to many young families, and finally its value could begin to be appreciated. It became the stage for organized play for children – Little Athletics – and later, a BMX bike reserve.

But as the area demographic changed and neighbourhood children grew up, use of the reserve declined and, in some minds, the space brought the character of the neighbourhood down with it. Motorcyclists would occasionally ride through the reserve, and others would use it as a ‘party spot’, usually drawing complaints from the residents whose houses backed onto the reserve. The local council would mow the grass around the edge, but no-one went into or used the central wasteland which became a convenient rubbish dump for old furniture and mattresses.

At the beginning of the 21st century local residents, in discussion with council, canvassed options for what had become a problem space. There were basically three choices. They could leave the land as it is; try and beautify the area as passive parkland and make the laneways narrower to prevent vehicle access; or reinvigorate the space as an active community asset. They chose the last option, opting to establish the first community garden in the wider locality.

The land area was subsequently levelled at council’s expense, and adjoining residents were given first option (held open for two years) on a plot within the space. Plot beds for the garden were based on the size of the sleepers used to build them. Various improvisations were trialled. When the local council switched to a new system of business rubbish collection, the community garden workers were given six hours to gather together as many of the old oversize business bins as they could. These are now used to store water. Small sheds also adorn the site; one was donated by a local, another by a former Ansett employee. It was reassembled from Tullamarine after the demise of the airline in 2001.

Although the project was started by middle aged locals (there was only one person under 50 in the original group), new arrivals meant a gradual inclusion of younger families. Today, a children’s garden has been created and a small playground put to good use. There are other plots within the space sensitive to members’ differing needs: for example, a ‘disability’ garden with a raised bed for use by residents from two local aged care facilities as well as those with back problems. The transformation in the nature of this once forlorn reserve could not be more complete, inclusive or inspiring. Yet were the Griffins and Henry Scott to visit today they would surely declare that this community-driven revitalisation of Tuppal Reserve was precisely what they had in mind.

The internal reserve as community locus: a brief history

The internal reserve became an essential component in best-practice suburban planning in the first decade of the 20th century. There were different variations but what Walter Creese termed the ‘superblock with a common allotment in the middle’

was the vital typology. The idea of the internal reserve as a centre for local agricultural production ‘undoubtedly derives from Lord Leverhulme’s model industrial village of Port Sunlight near Liverpool, which came mostly from the spirit of the 1890s.’² The design for Port Sunlight as it evolved from a rather informal settlement in the late 1880s through to a more formal showpiece by the 1910s allowed for a range of interior spaces intended to serve Port Sunlight’s workers – primarily, family men – with a recreational outlet in the form of growing vegetables. The allotments and other utilitarian household activities were confined to the rear of houses to preserve the aesthetics of the main street frontages (Figure 2).



Figure 2 – Village of Port Sunlight, early Twentieth Century (Port Sunlight Museum Collections Study Centre)

The Lever company expressed its commitment to the allotments in its 1896 *Sunlight Yearbook*:

Very little need be said as to the advantages of gardening. They are patent to all. Moderately indulged in, the occupation is one of the most beneficial recreations known, for both mind and body ... The exercise in the open air strengthens and invigorates the body, while the increasing demand for allotment gardens by men of limited means, amply proves that the pocket is also benefited.³

Forty years after Lever’s experiment, the leading planner Thomas Adams noted Port Sunlight’s allotment gardens as one feature (amongst a hall, schools and churches) as truly distinguishing the suburb from seemingly comparable planned communities: ‘Some well-planned municipal housing estates in recent years have failed to give satisfaction because of the omission of such features’.⁴

The architect-planner Raymond Unwin helped materially develop the idea of the internal reserve both theoretically and practically. In *Cottage Plans and Common Sense* (1902) he effectively connected the idea to the perimeter medium-density housing block common on the continent.⁵ He advanced the quadrangles of the hallowed halls of Cambridge and Oxford Universities as a model for perimetered open space in residential settings:

Squares, such as suggested, would always be sweet and fresh, being open to the sun and large enough to be airy without being draughty. The distance across, preventing the overlooking of windows, would ensure the essential privacy of the house, in spite of the want of back yards. The space in the centre would allow a few trees to grow, some gardens to be made, and a safe play space for the children to be provided, while it would afford a pleasant and interesting outlook for all the cottages.⁶

He surveyed the possibilities for a variety of different uses of these spaces, depending on their context, with allotments just one option:

In the planning and laying out of these squares it would be well to provide for all sorts of tastes, for it will be easy to get plenty of variety. In some cases the whole square could be filled with allotment gardens let to those who wanted them; in others the space might be devoted to a broad lawn for tennis or bowls; in some a band of small gardens might surround a children's central playground, and in others a public garden be established; in some cases there might be a roadway all round the quadrangle, while in others the road might run down the centre with gardens attached to the houses on each side.⁷

As it transpired, when Unwin came to develop the best-known of his iconic estate designs – notably Brentham and Hampstead Garden Suburbs in London – he and partner Barry Parker included a suite of open space forms, from extensive playing fields down to trademark internal spaces. In these suburbs the latter were mostly intended – and in many cases have had close to century of use as – agricultural allotments, as opposed to the ‘village green’-styled street frontage reserves often of approximately the same size, but which are grassed or landscaped spaces. Henrietta Barnett, wife of Canon Samuel Barnett and the idealistic instigator of Hampstead Garden Suburb, reputedly ‘always felt perfectly happy when her Canon was occupied taking plantains out of the lawn’⁸ and instituted a prize for best agricultural produce at Hampstead.

So popular was the allotment craze in some quarters, that interior spaces could be seen as a social problem. A conservative British councillor became concerned about the emergence of ‘allotment widows’, that is, women whose husbands neglected them in favour of local agricultural activities.⁹ There were also jokes about overly feminised men who lost perspective on their garden. A 1937 cartoon in the *British National Allotments Journal* shows an effete gentleman who, when asked by his wife ‘where are the vegetables?’ replies that he felt ‘the allotment looks such a picture that I thought it a shame to disturb it’.¹⁰

Garden suburb design in the United States frequently included internal reserves but the allotment tradition was less socially ingrained compared to Britain, although some early advocates highlighted the agricultural option. Frederick Law Olmsted Jr, in seeking a best-practice approach to planning a new suburban environment on Long Island called Forest Hills Gardens, looked to Hampstead for inspiration. He included internal reserve spaces in his design, and the historian Susan Klaus writes of Olmsted's ambitions for these 'private enclaves', the use of which were to be decided by residents:

Residents might decide to turn part of the space into tennis courts or use it for other forms of active recreation. Or they might want to keep it a quiet refuge from general pedestrian traffic, a safe play space for small children. They might even use it for a communal garden. "There are many people," Olmsted imagined, "who want to try their hand at a garden – more of a garden than is possible on the ordinary house plot – but who are either unable to buy the necessary area or feel too uncertain of their gardening success to risk the additional investment in land." A communal plot would allow residents to test their green thumbs, "and to increase or decrease this space or finally give it up, just as their experience may dictate."¹¹

One major difference between the approaches of Unwin and Olmsted was that, whereas Unwin's spaces were approachable by laneway and theoretically accessible to any member of the public, those at Forest Hills Gardens are entirely enclosed and accessible only to surrounding households (Figure 3). This changed the nature, use and character of the reserve space, making it far more exclusive and ultimately vulnerable to appropriation within backyards.



Figure 3 – Internal reserve, Forest Hills Gardens, 2008 (Photograph D. Nichols)

In Australia, internal reserves were promoted in the early days of the town planning movement as vital cogs in the desired hierarchy of urban open space (Figure 4).

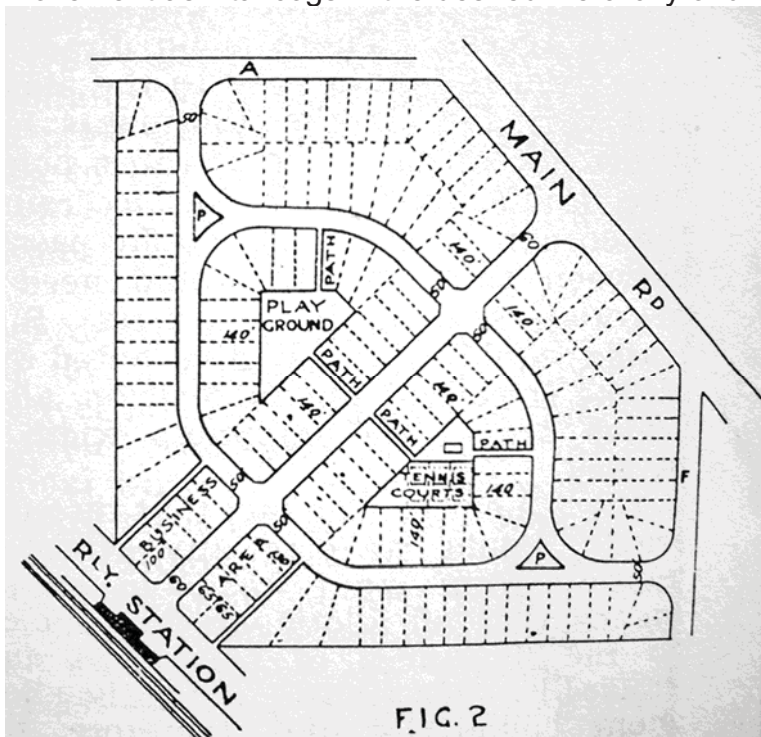


Figure 4 – Hypothetical Australian suburban design including internal reserve space.

(Saxil Tuxen, 'Design of Subdivisions in Victoria', Australian Surveyor Vol. 3, No. 3 1932 p. 178)

Perth advocate William Bold reminded delegates at a national planning conference in Brisbane in 1918 of the multiple benefits of planned open space ranging from increased land values to reduction of juvenile delinquency. He singled out internal reserves 'laid out either as allotment gardens, rest places, tennis or croquet lawns, or playgrounds for children' as particularly invaluable in 'improving the health of the occupiers of the houses abutting it'.¹² John Sulman, the most respected authority of his generation, underscored an argument which the Griffins had similarly advanced: pooling land within residential blocks provided safe spaces for children's playtime away from the street for they were 'under the eye of their mothers all the time from the kitchen or back yard'.¹³ Here as in other countries there was nonetheless less enthusiasm for these small parks and by the 1930s many spaces lay neglected and misunderstood, attracting illegal rubbish dumping and providing long-term maintenance headaches for councils and communities alike.¹⁴

For many, the internal reserve was (and continues to be) classed as unworkable and, far from engendering an active community spirit, actively illustrating its absence. A century ago, Klaus tells us, Olmsted was disappointed to learn that at Forest Hills Gardens 'the interior parks did not prove popular and it was difficult to interest residents in their upkeep'.¹⁵ As quickly as the internal reserve idea had spread around the world, residents and hence designers decided they were unworkable. Frederick Hicks' 1922 design for the model garden suburb of Marino, in Dublin, included seven such spaces accessed through pedestrian entries incorporated into the row housing.¹⁶ It was less than a decade after the first tenants moved into this highly desirable suburban milieu, however, that complaints were raised about what became known as the 'backers' in some blocks. A poll conducted in 1937 found that the 'overwhelming majority' of Marino residents whose homes adjoined such spaces were in favour of extending their gardens into them, a process which was slowly undertaken.¹⁷ The case of the disappearing internal reserve was evident elsewhere through a combination of land grabs, renewal schemes, and housing development pressures. Internal reserves were a feature of Barry Parker's Jardim America (1919) in Sao Paulo but by the 1930s all had been redeveloped to increase housing allotments by over 50%.¹⁸

Yet the internal reserve idea seems to have been continually rediscovered afresh. During and after the Second World War the American architect Henry Churchill was arguing for a 'new synthesis of design'¹⁹ which, in his own examples put forward in *The City is the People* (1945), included interior park space as a key element.²⁰ Churchill acknowledged prominent and well-known examples of planned suburban environments – such as Clarence Stein and Henry Wright's Chatham Village in Pittsburgh, a crucial cog in the story of Radburn-style site planning and a 'remarkable tour-de-force' according to Churchill.²¹ In Britain, the retired architectural professor Sir Charles Reilly, recently of the University of Liverpool, proposed a replicable village green arrangement for new suburban design which, he felt, would guarantee 'a more civilised way of life than the common people have known or can ever know so long as the relation of one habitat or another almost forces isolationism'.²² Such a scheme, in which oval spaces encircled by houses would 'radiate, like the petals of a flower, from a little City Hall' would, in Reilly's conception 'very often' contain allotments.²³ Few 'Reilly Greens' were actually realised but the idea testifies to the enduring significance attached to neighbourhood open space in planned communities.²⁴

Demise and Revival

Through the 1960s internal reserve forms bob up in very different settings as site planners experimented with the configuration of buildings and open spaces in various configurations and densities. The driving innovative force was the search for alternatives to traditional suburban subdivisions. William Whyte's book *Cluster Development* (1964) included interior parks in subdivision designs exemplifying best-practice as a vehicle for creating more opportunities for both social interaction and ecological conservation.



Figure 4 – Open courts at The Staiths, UK 2011 (Photographs: David Nichols)

It was not until the rise in popularity of the new urbanism in the late 20th century that the internal reserve made a comprehensive comeback. Two international examples here can stand in for many.

The Staiths, a new housing development in Gateshead, England – the southern neighbour of Newcastle-on-Tyne – is a riverside development focused around ‘the historic Dunston Staiths structure... one of the largest wooden structures in Europe’²⁵, a crumbling legacy of the region’s coal shipping past. Inserted into the plan for The Staiths by architects Hemingway Design are six enclosed courtyard spaces, surrounded by two-storey terraces with low back fences (Figure 5). These parks represent, according to developer Taylor Wimpey, ‘a choice of communal play areas allowing residents to meet and socialize with their neighbours.’²⁶ The rear gardens of the houses add to the feeling of space, while the court spaces themselves are all unique; one containing barbecues, another a rock garden, and so on. ‘As a result,’ wrote London *Times* architecture correspondent Hugh Pearson of the original plan, this new development ‘paradoxically has a slightly old-fashioned air about it,’

a dash of 1950s whimsy and 1960s utopianism, crossed with an almost Victorian paternalistic desire to create a “model village” (modern buzz-name, “urban community”) in an industrial setting. Fashion has never had any problem revisiting the past and giving it a new twist for the present, and this is exactly what the Hemingways are up to with their individually-landscaped courtyards...²⁷

In the United States another, comparable development – this time on former airport land and presently under development in Denver, Colorado is the Peter Calthorpe and Associate's-designed Stapleton. This project, boasts its website, is 'full of pocket parks ... meant to provide spaces for neighborhood games, BBQ's and general frolicking'.²⁸ Directly attributable to their neo-traditional design inspiration, these spaces directly evoke the early ideals of the town planning movement to build community, walkability and opportunities for healthy outdoor activity into the micro-scale of residential life. The spaces are not the exclusive retreats of Forest Hills Gardens, but permeable public zones, mostly play zones for kids, in which surrounding homeowners have a direct stake. In design terms, the trick has been to have the houses orientated towards the parks and then bind neighbourhood groups together in maintenance through mini home owners' associations. There is also one community garden. In new greenfields developments like this the internal reserve is being reborn as an accessible, user-friendly and individualised outdoor space. In some older American cities like Baltimore community greens and gardens are being created through reclamation of disused laneways.²⁹

Both these ventures are not worlds away from the rediscovery of the value of inherited spaces in the northwestern suburbs of Melbourne.

The future

Very few designers promoting the internal reserve as a device to initiate community in new residential areas have examined the fates of those which had gone before. What can be learnt from the past to ensure the sustainability and validity of such spaces in new designs of the 21st century?

The issues are, of course many and varied and even though elements pertaining to, for instance, class, aspiration and culture might be seen as key, it is also true that even within specific 'town-planned estates' just as some internal reserves thrive, others wither perhaps only a few streets away.

The authors, at present in the research phase of a longer work on this subject, can only offer preliminary findings. The following conclusions are based primarily on observation from site visits; they also derive, however, from a long-term process of discussion with other academics worldwide on this subject, as well as ongoing archival research. Six general observations can be made.

- **Internal reserves work best when people know what they are (meant) for.** In our research, we have found that the majority of residents and local government parks maintenance officials are ignorant of the history of the internal reserve space, even in 'icon' developments such as, for instance, Brentham. This lack of understanding is, naturally, a disincentive to investigate and liberate the potential of these spaces.
- **Internal reserves work best when local people have a stake in them.** While this may seem in itself obvious, it is also problematic. The issue of ownership of internal reserves explains something of the form's uneven history over the last century. Developers have often included them as a nod to requirements of open

space provision. Yet in the minds of many in local government, when they have been deeded ownership, such spaces if underutilised and perhaps associated with anti-social behaviour are local headaches and drains on recreation budgets. This has been a key factor in decisions to sell-off the space to surrounding landowners or for infill development like community halls and retirement homes. A variety of sustainable tenures are nonetheless evident. The best reserves are those where residents have a stake through title covenants, legal associations, or active cooperation. 'Ownership' in a metaphorical as much as legal sense creates interest, perception of value and desire to co-operate with neighbours.

- **Internal reserves' fortunes are often as cyclic as surrounding neighbourhoods.** Generally speaking, suburban areas undergo generational change. Internal reserves may be popular for a decade in which young families dominate in an area; they might then become seemingly redundant for other decades in a cycle. In many cases, it is only fear of the alternative (that is, infill medium-density redevelopment) which has saved many internal reserves. Reserves can change with generations and the two primary uses of reserves around the world (children's play and small-scale agriculture) accommodate this.
- **The most effective internal reserves are ones which double as a 'second backyard'.** When adjoining owners have either low (or even no) back fences, the message of use and surveillance of specific spaces is clear to intruders and users alike. Although this may often seem counterintuitive – that a high rear fence should be the best guard against intrusion – it is also true that a fence can provide cover for criminal activity as much as it can offer (limited) protection from trespass.
- **The best-used internal reserves are ones in which multiple activities are encouraged.** The Tuppal reserve is a good example of this assertion. While vegetable gardens dominate, the reserve is experiencing extensive activity possibly for the first time in its history.
- **Internal reserves work best when they are demonstrably the best local option.** That is to say, residents are more inclined to utilise and value their reserves when they do not have other larger or 'better' (for size or other reasons) reserves in their immediate vicinity. For example, of the eight internal reserve spaces in the eastern portion of Sättra, north of Stockholm in Sweden, the two hemmed in by other developments are those most developed and most used. The others, in close proximity to the area's broad open spaces, are comparatively neglected.

The vast majority of internal reserves were launched by the planners of a century ago as an elegant bloom in a bouquet of high ideals. But it takes more than an inspired beginning to create a successful working community 'pocket park'.

An innovation requires a certain amount of lucky circumstance – which eluded many internal reserves. They were seen by many as a practical solution to issues of open space provision (particularly useful in scenarios where experts and/or local government obliged developers to dedicate at least 10% of an estate to open space). They were also seen by many as a way of guaranteeing the safety of playing

children, kept away from streets – a moral as well as a physical danger. While the early proponents of the form were, however, sufficiently modern to predict the rise of the automobile – and to imagine the internal reserve as a remedy to the threat it posed – they could not anticipate the social change in our cities and suburbs. The internal reserve's success as a playground for children depended in large part on mothers willing and able to watch their young; on relatively coherent and like-minded neighbourhood residents; and on the 'community spirit' of exchange and voluntarism more prevalent in the early 20th century than in later decades. This was particularly problematic by the second half of the century, when western women were more likely to work, and western families, particularly in middle class neighbourhoods, became more introverted and centred on the house, rather than the external environment. A telling confirmation of this trend was the decision made in 1960 by Unilever to 'modernise' Port Sunlight's rear allotment spaces, extending backyards and replacing vegetable gardens with garages for cars and/or grassed greens.³⁰

The 21st century has seen, and will continue to see, this trend reverse. Government programs, and awareness campaigns highlighting the value of outdoor activities for both young and old will continue to underline the importance of identifying and accessing local open space. Recent research suggests that 'neighbourhood open space that is attractive and easy to visit can benefit older people's well being' and that 'communal gardening creates inclusionary spaces' to 'mitigate social isolation.'³¹ This might seem self-evident, yet the co-ordination between open space and community activity for old and young is in many cases inadequate.

Conclusion

We return to Tuppal Reserve in Keilor. The initiative looks set to spark a chain reaction, prospectively remaking all the Milleara estate reserves, one at a time. With the blessings and aid of the original committee a new breakaway colony has embarked on creation of another, similar garden to its south. In between the two lies a more informal internal reserve in which local residents have already cultivated sections of their space with both garden beds and fruit-bearing trees.

The Tuppal example is clearly a success, based primarily on local initiative with low-key but consistent support from local government. Importantly, it was a solution posed to a problem of unused land that was in certain respects the least worst option for local residents. But the outcome, with over sixty active participants in a very local area, has undoubtedly contributed to an improved local quality of life. Initiatives elsewhere in Melbourne are coming to light. At approximately the same distance from the CBD, in Reservoir, Darebin Council have taken the initiative by developing a mixed-use scheme for an internal reserve off Wilson Boulevard. It now boasts a landscaped array of olive trees celebrating the local population's Mediterranean origins, barbecue and picnic structures, and a space delineated for a future community garden.

Early garden suburbs were planned with many design features which active-living advocates promote today.³² Internal reserves offering opportunities for a variety of community uses are among them. The original creators of these spaces were often reticent to prescribe specific uses and, in the right circumstances, the form has in any case shown itself to be very adaptable to a variety of uses. As we have shown, it

was at least in part social change – attitudes to children and their safety, the role of mothers, advances in entertainment – that appeared to make many internal reserves redundant for a time. Changing attitudes to food security, recreation, the active aged and place-making may well mean that internal reserves are set to gain a valuable new lease of life.

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Effects of exposure to traffic noise on health

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Effects of exposure to traffic noise on health

Abstract

Traffic noise causes adverse effects on the health and quality of life of individuals and communities exposed to it, including annoyance, sleep disturbance, decreased performance at school/work, stress, hypertension, and ischemic heart disease. In Australia there are few standards or policies addressing noise in urban environments, with many discrepancies in noise level thresholds when comparing states and regions. Currently Victoria has a day-to-night threshold for noise levels well above accepted levels in Europe, and there is no standard for the late night period. A better understanding of the health impacts of noise in the Australian context is vital for informing development and implementation of policy and legislation for road traffic noise management. This paper reviews the evidence base and policies related to traffic noise in urban areas, and presents a case study of noise mapping and assessing population health impacts (eg. sleep disturbance), in Geelong, Victoria, Australia.

Keywords: *traffic noise, health, urban areas, policy, Australia*

1. Urban growth and traffic in Australia

The number of private cars in Australia has risen dramatically. In 1920 there was an average of 71 persons/car in Australia. In 1950, the amount of registered cars increased at a rate above population growth, whilst this average has declined to 11 persons/car. In 2003, Australia reached an alarming average of 2 persons/car resulting in more cars on the road and increased traffic volume and flows (ABS, 2005). The rise of car ownership in Australia was accompanied by a considerable decrease of public transport use. In the 1950s, private cars and public transport shared equal proportions of travels in capital cities. From the late 1970s to the present, there has been a significant shift, in which the majority of trips were by private cars (~90%) and less by public transportation (10%) (BTRE, 2007). Private vehicles remain a dominant force in Australia despite the economic and environmental cost involved, when compared to public transport (eg. fuel prices, registration, insurance, carbon emissions, changes to the natural landscape). For example, during 1977-96, car prices have increased 2.25-fold, fuel prices have increased 5-fold, the amount of cars per capita has also increased 1.3-fold, with vehicle kilometres/car/year almost unchanged (Hensher, 1998). Currently Australia has 16 million registered motor vehicles (Iftekhhar and Tapsuwan, 2010) for a country of around 22 million people.

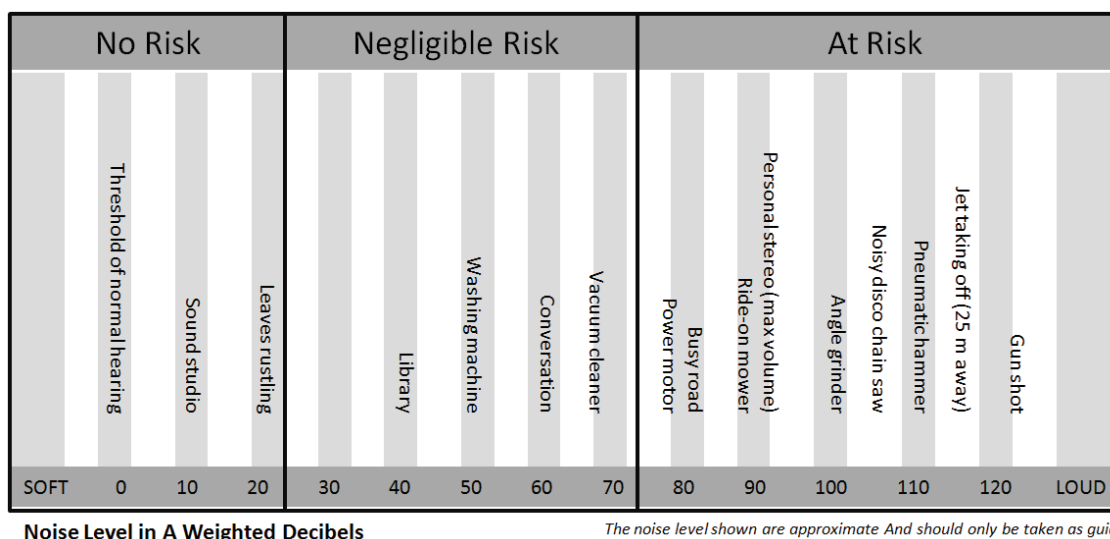
This personal mobility of Australians has fuelled the trend of decentralised housing development resulting in a low density pattern of urban development, spreading outwards from a central business district across a large area and extending the

urban fringe. Given the heavy reliance on private transportation, government has invested heavily in road infrastructure to connect distant parts of the urban sprawl. Highways and freeways are designed to provide fast connections within or outside metropolitan areas by allowing large flows of vehicles with reduced travel time, increased service access, and enhanced travel comfort. However, if outwards urban development determines the need for better transport connections and better accessibility between places, the required transport infrastructure can also stimulate new urban development in their vicinity; increasing the urban sprawl (Wegener, 2004). Most of freeways and highways are likely to be encapsulated by new housing developments in their surroundings over time.

Transport is an essential component of life and the positive effects include: i) access to education, employment opportunities and leisure activities; ii) contributing to economic development; and iii) enhancing the logistics of production and distribution of diverse goods and services. However, adverse effects also occur, particularly effects on health from heavy traffic on major highways. Adverse health effects of road transport result from air and noise pollution, roads crashes, insufficient physical activity related to reduced cycling and walking, potential social isolation, and poorer quality of life in neighbourhoods affected by heavy road traffic (WHO, 2007).

2. Noise in urban environment

Environmental noise has been defined as ‘unwanted or harmful outdoor sound created by human activities, including noise from road, rail, airports, and from industrial sites’ (EC, 2002:2). It is a side-effect of global trends of urbanisation (Gee and Takeuchi, 2004; Neitzel et al, 2009; OECD, 2010), with public health implications for citizens’ well-being and quality of life in everyday life (Passchier-Vermeer et al., 2000; WHO, 2007; WHO and JRC European Commission, 2011). Traffic noise is a major part of environmental noise in cities. Traffic volume in a 24-hour period and at different intervals during the day, evening and at night can affect people’s wellbeing. In motor vehicles, combined road noise stems from three main sources: i) power-train noise (cooling-fan, engine, drive-train, exhaust); ii) tyre-road interaction noise and wind noise; plus iii) speed and road surfaces (EEA, 2009). Figure 1 illustrates noise levels for different activities in urban areas. Busy roads are identified by an approximate level noise of 80dB(A), which lies in the range of risk for population exposure. dB(A) is the unit of measurement of sound pressure level. A-weighted decibels adjust the levels of frequencies within the sound spectrum to better reflect the sensitivity of the human ear (VicRoads, 2006).



Source: Adapted from Parliament of Australia (2010) - data provided by an Australian Hearing submission.

Figure 1: Approximate sound levels for common types of noise exposure (dB(A))

3. Adverse effects of traffic noise on population

Noise exposure from highway traffic is a public health problem. During the day road traffic noise causes annoyance, and at night it disturbs individuals' sleep. Long-term annoyance and sleep disturbance can result in more serious diseases (WHO, 2007). The human auditory system is continuously analysing acoustic information, which is filtered and interpreted by different cortical and sub-cortical brain structures. Signs and symptoms of ill-health may develop following endocrine and autoimmune responses to stress when exposed to road traffic noise in the immediate to long-term. The acuity and severity of ill-health depends on the levels/intensity, frequency and duration of noise that people are individually and collectively exposed to (Goines and Hagler, 2007). There are specialist areas of medicine for diagnosing and treating these health problems, such as sleep medicine, cardiology, audiology, and psychology.

There is sufficient scientific evidence that noise exposure can induce: hearing impairment (Ingle et al, 2007); annoyance (Bluhm et al, 2004; Michaud et al, 2008; Miedema et al, 2011; Neimann et al, 2006; Öhrström, 2008; Van Gerven et al, 2009); sleep disturbance (Ahrstom et al, 2006; Brankoljevic et al, 2006; Hong et al, 2010; Ising and Ising, 2002; Pirrera et al, 2010); decreased school performance (Clark et al, 2007; Stanfield et al, 2005); hypertension (Bendokiene et al, 2011; Bodin et al, 2009; Sørensen et al, 2011); and ischemic heart disease (Babisch, 2006; Babisch, 2008; Babisch, 2011; Bluhm and Eriksson, 2011; Ndrepepa and Twardella, 2011; Van Kempen et al, 2011). During the 1960s, most of the effects of sound on health and quality of life were already known, but later research using improved noise measures and more analytical tools further confirmed and expanded upon these findings, enabling precise assessment of exposure-response relationships and observation thresholds for noise effects on health (Passchier-Vermeer and

Passchier, 2000). Table 1 presents a general relationship between exposure to noise during the night and effects on health for different noise ranges.

NOISE LEVEL	EFFECTS ON HEALTH FROM EXPOSURE TO NOISE
$L_{\text{night,outside}} < 30\text{dB}$	Although individual sensitivities and circumstances differ, it appears that up to this level no substantial biological effects are observed.
$L_{\text{night,outside}} 30\text{-}40\text{dB}$	A number of effects are observed to increase: body movements, awakening, self-reported sleep disturbance, arousals. With the intensity of the effect depending on the nature of the source and on the number of events, even in the worst cases the effects seem modest. It cannot be ruled out that vulnerable groups (eg. children, the chronically ill, older persons) are affected to some degree.
$L_{\text{night,outside}} 40\text{-}55\text{dB}$	There is a sharp increase in adverse health effects, and many of the exposed population are now affected and have to adapt their lives to cope with noise. Vulnerable groups are now severely affected.
$L_{\text{night,outside}} > 55\text{dB}$	The situation is considered increasingly dangerous for public health. Adverse health effects occur frequently, a high percentage of the population is highly annoyed and there is some limited evidence that the cardiovascular system is coming under stress.

Source: adapted from European Centre for Environment and Health (2007)

Table 1: Relationship between night noise and health effects in the population

The expanding evidence base indicates human exposure to road traffic noise has multiple health impacts. This is especially relevant during the night, with noise levels $\geq 42\text{dB(A)}$, and over time leads to long-term effects on people's sleep patterns. Periods of rest and sleep enable individuals to recover from their daily activities; an important modulator of cardiovascular function. Noise-disturbed sleep is a potential cause for the development of cardiovascular disorders (Babisch, 2011).

Deloitte Access Economics (2011) has calculated estimates for the economic costs of sleep disorders experienced by Australians (age > 20 years) in 2010. Around 1.5 million Australians (9% total population) have sleep disorders, resulting in total health care costs of \$818 million, related to hospital and medical services, and the use of pharmaceuticals (eg. sleeping tablets) (2011:iii-iv). Indirect costs of sleep disorders are \$4.3 billion due to productivity losses (\$3.1 billion), lost revenue (\$472 million), informal care and other costs associated with workplace accidents (\$129 million) and motor vehicle accidents (\$517 million). While these calculations do not clearly indicate the proportion of sleep disorders attributable to road traffic noise (due to a lack of data), the large estimated costs are relevant to governments developing and implementing policy for noise management in urban areas.

4. Policies for noise management in urban areas

The prolific evidence base confirms the growing international and multi-disciplinary interest in road traffic noise as a global problem with local consequences, and also indicates significant gaps in knowledge (Thomson et al, 2008). Despite evidence of an association between traffic noise and public health, there are few standards or other regulatory measures addressing road traffic noise. Some factors contribute to

this situation. Firstly, many existing noise-related policies and legislation are not evidence-based and/or do not include a specific focus on road traffic noise. Niemann et al (2006) assert policymakers, the public and many experts still underestimate the health impacts of noise in the residential environment.

Secondly, diverse approaches are used in studies of noise-related ill-health, making it difficult to compare data across countries and locations. There are variances in sampling techniques, research methods (eg. case studies, cross-sectional, cohort, reviews, meta-analyses, national, multi-national), in focus of studies (eg. single or multiple health problems), distinguishing traffic noise from other environmental noises, a focus on particular population groups (eg. adults, children, older persons, pregnant women), plus different measures of noise (eg. time of day, distance from major road/intersection). The majority of studies addressing road traffic noise effects on health have occurred in Europe, with emerging recent research from Australia, Africa, Asia and the Middle East. There are limited Australian data available to provide a local context.

In Europe, the European Noise Directive (END) has established a guide for strategic measurement and mapping of noise in urban areas, to standardise procedures and compare results from different areas, regions or countries (EC, 2002). The directive, however, does not define a common threshold for all the countries in the European Union. Most countries have adopted a noise level threshold of 50dB(A) L_{night} for night time (12am-6am) and 55dB(A) L_{den} for day-evening-night (6am-12am).

Defining thresholds for noise exposure is not a trivial task. Different health effects occur from varied noise levels, and the frequency, volume and interval of exposure should also be accounted for. For example, according to World Health Organization (WHO) (2009), the threshold level for waking in the night and/or too early in the morning is 42dB(A), whereas the threshold for ischaemic heart disease is 50dB(A). With these findings, the WHO proposed a new guideline target for limiting outdoor night noise to 40dB as the annual average (EC, 2010).

In contrast, Australian policy efforts related to road traffic noise appears limited. Most of the concerns with traffic in relation to population and environmental health are focussed on air pollution, greenhouse gas emissions and climate change. Unlike other countries, there is no national environmental protection agency (EPA); instead each Australian state and territory has its own EPA with distinct priorities. There is a recently released national urban policy, which does not address road traffic noise (DIT, 2011). Only Tasmania and NSW have produced an evidence-based policy specifically addressing road traffic noise, noting Australian state/territory and international guidelines for noise management (DECCW, 2011; DIER, 2011). There are marked discrepancies in noise level thresholds and regulatory measures. In Victoria, for example, there are two thresholds: new highways are designed to attend a noise limit of 63dB(A) before sound barriers are installed, whilst noise levels up to 68dB(A) for existing highways are accepted before any mitigation measure is implemented to reduce the noise levels back to 63dB(A). These thresholds are very

high compared to current noise levels accepted in Europe. Of note, there is no specific threshold for noise levels during late night in Victoria (12am-6am). This is a serious limitation of the current regulation, since most of the adverse impacts on public health are related to long-term sleep disturbance.

In the following section we present a case study of road traffic noise data related to Section 3 of the Ring Road, Geelong, Victoria, Australia. The data were collected by VicRoads in 2009, and subsequent estimates of noise distribution in suburbs adjacent to the Ring Road occurred in 2011 (VicRoads 2011). These data were provided to the authors by VicRoads/Corio for further analysis, and rely only on average and maximum noise levels; data for minimum noise levels were unavailable.

The data used in this study was collected by consultant firms commissioned by VicRoads to conduct field work measurements of noise along section three of the Ring Road (VicRoads, 2006 and 2011). The data is in accordance to the noise measurements procedures prescribed by 'VicRoads Requirements for Acoustic Consultants'. Date, time, location, climate conditions, and noise measurements were recorded for the monitoring sites.

5. A preliminary case study

5.1. Ring Road, Geelong, Victoria, Australia

The Geelong Ring Road is a freeway (length: 25 km) beside Geelong's western suburbs (north-south direction), extending from the Princes Freeway at Corio (connecting to Melbourne) to the Princes Highway at Waurin Ponds (connecting to South Western Victoria). It also connects to the Midland Highway towards Ballarat, and the Hamilton Highway. The construction of the Ring Road was a recent initiative of the Victorian government towards providing faster and better accessibility from these areas in the south to Geelong CBD, and from Geelong to other areas of the state, especially to Melbourne.

Sections 1 and 2 of the Ring Road were officially opened in December 2008, and Section 3 in June 2009. Section 4A is a short overpass of the Princes Highway with a direct connection to Anglesea Road (and onwards to the Surf Coast and Great Ocean Road), which opened in December 2011. Section 4B, a short extension of 4A is currently under construction and estimated to be completed in 2013. Section 4C is planned to improve the connection to the Armstrong Creek, a Geelong suburb currently being developed (~50,000 new residents over 20 years) and the Surf Coast, another fast growing area in the region with coastal towns (eg. Torquay, Jan Juc, Anglesea, Lorne).

Since the official opening of the Ring Road, traffic volume and flow has also reduced in the centre of Geelong itself (eg. La Trobe Terrace, Shannon Avenue) and along High Street in the suburb of Belmont. The future spatial pattern of urbanisation will

put an extra demand on the use of the Ring Road and directly affect the level of noise to which residents are exposed.

This project analysed the situation of the residential area around Section 3 of the Ring Road in Geelong, under the jurisdiction of the Victorian state government agency: VicRoads (Figure 2).

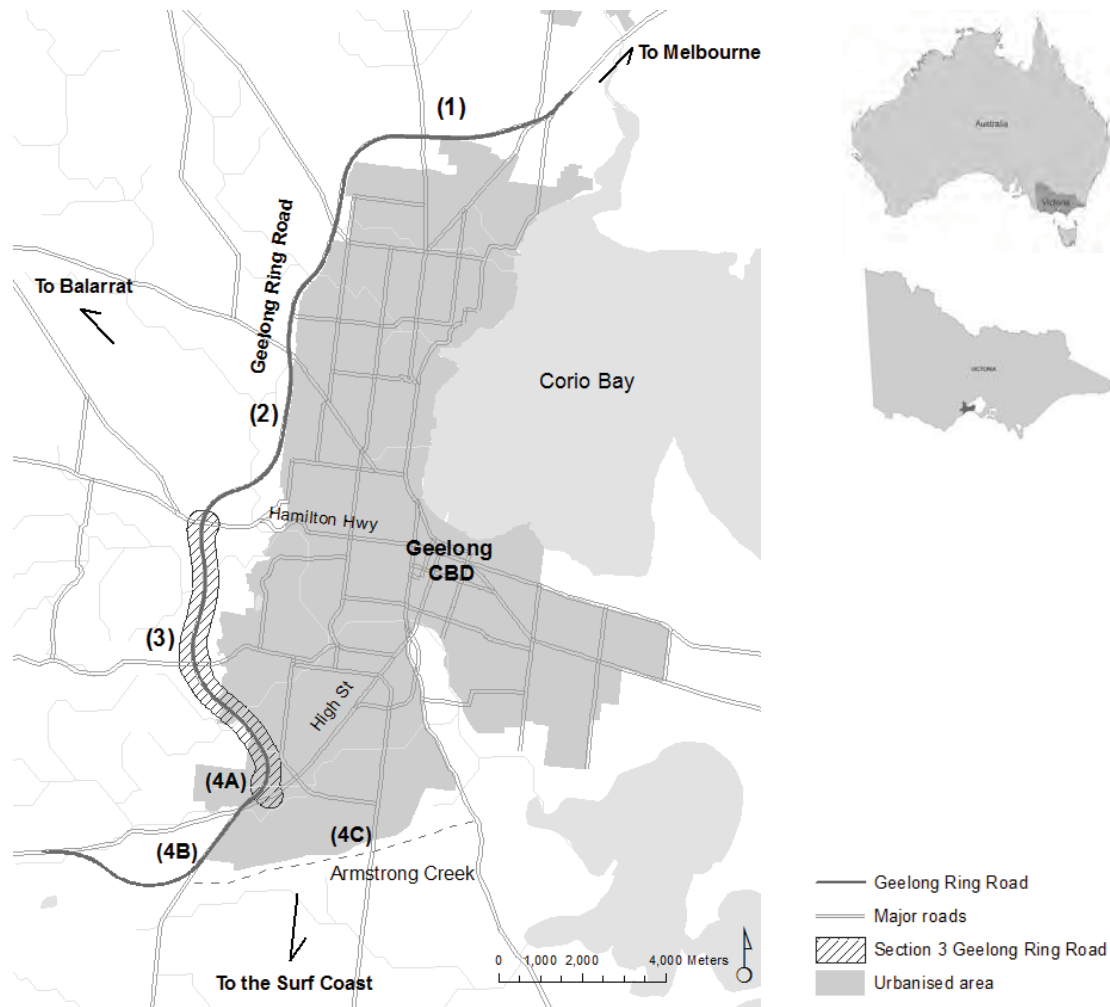


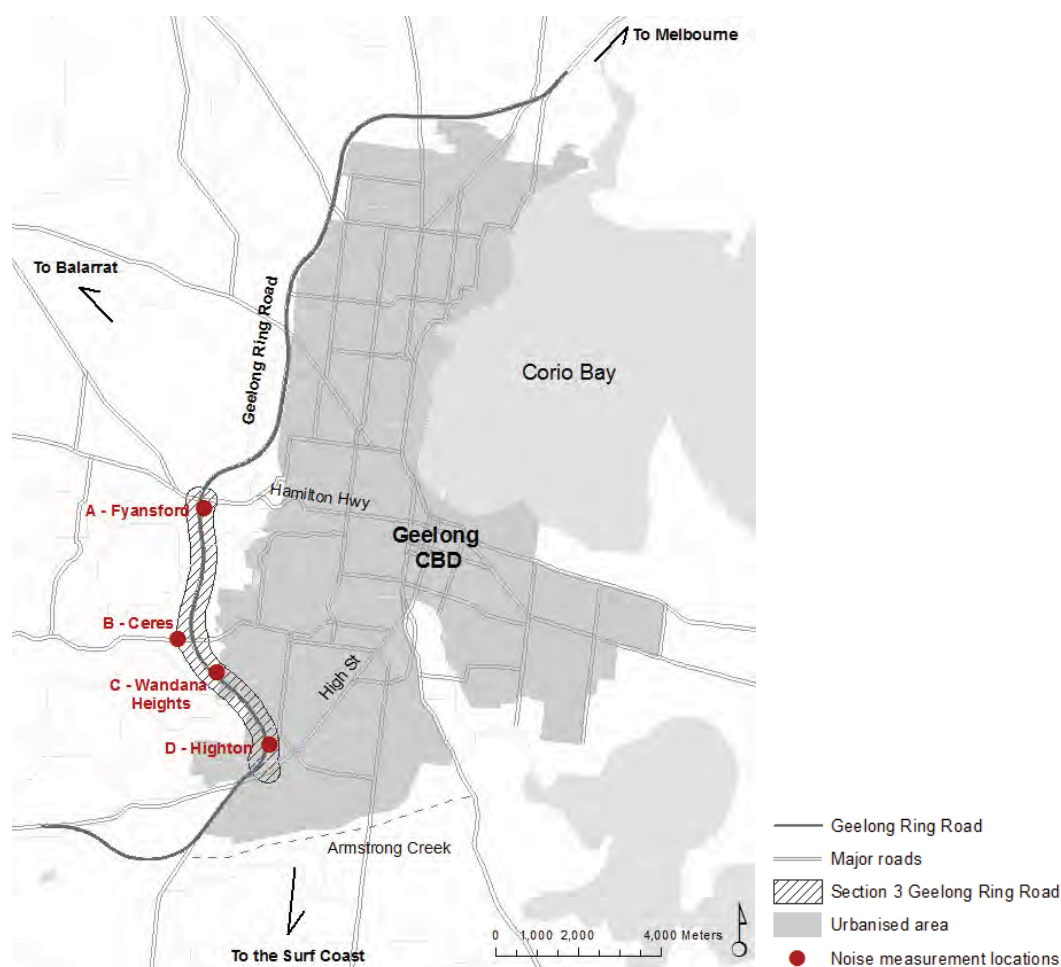
Figure 2. Study area: Section 3 of Geelong's Ring Road

5.2. Traffic and noise

Section 3 of the Ring Road has an average traffic volume of almost 18,000 vehicles/day, in both directions (north and south-bound), 8% are commercial vehicles, including trucks. Peak hours during the weekdays (Monday-Friday) are during 7am-8am, and 4am-5pm. The distribution of traffic volume throughout the day is: during the working hours (from 7am-6pm) (73%), in the evening and night (from 6pm-12am) (18%), and during late night to morning (from 12 am-7 am) (9%) (VicRoads, 2011).

Although most of the vehicle traffic occurs during working hours, the average noise level along Section 3 of the Ring Road is similar during the day, evening and late

night. Figure 3 presents the average and maximum noise levels in four different locations in Section 3 of the Ring Road for day and night (suburbs of Fyansford, Ceres, Wandana Heights, Highton). Late night accounts for 9% of the traffic volume, but the resulting noise level is only 8-11% lower than noise levels during the working hours, when 73% of the traffic concentrates. This is probably due to a larger proportion of commercial vehicles and trucks travelling along the Ring Road very early in the morning, despite a smaller total number of vehicles. This situation has a strong effect on sleep disturbance.



Noise Level (dB(A))			Location			
			A (Fyansford)	B (Ceres)	C (Wandana Heights)	D (Highton)
Average	Working hours	7 am to 6 pm	60	64	69	56
	Evening-night	6 pm to 12 am	57	61	68	51
	Late night	12 am to 7 am	54	59	62	51
Maximum	Working hours	7 am to 6 pm	84	89	88	94
	Evening-night	6 pm to 12 am	74	74	85	76
	Late night	12 am to 7 am	64	67	69	62

Source: Adapted from VicRoads Report 2011

Figure 3. Traffic noise along Geelong Ring Road, average and maximum (dB(A))

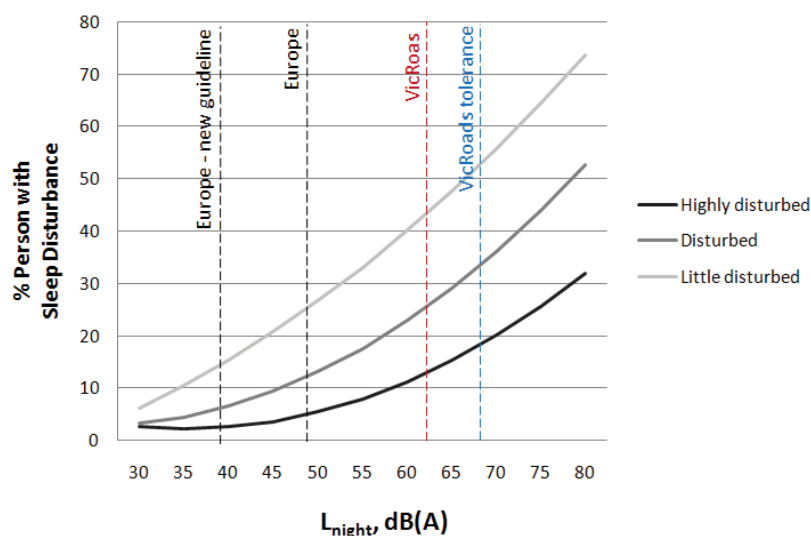
5.3. Potential health impacts

Medical research suggests that exposure to noise levels above 55dB(A) during the day, and 42dB(A) during late night can cause serious health problems to community residents (WHO, 2007 and 2009). In this case study, we focussed on sleep disturbance as a primary source of potential adverse effects on health from traffic noise in the vicinities of Section 3 of the Ring Road, Geelong.

As shown in Figure 3, people residing in suburbs close to the Ring Road are exposed to average traffic noise levels of 51-62dB(A) at night (12 am-7 am); the period of the day generally reserved for sleep. This is well above the recommendations of WHO (2009) (ie. 50dB(A)) and proposed night-time guidelines of 40dB(A). During the sleep period, residents can be also disturbed by short intervals of maximum traffic noise levels: 62-69dB(A).

Figure 4 illustrates the exposure-effect relationship for sleep disturbance with traffic noise for Europe. This graph has been built by the authors based on the equations provided in WHO, 2009, and using noise levels at night from 30 to 80dB(A). It presents an increase in the proportion of persons with sleep disturbance correlated with the increase in noise levels they are subject to during late night and early morning. Of note, it usually takes about 2-3dB(A) for a human to perceive a difference in sound level; and around 10dB(A) to perceive a doubling of the sound level (Kinsler et al, 1999).

Figure 4 also presents the current thresholds for noise level used in Europe and the Ring Road, Geelong, Victoria, Australia. These thresholds indicate the minimum noise level tolerated before installing noise reduction measures. VicRoads has established 63dB(A) for new highways, but accepts noise levels up to 68dB(A) in existing routes before mitigation measures are implemented to reduce the existing noise levels back to 63dB(A).



%SD vs. L_{night} equation, adapted from WHO, 2009.

Figure 4. Exposure-effect relationship for sleep disturbance with traffic noise in Europe, Thresholds in Europe and Victoria/Australia

We estimate if the European exposure-effect relationship curve (Figure 4) was valid for the Australian conditions, it would have the following impacts (Figure 5):

- *High sleep disturbance*: A decrease of the proportion of people highly disturbed during sleep by traffic noise from 12% (based on the current threshold for traffic noise in Victoria: 63 dB(A)) to 5% (if the threshold was the current European standard for traffic noise during night: 50 dB(A)), or to a minimum of 2% (if the new recommendation in Europe for traffic noise threshold during night was implemented: 40 dB(A)). VicRoads current tolerance (up to 68 dB(A)) would allow high sleep disturbance to increase from 12% to 19%.
- *Sleep disturbance*: A decrease of the proportion of people disturbed during sleep by traffic noise from 26% (based on the current threshold for traffic noise in Victoria: 63 dB(A)) to 12% (if the threshold was the current European standard for traffic noise during night: 50 dB(A)), or to a minimum of 8% (if the new recommendation in Europe for traffic noise threshold during night was implemented: 40 dB(A)). VicRoads current tolerance (up to 68 dB(A)) would allow sleep disturbance to increase from 26% to 34%.

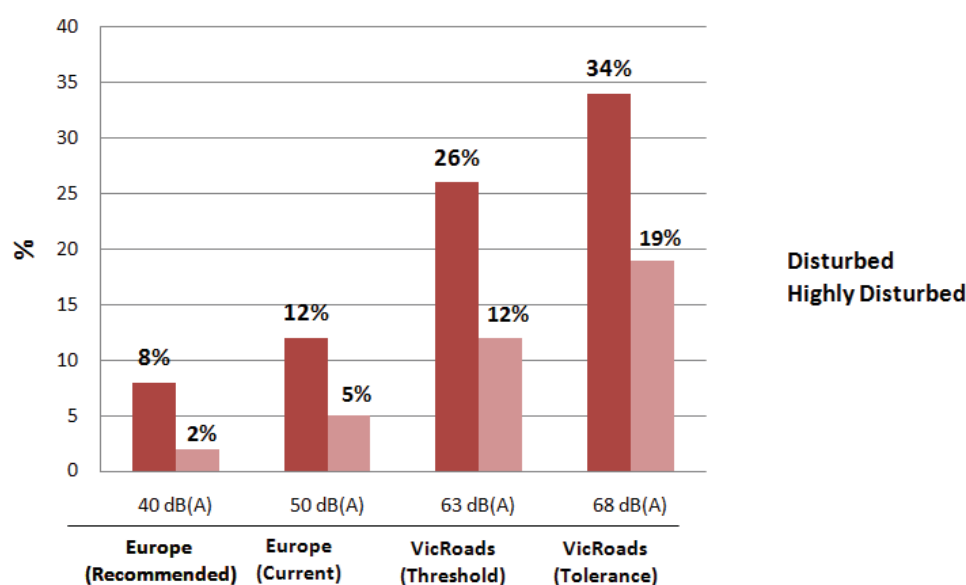


Figure 5. % of people disturbed or highly disturbed during sleep for difference noise levels; comparison of standards in Europe and Victoria/Australia

5.4. Exposure to noise

In this context, we are concerned residents' health and quality of life given their exposure to current and increasing noise levels related to population growth, urbanisation and heavier traffic volume on the Ring Road in the future. Figure 6 illustrates different situational exposure to traffic noise in the case study area (Section 3, Ring Road, Geelong), including: i) protection by installed sound barriers in parts of the highway; ii) the presence of natural vegetation as sound barriers; and iii) areas where dwellings are directly exposed.

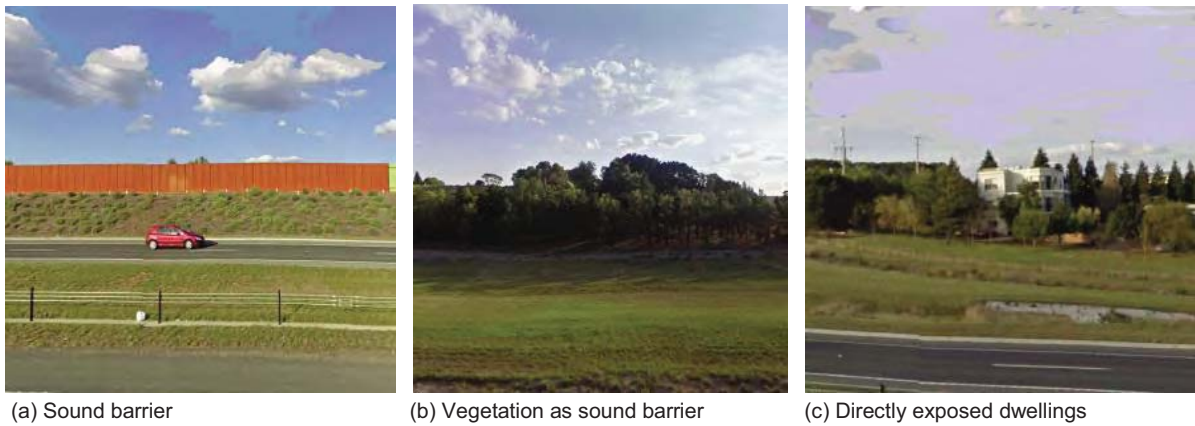


Figure 6. Views from Geelong Ring Road, Section 3 (2012)

Figure 7 presents the area estimated to have noise levels from traffic in the Ring Road $>50\text{dB(A)}$; the noise standard for night-time currently used in Europe. This noise map has been produced for a report commissioned by VicRoads (2006) as part of the study before the construction of the highway. It is based on characteristics of the route design (alignment, surface material, and speed limit), topography, vegetation, and potential traffic volume and composition. The estimates are similar to observed measurements of actual traffic flow and noise levels made in 2011 (VicRoads, 2011).

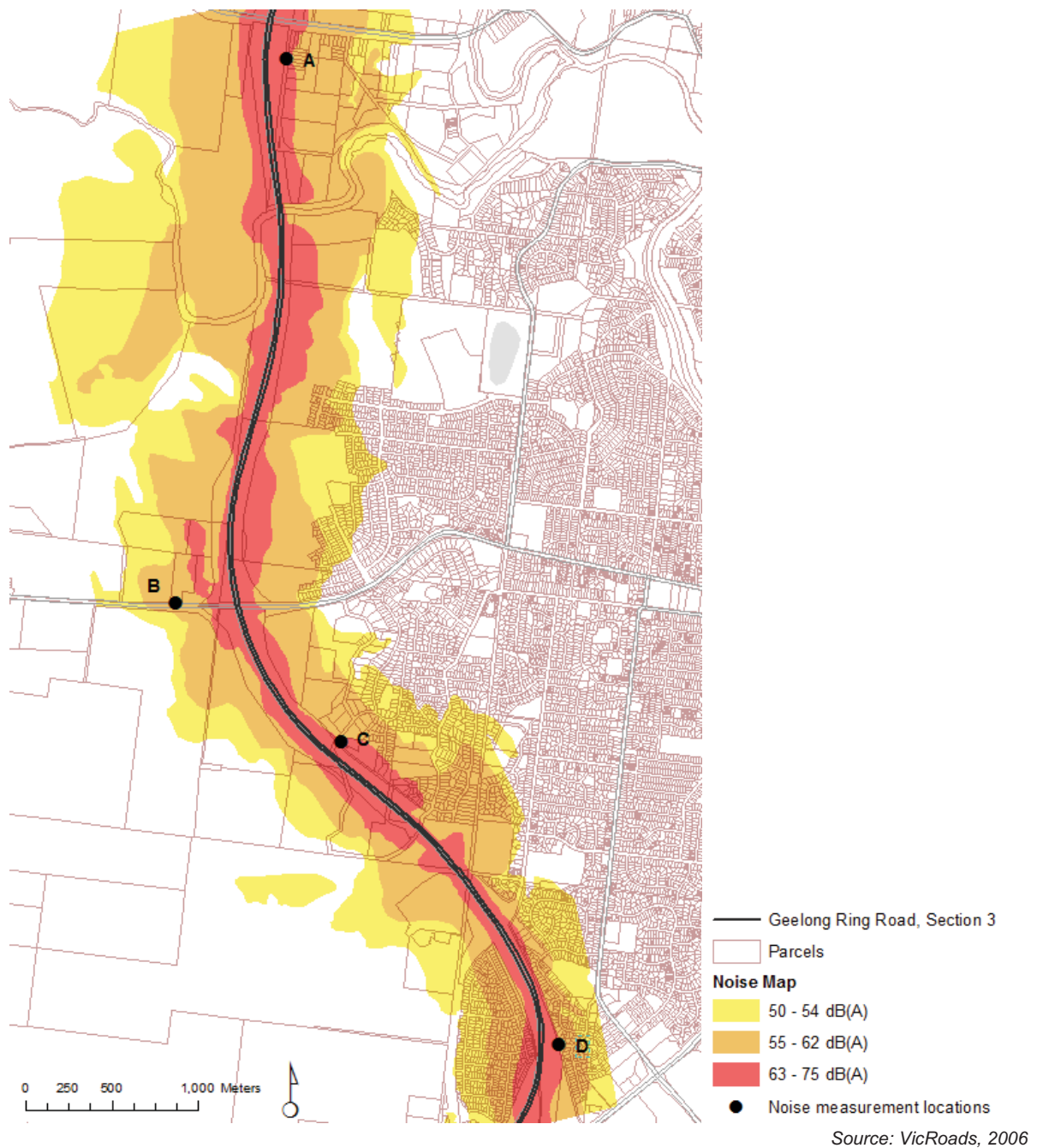
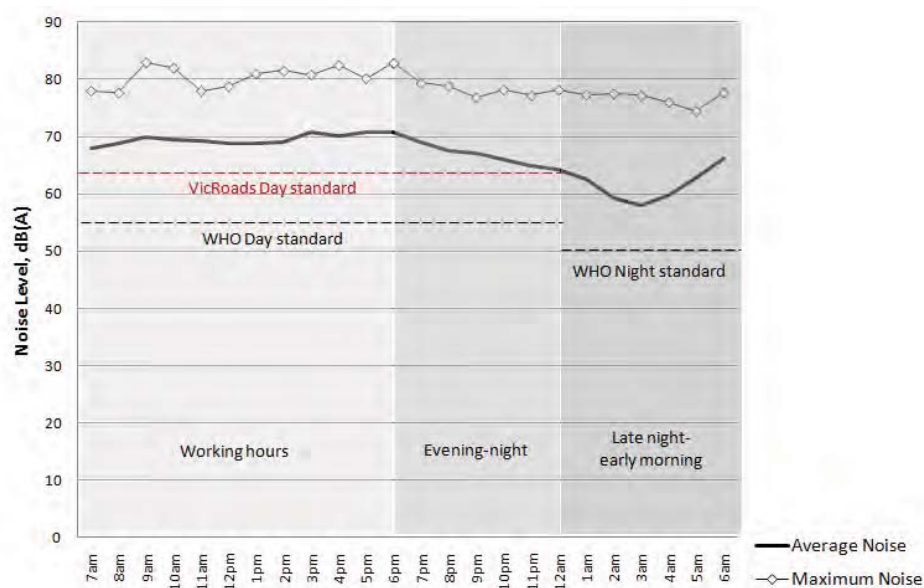


Figure 7. Estimated noise mapping in Geelong Ring Road - Section 3, 2011

There are 66 addresses exposed to noise levels above VicRoads standard of 63 dB(A). This situation increases to almost 600 dwellings if the European threshold of 55 dB(A) were used for day time. Residents of ~850 dwellings are exposed to noise levels >50 dB(A) during late night and early morning, potentially experiencing sleep disturbance. Approximately 3,500 people living within the buffer zone of Section 3, Ring Road are exposed to average noise levels during the night harmful to their health. Analysis of the demographic characteristics of the resident population indicates that around half are vulnerable groups, such as children (0-14 years) (39%), and older persons (>65 years) (15%) (ABS, 2006).

This situation is of great concern in the current context, but is even more dramatic if future scenarios are considered. The City of Greater Geelong population is projected to grow faster than the State of Victoria and metropolitan Melbourne in the next two decades (ABS, 2006). Most of the growth will follow previous trends and be distributed in the southern part of Geelong; especially in Armstrong Creek, a new residential development south of Waurn Ponds suburb as well as in the Bellarine Peninsula, Torquay and other coastal towns. Given housing, transport and community infrastructure associated with new developments, employment is expected to follow, extending the distribution of new major population centres. This growth will cause increased traffic flow along Geelong Ring Road and potentially higher levels of noise.

We have selected Location C (Wandana Heights) and Location D (Highton) as examples of the highest and lowest noise levels during a 24-hour period in the catchment area of this study. Figure 8 shows the variation of traffic noise levels, average and maximum values, for day and night at Location C, in Wandana Heights. Residents around this area are exposed to noise levels above VicRoads (2009) standards all day, evening and night (6am to 12am), and well above WHO (2009) standards during late night to early morning (12am-6am) of 50dB(A).



Source: Adapted from VicRoads Report 2011

Figure 8. Average and maximum traffic noise levels in Wandana Heights, Location C

Figure 9 indicates the variation of traffic noise levels, average and maximum values, for day and night at Location D (Highton). The situation at this location is significantly better than in Wandana Heights. Most of the day and night traffic noise levels are below the WHO (2009) standard, although valid only for average values. This location presents very high maximum traffic noise levels, particularly for day and evening. During late night, the average noise levels are also below the European

current standard. However, in the early morning (3am to 6am), residents' sleep is disturbed by traffic noise well above the recommended threshold.

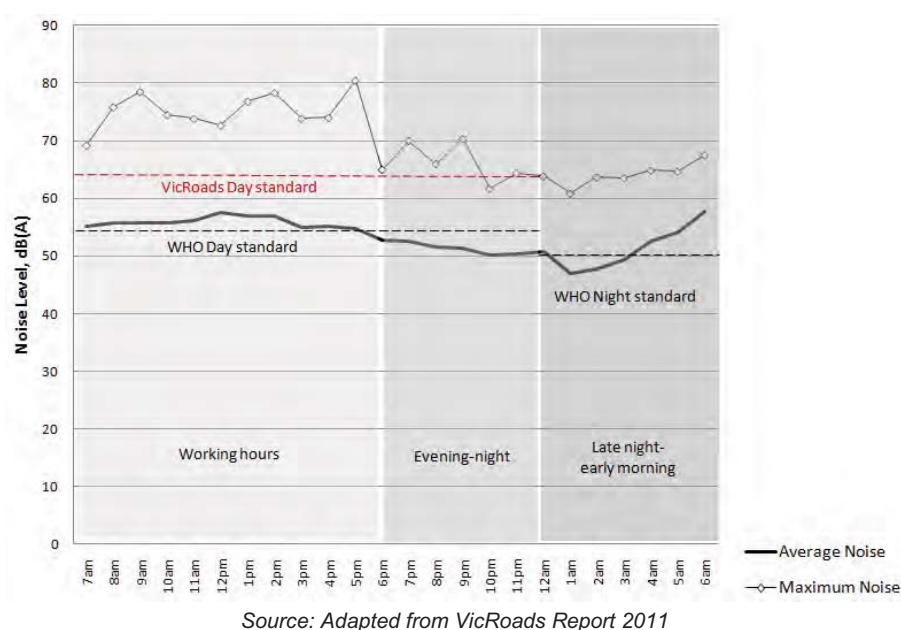


Figure 9. Average and maximum traffic noise levels in Highton, Location D

6. Conclusion

The vast and growing evidence base on road traffic noise (especially in Europe and less so in Australia) reveals a complex problem and numerous health and other consequences for diverse communities. As Brown (2003) and the OECD (2010) advocate, intersectoral collaboration and a multi-disciplinary approach to data collection and analysis on urban environmental quality is important to determine best practice approaches adapted to local conditions.

In public health terms, both legislation and policy are necessary to address and mitigate the effects of road traffic noise on residents' health and quality of life. This requires attention to decisions on locating key community infrastructure in urban planning and new areas of land-use development (eg. schools, shopping centres, residential housing, libraries, hospitals), developing and implementing innovative solutions whilst avoiding future medium to long-term problems or indirect effects (Amram et al, 2011; OECD, 2010).

The WHO Regional Office for Europe, European Commission (EC), United Nations Economic Commission for Europe (UNECE), WHO Alliance of Healthy Cities and European Environment Agency (EEA) have drawn on the available evidence base to inform system-level and cross-jurisdictional regulatory measures (including policies, legislation, standards and guidelines) to improve urban planning and reduce residents' exposure to environmental noise (including from road traffic) and health impacts. The measures refer to current and prospective practices and guidelines (eg.

strategic noise maps, social and economic evaluation, environmental and health impact assessments, vehicle design, noise barriers).

In Australia, increasing government and residents' concerns about the environment (eg. climate change, drought, increasing urbanisation, liveability and sustainability of cities) have led to policy development. Recently the federal government released a national urban policy, with few components specifically addressing road traffic noise (DIT, 2011). A national coordinated approach to reducing road traffic noise, across all Australian jurisdictions appears absent. There is significant variation in the jurisdictional tolerance for exposing communities to traffic noise across Australia, and most of the policies are not based on scientific evidence.

Since 1998, the WHO Alliance of Healthy Cities has an Australian chapter of full members and associate members. This includes the Corio and Norlane Development Advisory Board (CNDAB), Geelong, Victoria and other Australian cities. The Australian Chapter has been meeting and developing healthy public policy to address the liveability and healthiness of urban areas. The vision is broad:

Building cities and communities of peace where all citizens live in harmony, committed to sustainable development, respectful of diversity, reaching for the highest possible quality of life and enable equitable distribution of health, by promoting and protecting health in all settings (Alliance for Healthy Cities 2008).

Given the policy context and preliminary findings of this case study, we make recommendations for policy development and future research.

Policy development

- Develop and implement a national framework/guidelines for traffic noise measurement informed by: i) available Australian studies, ii) the European and other international evidence base on published studies, and iii) European Commission guidelines (EEC directive) as a common standard used in European countries.
- Involve other Australian jurisdictions (metropolitan and regional areas) as well national and other states/territories to inform development of a national framework/guidelines addressing road traffic noise in Australia.
- Include community representation in development of the national framework/guidelines, to provide citizens' perspectives.
- Develop and implement effective interventions to mitigate effects of road traffic noise on population wellbeing and quality of life, informed by European guidelines.
- Monitor the outcomes of these interventions over time, to ensure effectiveness, identify extraneous impacts and inform future measures.

Future research

- Undertake further Australian-based studies that are multi-disciplinary in focus with relevant expertise on project teams and project advisory groups – and contribute to the Australian evidence base.
- Consider different approaches to researching the effects of road traffic noise on people's health: 'control for intermediate factors' (eg. blood pressure), 'current behavioural risk factors', 'categorical data analyses (relative risk of different noise categories with reference to the lowest)', and 'continuous data analyses (relative risk per dB-increase, based on regression models) (Babisch, 2011).
- Conduct fieldwork for objective and subjective noise measurements and health-related effects on residents (specific population groups) given different proximal and distal distances from major roads in time and place, using well accepted recommended guidelines of the European Commission (2002) and the WHO Regional Office for Europe (2009).
- Use noise mapping technique for *all* facades of a residential dwelling (eg. house, apartments) plus indicate the location of rooms (quite, noisy), windows and balconies, and the presence or absence of noise reduction measures to determine the lowest and highest exposure to road traffic noise, rather than just the front facade.
- Assess the 'effects of combined exposures due to multiple noise sources (eg. different transportation noise sources or transportation noises and occupational noise)' (Babisch, 2011).
- Draw on health economics expertise to undertake a cost-benefit analysis of road traffic noise and health impacts (eg. potential health services costs, quality of life measures).
- Undertake a longitudinal study on the long-term effects of road traffic noise on children residing and attending schools near major roads.
- Monitor the effects of existing and new interventions implemented to mitigate noise traffic noise.

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Cultivation, Consumption and connection: How to make the most of local food.

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Cultivation, Consumption and connection: How to make the most of local food.

Abstract

Cultivation, Consumption and connection: How to make the most of local food.

The growing disconnection between urban residents and the food they buy and consume has been shown to have adverse effects on local economies, personal and community health, the environment, and social connectedness. Urban or civic agriculture and, in particular, local food movements, have been championed as ways of bridging this disconnect while simultaneously contributing to increased food security. To explore this potential, this paper identifies the key components of local food practices (production and retail outlets) in the Australian Capital Territory (ACT) and, through the use of ethnographic data gathered from community gardeners and those who purchase food at farmers' markets and farmers' retail outlets, it discusses the key ways in which these participants understand their points of connection to the food system. Our findings indicate that direct relationships exist between how food is provisioned and people's awareness and commitment to improving food security, reducing food waste and a broader commitment to healthy, sustainable urban living practices.

Keywords: *local food, food security and urban agriculture*

Introduction

Fears raised about future food security in relation to peak oil and climate change have increasingly politicized the food system, including what we eat, how it is grown, and the methods of distribution and sale (see Steele, 2009; Cribb, 2010; Latour, 1993; Shiva, 2000). While the advent of industrial agriculture has promoted multiple points of disconnection between people (particularly in cities) and the food system, over the last decade there has been a significant increase in food-based social movements and grass-roots initiatives imploring people to rethink their relationship to the food system and those whose livelihoods are tied to it. These initiatives are primarily mobilized through discourses of health, environmentalism, community/localism and anti-industrial agriculture and are most evident in the rise of forms of ethical consumption, from the purchasing of organic and fair-trade foods to shopping at farmers' markets. Based on ethnographic research into the values, beliefs and practices related to food production and consumption of community gardeners, and those who identify as shoppers at farmers' markets and farmers' retail outlets in Australian Capital Territory (ACT), this paper explores how these practices can encourage multiple points of reconnection with the food system, the environment, our landscape, local economies and our communities.

Points of Disconnection: Distance, health, environment and food waste

Since 2008 over half of the world's population has lived in urban environments (UN, 2010). Urban sprawl, and efforts to counteract this through a planning focus on inner-city densification/in-fill, has significantly reduced the land available for food production in urban and peri-urban areas (the shrinkage of the Sydney food basin is one example of this: Parker, 2007). This shift in where the world's population resides and the nature of cities suggests that fewer people are directly involved in medium and large scale food production than ever before. As Steele (2009) documents in *Hungry City: How Food Shapes Our Lives*, the character and culture of cities has been, in part produced by freeing people from the constraints of food production. The continued growth of cities and the development of some in geographically remote locations with limited local water has required significant amounts of effort, energy and money to be expended on providing the residents with food. Steele asserts that "the feeding of cities has been arguably the greatest force shaping civilisation" going on to note "and it still is" (2009: 9). However, the role of food in the planning of cities has tended to take a "back seat to other urban systems like housing, transportation, employment, and the environment" (Pothukuchi and Kaufman, 1999: 213). The lack of attention and distancing from food has fuelled a growing disconnection between

urban dwellers and the food system. Increasingly, research is indicating that this disconnection is having adverse effects on the environment, local economies and personal and community health (Pothukuchi and Kaufman, 1999; Lyson, 2004; Steele, 2009).

In Australia it is estimated that a minimum of 5% of Australians suffer from food insecurity, with just under half of these (40%) experiencing severe insecurity (Rosier, 2011: 2). Food security is made up of three key components: food access, food availability and food use (Rosier, 2011: 2). The last category is defined as “the appropriate use of food based on knowledge of basic nutrition and care” (Rosier, 2011: 2). The processes of disconnection and lack of attention paid to food are fuelling a lack of knowledge about how to provision and cook nutritionally sound meals. A lack of social inclusion and connectedness is also limiting peoples abilities to learn about nutrition and cooking from familial and friendship networks leading to significant impacts on personal and community health (Rosier, 2011).

The increasing physical disconnection from food has also led to a “lack of knowledge of—where, how and by whom foods are produced” (Scrinis, 2007). A lack of awareness and/or interest in the grower or producer is usually coupled with a failure to understand the effort and time required to produce food. The creation of a global food economy means that large-scale food production has largely been left to multinational agribusiness providers. The resulting focus on economic efficiencies lowers overall costs, seemingly to the benefit of consumers. However, this serves to further reinforce the idea that food is, and should be cheap and plentiful. This has the potential to cause economic hardship for farmers, as expressed by Ausveg, a vegetable growers body, the Australian Greens and the National Farmers’ Federation in the recent push for lower prices on fresh fruit and vegetables and milk in Australia’s two key supermarket players, Coles and Woolworths (Willingham and Howden, 1 February 2012). This misunderstanding about the inputs and values of food is fuelled by another outcome of disconnection whereby people are so used to food being available all year round that there is little understanding of seasonality. Indeed, a British survey carried out in 2005 found that 40% of 16–34 year olds thought fruit and vegetables were “in season” when you could buy them in the shops rather than when they were harvested or planted (Smithson, 2006). For many, food has increasingly become like any other commodity, a disembodied product disconnected from its life history and the human and non-human inputs required to produce it.

The growing concern with food waste is yet another outcome of this disconnection which highlights concerns from environmental, health and social justice angles. Approximately 40% of food in the developing world goes unconsumed as a result of inadequate storage, transportation and pest-inflicted damage (Gustavsson et al., 2011). In Australia, households discard between \$5 -7.8 billion worth of food each year (Baker et al., 2009; Do Something, 2012). This has a considerable

environmental impact, ranging from the wasting of water and phosphorous that went into the food's production to the resulting carbon emissions generated as it rots away in rubbish tips. As concerns related to climate change, peak oil and food security increasingly focus attention on improving sustainable urban living practices, the problem of food waste is starting to receive greater attention. Yet we know little about why people waste food. A policy brief produced by the Australia Institute in 2009 identified that 84% of Australian consumers express a sense of guilt at discarding food, but this does not prompt them to alter their behaviour (Baker et al.: 10). In response to this growing issue we have seen the introduction of communication and education campaigns designed to encourage households to reduce their food waste. In particular, the not for profit organisation Do Something is running the national *FoodWise* campaign while the NSW Government has adopted the *Love Food Hate Waste* campaign from the UK. However, there is a significant knowledge gap in understanding the motivations and behaviours that lead to food waste.

The research informing this paper explores the ways in which the Canberran participants in our research understand and engage with these multiple processes of disconnection through their local food shopping behaviours, gardening practices and management of their own food waste. We have found that all participants in our study are seeking some form of (re)connection with various aspects of the food system.

Local food: Urban agriculture and Ethical Consumption in the ACT

While there are indeed multiple points through which urban citizens have become disconnected from food, in recent years the developing world has seen the growth of a counter-trend in the rise of urban-based grass-roots movements centred on food. These include the more radical reactions of freegans, dumpster divers and guerilla gardeners as well as a myriad of more mainstream practices such as farmers' markets, community gardens, school kitchen gardens, seed savers and land share practitioners. Urban or civic agriculture has been identified as a key way of reconnecting us to the foods we eat in regards to how they are produced, sold and consumed. This paper explores urban agriculture as well as forms of ethical consumption motivated by an interest in "the local" in the ACT to understand the key contributions these practices could make to urban food security. It draws on ethnographic research into the values, beliefs and practices related to food production and consumption of community gardeners, participants in school kitchen gardens and those who identify as shoppers at farmers' markets and farmers' market retail outlets.

Between 2009-2012 we conducted 48 semi-structured interviews with volunteers who identified with the categories described above. In a semi-structured approach, a list of topics and key themes is prepared with no fixed ordering of either words or

questions (Minichiello et al., 2008). As the aim of the study was to understand the way in which the target group view their local food provisioning practices in relation to their broader values, beliefs, knowledge and behaviours related to sustainable living practices, the data was analysed through a social constructivist framework (Crotty, 1998). The aim was to identify key themes and issues relevant to these participants rather than data that could be generalised across the population. Participants were invited to become involved in the study via multiple means. The research was advertised on relevant websites, facebook pages (e.g. of Choku Bai Jo, the farmers' retail outlet) and e-mails circulated to specific target groups (such as community gardeners). An advertisement calling for volunteers was also run in a free local newspaper, *The Chronicle*, which is delivered to all homes in the ACT and the nearby NSW town of Queanbeyan. Approximately 70% of the participants were female and all lived in the suburbs of Canberra.

The aim of this research was to gather "thick" (Geertz, 1973), rich in-depth data of the issues under investigation, which are the links between those who engage in local food shopping and production and their awareness and commitment to improving food security, reducing food waste and a broader commitment to healthy, sustainable urban living practices. This required us to target volunteers already participating in local food networks rather than the general ACT population. There is no data available which enables us to determine what percentage of ACT residents participate in these activities. However, we know that they are likely to be in the minority, as nationally full service supermarket chains account for more than 70 per cent of all grocery sales (DAFF, 2011). We also know that the overall food spending habits are not significantly different to the rest of Australia with the average Canberra household spending just over \$24 per week on fresh fruit and vegetables and almost \$94 on fast food, alcohol, confectionary, soft drinks and junk food (ABS, 2011). Nationally in the same categories the average spend was almost \$22 dollars on fresh items and just under \$84 on the others (ABS, 2011).

The following section outlines the main forms of local food provisioning available in the ACT.

Ethical/Local Food purchasing opportunities in the ACT: Farmers' markets, Farmers' retail outlets and Community Supported Agriculture

Canberra, as the nation's capital is a unique city. It is planned in accordance with the ideas of Walter Burley Griffin, drawing heavily on the American interpretation of Ebenezer Howard's Garden City movement. It is also demographically unique, being the capital city with the highest levels of higher education attainment in Australia and with a higher average income (ABS, 2008). However, as outlined above, there is no evidence to suggest this has a significant impact on the food purchasing habits of the typical Canberran. However, the local food provisioning options, and access to them, may well be better than in other cities.

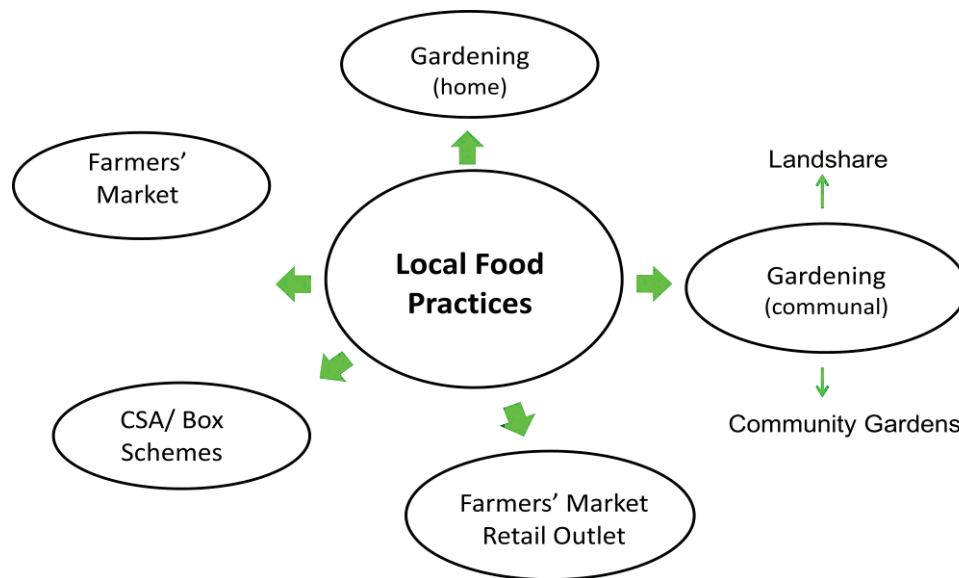


Diagram 1 – Local Food Practices in the ACT

The majority of ACT residents live within fifteen kilometres of one of the ACT's two farmers' markets. These markets attract crowds of around 10 000 people on an average weekend. The smaller, privately run Southside Farmers' Market operates on Sundays while the larger, and original (founded in 2003) Capital Region Farmers' Market (CRFM) is held on Saturday mornings on the city's northern edge. The CRFM is run by a not-for-profit community group, the Rotary Club of Hall. The Rotary Club asserts that the markets were established to provide benefits to the local community, producers and customers with all profits being directed to community schemes.

The second key element of the Territory's alternative food provisioning network is the presence of two farmers' retail outlets, one in the city's North and the other in the South. These are both an off shoot of the farmers' markets and are run by the same farming family. The shops are open for limited hours (2–7pm Monday to Friday and 8am–1pm on Saturday mornings) to enable the owners to harvest their produce in the morning and deliver it to the stores before the doors open to the public. The shops, known as Choku Bai Jo (Japanese for direct selling place), also stock other local and nonlocal food. To meet customer expectations of variety, stock is also supplemented by other Australian-grown fruit and vegetables sourced from wholesale markets in Sydney. Food is clearly labelled as local or not and organic or not.

Community Supported Agriculture (CSA/box schemes) run in the ACT, but, unlike the FoodConnect scheme in Brisbane and Sydney, they do not have a significant presence. CSA involves people buying "shares" from a farmer through the payment

of a subscription which results in the share owner receiving a regular box of farm produce (Brown and Miller, 2008: 1296-97). The most well-known CSA-hybrid example in the ACT is Allsun Farm a small-scale organic farm in the nearby NSW town of Gundaroo which provides a number of families and restaurants in the ACT region with fruit, vegetables and eggs for 7 months of the year. Demand for their produce is high and their service is fully subscribed.

Civic Agriculture in the ACT: Community Gardens and Landshare

According to Drescher et al., small-scale forms of urban agriculture can be referred to as “urban gardening” which they divide into three categories: home gardens, allotment gardens and community gardens (2006: 318). Pothukuchi and Kaufman claim that these gardening practices are integral to the “quality of urban life,” due to their ability to impact on the city’s economy, public health, environment, land use, and other community systems’ enhance the capacity for waste management insofar as they provide spaces in which biodegradable wastes can be turned into compost to be used for enriching and replenishing soil; contribute to improving micro-climatic conditions in urban areas, such as reducing heat island effects; and promote social inclusion (Saldivar-Tanaka & Krasny, 2004; Glover, 2004; Kingsley & Townsend, 2006; Tan & Neo, 2009). This last aspect is particularly evident in community gardens. As Firth et al. note, “[f]or this reason, community gardens have been appropriated by various statutory and voluntary agencies as an intervention to aid urban regeneration, social cohesion and related health problems” (2011: 555).

In the ACT, the majority of community gardens are run by the Canberra Organic Growers Society (COGS). To have a plot, gardeners must be fully paid-up members of COGS and are also required to pay an annual plot fee (just over \$2 per sq. metre). COGS has around 430 members and it currently manages 11 gardens with approximately 1.7 hectares of land. Three of these are in peri-urban areas with the remaining 8 located in denser suburbs and inner city locations (Steensby and Pearson, 2011: 7). Each garden has an individual convenor charged with the task of ensuring that the COGS’ constitution and gardening guidelines are followed. The key component of this includes maintenance of organic gardening practices in accordance with National Standard for Organic and Biodynamic Produce. COGS has entered into an agreement with the ACT Government to manage community gardens in the Territory’s suburban housing developments. The capacity for a fully volunteer-run organisation to meet this demand is questionable given that, as of 9 March 2011 the ACT Government has committed itself to providing space in all new subdivisions for community gardens.

A recent study undertaken by the authors of this paper and funded by the ACT Department of Health has identified that a number of other community gardens also operate in the Territory under a number of different forms of management. The map below (refer to Diagram 2) has been produced to identify these, along with the

location of school kitchen gardens. The diagram is a screenshot from the online interactive map that provides information such as contact details for garden managers/convenors, whether space is available, the facilities provided, bus routes (refer to Diagram 3), walking paths and public toilets.

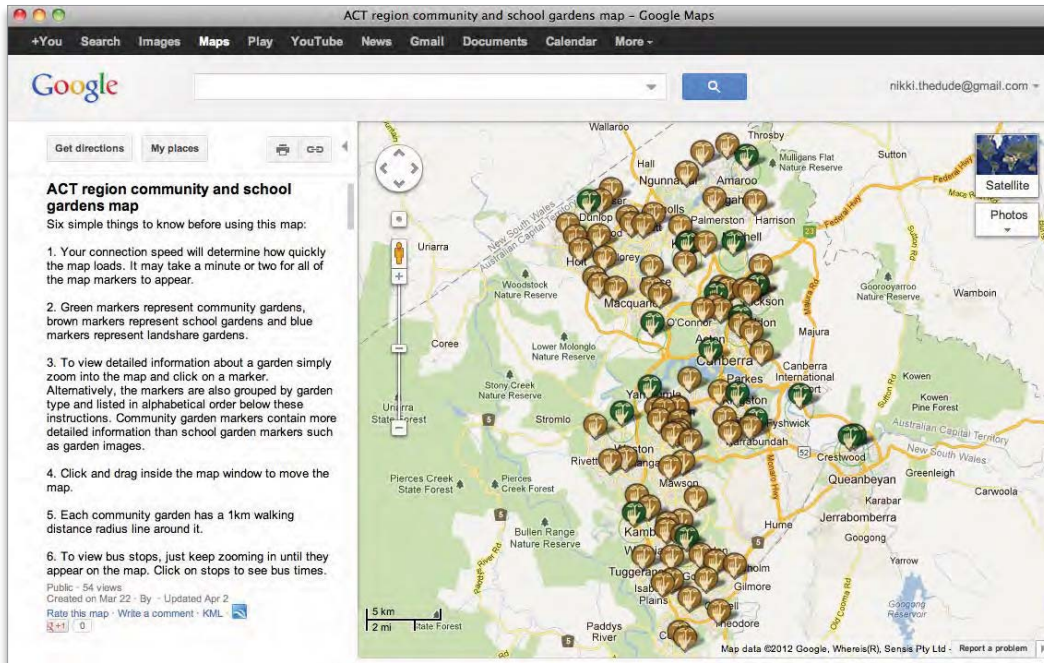


Diagram 2 – ACT Community Gardens Map

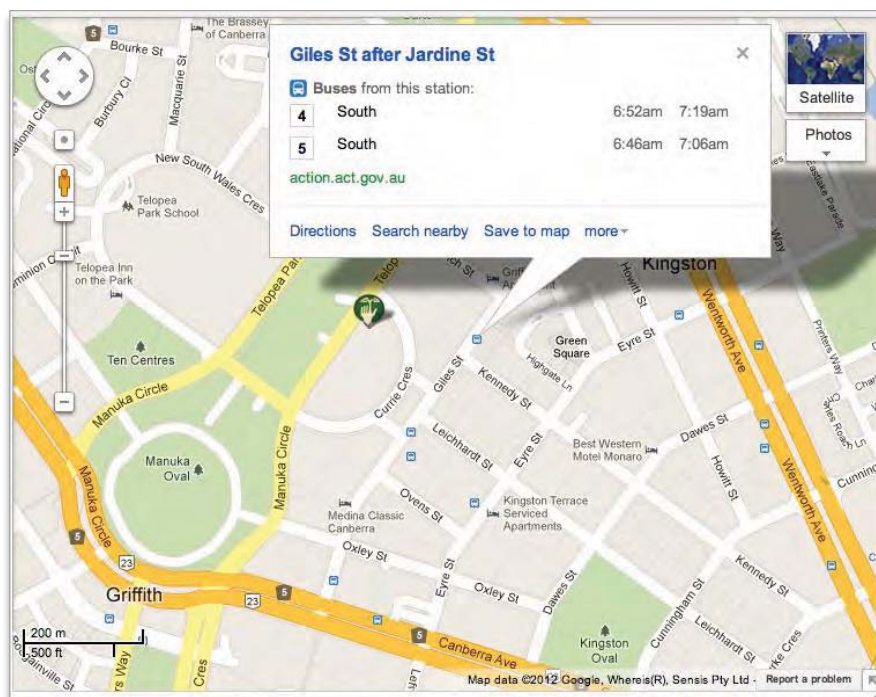


Diagram 3 – ACT Community Gardens Map- bus routes

Landshare also has a presence in the city. It is a scheme that enables those with backyards or space on their farms to register with an online site that then offers their land to potential fruit and vegetable growers. People seeking land and those willing to help with growing and/or harvesting can also identify themselves through the site. In Australia, there are currently over 57 000 participants in landshare (Landshare Australia, website). In May 2012 in the ACT there were 12 people currently offering land, 6 looking for space to grow and 4 willing helpers.

Through these various modes of production and local consumption practices, ACT residents have access to a variety of local food provisioning options.

Consumers and Growers in the ACT: Points of reconnection

This research aims to understand the links between local food and a commitment to broader practices of sustainable ecological living in urban areas. Those who purchase some of their food from within local food networks such as the farmers' markets and farmers' retail outlets and those who produce some of their own food in community or landshare gardens articulate an interest in (re)connecting to their food system through their practices of consumption and production. This (re)connection is directed towards 2 key areas: Human and Nature/Environment, with most interviewees expressing elements of both. Indeed, it was sometimes difficult for people to separate these two areas. Diagram 4 below summarises the key issues discussed in this section.

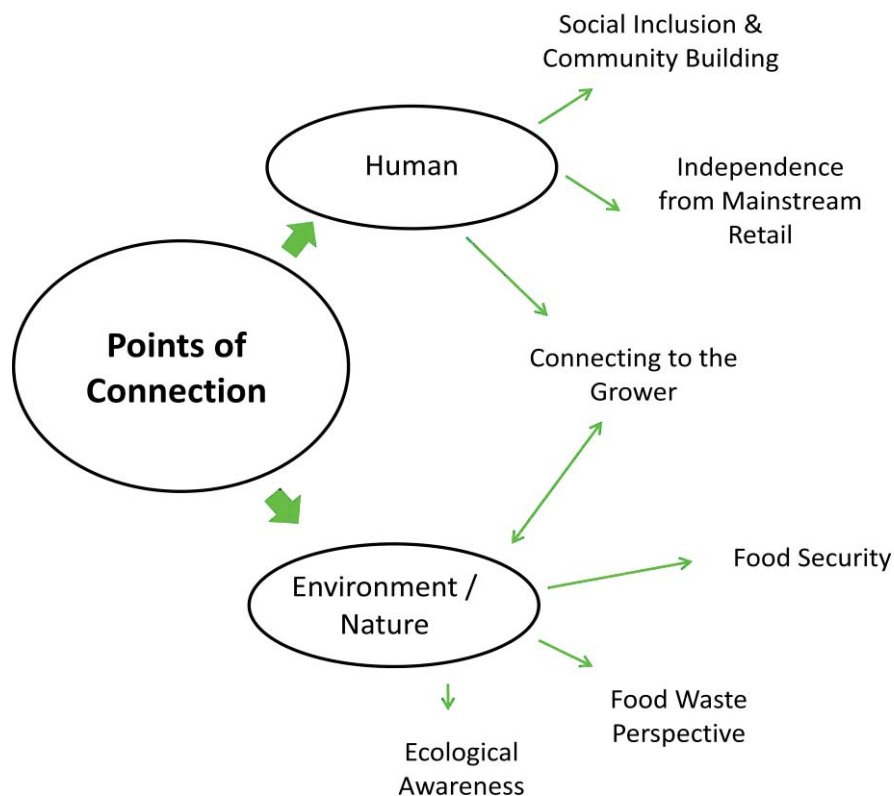


Diagram 4 – Points of (re)connection in the ACT

Human Re(connection)

Social Inclusion and Community Building

The human component was most often related to a sense of inclusion and community building (prominent among those who shopped at farmers markets and those who gardened in community plots). A key aspect of this involved the social aspect of community gardens and farmers' markets. In the gardens, participants spoke about their pleasure in meeting people they would never usually encounter as a result of age differences and simply operating in alternative social networks. This was exemplified by one gardener who notes: "[t]here's a whole sort of community thing that's happened here. People meeting each other they would never have met". The sentiment was echoed in other interviews in one of which a retired gardener noted "I like it here because you meet people you wouldn't normally meet in your life...When you get old you don't get many new jokes. You already told everything. Here you start again from the beginning. It's like becoming young again".

Independence From Mainstream Retail and Connecting to the Grower

Human reconnection was also expressed through peoples' desire to have a direct relationship with the food producer. This had two key elements: firstly it was related to people "voting with their wallet" through actively choosing to spend their money

with certain producers (quite often in the interviews this is contrasted with the “faceless” aspects of shopping in major supermarkets); and secondly, it was about knowing more about the food growing process through the development of a relationship with the producers: As one farmers’ market shopper notes:

Talking with the people who actually grow the food as well is nice...I have one stall this Japanese grower where the woman tells me very excitedly that she’s planted the Thai basil and I’ll have Thai basil again for the summer... So you have that connection with where the food’s actually coming from whereas at the supermarket who knows where it comes from.

This is not only about supporting local growers economically, nor is it simply a matter of being able to engage in a discussion about the food. It is also often intimately linked to the desire to connect with the process of production, inputs and efforts that go into the food people will soon be eating. Here we can see a blurring between the two key categories of connection, the human with nature/environment. Engagement with the farmer is seen as a conduit for linking people more directly to the environment. As one participant who shops at both the farmers’ markets and farmers’ retail outlets noted: “...if my daughter is standing next to me, and I’m talking to a farmer, and I’m asking them how much rain they got last night, and it had rained here as well, then my daughter’s getting some understanding about those processes that are nourishing her.” This interconnectedness between human and nonhumans is at the heart of ecological awareness (for further discussion of this please see Morton, 2007, 2010a, 2010b; Plumwood, 2002; Bennett, 2010).

(Re)connection with the Environment/Nature

Ecological Awareness: Care for soil and pursuit of organic methods

The points of connection to nature/environment were articulated by participants in numerous ways. For some the choice to engage in local food was motivating by broader environmental concerns “I feel like I’m feeding my kids right, and um and trying to ... use my money to support buying food that’s hopefully costing the planet less”. This was usually not simply seen to be a product of the food being local and thus having fewer food miles (though this did play a part). It was also an assumption that the foods being purchased had been subjected to fewer herbicides and pesticides than those purchased at supermarkets. Indeed, many people referred to the food at both the farmers’ markets and Choku Bai Jo (the farmers’ retail outlets) as being organic. While organic food is available at both these places, not all food on sale is organic. This consumer confusion in what is ‘organic’ has been previously documented (Henryks and Pearson, 2010). Though there was evidence of misrecognition around the idea of organic, people related their aspiration to purchase foods with fewer or no chemical inputs to health concerns for themselves and their families and also concern for the environment. Those keen on purchasing organic food expressed a desire to purchase food that had been grown in a way which best cared for the soil.

A key ecological theme revolving around the quest for variety in food arose amongst both the gardeners and local food shoppers in this research. This was expressed as excitement for the different and multiple forms of fruits and vegetables people encountered at the markets, things that would rarely be found in conventional supermarkets (such as heritage and heirloom variety of apples). For some this was motivated by concerns for food security and fears that large-scale monocultural production was threatening the world's ability to feed itself in the future. For some, this was a direct challenge to the big chain supermarkets with many people seeing their food production and shopping habits as "*giving the finger*" to Coles and Woolworths. For gardeners, this quest for different varieties revolved around a wish to increase independence: "*I think the whole gardening thing is a bid to be independent and different from the mainstream. To grow what you want to grow, varieties that you want*". This echoes the findings of Gaynor's study into suburban food growing in Australia which identifies notions of "independence" as a significant motivating factor for gardeners (2006). This sentiment was true for all interviewees who sought out food plants that were not mainstream, or readily available in Australia. The reasons for this are quite varied. For some it is linked to their cultural background, for others it is about health, or simply about experimenting with types of food and ways of growing that they were not common. For others it was an attempt to challenge the limitations imposed on the food consumption practices of people sourcing food primarily from supermarkets and thus, a challenge to industrial agriculture more broadly and wish to connect with nature/environment.

Food Waste Perspective

Perhaps the most common and significant finding of this research in relation to nature/environment connections relates to the issue of food waste. The majority of people we interviewed also gardened, whether in community gardens, landshare or in their backyards. While this not always fruit and vegetable gardening, the key finding was that these people were all intimately involved in avoiding food waste through the use of bokashi buckets, compost heaps, worm farms and the digestive systems of backyard chooks. In the interviews, people talked about gardens and the need to produce good, rich compost to feed them, as playing an important role in connecting them to nature/environment: "*It (gardening) keeps you attached to the earth... attached to the reality of where these things come from...*". Another noted that "*there's a kind of, almost like a Zen or a meditative space that you can get into when you're interacting with the soil, when you're cultivating and caring for something cos growing is all about noticing what is a plant doing, what is the soil doing, what is the air around you doing?*". This act of caring and point of connection was often expressed most vividly through compost. The link between decomposition and new life relied on the participants validating the labour of microorganisms and worms in the process. In fact gardeners spoke passionately about worms and the value of "*good*" compost. One new to vegetable gardening was amazed anything

was growing in her plot, seeing it as evidence that “*the soil always comes to the party*”. Through the process of gardening, participants identified a greater appreciation of human reliance on the non-human inputs (e.g. microorganism, worms, sun and water) required to produce food. In the interviews, gardeners and keen composters talked about the soil and compost as possessing agency; as having the ability to act in and on the world without constant human intervention. Gardeners spoke about how food gardening had increased their awareness and respect for the nonhuman elements of the ecosystem (even when they were pests). Many marvelled at the ability of a small seed to produce “mountains” of food for them and their families, nourished not only by human care, but also by the soil, its microorganisms, bugs and worms.

The participants who gardened also produced little to no food waste with meat scraps and dairy being the main source of food that was to become part of the municipal waste system. Our interviews asked participants to reflect on their food wastage broadly as well as asking exactly what they had done with their food waste over the week leading up to the interview. Food was frozen, preserved, eaten as leftovers and then anything else not able to be eaten by people was given to chickens, worm farms or compost heaps. In this way the uneaten or inedible food was not seen to be waste, but a vital source of renewal for the garden/nature/environment. This provides yet another point of connection that fuels a sustainable living practice.

Conclusion

Peoples’ engagement with local food systems indicates a myriad of ways in which they are seeking and/or fulfilling, a desire to (re)connect to the food system. This can occur through forms of social inclusion and community building as a conduit, but it is also expressed in ecological terms through expressions of connectedness with nature/environment. Through our interviews we found that, for our participants, the closer peoples relationship to food, either through engagement with the producer and awareness of the inputs that led to its production or through their own gardening, the greater their awareness of, and interest in, ecological interconnectedness. This related largely to articulations of an understanding and valuing of both the human and nonhuman inputs required to produce food. Of course, it is difficult to assess the cause and effect components of this and these results are not generalisable across the population. However, there is evidence that local food practices may well provide multiple points of connection to the food system for some people and these could have the benefit of promoting broader sustainable living practices. In our research we have found this has manifested itself most obviously in the arena of food waste. It is possible that by providing more opportunities for people to be intimately involved in the food system through local food, we may well see a reduction in food waste.

Further research is needed to confirm this and to develop strategies to most effectively harness this potential.

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Cities built on steeply sloped areas in Japan

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Cities built on steep slope areas in Japan

Abstract

In this paper, we created an urban condition evaluation method to express steepness according to differences in height and the average slope in each 100m×100m mesh area. “Slope degree” is introduced as the standard of measure. The “slope degree” of two typical cities in Japan (Yokohama & Nagasaki), which are well known for their steep slopes, are calculated and compared. Furthermore, the “slope degrees” of houses in those cities are also investigated. The landform character of each city is certified by a quantitative analysis.

One of the biggest problems in Japan is its aging society. Over the past few years, the population ratio of people over 65 years old has been increasing. Furthermore, the living conditions in sloped residential areas are not convenient for people of advanced age to go about their daily activities. Therefore, this study aims to establish a method for analysing sloped residences using GIS.

Keywords: *slope degree, steep slope area, aging society, living convenience, urban redevelopment*

1 Introduction

Many Japanese cities are well known for their steeply sloped topography. Furthermore, the suburbs around major metropolitan areas have developed into bed towns, and these contain a lot of residential buildings built on sloped areas. Residents who live in such areas can only access stations by walking up and down these steep slopes. In high density residential areas, narrow sloping roads are often the only access roads that people use in their daily lives. Moreover, some areas cannot be accessed by cars, and must be travelled on foot. Japan's aging society is becoming a serious problem. The ratio of the population which is older than 65, is over 25% in most Japanese cities. Slopes are a great hindrance to the daily activities of elderly people. However, the unique landscape view afforded by the top of these slopes also presents a kind of advantage in terms of urban-scape design and local revitalization. The total Japanese population is decreasing, but in the suburbs around Tokyo it is still increasing and there is still a great demand for residential development there. In some other rural areas, the decreasing population requires a compaction of city facilities and residential buildings. Assessments of slopes in various cities provide a platform upon which urban planning can try to improve current living conditions.

Japan is prone to earthquakes which can cause landslides. Asylum measures should be proposed before such disasters occur, and geographical data should be prepared for emergency measures. Quantified data is immediately appreciable and recommended for use during evacuations or rescue operations when time is limited.

2 Calculation method of slope degree

The GIS (Geographic Information System) is the software that can collect related databases for different fields onto a map¹⁾. It allows both the individual analysis diagram and the compound analysis to be easily achieved. Thus, GIS provides planners the more comprehensive understanding of an area upon which they are working. We also consider this study of GIS in urban planning as a development of GIS application^{2), 3)}. This paper presents new information of an evaluation method for urban planning, which provides more social information on the target area than previous methods and shares the results of information evaluations⁴⁾.

To express the steepness of these areas, "slope degree" is introduced as a standard of measure⁵⁾. Differences in height and average slope in each 100m×100m mesh can be calculated by counting the number of contour lines in each mesh area. As shown in chart 1, the slope degree is the same as the number of contour lines.

Slope Degree	0	1	2	3	4	5
Number of Contour Line						
Different in Height	5m	10m	20m	30m	40m	50m
Average Slope	1/20	1/10	2/10	3/10	4/10	5/10

Chart 1 – Definition of “Slope degree” in each mesh

Using the overlapping mesh layer and contour line layer seen in chart 3, we found the slope degree of each mesh. Consequently, the overlap of mesh upon building layer and the slope degree of each building can be expressed in different colours according to the different slope degrees (as shown in chart 4).

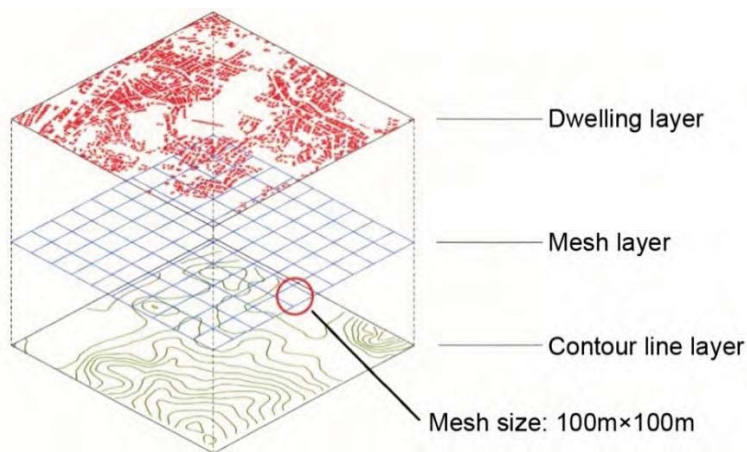


Chart 2 – Image of layer overlapping

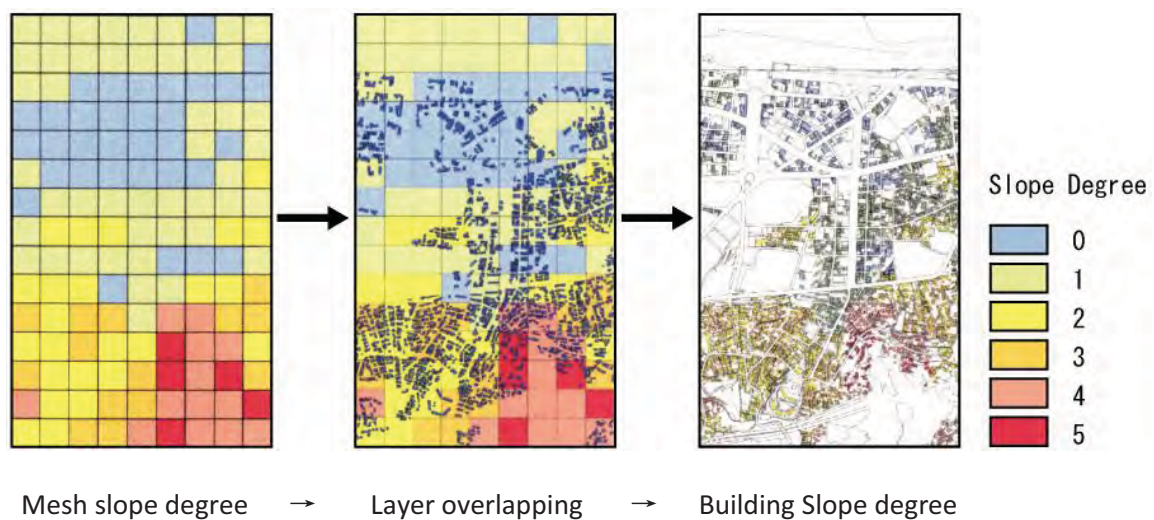


Chart 3 – Explanation of building slope degree

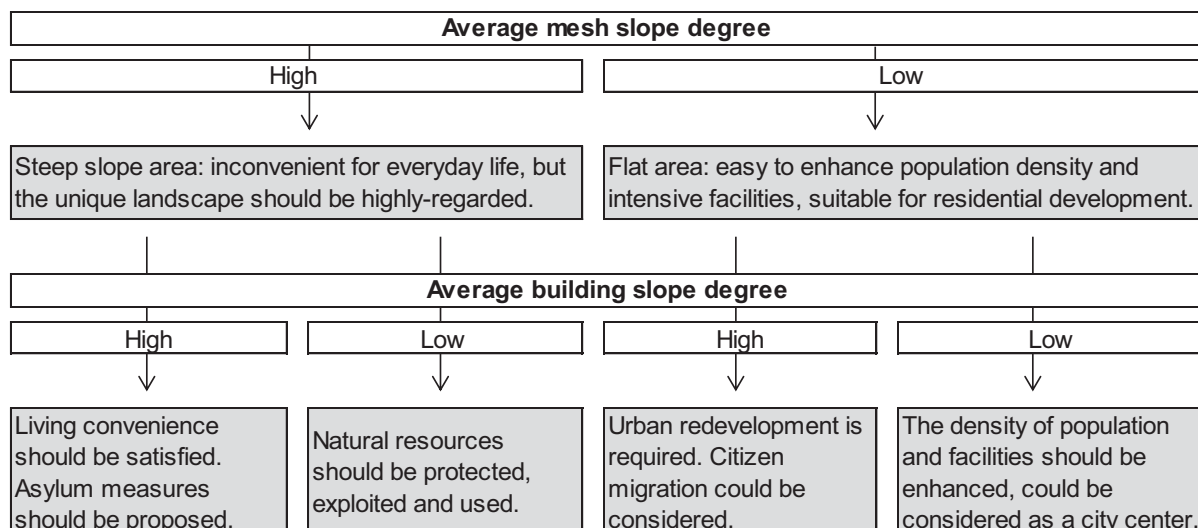


Chart 4 – Condition analyses by slope degree

According to Japanese law, a “steep slope” is defined as one whose gradient value is higher than 30°C (slope degree 3). This standard is set to protect residents from the effects of landslides. It means that a slope with a gradient value of over 30°C is not only considered to be inconvenient for living, but is also insufficiently safe.

Chart 4 shows condition analyses for urban planning with average mesh slope degree and building slope degree. It shows what kind of information you would get from the slope degree results. Considering both landform and building position, suggestions are given which show both advantages and problem solutions for the region.

3 Slope degree analyses through GIS

Two typical sloped cities in Japan, Yokohama and Nagasaki, are picked up for slope degree analyses through GIS and their characteristics will be compared. Both of these two cities are known as sloped cities.

Yokohama was developed as a seaport from the 1850's. Because it is situated only 30 to 40 km from Tokyo, it became a residential area to balance the high development of Tokyo. Therefore, residential development was extended from 1960's. At present, the population and residential density of Yokohama are the highest in all of Japan's cities. It also has the highest number of residential buildings in Japan that have been built on sloped areas. A great number of those residential buildings are apartment buildings.

Nagasaki is one of the oldest Japanese harbour cities. About 400 years ago, it used to be the only trade port in Japan. The population density in central Nagasaki is very

high. Around 78% of its citizens are living in 13.1% of the city's area, because the area ratio of slope is very high, and the slopes are very steep. Traditional residences on steep slopes have become a uniquely characteristic view of Nagasaki.

3.1 Broader area analyses

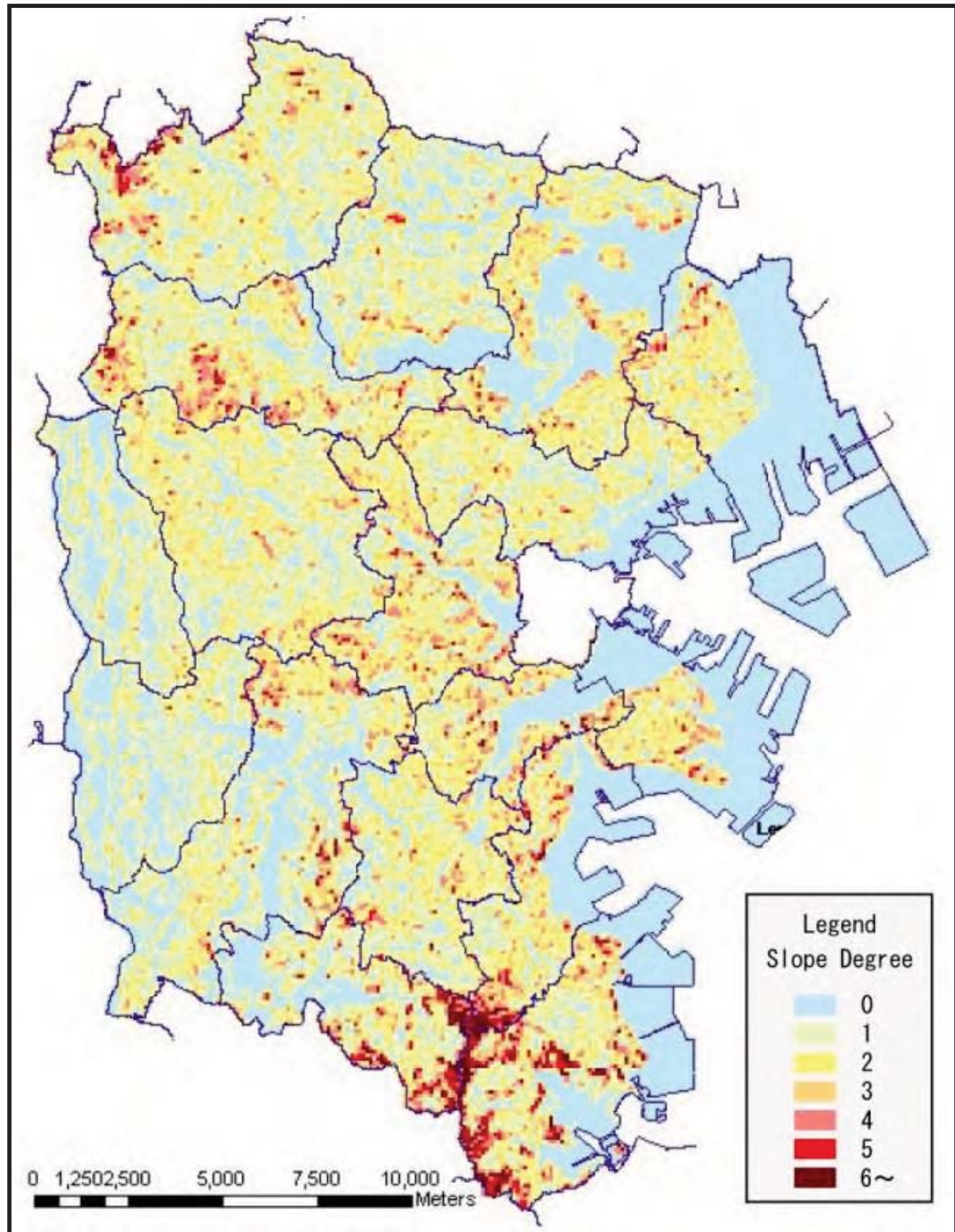


Chart 5 – Mesh slope degree in Yokohama

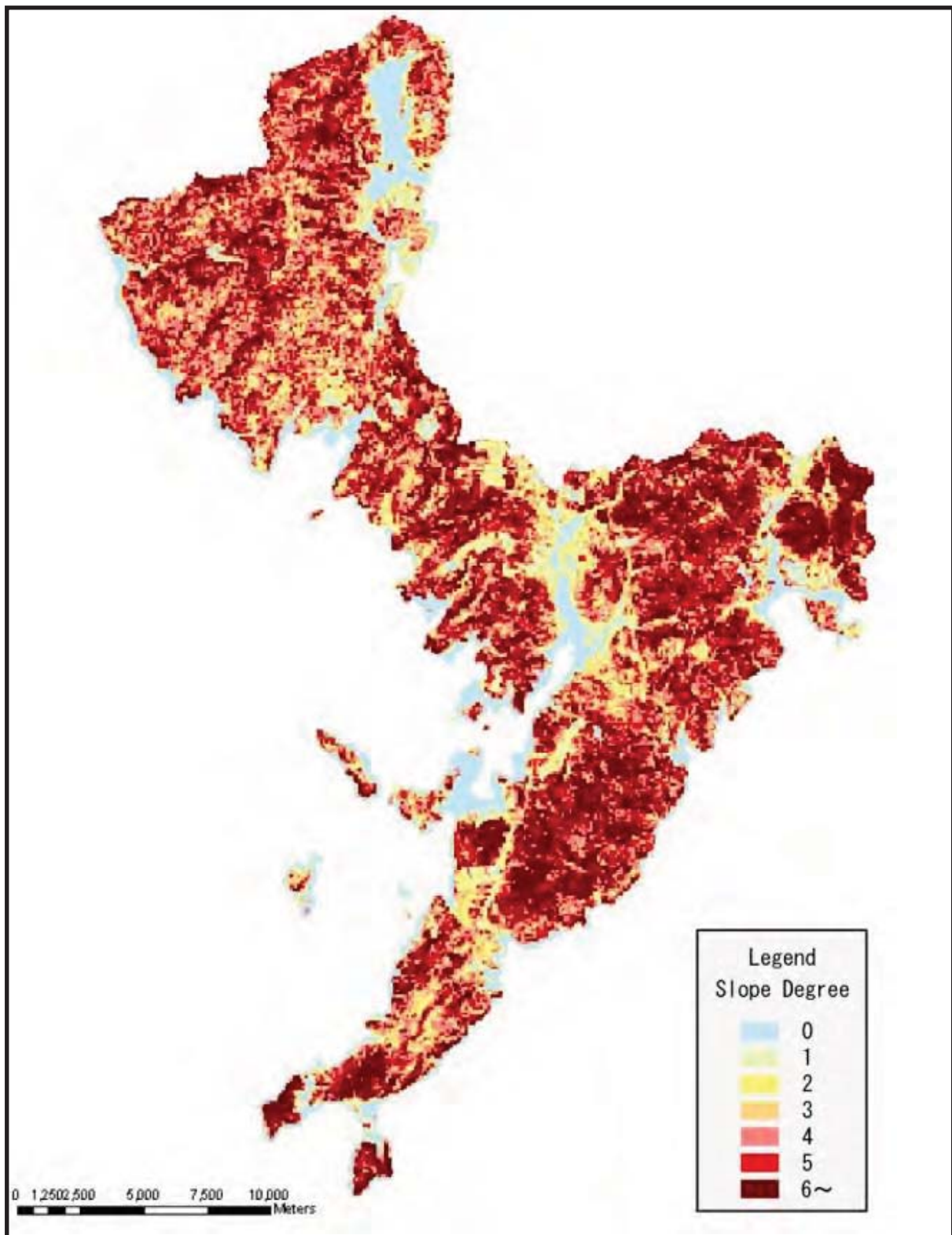


Chart 6 – Mesh slope degree in Nagasaki

Chart 5 shows the slope degree by meshes of Yokohama city. The slope degree is expressed by colours. It is clear that there are a few flat areas in Yokohama, and the steep slopes over slope degree 3 are not that notable.

Chart 6 shows the mesh slope degree in Nagasaki city. Generally, most areas in Nagasaki are over slope degree 3, and some are even slope degree 6. This means that most areas in Nagasaki are very steep.

These mesh layers are overlaid with building layers and present the situation of buildings in Yokohama and Nagasaki. The building slope degree expresses the correlation between landforms and living conditions.

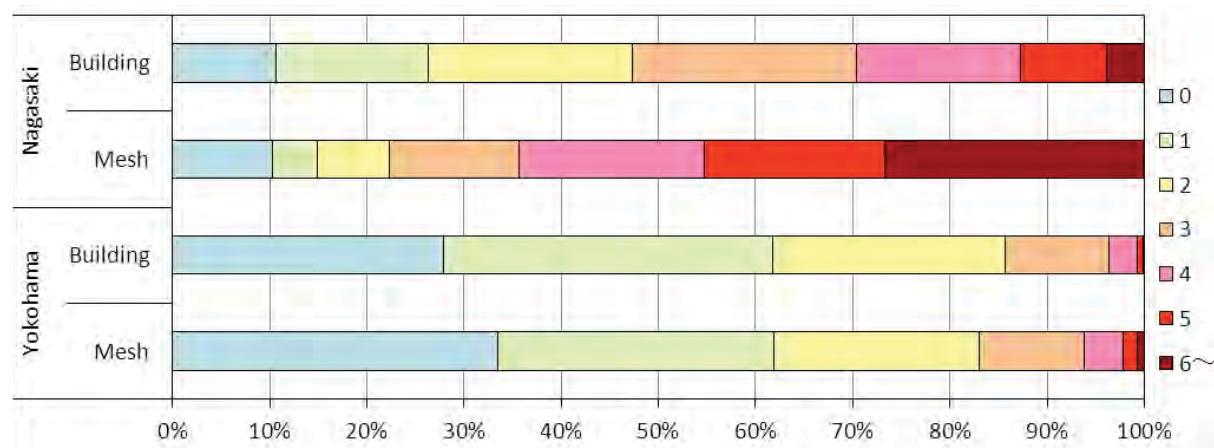


Chart 7 – Ratios of mesh and building slope degrees in Yokohama and Nagasaki

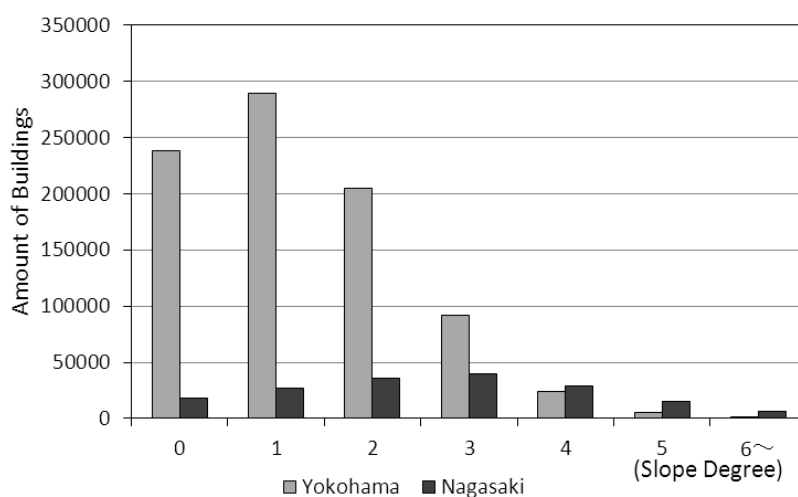


Chart 8 –Amounts of building slope degrees in Yokohama and Nagasaki

Chart 7 shows the ratios of mesh and building slope degree in all of the cities. In this chart, 17% of the area in Yokohama and 78% of the area in Nagasaki are over slope degree 3. Flat areas in Nagasaki are very limited. Furthermore, about 27% of the area of Nagasaki is over slope degree 6, and it's very steep. About 14% of buildings

in Yokohama and more than 52% buildings in Nagasaki are over slope degree 3. Living convenience in Nagasaki is worse than in Yokohama.

Chart 8 shows the amounts of building slope degrees in these two cities. The total area of Yokohama city is 437.38 km². This is very close to Nagasaki city which is 406.46 km². However, the total number of buildings in Yokohama is about 5 times that of Nagasaki, because there is a big residential demand, and the land form in Yokohama is somewhat more convenient than in Nagasaki. There are about 1.4 times more slope degree 3 buildings in Yokohama than in Nagasaki, whereas there are about 1.7 times more slope degree 4 buildings in Nagasaki, which is much more steep.

3.2 Analyses of city centres

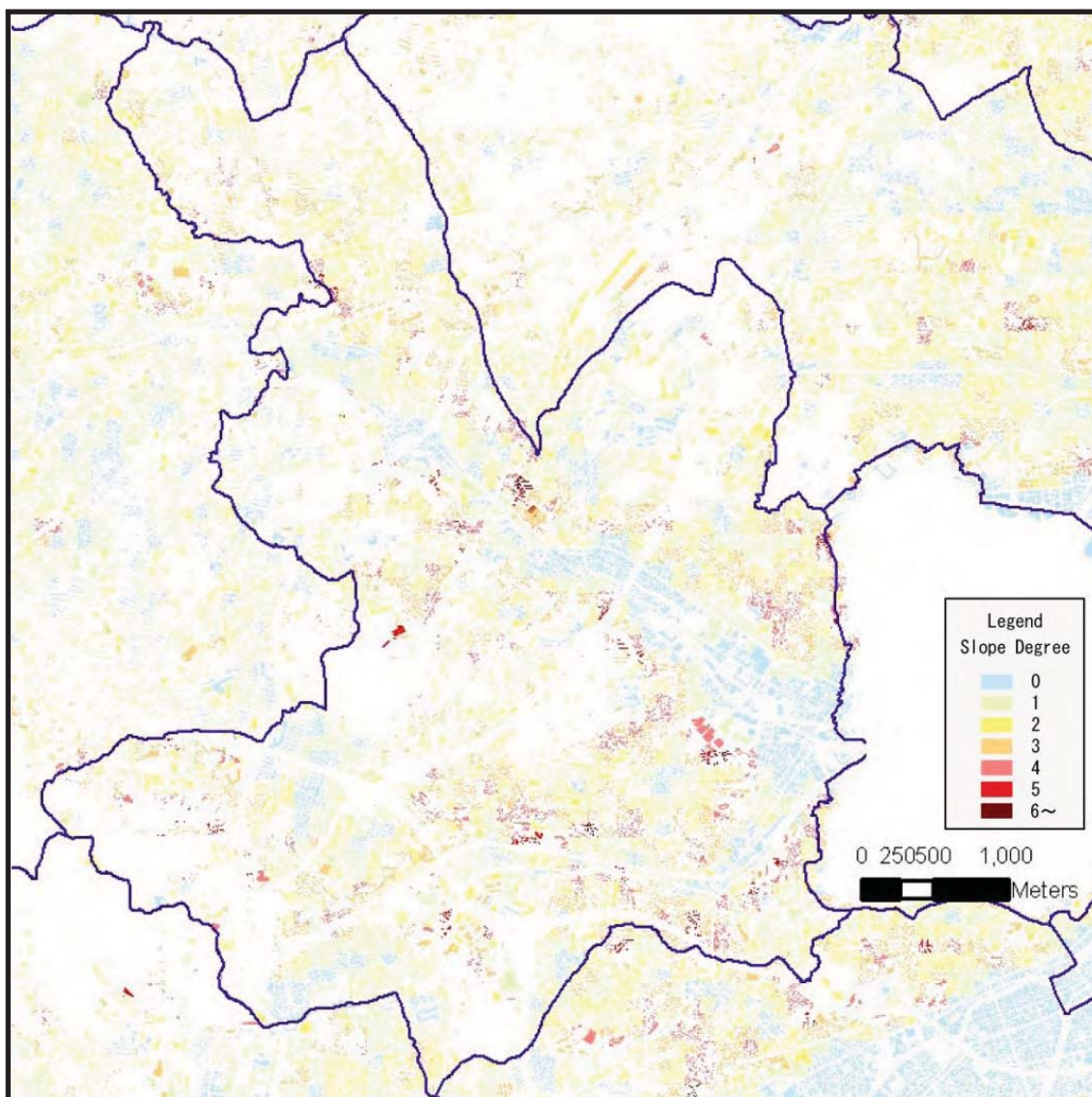


Chart 9 – Building slope degree in the centre of Yokohama

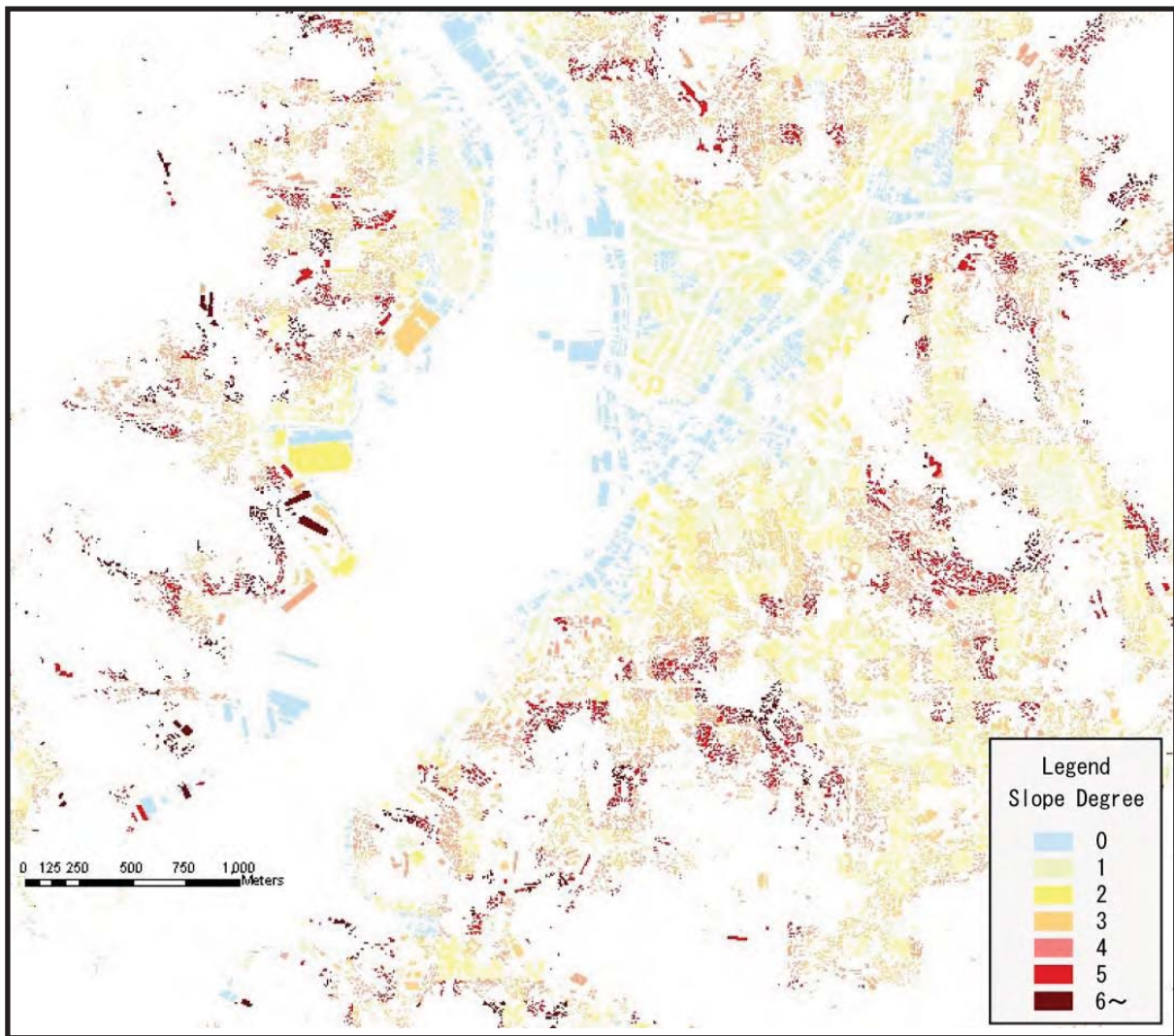


Chart 10 – Building slope degree in the centre of Nagasaki

Chart 9 shows the slope degree of each building in the centre of Yokohama city. Most of the building slope degrees are under 2. However, there are still buildings with a slope degree over 3; this is the problem.

Chart 10 shows the slope degree of buildings that are built in the centre of Nagasaki city. It shows that a lot of buildings are over slope degree 3; some buildings are over slope degree 6. As mentioned in the introduction of Nagasaki, this city has a long history, and the age of construction is greater than that of Yokohama. Therefore, it could be inferred that it has disadvantaged living conditions on its steep slopes, and the effect of seismic disasters would be bigger than that at flat areas. Urban improvement measures and emergency relief measures should be proposed for these areas with a high slope degree.

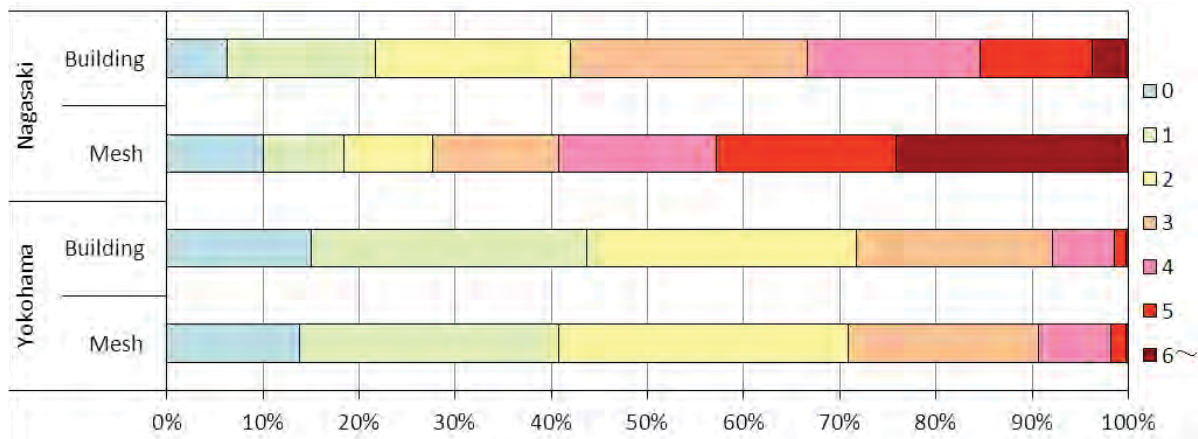


Chart 11 – Ratios of mesh and building slope degrees in central areas of Yokohama and Nagasaki

Chart 11 shows the ratios of mesh and building slope degrees in the central areas mentioned in chart 9 and chart 10. In Nagasaki, the amount of area that is under slope degree 1 is about 10%, but for buildings it is only 6%. It means there is still the possibility to increase building density on flat areas in Nagasaki. About 28% of buildings in Yokohama and 58% of buildings in Nagasaki are over slope degree 3.

4 Considerations

The average slope value in each 100m×100m mesh of Yokohama city and Nagasaki city is calculated. The steepness of these two typical sloped cities is expressed by slope degree which is a quantitative figure. About 17% of the area of Yokohama and about 78% of the area of Nagasaki are over slope degree 3. This means that the ratio of convenient residential area in Yokohama is higher than that in Nagasaki.

By overlaying mesh layers and building layers with GIS, the slope degree of buildings can be demonstrated. It shows the correlation between landform and living conditions. As a result, 14% of buildings in Yokohama and 53% of buildings in Nagasaki are over slope degree 3. Furthermore, about 27% of buildings in Nagasaki are over slope degree 6. Living convenience in Nagasaki should be improved, and emergency relief measures should be proposed.

5 Conclusions

In this research, “slope degree” is proposed and certified as an assessment method. “Slope degree” could be imported into urban redevelopment and improvement to demonstrate the landform condition. At the time of disasters, slope degree data in GIS could be used for establishing measures. There are also other usage potentials of “slope degree” data, which could play a role with other GIS data like building construction age, citizen population, communal facilities, and so on.

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Developing biomimicry in the built environment

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Abstract

Recently, there has been a rush to exploit biomimicry – translating biological principles to solve human technological problems. Architectural biomimicry has tended to focus on form, rather than function. This leads to some exceptional biomorphic designs, however the real potential of biomimicry remains untapped. Widespread performance breakthroughs in energy, indoor environment quality, materials and construction have not emerged. Several reasons exist: long lead times for innovative research, and much biomimetic research is in materials science at the microscopic scale. Further, building practitioners often do not have time, resources or expertise to fully develop a biophysical knowledgebase.

So can biomimicry become a catalyst for a step change in building performance? There is some encouraging evidence it can – exemplified by Cornwall's Eden Project and London's Waterloo International Terminal. Still, to reap performance benefits, holistic and systematic approaches are essential. Additionally, advances in materials are necessary to re-imagine construction as a whole-of-life process.

Keywords: *functional biomimicry, biomorphism, sustainability, performance, innovative materials, building design methods.*

Introduction and driving forces

The current pressures on our world – climate change, population growth, limited natural resources, habitat destruction – necessitate a change in mindset for today's urban planners and building designers. The concept of sustainable development has gained prominence within the built environment in the past twenty years due to the increasing scientific evidence indicating humanity's detrimental effects on the natural world, especially in relation to increasing energy and materials consumption.

Sustainable development includes social and economic sustainability, as well as environmental sustainability. Sustainable development should aim to improve the health and enrich the lives of the people, as well as conserve and advance natural ecosystems. Further, sustainable development needs to maintain an economic viability to remain justifiable in a capitalist society.

There is a consistent link between energy and sustainable development – the critical reason for this is the energy source. The majority of the world's energy is created from unsustainable sources. In Australia, as in many countries, the major source of energy is from fossil fuels. Coal- and gas-fuelled combustion turbines dominate electricity generation. Not only are the fuels limited, their combustion releases massive quantities of carbon dioxide into the atmosphere, contributing to global warming.

The global climate has already trended upwards. The three hottest years on record have occurred since 1998 and the year 2006 was recorded as the 6th warmest on record, since 1850 (Jones 2008). These temperature changes cannot be explained by natural causes. As stated by the Intergovernmental Panel on Climate Change: "Greenhouse gas forcing has very likely caused most of the observed global warming over the last 50 years" (Hegerl 2007, p. 665). In 2005, the United States National Climatic Data Centre concluded that the combined 1901-2004 trend was an increase by 0.6°C in global average temperature. This increase has accelerated in the past 25 years to 0.17°C per decade (*Observed Trends and Variability in Land and Ocean Surface Temperatures* 2008). The increase in global temperatures can be observed below.

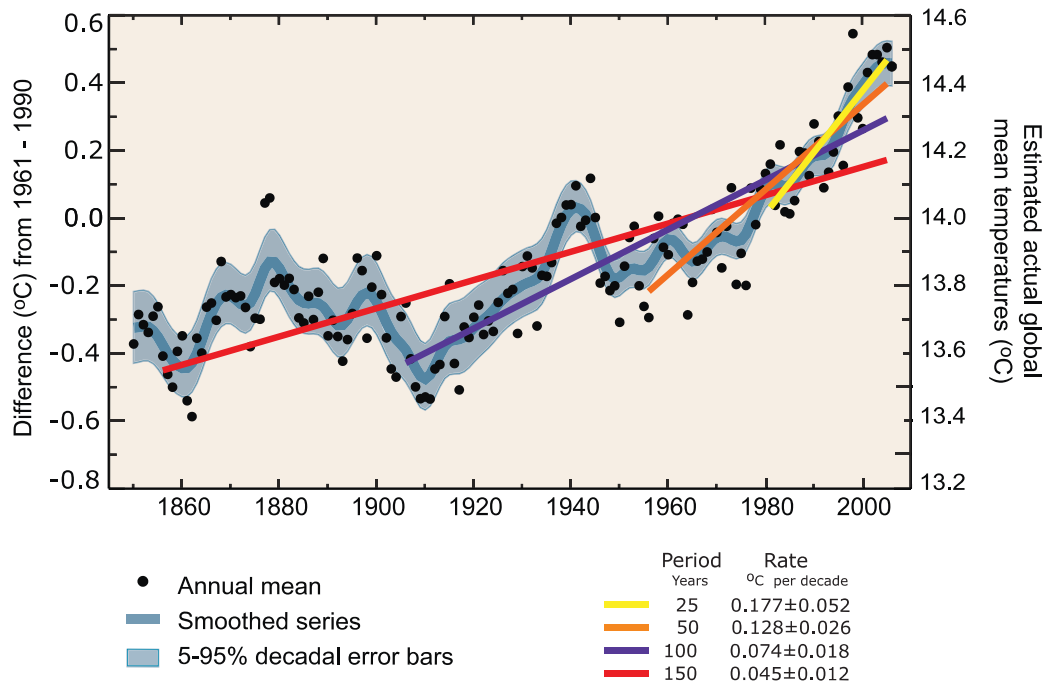


Figure 1 Global temperature observations and trends; from Figure TS.6, p37 (Solomon et al. 2007)

The IPCC projects that, if unchecked, carbon dioxide – equivalent concentrations in the atmosphere will rise to between 600 and 1550ppm by 2100. As a result, global temperatures would warm by 1.1-6.4°C, leading up to a 0.59m rise in sea levels (Solomon et al. 2007).

The consequences of global warming are predicted to be severe. If only a 2-3°C temperature increase occurs, Australia could face 97% reduction in the Great Barrier Reef, 80% loss of wetlands in Kakadu, 40% reduction in capacity for natural pasture to sustain livestock, significant decreases in water supply to Melbourne and flows in the Murray-Darling system, health-related effects such as the southward flow of tropical diseases, such as malaria and dengue fever, increased spending on road maintenance and an increasing demand for energy (Preston & Jones 2005).

In recent decades, there has been increasing evidence that environmental sustainability has a beneficial impact on social sustainability and positive effects on the health of the population. Reducing atmospheric and water-borne pollutants, as well as restricting or prohibiting toxic substances such as lead, asbestos and chlorofluorocarbons (CFCs) have a direct, positive effect on human health and advance the health of natural systems. Furthermore, the conservation of natural environments can have a health benefit in itself. As described by Huelat (2008): “Nature has the added benefit of reminding people that humankind evolved in concert with nature, and environmentalism is a necessity, not a luxury” (p 23).

Biomorphism, Biomimicry and Design in the Built Environment

A 'business-as-usual' attitude towards material and energy consumption can no longer be tolerated. To counter the existing trend, new design methods such as biomimicry are purported to offer opportunities for improvements in sustainability.

Historically, biomorphism has influenced buildings and architecture throughout the ages. Earliest civilizations mimicked the natural form of animals, such as the Sphinx of ancient Egypt. At a more fundamental level, Aldersey-Williams writes, "...we find that it is not entirely by chance that animals and buildings share some of their most basic characteristics" (Aldersey-Williams 2003, p. 12). The left-right bilateral symmetry found in many buildings is analogous to that observed in many animals – especially humans – and may serve as an inspiration (Aldersey-Williams 2003, p. 13). Further, George Hersey (1999) finds architectural inspiration in all natural forms, from individual cells, to beehives, to bird's nests to body parts. Hersey elaborates upon different architectural styles and examples mimicking or borrowing natural form. Hersey points to phyllotaxis, Fibonacci and the Golden Ratio as characteristics of nature that have been followed up in architecture. The use of the Golden Ratio has been a feature of ancient times since Pythagoras realised its significance in defining the proportions of the human body (Britton 2010).

In a more modern context, Aldersey-Williams (2003) presents a guide of animalistic and biomorphic architecture throughout the 20th Century, from Art Nouveau and the associated vegetal adornments, through to 'organic' architecture and, significantly, the use of steel framing. Aldersey-Williams identifies a synergy between periods of organic or biomorphic architecture with revolutionary engineering practices: Art Nouveau with the use of steel and glass, organic architecture in the 1950s with developments in concrete construction during World War II.

The concept of steel framing altered the approach to architecture mimicking nature (even if it was not intentional). It was no longer natural form being mimicked, but the essence of animal structure – an internal skeleton. The idea that characteristics from biological systems can be successfully translated to buildings is defined here as *functional biomimicry*, and is critical to developing technologies that improve building performance. A distinction is made between functional biomimicry and *biomorphism* or *biomorphic architecture*, where biological inspiration defines or enhances building form.

Michael Pawlyn (2011) acknowledges that architecture has explored biomimicry only to a limited extent. He focuses on functional biomimicry and shies away from biomorphic architecture. He notes that biomimicry has historical links back to Leonardo da Vinci and paper production from wood pulp rather than cotton fibres. Despite historical links, application of biomimicry to the built environment have been limited, Pawlyn recognises that spider webs and termite mounds are the two specific

ideas that have, so far, been the most commonly applied to the built environment (2011, p. 5).

The modern philosophy of biomimicry (in a functional and technological sense) is pioneered by Janine Benyus in her book “Biomimicry – Innovation Inspired by Nature” (1997). The basis of Benyus philosophy involves three axioms “Nature as model”, “Nature as measure” and “Nature as mentor” (1997, preface). Benyus offers building designers – indeed, innovators in all fields – “a canon of nature’s laws, strategies and principles” (1997, preface):

- Nature runs on sunlight.
- Nature uses only the energy it needs.
- Nature fits form to function.
- Nature recycles everything.
- Nature rewards cooperation.
- Nature banks on diversity.
- Nature demands local expertise.
- Nature curbs excesses from within.
- Nature taps the power of limits.

The inspiration provided by Benyus has spawned two organisations. The Biomimicry Guild is a consultancy that “helps innovators learn from and emulate natural models” (*About the Biomimicry Guild* 2010). The Biomimicry Institute is a non-profit group that maintains an online database of biomimicry ideas at asknature.org and advocates nature-inspired design via a “Challenge to Biology Design Spiral” (*Biomimicry: A Tool for Innovation* <<http://www.biomimicryinstitute.org/about-us/biomimicry-a-tool-for-innovation.html>>). This methodology includes phases of “identify”, “interpret”, “discover”, “abstract”, “emulate” and “evaluate” (see figure below). Researchers and architectural innovators have, to some degree, followed similar principle steps when exploring biomorphic and biomimetic designs. However, this present paper recognises a deficiency in the “abstraction”, “emulation” and particularly the “evaluation” phases of the methodology, leaving the potential performance gains unfulfilled.



Figure 2 Challenge to Biology Design Spiral; from *Biomimicry - A Tool for Innovation*; <<http://www.biomimicryinstitute.org/about-us/biomimicry-a-tool-for-innovation.html>>; viewed 06 Apr 2012

The *potential* for biomimicry has been recognised. Maibritt Pedersen Zari has created a classification of biological inspiration with respect to the built environment (Pedersen Zari 2007). Pedersen Zari contends that biomimetic approaches may provide an approach beyond sustainability whereby buildings can become environmentally “restorative” (p. 1). Petra Gruber (2008) explores “The signs of life in architecture” (p. 1) by illustrating various biological analogies between life and architectural case studies. According to Gruber, “The superposition of the life sciences vocabulary onto the built environment delivers new insight, questions and solutions” (p. 9), and “It will enhance innovation in architecture highlighting future fields of design” (p. 9). However, we do not yet see embodiment of these ideas, as researchers and designers have yet to exploit the potential of biomimicry.

Independent of the built environment, a more general, technically-oriented, approach has been proposed by Julian Vincent (Vincent, Julian F. V. & Mann 2002). Vincent’s thesis is to combine biomimicry with TRIZ, Teoriya Resheniya Izobretatelskikh Zadatch, loosely interpreted as a “Theory of Inventive Problem Solving”. By investigating patent databases (quoted as 3,000,000) in a sophisticated manner, researchers have been able to elucidate a predictable set of engineering problem-solving tools (Vincent, Julian F. V. & Mann 2002). TRIZ converts a specific problem

into a general problem, which, using TRIZ, leads to a general solution (Domb 1997). The conversion to a general problem involves inherent “contradictions” (i.e. trade offs) within the design problem, which can be resolved via “40 Principles of Invention” (Domb 1997, p. 3).

In later research, Vincent (2006) proposes that the technological contradiction matrix espoused by TRIZ can be recreated, researching biological rather than technological phenomena. Accordingly, “We have analysed some 500 biological phenomena, covering over 270 functions, at least three times each at different levels of hierarchy. In total, we have analysed about 2500 conflicts and their resolutions in biology, sorted by levels of complexity” (Vincent, Julian F. V. et al. 2006, p. 476). The result – termed “BioTRIZ” – is a 6x6 matrix summarising how biology “solves” contradictory objectives, and offers biological “inventive principles” for designers to try to resolve these contradictions (Vincent, Julian F. V. et al. 2006, p. 477). Despite these additional analyses “comparisons between the technology trends uncovered by TRIZ and nature are still sparse. The likelihood is that nature has much to teach in terms of both examples of the trends in action and existence of additional trends thus far not uncovered in a technical sense” (Vincent, Julian F. V. & Mann 2002, p. 164). Vincent’s thesis is that, despite emerging recognition, biomimicry remains an underutilised source of new ideas for technical problems solving.

Beyond attempts to directly apply and categorise biomimicry, several researchers have recognised potential health benefits when nature can be incorporated into design. This furthers the idea that design integrated with nature leads to healthy building and healthy cities. Huelat (2008) states that the word “disease” derives from “dis-“, or “apart from”, and “ease” or “balance” (p 23). She suggests that “nature is our guide to balance and harmony”, is important for human health, and can assist the body to heal itself (Huelat 2008, p23). Following on from Edward O. Wilson's ‘Biophilia’ – ‘love of life’ – hypothesis, researchers have begun to recognise and quantify the health benefits of nature beyond humanity’s innate desire for a connection with the natural world (Frumkin 2001). As Frumkin (2001, p. 239) states, “we need to act on emerging evidence of environmental health benefits.”

As noted above, several researchers have developed frameworks to formalise the process of introducing biomimicry into engineering innovation. Yet there are gaps in the Biomimetic Design Spiral and Vincent (2006) notes the lack of biomimetic exploration. The difficulty, it seems, is not a lack of understanding of biological systems, their potential in technology, or the availability of biomimetic methodologies – it is in the application of knowledge and method. The successful application of functional biomimicry in the built environment faces a number of challenges. This paper explores several of the key challenges and seeks to understand the future prospects for functional biomimicry.

Current practice can be improved – Case Studies and examples in the built environment

Emphasis of form over function

Architecture focuses on what Forbes classifies as organicism, which is more how buildings are shaped rather than any functional aspects from nature. The 2003 Zoomorphic exhibition, also a heavy focus of Aldersey-Williams (2003), is held up as an example of architects following bio-inspiration. Indeed, many designs showcased at this event did evoke natural forms and biological ideas, but few exemplified a functional reason for incorporating the natural elements. Forbes indicates that the current architectural fascination with organicism and bio-inspiration is an “attractive option”, after the “turbulent history of architectural styles since the early 20th-century modernist revolution” (p 27). However, “it uses the same materials as hi-tech architecture, and both organic and hi-tech architecture seems an attractive option”. Forbes also notes that prominent biomimicry researcher Julian Vincent has been severely critical at what he perceives to be an insubstantial appropriation of biological ideas applied to architecture. Forbes (2005, p 198) characterises Vincent’s opinion as “the architect’s approach comes down to: ‘I’ll say I got the structure from an animal. Everyone will buy one because of the romance of it.’”

In his book, Hugh Aldersey-Williams (2003) examines and expands upon the biomorphic architecture represented at the 2003 Zoomorphic exhibition. As noted above, Aldersey-Williams (2003) presents a guide of animalistic and biomorphic architecture throughout the 20th Century. However, biomorphic architecture, as explored by Aldersey-Williams, is mostly about shaping buildings to a particular form. The idea of biomorphism as a scientific metaphor is raised on multiple occasions. It is true that Aldersey-Williams expands upon biomorphism as a functional inspiration. He also limits his treatise to animal-inspired architecture, excluding inspiration from plants, humans and ‘animal architecture’ (the constructions of animals themselves). Still, in the designs examined we do not discover a design revolution. For even as sustainability (p20) and performance are mentioned, in the case studies these prerogatives are not borne out: “The visual analogy is frequently only expressed at the largest scale, and the focus so far has been on the *superficial* appearance of an organism evoked by the integument of an individual building, with little attention given to the biological lessons that might apply to the building’s physical and environmental *performance*” (p 28).

The work of Santiago Calatrava (Calatrava Valls) evokes clear animal symbolism – the public “instantly comprehend his buildings” (Aldersey-Williams, 2003). His work on the Quadracci Pavilion the Milwaukee Art Museum is a striking biomorphic design (*Santiago Calatrava - The Milwaukee Art Museum* 2012). The great birdlike ‘wings’ of the Burke Brise Soleil tower above the main atrium, seemingly ready to lift off

across Lake Michigan. The 72 beams of the brise-soleil are between 8 and 32 metres long (Aldersey-Williams, 2003, p 51), and can be actively opened and closed to optimise thermal comfort and daylight in the reception hall below. While this active adaptability may improve performance, it plays a secondary role in comparison to the structure's primary function – as a giant animalistic symbol. Further, the functional performance derived from the brise-soleil has little, if any, relation to the biomorphism on display. There is a disconnect between the bird structure and any biologically beneficial function that has been transferred to the building. Indeed, while the expansive monument provides an instantaneously recognisable symbol (so much so it was featured in the movie *Transformers 3*), it provides a functional benefit disproportionate to the resources required to construct it – counter to Benyus' thesis on nature fitting “form to function” and using “only the energy it needs” (Benyus, 1997, p7). Indeed, Pawlyn (2011, p 20) acknowledges that, while “his exuberance is to be enjoyed, there is a sense in which the biomorphic extravagance occasionally occludes a rational structural basis for the schemes”. Seemingly following on from Benyus, Pawlyn notes that “the beauty found in nature is often derived from its economy”.



Figure 3 Milwaukee Art Museum Quadracci Pavilion; Milwaukee Art Museum; <http://en.wikipedia.org/wiki/Quadracci_Pavilion>; viewed 01 Jun 2012

Another Calatrava project, the Lyon Airport Station, also appears to contradict several tenets of functional biomimicry. This is a “richly allusive building” (Aldersey-

Williams, 2003, p54), evoking images of birds, dragonflies and anteaters. Some of the structural elements are reminiscent of animal ribcages, and the structural efficiencies garnered are noteworthy. However, the structural similarities stem more from the needs of both buildings and skeletons to balance similar forces rather than a biomimetic approach. The majority of remaining biomorphism remains symbolic, not driven by biomimetic principles but by a sculptural and metaphoric style.

Other designers have experimented with biomorphism, including Renzo Piano and Gregory Burgess. Piano's Auditorium Parco della Musica (in Rome, Italy) expresses organic forms evocative of an armour-plated turtle or black rhino beetle (*Renzo Piano Building Workshop* 2012 <<http://www.rpbw.com/>>). Meanwhile, Burgess' Uluru-Kata Tjuta Cultural Centre (*Uluru Kata-Tjuta Cultural Centre* <<http://www.gregoryburgessarchitects.com.au/projects/1995/uluru-kata-tjuta-cultural-centre/>>) symbolises the snakes important in local Aboriginal culture. The biomorphism is readily observed in both projects, and such metaphors can be important in social and cultural contexts. But again there is a lack of functionality and a focus on formal biomorphism.

Researchers and practitioners recognise the challenges facing functional biomimicry in the built environment. Chris Garvin (senior associate at Cook+Fox Architects and a partner in New York-based consulting firm Terrapin Bright Green) identifies nature's ability to use a single structure to perform multiple functions - "...rarely do we see a form that manages to use one function to achieve myriad results, as we often find in nature" (Jana 2011). Green expands on this point: "Rarely do we see a product made with a material that is non-toxic, recyclable, and manufactured at room temperature, under low pressure." Finally, like Aldersey-Williams, Green notes a tendency towards the superficial or trivial when designers explore biology, as "... the tendency has been to oversimplify how nature works".

Other researchers and architects have seemingly forgotten the original goals of biomimicry in the built environment – to improve environmental performance and reduce humanity's impact on that environment. Belgian architect Vincent Callebaut clearly has a broad vision of eco-design. His project concepts, such as the Lilypad (*Lilypad, a Floating Ecopolis for Climate Refugees* <<http://vincent.callebaut.org/page1-img-lilypad.html>>) and Hydrogenase (*Hydrogenase, Algae Farm to Recycle CO2 for Biohydrogen Airship* <<http://vincent.callebaut.org/page1-img-hydrogenase.html>>) offer a hopeful vision of technological and biological fusion. These organic-form buildings would act in harmony with the environment to generate energy, save water and improve air quality. However, by offering such enormous concepts, Callebaut has misplaced the real potential of biomimicry. His concepts are impractical – without radical changes to materials and construction practices, these developments would be difficult to construct and costly to maintain. The concepts of Benyus, such as curbing excesses and tapping the power of limits, are seemingly forgotten.



**Figure 3 Vincent Callebaut Lilypad; from Vincent Callebaut Architectures;
<http://vincent.callebaut.org/planche-lilypad_pl04.html>; viewed 05 May 2012**

Architecture firm soma (*Soma Architects* <<http://www.soma-architects.com/>>) also produces creative, futuristic concepts that convey a sense of synergy with the natural environment. Their Fibrous Tower (Mok 2012) – a zero-carbon skyscraper of the future – reveals a biomorphic form that was derived from software algorithms based on an understanding of biological processes. The design aims to include renewable energy generation from roof-mounted and façade-integrated photovoltaics, as well as active climate adaption. The “biomimetic lamellas”, modelled on flower petals, are supposed to open and close in response to the environment to optimise indoor environment quality for occupants.

The soma design introduces some thought-provoking features in an original concept. However, there is a gap between such concepts and a functional biomimicry based on a detailed understanding and application of biological systems. In the soma work an original organic form is derived using genetic algorithms, but it is curtailed and limited to produce a viable building shape. Such forms are not necessarily biomimetic. Unlike true biological systems, these algorithmic concepts never face the challenges faced by evolving organisms over many millennia. Humans intervene early in the ‘evolutionary’ process, selecting attractive or aesthetically pleasing designs that meet project objectives other than a complete optimisation and harmonisation with the natural environment. Indeed, the consulting engineers were aiming for complexity, as quoted in Vinnitskaya (2012): “By using probabilistic

optimization methods complexity in the topology of structures is achievable". Thus the genetic algorithm allowed an organic form to emerge, but as a means to express complex typology, rather than adhering to nature's tendencies towards minimisation.

Soma's Fibrous Tower also shares similarities with the work of Callebaut with respect to scale and grandeur. The proposed structure brings a unique aesthetic, but the functionality of the curved, multi-stemmed form is questionable. Curves may be organic and reminiscent of nature, but without a functional basis they only imitate nature, instead of learning from nature. While conceptually imaginative and offering ideas for potential buildings for the decades of the future, these designs point towards shortcomings with some large-scale biomimetic concepts. They rely too heavily on their formal, rather than functional, aspects. Their impracticality stems from large quantities of specialised material resources, requiring energy-intensive construction and fabrication techniques that are pre-requisites for such radical architectural concepts to become physical realities.

Reasons for optimism

As indicated, much biomimicry in the built environment has thus far focussed on formal biomorphism rather than embracing functional biomimicry. However, design engineers have recognised structural efficiencies in nature, quantified the gains, and have used such principles successfully in buildings and infrastructure projects. Furthermore, recent developments suggest researchers are realising the potential of other natural systems to improve and enhance building design.

Claus Mattheck has studied biological structural efficiency, which follows the simple rule of the "axiom of uniform stress" (Mattheck 1998). Essentially this principle recognises that material is built up in areas of greatest stress concentration to evenly distribute forces, while in unstressed areas there is no material. Mattheck emphasises the evolutionary pressures that determine the basis for biological optimisation – trees cannot afford to sacrifice height and light absorption for extra safety ballast and animals cannot become greatly overburdened with structural weight if they are to remain competitive and avoid predators. The reduction in energy use is paramount. This contrasts with engineers, who overcompensate in safety rather than achieve fuel or material savings. Yet due to Cartesian geometrical conventions and ease of manufacturing, artificially engineered components still contain weak notches susceptible to fatigue and fracture. As a foremost inspiration, Mattheck analyses trees in detail: basic growth patterns in response to branching and loading, adaptive growth for injury, notches developed from branching, roots and soil interactions and finally tree failure.

Mattheck developed his process of structural optimisation, based on universal loading, into two computer programs that reform a homogeneous component into the most efficient structure possible. For a particular scenario with imposed loads, Finite

Element Analysis, loads, is conducted on a generic, oversized form. Using an iterative method, termed the 'Soft Kill Option', successive analyses are conducted until unloaded regions are removed, or 'killed off', leaving an efficient structure capable of withstanding the imposed loads. This is followed by 'Computer Aided Optimisation', an innovative process where FEA stresses are translated to temperatures, and regions that are the 'hottest' are allowed to grow. This provides reinforcement in the areas of greatest stress concentration. If applied to structures in the built environment, this process offers savings in materials resources and also in structure weight, allowing further savings in fixtures, substructures and foundations.

Other researchers have explored potential improvements in the thermal efficiency of building fabric, reducing the need for artificial heating and cooling. Craig et. al. (2008) employ BioTRIZ to design a radiative roof cooling system. The authors apply the physical problem to the BioTRIZ matrix, and decide "the simplest solution to the problem at hand seems to be a structural change in the insulation" (2008, p. 61). The resulting honeycomb structure for insulation allows the roof to radiate heat to the sky, while a convection guard prevents convective heat transfer gain. Based upon their modelling, the "new" roof showed potential cooling benefits – "if the averages of the mid points of both masses are compared, it can be seen that the new roof is 4.5°C cooler than the standard roof" (Craig et al. 2008, p. 65).

Webb, Hertzsch and Green (Webb, Hertzsch & Green 2011) explored the potential of applying animal fur to an opaque building façade. Focussing on heat transfer, a time-dependent mathematical model, incorporating the unique performance characteristics of animal fur, was developed. By optimising the natural properties, Webb et. al. (2011) were able to show a thermal conductivity of 0.055 W/mK compared to a similar deer fur of 0.091 W/mK. When applied to an example building façade, the fur layer was able to reduce heat gains in summer by 50% and also reduce heat losses in winter by 50%. Beyond its static thermal performance, animal fur has adaptive characteristics, such as angular orientation and changes in thickness ("equivalent to animals' fur standing up during piloerection" (Webb, Hertzsch & Green 2011, p. 462). If harnessed and controlled, these active adaptations – of which animal fur is but one example – offer opportunities for gains in material efficiency and large savings in operational energy consumption.

Due to its embodiment of these types of functional innovations, The Eden Project, in Cornwall, England, remains an iconic expression of biomimetic architecture. Designed by Grimshaw Architects, the design employs a number of biomimetic strategies to drive sustainable outcomes. To improve structural efficiency and meet the project brief for to successfully contain a diverse range of plants, on a very uneven ground surface, the architects were inspired by the creation and interconnectivity of soap bubbles. The designers also wanted a structure as light as possible, and studied many natural possibilities, "from carbon molecules and single-celled animals such as radiolaria thought to pollen grains" (Pawlyn 2011, p. 18). The results of this pattern revealed that arranging pentagons and hexagons in geodesic

forms was the most efficient structural form. The design was optimised to maximise daylight penetration. As traditional glazing would have been too heavy to fill the transparent spaces between structural members, Ethylene tetrafluoroethylene (ETFE) was selected for its low density and transparency. By creating a triple-layer element, ETFE “pillows” could be fashioned that would provide both the necessary and more insulation capacity than traditional glazing. The ultra-lightweight solution provided added bonuses: fewer structural members were necessary, admitting more daylight and reducing artificial heating requirements, and a less substantial substructure was required. Using functional biomimicry, the design team were able to create a much more efficient structure, using “a fraction of the resources of a conventional approach” (Pawlyn 2011, p. 18). There were economic benefits too – costs were approximately a third of the rate compared to a standard greenhouse.



Figure 4 Eden Project Biomes, from Matthew Webb; personal collection; 18 Jun 2011.

Beyond the structural achievements, it can be argued that the biomes’ form also creates a more sympathetic relationship with the surrounding environment than the traditional rectilinear buildings constructed on levelled sites. Calatrava’s Milwaukee Art Museum dominates the vista and potentially detracts from the surrounding natural beauty. This may be a matter of perspective, but, as Pawlyn states “the Eden Project Biomes accommodated the existing form of the site with a minimum of excavation, and suggests a more respectful reconciliation between humans and the natural world” (Pawlyn 2011, p. 19).

The functional biomimicry expressed in the Eden Project successfully illustrates a design methodology that seeks to identify and abstract innovation from natural systems, as suggested by the Biomimicry Institute. Emphasis is placed on the translation to a technological medium, so that natural characteristics can be successfully emulated, rather than directly copied or visually mimicked. Finally, the Eden Project designers sought to evaluate their designs against known benchmarks, quantifying improvements in performance.

However, the Eden Project designers turned to innovative materials to successfully achieve performance gains. Conventional construction materials did not provide the necessary flexibility to reflect designers' ideas. This insufficiency is a further challenge to the implementation of functional biomimicry in the built environment.

Material concerns

Bringing products to market

Humans have been eternally fascinated by the seemingly wondrous properties of spider silk. Numerous studies have been conducted through the past hundred years to elucidate the diverse chemical, genetic and mechanical properties of spider silk and how spiders produce silk to build their webs. Among multiple research streams, Vogel (1998) summarises some of the desirable properties, Gosline, DeMont and Denny (1986) investigate the structure-property relationship, while Hansell (2005) provides a detailed exposition of the varied properties of the different types of spider silk. Forbes (2006) devotes an entire chapter to the research and development surrounding the search for a technological analogue to spider silk, in order to fabricate strong, flexible materials for use in tensional and shock-absorption applications. However, despite numerous attempts, patents, chemical processes and physical testing, no commercially viable production method or end product is yet to reach market. Indeed, Cranford et al (Nature, 2012, <http://www.nature.com/nature/journal/v482/n7383/full/nature10739.html#author-information>) report that: "In spite of much research into the molecular design underpinning the outstanding performance of silk fibres, and into the mechanical characteristics of web-like structure, it remains unknown how the mechanical characteristics of spider silk contribute to the integrity and performance of a spider web". At present, some of nature's subtle manufacturing processes prove intractable to human technology. (http://en.wikipedia.org/wiki/Spider_silk#cite_ref-70)

However, self-cleaning paint and self-cleaning glass are successes in the field of biomimetic materials science. Indeed, these products are held up almost as ambassadors for functional biomimicry. The Lotus-Effect® is now a recognised trademark for self-cleaning properties and has been applied to paints, resulting in Lotusan™ (produced by manufacturer Ipso) (Forbes 2006). It is based on the principle of decreasing the wettability of surfaces by manipulating surface roughness

at the micro- and nano-scale. This mimics the surface of lotus leaves. By manipulating the surface of its leaves with tiny, hydrophobic bumps, the lotus plant can remain clean in an otherwise dirty and biologically active swamp environment. The cleaning effect is explained thus: when it rains, dirt (or bacterial) particles on the surface of the leaf have limited points of contact with the leaf surface and are far more attracted to the water particles rather than the leaf surface. Hence the dirt rolls away with the water droplets (Forbes 2006). Creating nanoscale roughness on artificial surfaces with specialised paints produces the same effect – resulting in ‘self-cleaning’ surfaces.

Recently, products have been marketed that employ the Lotus Effect in health care products, such as textiles, hardware and seating to minimise bacterial growth on surfaces and make them easier to clean (Huelat 2008, p26). The use of such products in health and child care facilities has potential to improve the health and wellbeing of occupants.

While the Lotus-Effect® uses ‘super-hydrophobicity’ as a self-cleaning mechanism, self-cleaning glass – marketed originally by Pilkington as Activ™ – instead uses ‘super-hydrophilicity’. The manufacturing of Activ™ glass panes involves the deposition of an extremely thin (Forbes 2006, p. 45) layer of titanium dioxide. When titanium dioxide is exposed to sunlight, it becomes electrically charged and acts as a photocatalyst to oxidise organic material (dirt) through the ionization of water and air particles (Forbes 2006, p. 44) . As the substance is highly hydrophilic, water falling on a surface at a significant angle forms sheets that quickly wash off, taking the oxidised organic material with it.

Both of these self-cleaning products illustrate the potential for biomimicry at its most effective: inspiration from nature has resulted in functionally superior materials – and the end results do not identically resemble their natural counterparts. However, they also illustrate one of the key challenges: such technically sophisticated products have taken many years of research and development to prove viable in the competitive commercial world. The research underpinning Lotus-Effect® was initiated by Professor Wilhelm Barthlott in the early 1960s (Forbes 2006, p. 32) and was significantly enhanced through the invention of the Scanning Electron Microscope (SEM). However, it was not until 1994 that Wilhelm applied for a patent and only in 1998 was Lotus-Effect® patented, with the Lotusan™ product released in 1999. Similarly, Pilkington worked for more than a decade to develop Activ™ glazing (Forbes 2006, p. 45) – and this was a product development project with the backing of one of Europe’s largest glazing manufacturers, using material properties known to glaziers since the 1960s.

Furthermore, once developed and tested, such products must meet customer expectations to carve out a viable market. As Forbes (2006, p. 45) states: “The final stage in the development of a technical innovation is its emergence into the real world, where it is hoped it will find a niche among ‘real’ people”. Forbes (2006, p. 45)

quotes Kevin Sanderson, one of Pilkington Activ's creators – "Activ has caught people's imagination but for many people glass is glass; we have to educate them into thinking glass can do other things as well". New products based on technological advancements, such as nanotechnology, also face a societal stigma that often accompanies such change.

New developments

Beyond challenges in developing and marketing biomimetic materials, building designers must also face the reality that while architectural practice may use 21st Century technology for design, construction processes and materials are deeply rooted in the 20th (and earlier) century, sharing little in common with biological ecosystems. When considered in a biological context, vast amounts of energy and resources are expended in an inefficient and wasteful process.

In this sense, building materials manufacturers and construction sites are little different from the rest of Western society. McDonough and Braungart (2002) present a critical view of such practice since the industrial revolution, highlighting the issues of energy consumption and harmful materials that are used throughout many industrial processes. Of particular dissonance with the goals of biomimicry are the cradle to grave processes in manufacturing and the general tendency to design for the worst case scenario. This leaves society with a single pass linear economy (few resources are recycled) and oversized products produced without regard for location, climate or local climate. McDonough and Braungart (2002, p. 27) describe the end result as "intergenerational remote tyranny" – the tyranny of the current generation over future generations who must live with today's decisions, with detrimental effects on health and wellbeing. This is the antithesis of natural ecosystems, which rely on optimal use of resources, recycling and a continual process of renewal that provides for the next generation.

Countering this societal inertia, several researchers have offered radical alternatives to the status quo, challenging our definitions of 'construction' and 'building materials'. Rachel Armstrong argues that, as currently practiced, "the practice of biomimicry does not fundamentally alter the way buildings are made, nor does it change their material nature" (<<http://hplusmagazine.com/2012/03/30/5117/>>). Armstrong instead suggests that buildings connect and interact with their local environment, in essence becoming part of the local ecosystem rather than isolated from it (<<http://changents.com/rachel-armstrong/biography>>). Integration with nature has the added benefit of connecting building occupants with nature, furthering the idea advocated by Huelat (2008) that nature can bring a "balance" to people's lives and improve health and wellbeing.

To achieve this, new materials and construction methods are needed. Spiller and Armstrong suggest humanity develop "architectural paradigms and technologies that

cooperate with and embrace, rather than dominate, natural imperatives” (2011, p. 17). To achieve this, Spiller and Armstrong propose a ‘synthetic biology’ – protocells. According to Spiller and Armstrong “protocell is the output of research programmes aimed at the construction of a chemical life-like ensemble in the form of an artificial cell system that is able to self-maintain, self-reproduce and potentially evolve” (2011, p. 17). Such materials lie in a transition between inert and living matter, and through careful manipulation could offer solutions for the built environment. The basis of ‘metabolic materials’ are protocells, essentially a collection of designed organic chemicals energised by a battery. The protocells are created with the ability to interact in a way similar to living cells: they can sense their environment, react under certain conditions to produce other compounds, and repair themselves (*Living Buildings* <<http://changents.com/rachel-armstrong/biography>>). Such protocells could be the basis of a new generation of materials that are able to adapt and integrate into their environment. Armstrong offers the example of a protocell that could mimic a coral reef. The protocells would produce a limestone-like substance by fixing carbon dioxide from the atmosphere during building construction building. However, apart from providing an ecologically friendly method for building construction, the protocells’ ‘metabolism’ could be reactivated to repair and maintain materials during the building’s lifetime (*Living Buildings* <<http://changents.com/rachel-armstrong/biography>>).

Similarly, Neri Oxman states that architecture is in a “crisis of form” – with form taking precedence over function. Oxman’s opinion is related by Ferrante (2010): “There is a disintegration of materials and performance...We have designers, engineers and fabricators – and our process is generation, analysis and production. Of course, nature doesn’t act that way”. Oxman argues that the current “digital processes of modelling, analysis and fabrication” follows on from “Modernist separation of form, structure and material” (2012, p. 90). This leads to inefficient geometrically-driven designs: “compared to nature, our own material strategies appear to be much less effective, and mostly wasteful” (Oxman 2010, p. 80). Instead, we can use our technological sophistication to manipulate matter in a much more detailed manner, inspired by the driving forces in natural systems – minimisation of materials and energy.

In making a distinction between structural and functional material properties, Oxman notes that natural materials are embedded with varying degrees of anisotropy “to achieve the structural, mechanical and environmental functions required” (2012, p. 92). This anisotropy is “central to the structuring of materials and their behaviours” (Oxman 2012, p. 93). Further, “Such natural materials offer material and structural efficiencies at various length scales” (Oxman 2012, p. 93), in contrast to conventional building materials that are largely homogeneous. There are three key categories of anisotropy: “Functionally Gradient Geometrical Anisotropy” – achieved by altering geometry, e.g. bird feathers, “Functionally Gradient Structural Anisotropy” – achieved by subtle changes to material structure, e.g. sycamore seeds, and

“Functionally Gradient Material Anisotropy” – achieved through material property variations, e.g. the pores in a sea sponge (Oxman 2012).

Architectural design and manufacturing processes are not established to exploit material anisotropy. CAD (Computer Aided Design) software, modelling analysis, and fabrication techniques are based around components that are homogeneous, with only limited macroscopic anisotropy, such as pre-fabricated wall panels. Oxman proposes “Functionally graded digital fabrication” (Oxman 2012, p. 94) as an alternative, whereby manufacturing processes can introduce detailed, repeatable variations in the material properties and structure. The resulting anisotropy produces a customised component to suit a particular purpose. Two approaches are being tested at MIT: a variable-density concrete system and a variable-elasticity polymer system (Oxman 2012). Oxman concludes that “this approach could potentially contribute to efficient conservation of material usage, high performance of integrated structures, optimised response to mechanical stimuli, and overall improved product life spans” (Oxman 2012, p. 95). These types of innovative manufacturing processes complement the material optimisation design process proposed by Mattheck (described above). Components designed by SKO and CAO could be subsequently manufactured using Oxman’s “functionally graded digital fabrication”.

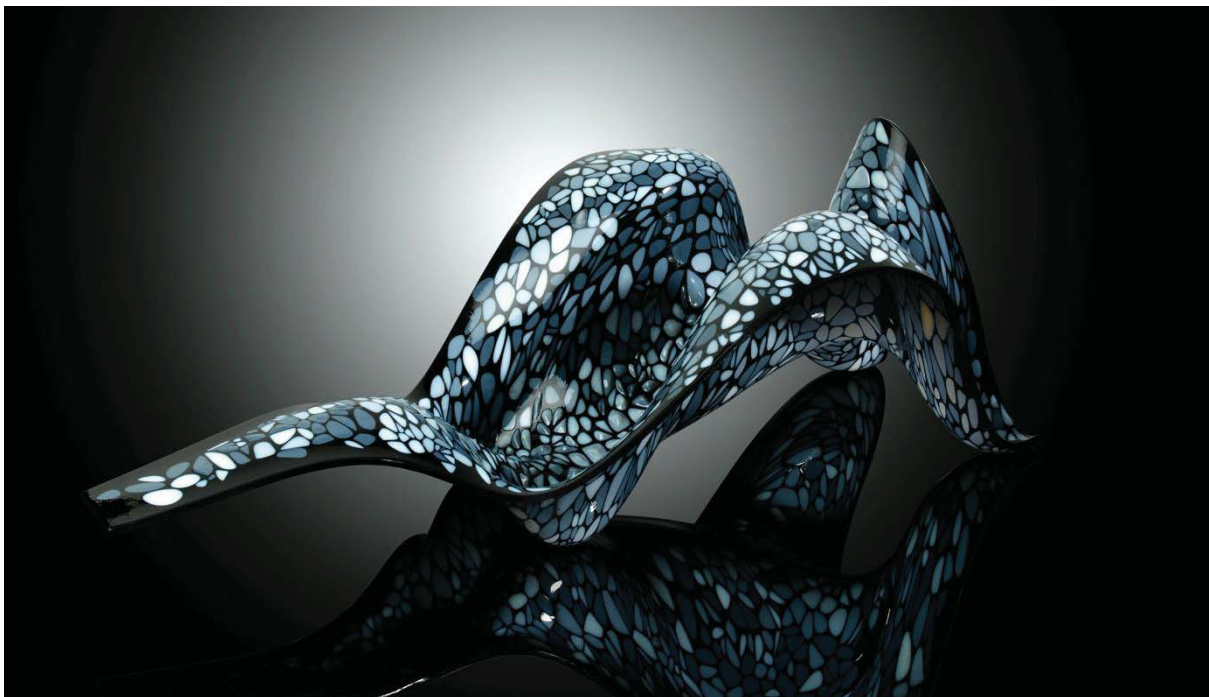


Figure 5 Ergonomic chaise lounge (“Beast”) designed by Neri Oxman showing variable materials properties to better fit the human form; from Jen Leslie; “Neri Oxman: Biology meets Design”; <<http://jenleslie.wordpress.com/2011/05/14/neri-oxman-biology-meets-design>>; viewed 01 Jun 2012

The radical alternatives proposed by researchers such as Armstrong and Oxman are unlikely to become immediate commercial successes. Experience has shown, with the examples of LotusanTM and Pilkington’s ActivTM glazing, that even evolutionary advances to construction materials take years – sometimes decades – to achieve

commercial viability (Forbes 2006). However, protocells and functionally graded digital fabrication provide some direction for the development of functional biomimicry in the built environment. Through such technologies, designers will be able to more closely mimic the tendencies of nature – resulting in more efficient, ecologically sensitive buildings that can connect with nature and improve the health of occupants.

Integration and Implementation

Despite only a few projects successfully exploring functional biomimicry, and the slow development of alternatives to homogenous construction materials, integration of functional biomimicry in contemporary architecture is still possible. It is necessary to firstly identify sustainability performance targets, or alternatively, a design ‘conflict’, as in the TRIZ process (Vincent, Julian F. V. & Mann 2002), so that any biomimetic innovation can be understood in performance terms and provides a functional benefit to the project. In other words, it establishes a benchmark to “evaluate” (in terms of the Design Spiral) the biomimetic initiative. Secondly, an awareness of applicable biology is clearly desirable. The Biomimicry Institute has established [asknature.org](http://www.asknature.org), a resource dedicated to providing information a large array of possible biological functions (*Ask Nature* <<http://www.asknature.org/>>). Other researchers such as Vincent (2003, 2005 & 2006), Vogel (1988, 1998 & 2009) and Schmidt-Nielsen (Schmidt-Nielsen 1997) offer accessible knowledge on biological systems.

Design integration is necessary, and where applicable ideas are discovered, the “Design Spiral” offered by the Biomimicry Institute (*Biomimicry: A Tool for Innovation* <<http://www.biomimicryinstitute.org/about-us/biomimicry-a-tool-for-innovation.html>>) indicates the broad steps required. Abstracting and emulating the ideas, following a TRIZ-like process, can assist in isolating the desired functionality, rather than directly attempting to mimic complex biological processes. The categorisation of BioTRIZ (Vincent, Julian F. V. et al. 2006) may be of use. Of critical importance is to understand the biological mechanism that is mimicked, and not follow a conveniently simplified model (Vincent, 2011, personal communication). During this integration stage, the designer can consider the impact of the biomimetic strategies on the health and wellbeing of building users and occupants, as well as the potential health impact on wider community.

Performance testing and verification is necessary as the design is developed. The design team should critically analyse the biological translation and adapt the design – what works in the biological world cannot always function successfully within human technology. The ‘natural laws’ offered by Benyus (1997) offer general guidance for design development. Again, a direct facsimile is not the goal, the emphasis is on the functional – and performance – outcomes. To fully exploit the

design potential of functional biomimicry, holistic techniques are required with robust, measurable sustainability credentials in terms of energy, water, materials, operation and life cycle costs.

Synthesis and Conclusions

Biology has inspired and influenced formal and aesthetic aspects of architectural design from earliest human civilisation. In the past half century, numerous projects have demonstrated the growing fascination with formal biomimicry, or biomorphism. Examples include Calatrava's Milwaukee Museum of Art, Renzo Piano's Auditorium Paco della Musica or Gregory Burgess's Uluru-Kata Tjuta Cultural Centre. At the other extreme, several designers have unveiled concepts that are complex in form, constructed from as-yet undeveloped materials and produce their own energy. Both design types, however, do not readily employ the precepts of functional biomimicry – a systematic transfer of natural traits and systems to improve performance in the built environment, while remaining sensitive to natural tenets.

Several architects have used functional biomimicry with success – the Eden Project in Cornwall significantly improved structural efficiency, with positive flow-on effects to climate control and structural foundations (Pawlyn 2011). Other researchers, such as Craig et. al. (2008), Webb, Hertzsch and Green (2011) and Mattheck (1998), have demonstrated functional biomimetic systems that can be applied to the built environment. Still, functional biomimicry remains an emerging field.

In part, the slow development of functional biomimicry is due to slow development of design methods and materials to support the desired performance outcomes. Research into artificial spider silk has continued apace in the past 20 years, yet remains a developing prospect at best. Commercially viable product lines, such as LotusanTM and Pilkinton ActivTM, have had development pipelines longer than 10 years (Forbes 2006). Still, such products are beginning to have direct health benefits, especially for occupants of health care facilities (Huelat 2008).

Yet while these products certainly enhance performance, they are not ecologically sustainable over their full life cycle. Such biomimetic products require large energy quantities to manufacture, cannot repair themselves and have a built-in obsolescence without (necessarily) the capacity to recycle, while natural systems tend towards minimal energy use in production, curb excesses and recycle everything. To create a built environment that more closely emulates natural systems, researchers such as Rachel Armstrong and Neri Oxman are attempting to revolutionise material design and manufacture. Armstrong is developing protocell technology, where non-living cellular chemistry is harnessed at the microscopic level to create a new generation of building materials that use natural ingredients, can fix carbon dioxide from the atmosphere and have the capacity to be self-repairing (Armstrong 2011). Oxman's functionally graded digital fabrication techniques can be

used to generate anisotropic materials with specialised geometric, structural or other heterogeneities (Oxman 2012).

To this point, architecture as a discipline has not fully grasped the benefits and opportunities offered by biomimicry. But as scientific techniques improve, humanity's detailed and functional understanding of the natural world will continue to increase, providing even more opportunities for biological inspiration at the functional level. The information, tools and ideas available to building practitioners from the natural world will all increase substantially. Design pathways have been established by the Biomimicry Institute via the 'Design Spiral' (*Biomimicry: A Tool for Innovation* <<http://www.biomimicryinstitute.org/about-us/biomimicry-a-tool-for-innovation.html>>) and BioTRIZ (Vincent, Julian F. V. et al. 2006). Already, engineers and designers are finding more advanced methods to analyse and translate biological information to the built environment. New products are likely to gain viability and revolutionary breakthroughs in materials science appear probable, if not certain. The benefits of nature on human health and the healing process provide compelling reasons to integrate biomimicry into buildings and communities. As such, biomimicry will become an increasingly important design and engineering methodology in the first half of the 21st Century. If the concept is embraced holistically – where function takes precedence over form – biomimicry offers practitioners new methods of creating healthier, more sustainable buildings integrated within social and natural environments.

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