A Framework to Determine if Australia’s Suburbs Have Ever Been Sustainable

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Australia is a suburban society. It has been since Europeans came. Unlike many other urban societies at the time, there was no existing hard infrastructure to provide the essential needs of human urban life - clean water, food, shelter and waste management. These had to be met by individual residents in the emerging cities and towns until infrastructure could be provided to local communities by Government. This reality led to Governor Phillip establishing the block size in Sydney as being large enough to provide food and treat waste within its boundaries. The block dimensions were a major influence on Australia’s urban form for the next two centuries and with social developments not only led to low density urban form, but also fostered a strong connection with the backyard and a societal love of gardening at home.

Despite a push to densification in the past two decades, low density suburban form is physical and cultural and is likely to be dominant for the foreseeable future. Gardening at home is also likely to continue to be a favourite pass time. While some Australian research has started to explore the role of backyards and gardening in increasing urban sustainability, little work has been done on to what extent the suburban block has and can meet the core needs of people. Even less has been done on determining the impact of suburbs on underlying ecosystem services that provide these core needs.

This paper provides a brief history of backyards in suburban Australia, a conceptual framework for assessing the sustainability of Australian suburbs over time and a description of the major ecosystem types in what is now urban Geelong at the time of European settlement. It provides the foundation for future sustainability assessments of the residential block in various periods of suburban development in Geelong.

Keywords: urban sustainability, suburbs, backyard, gardening, core human needs, ecosystem services, Australia, Geelong
Sustainability of Australian cities

Despite cities covering less than 1.3% of the Australian continent, Register (2006) states that designing, building, and operating cities has the greatest destructive impact on nature of any human activity. The magnitude of local impacts is relatively large, mainly because they involve more or less complete and permanent removal of habitat and fundamental changes to the physical environment, and because they are in relatively productive and fertile environments (Lindenmeyer, 2007).

A 2010 assessment of the sustainability of Australia’s largest 20 cities found that Geelong was the second least sustainable city of all cities assessed (Trigg et al, 2010). This paper seeks to gain an understanding of why Geelong is so unsustainable by looking at how urban Geelong has developed since 1851, how and where people interact with the environment and how the underlying ecosystems work.

The design of cities is critical because design typically costs in the vicinity of 5% of total cost but locks in 80% of a products’ environmental impacts (Natural Edge Project, 2007).

A central part of the design of cities is the provision of infrastructure. Traditional, also known as ‘gray’ or ‘hard’, infrastructure includes the water, energy, transportation and communications services required to support society needs. In recent times the concept of ‘green’ infrastructure has emerged. The Australian Institute of Landscape Architects (2009) defines green infrastructure as ‘the network of natural landscape assets which underpin the economic, socio-cultural and environmental functionality of our cities and towns - i.e. the green spaces and water systems which intersperse, connect and provide vital life support for humans and other species within our urban environments’. Very little is known about green infrastructure in Australian cities.

Most of Australia’s urban hard infrastructure uses nineteenth century technology (Troy, 1996) demonstrating that the design life of cities is often centuries. As such, in 2029, over 90% of infrastructure of Australian cities will have been built prior to 2010 (CoM & DoT, 2009). Therefore, getting the design of cities wrong has dire and long term consequences.

The sustainable cities concept has existed for over four decades. From a landscape architecture and planning perspective, it emerged in the 1960s with Ian McHarg’s Design with Nature and later with Anne Whiston Spirn’s The Granite Garden as part of what Wheeler (2004) identifies as a broader response to dramatic growth in understanding that modern development practices were leading to worldwide environmental and social crises. The concept of sustainability arose as part of this response.

The notion of sustainable cities gained widespread momentum following the release of the Brundtland Report Our Common Future in 1987 that defined the generally accepted meaning of the term ‘Sustainable Development’ as ‘development which meets the needs of the present without compromising the ability of future generations to meet their own needs’.

While there has been much conjecture around the notion of sustainable development, it has only been in the past decade that there has been significant definition of need, largely through the 2005 Millennium Ecosystem Assessment. The definition of human needs is critical in establishing humanity’s fair share of resources that can be developed, and then determining whether the
ecosystems that provide these resources can provide them in a sustainable manner. Ecosystem services are what provide these needs.

From a landscape perspective, Steiner (2000) says that ‘sustainability means maintaining the health of ecosystems, which provides a variety of benefits over time. This has parallels with the notion of green infrastructure.

Much of the focus on sustainable cities in Australia has been around density as the key sustainability determinant. However as Infrastructure Australia (2010) state, the opportunities of efficiency and reduced environmental impacts offered by more compact forms of urban living, inner city households of capital cities, followed by the inner urban suburban areas, feature the highest consumption of water use, energy use and ecological footprints even when reduced car use is taken into account.

This is important as Victoria’s ecofootprint, which is largely invisible to most of us (Corste, 2003 in Franz & Papyrakis, 2009), is already three times that of resources available (CES, 2008) and over 80% of Victorians live in cities over 100,000 people.

A number of studies in the past decade have started to quantify the human impact on the environment through tools such as the Ecological Footprint and the Millennium Ecosystem Assessment.

The Millennium Ecosystem Assessment identified that 60% of the 24 critical ecosystems are either degraded or being used unsustainably (CES, 2008), including half of the provisioning services such as food and water supply and 70 per cent of regulating and cultural services (Washington, 2013).

While these sustainability assessment tools provide an overall understanding of human use and impacts on the environment, the focus is at best regional and often state or nationwide. The approach used is generally a top down one. It doesn’t relate to the average citizen.

Good relationships with the average citizen are important because in cities like Melbourne and Geelong, the largest land managers are individual residents who are responsible for 70% of land (Melbourne Water and EPA, 2009). While individually residents manage very small parcels of land, cumulatively their impact on the environment is very significant. The Ecological Footprint assessment undertaken by the Victorian Environment Protection Authority in 2005 demonstrated that approximately two thirds of the Victoria’s ecological footprint occurs at home. The Australian Bureau of Statistics also shows that the average person spends two thirds of their time at their home.

Hill (2008) believes that to make responsible choices, citizens must understand and own the environmental risks and solutions applicable to their neighbourhood, and exercise their choices through the democratic process.

Hough (2004) in his book *Cities and Natural Process* identifies that little attention has been paid to understanding the natural processes that have shaped the city’s physical form and which in turn have been altered by it. While in Western society this is starting to change for government bodies responsible for land management, Hough (2004) believes that most residents are still unaware of
the natural processes lying beneath the surface of the city partly because humanity and nature have long been understood to be separate matters. It has also been acerbated by drastic increase during the 20th century of people moving from rural areas to the city, meaning that most urbanites are now illiterate in reading and understand the local natural environment and its broader landscape. Hough (2004) believes that this environmental education begins at home.

Research shows that individual residents are hard to engage in environmental matters, particularly when using a top down approach. Part of the difficulty relates to a distortion between attitudes and actions (McKenzie-Mohr et al, 1999), part to a lack of information, part to the strong cultural factors that influences behavioural changes both at an individual and community/societal level, part to competing interests for our time. Given that individual residents manage 70% of our cities, any approach to creating a sustainable city must link to where people are at and what is important to them.

McKenzie-Mohr et al (1999) believes that if we are to make the transition to a sustainable future, we must concern ourselves with what leads individuals to engage in behaviour that collectively is sustainable, and design our programs accordingly. They emphasises personal contact because social science research indicates that people are most likely to change some behaviour in response to direct appeals or social support from others.

Nassauer et al (2009) explored how cultural norms for the appearance of landscapes may affect adoption of ecological design in exurban residential landscapes in Detroit, United States of America. They concluded that ‘... efforts to introduce ecologically innovative designs to metropolitan residential landscapes should approach change at the neighbourhood scale in order to enhance initial success and long term cultural sustainability. We also note that individuals who innovate on their own properties may want to enlist nearby neighbours in similar innovations to create a threshold of cultural sustainability’.

Nassauer et al’s (2009) work supports findings from a recent gardening study commissioned by the Nursery & Gardening Industry Australia (Newspoll, 2009) that 75% of Australian’s interviewed get their own inspiration for their own gardens from other peoples gardens, more than from gardening or lifestyle TV shows (68%) and from garden centres (53%).

**Suburban Australia**

Today three out of four Australians live in cities like Geelong with populations greater than 100,000 (DIRT, 2013). In 2006, 74 percent of Australians lived in detached houses, a figure that has only slightly reduced from 78 percent in 1976 (Kelly et al, 2012). Thus, as Lewis (1999) says, the suburban way of life and the aspiration to own and occupy a detached house have long been Australian characteristics. In fact, Davison (1994) calls Australia the first suburban nation. The suburbs have always been the dominant place where day to day living needs have been met.

Suburbs as we know them first appeared at the end of the eighteenth century, after the Industrial Revolution had brought masses of people into urban centres (Timms, 2006). The general character of individual Australian suburbs can be roughly divided into specific periods for identification. Each
has a particular urban flavour and is accompanied by distinctive characteristics and fashion in the surrounding gardens (Cox et al, 2011).

There are numerous ways to determine these periods (see Table 1). Freestone (2010) looks at suburbs through the lens of urban planning in Australia. In the United States, the Historic Residential Guidelines for Evaluation and Documentation for the National Register of Historic Places (2002) categorises suburbanisation along transportation lines. The Heritage Council of Victoria views suburban development through housing styles, while Aitken (2010) does the same through garden styles.

Table 1: Various ways to assess periods of suburban development in Australia.

<table>
<thead>
<tr>
<th>Author</th>
<th>Focus</th>
<th>Era Name</th>
<th>Era dates</th>
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<td>Urban planning</td>
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<td>Historic Residential</td>
<td>Transportation</td>
<td>1. The Railroad and Housecar Suburb</td>
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<td>3. Early Automobile Suburb</td>
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<td>4. Post World War 2 and Early Freeway Suburb</td>
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<td>Heritage Council of</td>
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<td>Victoria</td>
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<td>5. Modern</td>
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<td>6. Contemporary</td>
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<td>Aitken</td>
<td>Gardens</td>
<td>1. Embarking on the Australian bush</td>
<td>1780-1829</td>
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<td>2. Colonial Modernism</td>
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<td>4. Planting of scenic effect</td>
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<td>7. Australian plant gardens</td>
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<td>8. So many gardens, so little time</td>
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Given the multifunctionality of suburbs, the proposed approach is to use a combination of the above investigate the impact of suburbia on sustainability in Geelong, Australia. Three distinct periods of urban development in Geelong since the state of Victoria was formed in 1851:

- Victorian (1851-1900),
- Garden Suburbs/City Beautiful (1901-1950) and
- Modern (1951-).
Each stage is associated with major changes in suburban land use modes of transport and major periods of architectural and landscape design.

The Victorian Era of suburban development was heavily influenced by urban development in the UK. The establishment of suburbs was small in scale and largely organic. Public infrastructure was limited to the supply of potable water and roads and the treatment of waste was the responsibility of individuals. Suburban blocks were of varied size, largely due to land speculation and associated subdivision (see Figure 1). This era covers the establishment of colonial capitals and spread of settlement, largely through the proliferation of grid iron towns (Freestone, 2010).

Figure 1: Newtown and Chilwell, Geelong’s first suburb, 1866. Source: State Library of Victoria.

Beginning at the start of the 20th century, the Garden Suburb/City Beautiful era was influenced by movements originating from England and the United States respectively, the emergence of local government’s role in planning at the suburban scale via the Local Government Act 1915; the widespread establishment of infrastructure such as sewerage services, tram networks and bitumen roads. Suburban blocks were now legislated to be a minimum of 150 m² and recommended by Melbourne’s Metropolitan Planning Commission in 1929 to be a minimum of 372 m² (Dodson and Gleeson, 2007), but many continued to be a quarter acre until early post World War II when the
installation of sewerage and arrival of cars led to blocks of these size no longer being needed (Troy, 2004). Freestone (2010) says that this is the era where town planning began and represents the arrival of modern planning thought and planned communities.

The Modern Era is characterised by the widespread adoption of the motor vehicle as the primary mode of transport, the creation of large subdivisions, the introduction of industrialised food and substantial suburban population growth created by immigration and the Baby Boom. It covers the institutionalisation of planning at local, state or more cyclically federal levels, metropolitan planning strategies, regional development initiatives, and competing notions of both good planning and the good city (Freestone, 2010).

The backyard

Backyards have long been symbolic of Australian suburban life; indeed the word ‘backyard’ is an Australian one (Holmes et al, 2008).

The first Governor of the Colony of New South Wales, Arthur Phillip decreed that land blocks in cities should be a quarter acre in size, mainly to enable residents to be self-sufficient in providing food and treating wastes. Individual residents needed to be self-sufficient due to the lack of existing hard infrastructure typically found in European cities of the time and the large distance between England and Australia meant that there was a significant time lag in the delivery of key provisions. Hall (2010) says that despite the obvious ‘cliché’ of the ‘quarter acre block’ (1012m2), lots of this size although they exist, have never really been common place.

In 1996, Patrick Troy was one of the first scholars in Australia to suggest the backyard as a solution to the inherently unsustainable nature of cities. Troy (2004) believes that once developed, the effect of this relatively low-density form of development was to enable successive generations of households to attain a high degree of self-sufficiency.

In more recent times, Adams and Loader (2008) have echoed similar sentiments, that because cities contribute 75% of greenhouse gas (GHG) emissions, the need for transformational change within Australian city boundaries are significant. They argue that Australians have a love affair with the suburban block that is deep and not going to change in the short-term and by crafting the solution back into the Australian dream, 90% of the city, namely the suburbs, remain largely in their current although improved form. Noble & Martinelli (2009) identify that from the average home GHG emissions can be reduced by more than 75 % with energy efficient design and appliances.

Smith and Scott (2006) also identify that at the household scale, home choices add up to a major overall impact on the environment in urban areas. They identify basic choices of dwelling size, house orientation relative to the sun, the design of ventilation and cooling appliances, water capture and storage methods, and whether to buy a second, third or fourth car, are some of the decisions which make a big difference to the impact of the individual and family on the environment. While this is true, the home, particularly in Australia, is much more than these components. It also includes the landscape surrounding the house- the front, side and backyards.

Seddon (1998), the first scholar to really look at the Australian landscape and the post European arrival relationship to it in an integrated way, states that the instinct to garden and the human needs
met by gardens may be virtually universal. Similarly, Doolittle (2004) sees gardens as fascinating topics of study in no small way because they truly transcend time, culture, environment/nature, gender and thought. Australia has a very long gardening history that as Holmes et al (2008) says, began not with the arrival of Europeans but with Aboriginal land management practices shaped the landscapes that the colonists imagined as pure nature. In fact, gardening is identified as being the most popular leisure activity in Australia with 86% of Australians believing the health, wellbeing and relaxation benefit their garden provides being the top reason they spend time in their backyards (Newspoll, 2009). The Newspoll 2009 study also found that 57% of Australians grow their own fruit, vegetables and herbs. Gaynor’s (2006) study shows that this has been a consistent trend from the 1850s onwards, with at least 50% of the Australian population grow fruit and/or vegetables in their backyard. The proportion of home grown food that is in the family diet though has changed over time.

Head and Muir (2007) elaborate on the positive impacts of the backyard including recycling, water collection, subsistence agriculture and environmental education and experiences, particularly for children. They also identify that backyards contribute to the direct negative impacts of suburban expansion- land clearing, quarrying, spread of pavement, increased car travel, and expanded habitats for feral animals.

Troy (1996) sees that a significant issue is that many of the previous solutions to pollution problems that have been proffered and adopted have done so with scant regard for scientific evidence either about the extent of the problems and their sources or any understanding of the history of the cities and why they take their form. Likewise Radovic (2009) states that a sustainable city has to be confident about its own past, exist in the present time, and project a multiplicity of trajectories towards possible, desirable future.

Since Troy’s comments in 1996, there has been increasing scholarly research and understanding of the role of the suburban house and block in individual lives and Australian society more broadly. Authors such as Seddon, Davison, Head and Muir, Aitken, Gaynor, Timms, Hall, Ghosh, etc have all investigated various aspects of the suburban block and the backyard. While Troy in 1996 raised notions of the backyard as having a significant role to play in the future of sustainable cities in Australia, only Head and Ghosh (2009) have begun to look at the backyard in an integrated way. Head and Ghosh’s focus however has only been on the role of the backyard in providing provisioning services to households. Smith et al (2008) have undertaken similar work in the UK through their book ‘Residential Landscape Sustainability: A Checklist Tool’. They too only look at enhancing sustainability at the home scale and within the site boundaries, and do not consider the impact of the suburban block on the broader environment.

The lack of research undertaken at the suburban block scale on how the underlying ecosystem services function, how they have changed since European arrival and when most change and impacts occurred is a major concern. Understanding these elements individually and collectively is critical in understanding the carrying capacity of urban landscapes and how these landscapes can be managed in a sustainable manner in the future.

This situation regarding research into the impact of the suburban block on broader ecosystem services in now likely to change with the release of the American Sustainable Sites Initiative (SSI) in
2009. This tool is intended to foster a transformation in land development and management practices that will bring the essential importance of ecosystem services to the forefront (American Institute of Landscape Architects et al, 2009). They see land practices as sustainable if they enable natural and built systems to work together to “meet the needs of the present without compromising the ability of future generations to meet their needs”. They also see that any landscape, whether the site of a large subdivision, a shopping mall, a park, an abandoned rail yard, or a single home, holds the potential to regenerate the natural benefits and services provided by ecosystems in their undeveloped state.

While the work of the SSI is most welcomed, Hall (2010) has identified that since the start of the 1990’s, the size and function of the backyard in suburban Australia has undergone a radical transformation. Prior to this time general lot coverage of a house for the older suburbs is less than 30%, sometimes much less than this, meaning that the typical backyard is in the order of 200 m² (Hall, 2010). Since the 1990s, the average lot coverage in the examples from the new suburbs is in the range of 40-70% and that backyards now rarely creep above 100 m² and a very significant proportion is below 50 m² (Hall, 2010). This means that the suburban block is even less able to positively influence underlying ecosystem services than it does now.

Despite these recent changes, Davison (1994) sees that for over two centuries, our dreams of the good life have been shaped by a cluster of interrelated ideas we may loosely describe as the suburban ideal and that much of Melbourne’s designation as ‘the world’s most liveable city’ owes to the suburban form.

The Good Life

In 2005, the Ecological Footprint and Millennium Ecosystem Assessments identify basic human needs to be satisfied for people to live a healthy and fulfilling life. There is a very strong correlation between these basic human needs and those outlined by Abraham Maslow in the 1940s. Maslow’s hierarchy of needs echoed very strongly those espoused by Epicurus, the Ancient Greek philosopher and his notions of the Good Life.

Maslow’s Hierarchy of Need

Abraham Maslow, an American psychologist, released a paper in 1943 that had a pyramid of five levels of needs that is today referred to as ‘Maslow’s Hierarchy of Needs’.

Maslow (1943) identifies at least five sets of goals, which he calls basic needs: physiological, safety, love, esteem, and self-actualization. These basic goals are related to each other, being arranged in a hierarchy of prepotency (Maslow, 1943), or greatest influence. The home is the place where physiological, safety and love/belonging needs are predominantly met.

Epicurus

The link to Epicurus is particularly relevant to the contemporary Australian context in that Epicurus established his philosophical school in a private garden in the outer suburbs of Athens. He was the first suburban philosopher. Central to Epicurus philosophy was self-sufficiency, restraint and working closely with neighbours and friends. This was in contrast to Plato and Aristotle who had also
established their philosophical schools in gardens, but these gardens were public and in the middle of the city of Athens. From the very beginnings of Western society in Ancient Greece, there have been conflicts between the city and the suburbs as well as strong links between the suburbs and meeting basic human needs.

![Figure 2: Maslow’s Hierarchy of Need.](image)

**Ecosystem Services**

- **Provisioning**
  - Products from ecosystems
    - Food
    - Fresh water
    - Fuelwood
    - Fiber
    - Biochemicals
    - Genetic resources

- **Regulating**
  - Benefits from regulation of ecosystem processes
    - Climate regulation
    - Disease regulation
    - Water regulation
    - Water purification

- **Cultural**
  - Nonmaterial benefits from ecosystems
    - Spiritual & religious
    - Recreation & ecotourism
    - Aesthetic
    - Inspirational
    - Educational
    - Sense of place
    - Cultural heritage

- **Supporting**
  - Services necessary for production of all other services
    - Soil formation
    - Nutrient cycling
    - Primary production

![Figure 3: Ecosystem Services. Source: Millennium Ecosystem Assessment, 2005.](image)
**Ecosystem Services**

Ecosystem services are commonly defined today as the direct and indirect contributions of ecosystems to human wellbeing (DeGroot et al, 2010 in Washington, 2013).

In 2005, the United Nations released the Millennium Ecosystem Assessment. This report identified four key elements of ecosystem services - provisioning, regulating, cultural and supporting (see Figure 3).

**Ecosystems in Geelong**

Before being able to look into the impact of suburbia on the Geelong environment, it is important to first understand the environment encountered at the time of European settlement. The rest of this paper aims to establish what the ecosystems around Geelong looked like at the time of European arrival.

Changes were so rapid to most Australian landscapes on the arrival of Europeans that it is very difficult to understand the structure and functioning of Australian ecosystems and the role that people had in it. An historical ecological approach will be utilised to provide a description of the key ecosystems found in and around current urban Geelong. This will be achieved by a combination of historic accounts and contemporary scientific understanding of these ecosystems.

Lunt and Spooner (2005) see historical ecology as a new interdisciplinary paradigm in which ecologists view ecosystems as historically and spatially influenced non-equilibrium systems that are complex and open to human inputs. While historical ecology is relatively new in Australia, it has been used in the US since the 1960s.

The historical ecology perspective highlights the overriding influence of land-use history in creating past, current and future patterns of biodiversity across a range of spatial scales (Lunt and Spooner, 2005). It allows more realistic goals to be set for future research and restoration activities (Lunt and Spooner, 2005).

Major historical ecology approaches in Australia include ‘The Future Eaters’ (1994) by Prof. Tim Flannery and ‘The Place for a Village- How nature has shaped the city of Melbourne’ (2008) by Dr Gary Presland. While Presland (2008) looks at how urban development has been influenced by nature, my interest is more about how urban development impacted on nature.

There are three main ecological vegetation communities in urban Geelong around the Barwon River. These are plains grasslands, grassy woodlands and riparian forests.

Prior to European settlement, temperate woodlands such as Grassy Woodlands occupied over 7 million ha in Victoria, or 32% of the state, grasslands 8% of Victoria and riverine grassy woodlands such as riparian forests about 4% (Lunt and Bennett, 1999). Hence not only were these vegetation communities very common in what is now urban Geelong, they were also very common in Victoria.
**Basalt Plains Grasslands**

The vegetation of south western Victoria was dominated by grasslands from 16,000 years ago to present, (Jones, 1999). This include the vegetation of inner and western Geelong.

Foster Fyans was the first police magistrate of Geelong and later Commissioner for Crown Lands. His guide on his initial explorations of the Geelong region was William Buckley, 'The Wild White Man' who escaped from the first Penal Colony at Sorrento in 1803 and lived with the local Wathaurong until meeting John Batman, the founder of Melbourne, in 1835. On his first trip as Land Commissioner, Fyans found that his 'thoughts were often carried away with the extreme beauty of the country ...abounding in rich pasture, the plains covered with flocks of bustard, and emu in great abundance' (Shaw, 1996).

Natural temperate grasslands are essentially treeless communities that were dominated by perennial tussock grasses such as *Themeda*, *Austrodanthonia*, *Austrostipa* and *Poa*, with inter tussock forbs, smaller grasses and sedges (Lunt & Morgan, 2002). Gammage (2012) says that the grass originally grew in large tussocks, standing from two to twenty feet apart, according to circumstances and bore no resemblance to a sward.

Naturally low in nutrients- up to 12 times lower in extractable nutrients such as N, P and K than rainforests (Wijesuriya, 1999), grasslands occupy mostly freely draining red loamy basalt-derived soils in areas receiving at least 500 mm annual rainfall (DSE, 2004a). Burrowing animals (Wong and Morgan, 2007) and human intervention through fire and cultivation played an important role in nutrient cycling and creating gaps for herbaceous plants (see Figure 4). These relationships meant that soil was soft enough to push a finger into and water was able to soak in rather than runoff and that less rain sustained more plants (Gammage, 2012).

![Figure 4: Wathaurong women cultivating yam daisy roots from grasslands around Geelong. Source: Brown, 1989.](image-url)
Kangaroo Grass roots played an important role in enhancing soil health and structure by binding and aggregating soil particles, increasing soil porosity, cycling nutrients, increasing soil organic matter and supporting a large number of soil organisms (Cole, 2003).

Fire frequency has the most profound influence on grassland composition and structure, (Lunt & Morgan, 2002). The absence of low intensity fire increased perennial shrubs and small trees in some areas (Flannery, 1994; Lindenmeyer, 2007) and reduces plant species richness (Wong and Morgan, 2007). Absence of fire in Themeda grasslands for three years provides few gaps for non-grass species to germinate or thrive (Gott, 2005). Once the inter-fire interval reached 11 years few live tillers or tussocks remain and that below ground biomass has been reduced and that a single fire 12 years after last burn did not immediately return the grassland to a good state (Morgan and Lunt, 1999).

The absence of fire creates litter accumulation, which ties up nutrients or blocks seedling growth, limits their net productivity (Raven & Johnson, 1989 in Phillips, 2000).

Almost all early Europeans commented on the amount of previously burnt country in both grasslands and woodlands on either side of Port Phillip Bay (Jones, 1999). Mature grasslands were described less often, although Gellibrand reports waist high grasses travelling from Melbourne to Geelong in 1836 (Billot, 1979 in Jones, 1999).

These fires were the result the traditional owners of the land- the Wathaurong, and their intimate knowledge and understanding they had developed over thousands of years in managing their land.

Gammage (2011) describes that in 1788 most were `cool', whereas today they are `hot'. Cool fire could burn one species without much harming another, let people hunt close up and manacle hot fire by restricting fuel while hot fire cleaned country and helped needful plants regenerate (Gammage, 2011). Regularly burnt grasslands provided refuge for flora, and vertebrate and invertebrate fauna (Wong and Morgan, 2007).

Fires occurred in late summer/autumn every 3 to 5 years when most grassland species are dormant (Lunt & Morgan, 2002). Consequently, Lunt & Morgan (2002) identify that 92% of all perennial grassland plants resprout after annually burning in western Victorian grasslands.

**Grassy Woodlands**

Exploring the Bellarine Peninsula, John Batman found well-grassed land `of a most superior description- beyond the most sanguine expectations- excellent and very rich’ (Shaw, 1996). Lunt (1998) estimated that in the early 1800s there were less than 20 trees per hectare (Gott, 2005). This is the same vegetation community that was found in the higher parts of Geelong.

DSE (2004b) describes the grassy woodlands around Geelong as follows:

A variable open eucalypt woodland (*Eucalyptus ovata*, *E.radiata* and *E.viminalis*) to 15 m tall or occasionally Sheoak/Acacia woodland to 10 m tall over a diverse ground layer of grasses and herbs. The shrub component is usually sparse. It occurs on sites with moderate fertility on
gentle slopes or undulating hills on a range of geologies. The overstorey density was 15% tree canopy cover and a density of 15 trees per hectare. It had a 20% organic matter cover.

White (2012) states that Western Plains Woodland like those found around Geelong were dependent on fire. Cheal (2010) identifies that the minimum fire interval for low severity fire is 4 years and for high severity fires is 30 years; the maximum fire interval is 12 years (White, 2012). Fires were typically patchy, high severity fires rare and recovery from high severity fires slow (White, 2012). Jones (1999) describes that the result of this regular burning regime was the constant mentioning by early settlers of the resemblance of the woodlands surrounding Port Phillip to parkland.

The loam to loamy clay soils were fertile, moist in winter and parched in summer (White, 2012). The ecosystem productivity is relatively high (White, 2012) compared to other ecosystems. However high forb diversity requires low soil nutrients (Prober et al, 2002).

Under forested conditions, daily rainfall of 10-30 mm would be required to produce runoff, which would occur about 5 to 15 days per year (Ladson et al, 2006). This meant that in undisturbed natural catchments, trees, shrubs and grass intercept flow and less than 20% of annual rainfall became surface runoff (Argue, 2004 in Parker, 2010).

**Floodplain Riparian Woodland**

DSE (2004c) describes the Floodplain Riparian Woodland as:

> An open eucalypt woodland to 20 m tall over a medium to tall shrub layer with a ground layer consisting of amphibious and aquatic herbs and sedges. They occur along the banks and floodplains of the larger meandering rivers and major creeks, often in conjunction with one or more floodplain wetland communities. Elevation and rainfall are relatively low and soils are fertile alluviums subject to periodic flooding and inundation.

*Eucalyptus camaldulensis* (Red Gum) and *Eucalyptus ovata* (Swamp Gum) occur at a density of 15 trees per hectare and comprised a tree canopy cover of 20% (DSE, 2004c). Organic litter component of 40% (DSE, 2004c).

Floodplain Riparian Woodland occurs in the broader ecosystem type defined by White (2012) as ‘Riparian Forest’. Flooding is the main regeneration event (Cheal 2010) in riparian forests with the desired interval between floods varying between 5-10 years. (White, 2012). GHD (1982) found that generally 75 mm of rain from the Barwon, Leigh and Moorabool catchment over three days on a wet catchment or 150 mm rain on a dry catchment will cause significant flooding in Geelong.

Floodplains are crucial for the ecology of Australian rivers, being significant sources of carbon and nutrients for the river ecosystem (Davis and Koop, 2006).

While fire does occur in riparian forests, White (2012) identifies that this ecosystem type is flammable only occasionally, and fires tend to be low severity and patchy. The minimum frequency for low severity fires is 10 years and for high severity fires it is 30 years (White, 2012).
The riparian zone, the interface between rivers, wetlands and their terrestrial catchments (Boulton and Brock, 1999) plays a critical role in these and other ecosystems. Although only occupying a small proportion of the landscape, riparian areas are among the most productive ecosystems on earth (Lovett & Price, 1999). They are extremely important in landscape scale processes as they allow the movement of energy, materials and living organisms through the landscape (Ede & Hunt, 2008).

Riparian vegetation has a controlling influence on ecosystem function by reducing solar radiation and therefore limiting in-stream primary production (Boston & Hill, 1991; Cummins et al 1995 in Deegan and Ganf, 2008, p.680). Riparian cover upstream of an area may have more influence on local water quality than local riparian cover (Death & Collier, 2010 in Thomson et al, 2012).

**Barwon River**

South east Australian rivers are characterised by low but highly variable flow, high colour and turbidity, high salinity and low nutrients. Flows in Australian rivers and streams are nearly three times more variable than the world average (Boulton & Brock, 1999). As Otto (2011) describes a ‘once in a hundred year’ Australian flood is on average five times, but sometimes twenty or thirty times, the size of an annual flood; whereas in the rest of the world a hundred-year flood is usually only two or three times the annual average size.

The aquatic environment encountered by Europeans was not in stasis; rather it was dynamic and under influence of, among other influences, the dominant humans of the time (Humphries, 2007). In Geelong this was the Wathaurong. The dynamic nature not only occurred within the year, but as Barmuta (2003) suggests, over years, decades and centuries for elements such as flow and salinity levels.

In August 1836, on the first launch of a European boat on the Barwon River, Captain Edward Primrose Tregurtha, described it as having ‘...a depth of 2½-4 fathoms (4.57-7.3 metres), with a moderate tide, and free of snags, and stumps, a most lovely country and the river itself alive with wild fowls of all descriptions’. A year earlier, John Helder Wedge, in his explorations of the Geelong region with William Buckley recorded that on 24 August 1835 that the Barwon was little more than knee deep near just above its entry to Lake Connewarre (Brown, 1989).

However water was not always plentiful, or visible, and its lack was a frequent observation for early European explorers around Geelong. Matthew Flinders, in climbing the You Yangs at the beginning of May 1802 and returned to the coast having “walked twenty miles without finding a drop of water” (Edmonds, 2004). Likewise in the major drought of 1837-42, the Barwon River dried up to a series of small pools (Edmonds, 2004).

With the Barwon River being a lowland river in Geelong, flow would have been slow except in floods when the water would have had a turbid appearance. However, as Otto (2011) says of the Yarra River in Melbourne, that while the water may look dirty, in terms of pollutants or harmful bacteria, it is comparatively ‘clean’.

At the other end of the hydrological spectrum, just before pools in ephemeral wetlands and rivers dried up, water quality for salinity and nutrients was extremely poor (Boulton and Brock, 1999). This natural drying of pools is critical in enabling bacteria to rapidly take up soluble phosphorus and
making it unavailable until rewetting (Boulton & Brock, 1999). This meant that algal blooms were a natural feature of Australian rivers and wetlands (Boulton and Brock, 1999).

**Wetlands**

Boulton and Brock (1999) define a wetland as `... any area of temporarily or permanently waterlogged or inundated land, natural or artificial, with water that is standing or running, ranging from fresh to saline, and where inundation by water influences the biota and ecological processes occurring at any time’

At the time of European settlement wetlands covered 3.5 % of the Victorian landscape. The wetlands of the Barwon River floodplain around current day urban Geelong were ephemeral. They would usually dry in summer and refill in winter or spring (Boulton & Brock, 1999).

Straddling aquatic and terrestrial environments, wetlands are one of the most productive ecosystems on Earth. Wetland plants are among the most important primary producers in the wetland ecosystem, providing support for nearly all wetland biota (Tucker, 2003). The flora in these wetlands were more diverse than the adjacent river (Boulton & Brock, 1999). Connectivity between river channels and adjacent refuge wetlands was important in providing area to recolonise following long dry periods (Nielsen and Brock, 2009).

Hydrology is the most significance influence on the functionality of wetlands in Australia. Under natural conditions, much of the rainfall in the wetland catchments was trapped and salts were drawn down into groundwater aquifers. Water was either transpired by deep rooted vegetation, (keeping the groundwater aquifers well below the soil surface) or evaporated. The salts entering the wetlands were concentrated by evaporation, and flushed from the wetlands during the next high flow events (Nielsen and Brock, 2009). Rainfall (Pittock, 2003) and salinity has been variable and changeable over thousands of years (Nielsen and Brock, 2009) as well as during seasons and across years, decades and centuries. Biota of rivers and wetlands either tolerate these fluctuations or move to more suitable habitats. Biota that stay are tolerant to high levels of pollution while those that move are sensitive to it (Thomson et al, 2012).

Flooding releases a pulse of nutrients that, together with light and water, provide the resources for germination and growth of both micro and macro photosynthesizers (Boulton and Brock, 1999). Hence, natural wetlands were fertile environments that became more fertile with time, as nutrients were washed in from the terrestrial systems surrounding them (Romanowski, 2009).

Erosion of soil and sedimentation of wetlands is a natural process. It may occur as slow removal by gentle sheet flows or rapid loss during torrential downpours or landslides and comes from two main sources: catchment and channel (Boulton and Brock, 1999).

**Conclusion**

Contemporary cities have arguably the biggest impact of all human land use. From recent eco footprint and ecosystem services assessments, it is clear that the current mode of suburban living is not sustainable and cannot continue without dire consequences. Australians have a strong cultural and physical attachment to low density living in the suburbs. The suburban house and backyard is
where Australians spend most of their lives, and hence get their core human needs met. However there is a very low visibility, literacy and understanding within Australian society of the ecosystem services that underpin the provision of these core human needs. Gardening forms a critical part of the suburban experience and individual residents are most influenced by the gardens of other people, principally their neighbours. For many urban Australians home gardens/backyards are the only place that they can connect with the outside environment on a daily basis. It is also the place from which a renewed environmental and landscape literacy can emerge. For Geelong, this paper has provided the first steps towards making the ecosystems that existed, and how they functioned, at the time of European settlement visible. It also provides an insight into what were the influences on suburban form in Geelong over time. Such an understanding is needed to start to determine the impact that suburbia has had on the Geelong environment in the past and thereby help determine the ecological limits that we must operate in to enable a sustainable future.

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