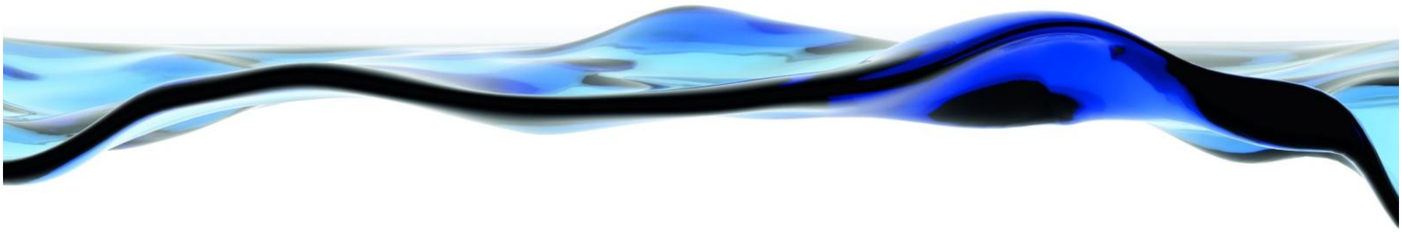
The importance of irrigated urban green space: health and recreational benefits perspectives

Schebella M, Weber D, Brown G, Hatton MacDonald D.



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Enquires should be addressed to:

Goyder Institute for Water Research, Level 1, Torrens Building

220 Victoria Square, Adelaide, SA, 5000

tel: 08-8303 8952 e-mail: enquiries@goyderinstitute.org

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The metropolitan region of Adelaide has multiple sources of water – surface water, groundwater, desalinated water, stormwater, roof or rain water, recycled water and the River Murray – that can be utilised and managed for supplying the city's water needs. Determining the 'optimal mix' of these sources is necessary to underpin an efficient and sustainable solution for Adelaide. To achieve this, consideration must first be given to the trade-offs between a range of important objectives, from supply security and economic costs to social preferences and environmental impacts. The Optimal Water Resources Mix project was designed to build a strong information base to inform these discussions and planning initiatives through:

- engaging with stakeholders to provide an effective communication pathway and an agreed basis for evaluating alternative water supply mixes
- providing a model that simulates the Adelaide water supply system
- developing a multi-objective optimisation methodology to assess trade-offs
- monitoring household water use to better predict demand
- performing legal and governance analysis in delivering water solutions
- conducting economic analysis of the direct and in-direct costs of supplying water from the multiple sources
- improving understanding of social values and preferences regarding water solutions.

The field study reported herein was conducted by Morgan Schebella as part of her honours thesis at the University of South Australia, and partially funded by Campbelltown City Council (Adelaide). This field work was augmented by the inclusion of a wider literature review with an emphasis on the role of water. This latter component was supported by the Goyder Institute for Water Research as part of the economic analysis component of the Optimal Water Resources Mix Project. Thesis supervision was provided Dr Delene Weber, University of South Australia. The PPGIS map was developed by Dr Greg Brown, University of Queensland.

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Executive summary

This project report is part of Task 6 – Economic Analysis of the Optimal Water Resources Mix Project. This report reviews and summarises the general results that can be gleaned from the existing international literature on green space relevant to human health and well-being. Results of empirical data collection and research are presented in an effort to provide more local context on the relationships between types of green space, types of social and physical activity and water in an urban landscape. The empirical work is undertaken at the scale of a local government area in the Adelaide metropolitan area.

There is a growing body of evidence that links human health and the natural environment. The importance of contact with nature is highlighted in this literature as providing a wide range of physical and mental health benefits. Contact with nature, whether physical or visual, has been shown to reduce stress, strengthen immunity, promote healing, improve mood, and reduce anger, anxiety and depression in urban settings (e.g. Hartig et al., 2003; Maller et al., 2008; Townsend & Weerasuriya, 2010). Within the urban environment, green space is also found to be a successful facilitator of physical activity (Schebella, 2012), which carries important physical health benefits such as the maintenance of healthy body weight, reduced blood pressure, lower cholesterol, improved muscular and skeletal strength, and ultimately, a reduced risk of premature death from heart disease, obesity, Type 2 diabetes and cancer (AIHW, 2010). It is now thought that green space satisfies many human needs that are difficult to satisfy by any other means (Maller et al., 2008), and for this reason, such spaces are beginning to be recognized as valuable health resources in many parts of the world (Frumkin & Coussens, 2007).

One challenge that researchers have sought to address is the specific characteristics of nature than facilitate positive health outcomes. In terms of their impact on human health, are all types of green space equal? Do the highly variable characteristics of green space – for example, size and configuration, vegetation height, species diversity, plant colour, composition and health – make any difference to the way people feel when they experience natural spaces? The answers to these questions have implications for the way land is used and resources are managed in urban areas. Kaplan & Kaplan (1989) suggest that people have an intrinsic preference for natural spaces over predominantly man-made ones but in terms of the variability that exists in green space, there is still much to be determined. Research over the past few decades has advanced our knowledge in this area. Studies have typically focused on quantifiable characteristics such as park size (Cohen et al., 2007). In contrast, some studies have also focused on more qualitative characteristics of parks, such as condition, quality and aesthetics (McCormack et al., 2010). Together, this body of research contributes to an understanding of the types of green spaces that should be established to maximise health benefits in urban areas. Unfortunately, the majority of research has occurred in the northern hemisphere with countries with temperate climates. Therefore, although this research may identify the types of parks that successfully facilitate health benefits in temperate regions, maintaining such parks in the hot, Mediterranean climate of South Australia offers unique challenges, due to the limited availability of water.

Water is an essential component of green space. When it can be seen, water is pleasing to the human eye; people often prefer landscapes that contain bodies of water, or water features (Lothian et al., 2010). Just as importantly, even when water cannot be seen, it is enjoyed. Water is what keeps vegetation alive, and water is what enables vegetation to cool the environment through transpiration (Ely & Pitman, 2012). Some researchers believe that the human preference for lush, green landscapes is the result of evolution, and stems from the fact that these environments appear fertile and potentially survival-enhancing to people (Orians & Heerwagen, 1992; Lothian et al., 2010). In South Australia, which experiences hot, dry summers, it becomes very difficult and resource-intensive to maintain lush, green landscapes throughout the year. Historically, urban green space in Adelaide was allowed to dry out during warmer months and become brown, as most public open space was not irrigated. Between the 1960s and 1980s community perceptions of green space changed, and the urban population developed an expectation, that their green space indeed be green. During this time green space in Adelaide increased substantially (Pitman, 2010). As many of the city's parks were influenced by European landscapes and gardens, they require considerable irrigation to sustain them, and this soon became problematic when the State was struck by the Millennium drought (1997-2009).

As climate change is expected to bring hotter, drier summers to South Australia, as well as more frequent and severe droughts, it is important to determine whether it is important to continue maintaining such resource-intensive spaces, or if it makes more sense to minimise urban parks, or alter them to suit their local climate. Such alterations could include such things as reducing areas of lawn and turf by increasing paved or mulched areas, replacing existing vegetation with drought-tolerant species; or reverting back to the pre-1960s approach of allowing vegetation to brown during drier months. Clearly, such adaptation strategies will result in a reduction of lush, green open space that much of the community has become accustomed to. Even by replacing existing vegetation with native plant species, which as a result of their physiological adaptation to the local climate are often less lush and green than introduced species, Adelaide's urban parks would change. It is essential that decision-makers be aware of how this change might impact the community, as an adaptation strategy that inadvertently reduced park usage, and reduced physical activity as a result, would further exacerbate the health impacts that are associated with climate change and urbanisation.

This report describes a pilot study that examined the influence of park irrigation on park-based physical activity and benefit attainment in urban South Australia. The location of the study was the City of Campbelltown in Adelaide's eastern suburbs. This investigation was part of a larger study into the influence of different park attributes on human health and wellbeing (see Schebella, 2012). The report comprises a review of the literature relating to human health and nature, as well as the results of the pilot study. The study utilized a Public Participation Geographic Information System (PPGIS), which enabled participants to plot the spatial location of their park-based physical activities and benefits on a web-based map of their local area. This allowed the relationship between physical activity levels and park irrigation to be explored. Green space within the Council area was also categorized into six different park types, such as sports fields and linear parks, to allow the relationship between park type and park-based recreation to be determined.

During the 2011/2012 financial year, Campbelltown Council used 84,100 kL of water to irrigate a relatively small selection (approximately 10%) of its parks, reserves, and sports fields (Boyle, G. 2013, pers. comm. 23 April). This volume is equivalent to the average annual water consumption of 1,200 South Australians (ABS, 20123), which is a relatively small number of people, given Campbelltown alone contains more than 48,000 residents. In times of water shortages, outdoor water use on both public and private green space has been subject to water restrictions, as irrigated green space is often considered to have less immediate consequences during such periods. Indeed, since 2003, there have been substantial reductions in irrigated green space across Adelaide, with some Councils terminating irrigation in more than 60% of their green space (Pitman, 2010). As recent water planning has often been associated with drought response strategies, decision-makers have had to make assumptions about the level of water restrictions that are acceptable to the community (White et al., 2008). There is increasing need for decision-makers to acknowledge all impacts that arise from their management of natural resources, including impacts to human health and wellbeing (Rogan et al., 2005).

Data do not exist prior to the recent dramatic shift in irrigation practices to determine how it has affected outdoor recreation and physical activity levels in the community, or furthermore, how it has influenced physical and mental health. As such, this data provides an important benchmark for future research in this area. According to the International Council for Science (2011) there is now an urgent need for a deeper understanding of urban health and wellbeing that integrates a range of different processes and factors, such as those associated with urbanisation and climate change. Proust et al. (2012) highlight that "an urban climate-health system is overwhelmingly complicated" (p. 2136) but attempts to integrate urban health and climate issues will be a vital contribution to the global response to climate change. This pilot study sought to contribute to the limited body of knowledge in this area.

Results

The study revealed an association between the level of physical activity and benefit attainment facilitated by different types of urban parks. For example, linear parks (e.g. Torrens River Linear Park) were found to facilitate significantly more physical activity than traditional community parks (e.g. Thorndon Park). However, community parks were found to facilitate significantly more non-physical benefits, including mental health, environmental, and social benefits. In terms of irrigation, irrigated parks were significantly associated with a range of physical activities, such as sports and low intensity activities (e.g. slow-paced walking). Most trail-based activities, such as cycling, walking and running were significantly associated with non-irrigated parks, however, this is likely due to the high percentage of these activities that take place along the Torrens River Linear Park, which is largely unwatered. Future studies will need to control for variations in park type in order to determine the influence of irrigation on physical activity and benefits.

Insights

- There is potential to link parks such as Torrens Linear Park and Thorndon Park using bike and walking paths to create spaces that are associated with increased physical activity levels.
- Connecting parks with vegetated corridors has the potential to provide habitat areas for birds and other native species.
- Where land for establishing additional green space is limited, there is potential to maximise use of roadsides and footpaths by planting vegetation and trees to make them more attractive for physical activity. This will contribute to the overall 'greenness' of neighbourhoods, which carries important physical and mental health benefits, and will also assist in cooling the urban environment.
- To promote and increase greenness on medians and roadsides to reduce brown off, there are benefits of planting drought-tolerant groundcovers
- There may be potential water and health trade-offs to be re-evaluated with the level of use occurring at different parks. If low use is occurring in sports fields, for example, which are one of the greatest consumers of water in urban areas, consideration might be given to reconfiguring the portfolio of park types and converting some areas to parks with plantings of native vegetation, which have a lower water demand and greater potential for irrigation using stormwater.
- Further studies into the influence of irrigation on physical and mental health, which control for differences in other attributes, such as park type, park size, and the presence of water bodies are required to fine-tune urban green space.

Table of contents

Figures

Tables

1 Introduction

During times of drought, potable water resources are dedicated to those uses that ensure human health and survival. Historically, water restrictions have targeted outdoor water use, particularly in public and private green space, with limitations placed on the frequency, duration, and timing of irrigation within these spaces. A series of state government-imposed water restrictions and permanent water conservation measures over the past decade have resulted in substantial water savings throughout Adelaide, albeit at the cost of the declining condition of many urban parks and gardens (Fam et al., 2008; Connellan, 2012). The cessation of irrigation in many parks that are considered to be under-utilised or of low value, continual calls for improvements in water application efficiency and increased use of drought-tolerant plant species have all contributed to modifying Adelaide's green space in some way in recent years.

In 2008, introduction of the Irrigated Public Open Space (IPOS) Code of Practice, a strategic initiative of the Water Proofing Adelaide strategy (Waterproofing Adelaide 2005), resulted in large-scale reductions in potable water consumption across Adelaide. In the City of Campbelltown, potable water use in the 2007-2008 financial year reduced by 57% (SA Government, 2008). Although this was subsidized to a small extent by bore water (Boyle, G. 2013, pers. comm., 23 April), the majority of this water saving is the result of irrigating a smaller selection of the Council's green space than was irrigated in previous years. Similar cuts have been made throughout Greater Adelaide metropolitan area with Councils such as Playford and Mitcham completely cutting irrigation to 60% of previously irrigated green space by the late 2000s (Pitman, 2010).

From the literature, certain characteristics of green space, such as park size and number of facilities, have been found to influence park use and play a role in the types of benefits people derive from these spaces (Giles-Corti et al., 2005). Although one might assume that green space of any kind is beneficial to urban inhabitants, research is placing increasing importance on the quality of these spaces in facilitating use and ultimately, generating health outcomes. Whilst many studies have attempted to determine the features of urban parks that attract users (Corti et al, 1996) and to identify the types of landscapes that people prefer to experience (Hill & Daniel, 2007), the majority of these studies have taken place in temperate climates. As green space in such climates is typically green throughout the year, it is not surprising that the value of irrigation of urban parks remains relatively unexplored within the literature.

This project report provides an overview of the benefits of green space and seeks to investigate the relationship between human activity levels and irrigated versus non-irrigated green spaces. These data will serve as a valuable benchmark for future assessment of the impact of changes in irrigation patterns. This report has two components:

- relevant issues drawn from a review of the literature
- a pilot study conducted in Campbelltown, South Australia, which looked at levels of activity associated with a range of different urban green spaces.

1.1 Literature review method

A potential set of literature was compiled through searches on Google Scholar and Web of Science using standard search terms for this literature "benefits+open space", "benefits+green space", "physical activity+open space", and "natural areas+health". Titles and abstracts were reviewed for relevance. References in articles identified in this preliminary search were examined for additional titles (more details can be found in Schebella 2012). Of the 64 studies identified as relevant from the title and abstracts, 36% of the titles are local or national studies with an emphasis on Australian conditions and the remainder are international in focus. This report tailors the literature search to focus on:

- the impact of climate change on urban health
- the importance of park attributes
- the importance of water in urban green space.

1.2 Pilot study method

Empirical evidence was captured from a pilot study conducted in Campbelltown, South Australia, which investigated the level of physical activity and benefit attainment facilitated by a range of different urban green spaces. The study used Public Participation GIS (PPGIS) to examine the spatial distribution of park-based physical activities and other benefits within irrigated and non-irrigated parks and reserves.

The results are presented, and then discussed, by the following topics:

- associations between recreation (physical activity) and park type (attributes)
- benefits as a function of park type
- physical activity as a function of park type
- physical activity as a function of park irrigation
- benefits as a function of park irrigation.

2 A review of the literature

Countries throughout the world are experiencing rapid rates of urbanisation, with more than half of the global population now reported to live in urban areas (Amhad, 2007; ICSU, 2011). All over the world, urban infrastructure, services, and environments are facing increasing pressure to accommodate rapidly rising populations. In many cities and towns, demand for infrastructure to meet the needs of these growing populations has been met through the development and modification of natural areas, such as open spaces, fields, parks, and wetlands (Kong & Nakagoshi, 2006; DEH, 2008; Byomkesh et al., 2012). Such rapid urbanization is associated with the destruction of urban green space, concomitant decreased quality of life (Dewan & Yamaguchi, 2008), the emergence and spread of infectious diseases (The World Bank, 2011), increased atmospheric pollution and changed microclimates in many cities throughout the world (Byomkesh et al., 2012).

Although urbanisation in Australia is now occurring much more slowly in comparison to less developed regions of the world, Australia's urban centres will bear almost all of the country's population growth over the next four decades, and by 2050 its cities are expected to account for more than 90% of the national population (DESA, 2012). In South Australia, the urban population continues to grow each year, with 76.7% of South Australians now residing in Adelaide (ABS 2011). Some features of urban environments that discourage physical activity may be contributing factors to the rising levels of obesity, diabetes and depression in developed countries (Townsend & Weerasuriya, 2010). Such features include an absence or insufficient amount of green space and areas for recreation (Giles-Corti et al., 2003). Studies also reveal a potential disconnection between people who live in urban communities and the natural environment, which may be having a negative impact on their physiological and psychological health (Maller et al., 2008).

Contact with nature can be beneficial to people's health and wellbeing (e.g. Hartig et al., 2003; Maller et al., 2008; Townsend & Weerasuriya, 2010). Urban parks are often regarded as the last remnants of nature in cities (Beatley, 1999) and for this reason great value is placed on them for their ability to reconnect people with the natural environment (Harmon & Putney, 2003). Furthermore, urban green spaces provide essential ecological services, such as the maintenance of biodiversity (Attwell, 2000), the prevention of soil erosion, the purification of air and water, and the stabilization of microclimates (Chiesura, 2004). Consequently, the lack of green space in some urban areas may contribute to increased air pollution and the formation of urban heat islands (Proust et al., 2012). In addition to these environmental consequences, many city inhabitants also suffer from overcrowding, alienation, and reduced opportunities for physical activity and rest as a result of urbanisation (Proust et al., 2012).

Parks may provide people with unique opportunities for physical activity, wider social interaction, escape, and enjoyment of nature (Hayward & Weitzer, 1984). Parks are found to be successful facilitators of physical activity in urban populations (Wilhelm-Stanis et al., 2010).,

According to Bauman et al. (2006), there are five measurable components of physical activity, namely, the frequency, duration, and intensity of physical activity, the type of activity, and the setting in which it occurs. The first three components can be used to measure the health benefits of physical activity, and in fact, minimum thresholds of frequency, duration and intensity must be met in order to yield any aerobic benefit (Wilmore et al., 2008). Worldwide, governments and health organisations have set this threshold at 30 minutes of moderate intensity physical activity, at least five days per week, for a total of 150 minutes per week (Wilmore et al., 2008; WHO, 2010). Any person exercising less than this level is considered to be physically inactive. The fourth and fifth components of physical activity, i.e. activity type and setting, are important considerations for planners and park managers who play a role in facilitating physical activity.

A study by Kaczynski and Henderson (2007) found that proximity and access to parks and natural spaces were more likely to be associated with higher levels of physical activity than exercise facilities such as gyms. Access to urban parks has been shown to increase physical activity levels in the elderly (Sugiyama & Thompson, 2008), in children (Floyd et al., 2011), and in the general population (Wendel-Vos et al., 2004; Giles-Corti et al., 2005). Cohen et al. (2007) identified residential proximity to parks as being the most important predictor of park use and leisure-time physical activity; but this can also be influenced by the size of parks (Giles-Corti et al., 2005), their aesthetic appeal (Giles-Corti et al., 2005; Evenson et al. 2006) and perceived safety (Evenson et al. 2006).

Factors such as being overweight, obese or physically inactive are comparable to tobacco smoking in terms of the health risk they represent to society (Begg et al., 2007). For Australia as a whole, physical inactivity has been estimated to cost the country's economy $13.8 billion per year and causes over 16,000 premature deaths (Medibank Private, 2008). The sedentary lifestyle of many people in modern societies is said to be a natural response to the urban environment, as reliance on cars increases (Medibank Private, 2008). In South Australia, 42% of the population is classed as being physically inactive and 56.3% of the population is overweight or obese (SA Health, 2009). Despite self-reported physical activity levels showing some improvement in recent years, the percentage of overweight and obese individuals in the state continues to increase (SA Health, 2009). From a cost avoidance perspective, there is merit in exploring means of reducing the direct burden of avoidable illnesses associated with physical inactivity, including, but not limited to obesity, Type 2 diabetes, cardiovascular disease, osteoarthritis, depression, and some cancers (Maller et al. 2008).

2.1 The impact of climate change on urban health

Over the next century, climate change is expected to cause temperature increases of between 0.4 and 5.4°C in Australia (IPCC, 2007). Associated impacts of this to the southern parts of the country are increased evaporation, decreased runoff, increased frequency of very high or extreme fire danger days (IPCC, 2007) and increased UV radiation (Bentham, 2001). In South Australia, rainfall may decrease by as much as 80% (IPCC, 2007) and the number of days per year with a temperature above 35°C could nearly triple (CSIRO, 2007). According to the CSIRO (2006), South Australia's maximum temperature is increasing at a faster rate (0.21°C per decade) compared to national trends (0.15°C per decade), while its minimum temperature is increasing at a slower rate. In the past, the focus of climate change research has been on impacts and mitigation (Kates, 2000) however, in recent years, scientists, planners, and governments worldwide have recognized the importance of developing climate change adaptation strategies. As Mertz et al. (2009) state, the inertia in the climate system means some climate change adaptation is now inevitable, regardless of past or future attempts to reduce carbon emissions.

Studies have shown that precipitation, humidity, and temperature also influence physical activity levels. In the southeast United States, Wolff & Fitzhugh (2011) found that participation in physical activity rose in warmer weather, but peaked at a temperature of 29°C, after which, it steadily declined with every additional 1°C rise. Similar studies have found this peak temperature to be 24°C, also in the southeast United States (Burchfield et al., 2012), and 30°C in Ontario, Canada (Brandon et al., 2009). The impact of weather variability on physical activity could be of great importance in South Australia.

From the climate adaptation literature, it is anticipated that cities are locations where climate change will have the greatest impact on people's health (Bambrick et al., 2011). Its impact may be felt in several ways, including increased morbidity and mortality from heat stress and gastrointestinal and vector-borne diseases; exacerbation of cardiovascular and respiratory diseases as a result of air pollution (Luber & Prudent, 2009; Bambrick et al., 2011; Blashki et al., 2011); increased mental health stress (Luber & Prudent, 2009; Blashki et al., 2011); increased mortality and morbidity from catastrophic events such as flooding and bushfires (Bambrick et al., 2011); and increased rates of skin cancer (Bentham, 2001). In Australia, longer-term health impacts may also result from reduced levels of physical activity as a consequence of temperatures being perceived as too hot for outdoor recreation for certain periods of the year and fear of the health risks caused by increased UV radiation (Townsend et al., 2003).

According to Bambrick et al., (2011) reducing the underlying burden of disease in Australia will have the greatest impact on reducing the negative health consequences of climate change. This is because climate change will exacerbate already existing health conditions and risk factors (Bambrick et al., 2011), such as the chronic illnesses associated with Australia's high levels of physical inactivity. Hence, urban green space is potentially an important component as part of a preventative health strategy to facilitate increased physical activity and improve human health and quality of life in urban areas. Additionally, urban green space provides other environmental benefits that can reduce the impacts of climate change, such as the heat ameliorating effects of urban parks (Cao et al., 2010; Kleerekoper et al., 2011).

Vegetation within parks and reserves can cool the environment through the natural processes of evaporation and transpiration (Kleerekoper et al., 2011). This is particularly relevant to cities, which often experience a phenomenon known as the Urban Heat Island effect (UHI effect), wherein urban temperatures are up to 5° to 12°C warmer than those in surrounding rural environments, due to the heat given off by roads and buildings (Gill et al., 2007; Cao et al., 2010; Kleerekoper et al., 2011). Urban parks can form a Park Cool Island (PCI) within cities, as on average, they are 1-4.7°C cooler than their urban surroundings (Cao et al., 2010), and can extend this cooling effect beyond their park boundary, 100-1000 metres into a city (Cao et al., 2010; Kleerekoper et al., 2011). Given that one of the most direct health impacts of climate change is likely to be greater morbidity and mortality as a result of exposure to high ambient temperatures (IPCC, 2007), the aforementioned heat ameliorating effects of urban parks will be of increasing importance.

The quality of urban greenspaces could be at risk with reduced rainfall, greater frequency and duration of droughts, increased dieback of vegetation, decreased biodiversity (Saunders, 2009) and stricter irrigation regimes (MAVSSTV, 2007). A wide range of potential strategies exist for dealing with these risks, for example, replacing exotic species with drought-tolerant green vegetation, allowing water features to dry up, increasing paved areas, closing parks during warmer seasons, and increasing the use of water sensitive grasses (Weber & Brown, 2011). As there may be negative consequences to any adaptation strategy, such as the reduced aesthetic appeal of grassed areas that are left to die off under strict watering regimes, it is important to understand community attitudes in relation to a variety of alternatives. Saunders (2009), states that the effect of climate change on urban parks may be exacerbated as water restrictions become stricter and it becomes more difficult to maintain healthy trees and quality turf for parks and ovals. While there is much research on the colour green and the psychological benefits of green landscapes (e.g. Akers et al., 2012), limited research has been conducted on 'brown' landscapes. However, existing research does suggest such landscapes may not be as appealing to the general public as green landscapes. Mahmoudi et al., (2013) found that green sport parks are valued by homebuyers. Un-watered natural bushland, which is characteristically brown and dry in summer, detracted from proximate property prices (Hatton MacDonald et al., 2010), reflecting a lower value placed on these areas by local residents. Further research is needed, but if these dry, brown parks are valued less than traditional, European-style 'green' parks, and facilitate fewer health outcomes as a result, this could further exacerbate the health impacts of climate change in South Australia. If certain park features, such as vegetation colour, play a role in influencing physical activity, it is of interest to determine what these features are.

2.2 The importance of park attributes

The influence of different park characteristics on physical activity and human health has only begun to be explored in recent years (Giles-Corti et al., 2005; Kaczynski et al., 2008). Studies have shown that large, attractive parks are more likely to facilitate physical activity (Giles-Corti et al., 2005), but what makes one park more attractive than another? Studies show that parks containing a variety of different features, such as clean toilets, water fountains, barbeques, picnic areas, seating, signage and shade are considered to be more attractive to park users (McCormack et al., 2010). The size of the park is an interesting factor. Larger parks have the capacity to and are more likely to contain a greater number of these features. As such, they are more likely to be considered as attractive, as they provide a greater level of service to visitors (Giles-Corti et al., 2005).

Studies have shown that certain park features are more strongly associated with physical activity than others, for example, Kaczynski et al., (2008) found that parks with paved trails, unpaved trails, or wooded areas were more than 7 times as likely to be used for physical activity as parks that did not contain these features. Additionally, it is believed that parks that facilitate both structured physical activities such as competitive sports, and unstructured physical activities such as walking, are important for encouraging greater levels of park use (McCormack et al., 2010). However, it is not only park size and the variety of features that contribute to a park's attractiveness. Studies have also found that a lack of safety, fear of theft or sexual assault, the presence of homeless people, the presence of graffiti, and insufficient lighting detract from a park's appeal and result in lower levels of park use (McCormack et al., 2010). Additionally, factors such as poor maintenance of park facilities, the presence of vandalism, rubbish, and uneven footpaths are found to discourage park use (McCormack et al., 2010).

Not all park features are likely to encourage people to be physically active. For example, a park with picnic and barbeque facilities is likely to attract families for passive recreation and may not necessarily encourage physical activity or attract those park users who are looking to exercise (Corti et al., 1996). Studies have found that sporting fields and ovals represent a disproportionate amount of green space in Australia, despite the majority of Australians preferring unstructured physical activities such as walking and cycling (Hahn & Craythorn, 1994). Due to their characteristically flat, even surfaces, these sporting ovals are unattractive to walkers, and therefore, are underutilised when not being used for organised sports (Hahn & Craythorn, 1994; Corti et al., 1996). Furthermore, a study by Floyd et al. (2008) found that certain types of sporting ovals, such as baseball and softball fields facilitated relatively low levels of health outcomes, due to the amount of time people are inactive whilst fielding or waiting to bat.

Defining Park Configurations - A common way to categorise differences in parks and park settings is the Recreation Opportunity Spectrum (ROS) developed by Driver and Brown (1978) and Clarke and Stankey (1979). However, it offers limited value in studies of urban parks, as the setting conditions are typically characterised by high levels of development (as such there is limited differentiation between ROS classes). Although the Queensland state government has subdivided the developed ROS category into 'intensive' and 'urban' (Worboys et al. 2005, p. 436), no other Australian research was found that had focused on operationalising the differences amongst urban parks. Some attention, however, has been directed toward this issue in the United States. The United States National Recreation and Park Association (NRPA) developed an urban park classification system and set of guidelines, which was designed to promote recreation opportunities within urban areas (Mertes & Hall, 1996; Brown, 2008). Table 1 outlines these classifications, which are categorised according to the characteristics of size, function, shape, and level of human development.

Table 1. The five categories of park type, according to the NRPA classifications

NRPA Classifications		NRPA Size and Location Guidelines
1	Mini-Park Neighbourhood Park School-Park	Mini-park—an open area between 230 and 400 sq. ms, <400 m access walking distance in residential setting Neighbourhood-park—2 to 4 ha optimal, 400–800 m access walking distance School-park—variable size, location determined by school
2	Community Park Large Urban Park	Community—usually between 12 and 20 ha, 800 m to 5 kms access walking distance Large urban park—usually a minimum of 20 ha with ≥30 ha optimal, usually serves entire community
3	Special Use Sports Complex	Special use—size variable, location variable Sports complex—usually a minimum of 10 ha with 16-32 hectares optimal, strategically located
4	Natural Resource Areas	Natural resource areas—size variable, location depends on availability and opportunity
5	Park Trails/Linear parks	Trails–2 ha per 1000 people, location variable

Different park features may facilitating different activities amongst park users, for example, walking trails are much more successful at facilitating physical activities such as walking and cycling than flat, grassed areas. Linear green spaces (or corridors) are essential for facilitating movement within the urban environment and connecting trails may promote human physical activity. Noss (1993) argues that greenways and corridors should not be considered a substitute for large expanses of green space in the urban landscape for ecological reasons, as such areas contribute to the maintenance of animal populations, and are required as source areas for colonist species. As well, people benefit for the educational and amenity values of wildlife in urban areas as well as the existence values associated with habitat. Similarly large urban parks facilitate the experience of more general benefits, such as family bonding, relaxation, and mental health benefits. Thus, linear parks and greenways serve a different role than large urban parks. The challenge for urban planning is in understanding which park configurations across new and existing urban neighbourhoods could maximise human health and well-being. Large new parks containing lots of facilities are not able to be developed within existing residential areas. Existing neighbourhoods may only be able to accommodate small changes in the configuration of green space. This is a distinct thread in the literature where researchers have focussed on the features that managers could easily manipulate, such as trails, picnic grounds and other visitor related services. A separate group of researchers have made a significant contribution to the role of scenery and aesthetics, while a third group has paid attention to the biophysical attributes of parks, such as biodiversity (e.g. Fuller et al., 2007). In doing so, it appears that an important opportunity has been missed, this being the examination of how biodiversity and the aesthetics of a park, impact the level of physical activity that occurs within the park.

In South Australia, one of the biggest obstacles to establishing and maintaining green space is the scarcity of water. As a park attribute, water alters green space in a manner much more obvious to people than many other attributes, as green space that is insufficiently watered soon becomes brown and dry. For this reason, it is of interest to determine just how irrigation of parks contributes to human health and wellbeing in South Australia.

2.3 The importance of water in urban green space

Despite irrigated green space providing a range of environmental benefits, such as habitat provision, the key reason for irrigation in urban settings is based on the assumption that such spaces are more attractive to people and if they are more attractive, that they will be of greater benefit to the community. Research into the aesthetic qualities of urban parks has explored two main areas. The first seeks to identify the presence or absence of negative characteristics that people consider to detract from a park's aesthetic qualities, such as litter, vandalism, and cracked pavement (McCormack et al., 2010). The second attempts to determine what it is about nature that people find beautiful or aesthetically pleasing, however, this is often done with little detail. McCormack et al. (2010) identified trees, bushes, gardens, grass, flowers, natural settings, water features and fresh air as contributing to park aesthetics. However, if someone is asked to simply list the features that parks contain, these elements are likely to be many of those that they describe. These are the features that form a park, and one that contains them all could still be considered unattractive to park users.

In Australia, very little is known about human perceptions of vegetation and landscapes, particularly in urban settings. To date, few studies have examined whether Australians prefer the traditional, European-style parks and gardens that influenced much of Adelaide's green space prior to the 21st Century (Pitman, 2010), or whether they prefer their country's native vegetation. As native vegetation has adapted to the harsh Australian climate and is likely to be irrigated only during establishment, knowledge of these preferences is highly relevant to discussions of water use in South Australia. More importantly, researchers have not investigated which type of open space – irrigated green parks or un-watered, natural open space – facilitates greater benefit attainment and health outcomes as a result of these preferences.

A South Australian study exploring landscape quality across different regions in the State (e.g. mallee country, pastoral lands, etc.), found that respondents rated native vegetation 15.5% higher than introduced pine or willow species (Lothian, 2000). However, as higher preference was given to dead trees in rivers than was given to live pine trees, it is thought that this particular finding is a greater indication of the positive influence of water in landscapes, rather than of vegetation preferences (Lothian, 2000).

Studies show that people generally prefer landscapes containing natural elements, rather than landscapes that are predominantly developed or man-made (Kaplan & Kaplan, 1989). Velarde et al., (2007) summarise over 30 studies on the effects of natural settings versus urban settings on human health. However, there may be a point at which naturalness becomes unappealing and appears unkempt or unsafe to people. Research shows that human preferences for natural landscapes may not be consistent with what is beneficial for the protection of biodiversity and ecological quality, such as a preference for landscapes containing little understory (Williams and Cary, 2002).

This study by Williams and Cary (2002) explored Australian's preferences for rural landscapes of varying ecological quality. Although the study did not investigate preferences for native versus European-style landscapes, nor issues to do with water, several of their findings are of relevance to the discussion of irrigation. Firstly, respondents showed a significantly lower preference for landscapes containing particular types of vegetation. Interestingly, these landscapes contained the native, drought-tolerant Casuarina species, which respondents believed appeared to be dead, dry, or fire-damaged, despite being perfectly healthy plants. According to Williams and Cary (2002) this finding highlights the importance of water and healthy vegetation in the environment. The characteristics of these plants that were interpreted by respondents as representing a dry or dead landscape, such as their needle-like foliage, are unique physiological adaptations to Australia's hot, dry environment. The use of drought-tolerant plants in public spaces is common practice in South Australia (Pitman, 2010) and is encouraged by local and state governments. However, if vegetation that has adapted to the local climate is considered to be less attractive, it is important to be aware of this before such plants are used to replace vegetation that people do find attractive, in an effort to reduce water consumption. It is possible that human landscape preferences are inconsistent with what is required for the conservation of water in urban communities.

In South Australia, the Irrigated Public Open Space (IPOS) Code of Practice was introduced in 2007, when Adelaide was under Level 3 water restrictions. These water restrictions placed such strong limitations on the irrigation of outdoor spaces that there was concern the city's parks and sports grounds would no longer be maintained to a standard that was 'fit for purpose' (Charlton, 2009). The IPOS Code of Practice enables public green space to be exempt from water restrictions, but imposes limits on their irrigation that are directly related to their functional value. For example, sports fields can be irrigated more often than local neighbourhood parks, because they are considered to offer a greater level of service to the public. Areas considered to have no functional benefit, such as roadsides and medians are not permitted to be irrigated (Charlton, 2009). The Code of Practice has been the driver behind most of the reductions in local government water consumption over the past few years, as it ensures that monitoring and reporting of water use occurs; promotes the planting of drought tolerant plant species; allows the browning off of low functional sites; and imposes penalties for non-compliance (SA Water, 2012).

Whilst this has been effective for water conservation during a severe drought, it have unintended consequences on human health. Research shows that South Australians who perceive their neighbourhood as being very green, are much more likely to report better physical and mental health than those who do not perceive their neighbourhood to be green (Sugiyama et al., 2008). This is supported by studies that objectively measure urban greenness and health outcomes, such as the study by Bell et al., (2008), which found that greater urban greenness (measured using the NDVI: normalized difference vegetation index) was associated with lower Body Mass Index (BMI) in young people. It has been suggested that the experience of watching environments die or become degraded can have serious mental health consequences in rural areas (Hanigan et al., 2012) and it could be assumed that similar consequences may arise in urban areas.

Watering is a relatively recent phenomenon in the history of metropolitan Adelaide. Prior to the 1960s, very little of Adelaide's green space was irrigated and the vast majority of it was left to naturally brown off and become dry during the hot summer months, with the exception of some sports fields (Pitman, 2010). However, between the 1960s and 1980s, the community developed an expectation that green space would be maintained to a certain standard, and the irrigation of urban parks throughout Adelaide became widespread during this period (Pitman, 2010). In response to the Millennium drought, a series of permanent conservation measures and water restrictions of varying severity, the way South Australia used its water resources changed. Councils began to minimise irrigation of urban parks and reserves during the drought and in some Council areas such as Mitcham and Playford, more than 60% of irrigated green space stopped being watered (Pitman, 2010). Despite the latest drought having officially ended in late 2010, and water restrictions having been lifted, permanent Water Wise Measures have been put in place. These measures continue to place restrictions on outdoor water use, and call for continual improvements in the efficiency of water use in parks and gardens (Charlton, 2009). Data do not exist prior to this dramatic reduction in green space irrigation, to enable us to determine how it has affected outdoor recreation and physical activity levels in the community, or furthermore, how it has influenced physical and mental health. There are indications that such reductions may be impacting the population however, such as in Unley Council, where reduced irrigation of most of its already limited green space has resulted in greater use of the two areas that are still irrigated: Goodwood Oval and Unley Oval. The two ovals are being placed under great stress as other areas of previously irrigated green space become less attractive to the public. This raises concern as to what will happen if these ovals are stressed to the point that they are no longer 'fit for purpose'.

Raxworthy (2010) states that, "after 200 years of white settlement, Australians still have not really come to terms with the real dryness of their country, and still exploit European paradigms that attempted to transplant European aesthetic conditions, greenness, to the brown land of Australia" (pg. 37). Further, Raxworthy suggests that planners and designers of public spaces have an important role to play in changing the population's perception of Australian landscapes, which might help to transform their water use practices. By implementing non-irrigated, drought-tolerant design styles, such as Xeriscaping (from the Greek word 'xeros' meaning 'dry'), Raxworthy believes designers can help change the way people view open space that is not lush and green, by teaching them to appreciate it for what it is: sustainable. In essence, Raxworthy suggests that if the population were aware of the benefits provided by drought-tolerant environments, they would begin to find such landscapes aesthetically pleasing. This is similar to the view of researchers such as Gobster (1999) who believed environmental education and the provision of information could work to create an informed 'ecological aesthetic' in which people's uninformed 'scenic aesthetic' preferences were modified to align with the landscape features of ecologically valuable environments (Gobster, 1999). However, other studies suggest that human landscape preferences may be too deeply engrained for such changes to be expected, and many researchers testing this theory have been unsuccessful in changing people's landscape preferences by providing respondents with ecological information (e.g. Hill & Daniel, 2007). Landscape preferences may be the result of evolutionary forces (Orians & Heerwagen, 1992) and developed when humans inhabited savannah-like environments, which continue to appear safe, fertile, and aesthetically pleasing to people even today (e.g. Williams & Cary, 2002; Hill & Daniel, 2007; Connellan, 2010).

Perhaps as a result of these evolutionary forces, humans tend to prefer natural landscapes that are relatively open, have low groundcover like lawn or turf, a source of water that is obvious, such as a stream, or implied, such as green vegetation, and contain scattered clumps of trees and shrubs (Hill & Daniel, 2007). This is of importance to Councils and urban planners, as an Australian study revealed that adults who did not perceive their environment to be aesthetically pleasing were less likely to participate in walking for physical activity or recreation (Ball et al., 2001). This has strong implications for population health in a city such as Adelaide, where physical activity levels are already insufficient, and the irrigation of green space has faced severe reductions over the past decade. Additionally, studies suggest that the quality of urban parks in a person's environment may have a stronger impact on mental health than previously identified variables such as the number and proximity of urban parks (Francis et al.,, 2010). Interestingly, research reveals that the relationship between park quality and mental health may not be affected by the frequency of use of parks, suggesting that people do not need to use parks often to benefit from them mentally (Francis et al., 2010). For this reason, it is possible that the mental health benefits of irrigated urban green space might not be effectively measured by simply studying the level of use that irrigated parks receive in comparison to non-irrigated parks, however, this is likely to give an indication of physical health benefits and community preferences.

Within natural environments, water is not only valued for its ability to sustain vegetation, but also for its own aesthetic worth. People often prefer landscapes that contain bodies of water such as lakes, or water features such as fountains (Lothian et al., 2010). As with urban green space, properties close to water or with water views often increase in value, for example, properties in three Adelaide suburbs built around significant water features were found to be valued 29% higher than surrounding suburbs (Lothian et al., 2010). In contrast Mahmoudi et al (2013) finds a property's proximity to the Adelaide coast is quite important but proximity to man-made lakes is not statistically significant across the metropolitan area. The source of people's natural affinity for landscapes containing water, or waterscapes is unknown. Like green space studies, researchers have put forth explanations ranging from evolutionary perspectives – such as water's importance for human survival – to cultural and religious perspectives, such as wishing wells or fountains often being regarded as symbols of purity (Lothian et al., 2010).

Exposure to 'blue space' or aquatic environments has been shown to provide benefits to human health and wellbeing, similar to that of green space, however, this topic has received far less research attention than the relationship between human health and nature in general (Volker & Kistemann, 2011). As expressed by Hill & Daniel (2007) lush, green vegetation is indicative of water in natural environments, as such vegetation could not survive without an adequate water supply. For this reason, it is possible that irrigated green space may be of greater value to people than non-irrigated green space, as it is an expression of two natural elements that are both highly regarded by humans and beneficial to their health.

In addition to providing health benefits through the creation of aesthetically pleasing landscapes, irrigation also contributes to maintaining urban microclimates and helps to ameliorate the effects of urban heat islands (UHI), as discussed earlier. As mentioned, urban parks are able to form a park cool island (PCI), which may be several degrees cooler than surrounding urban environments, however, this cooling effect is highly dependent upon the features of such spaces. For example, without access to moisture in the soil, a plant cannot cool the environment through transpiration. If the water supply to vegetation is not adequately matched to its needs, transpiration and the consequent cooling effect of green space will be minimal, i.e. the higher the level of moisture in the soil, the more plants are able to transpire at maximum efficiency (Ely & Pitman, 2012). In South Australia, a common practice in urban water management and climate change adaptation is to use low water-use, drought tolerant plants in parks and gardens (Pitman, 2010), which transpire at a slower rate and are thus less dependent upon irrigation to survive. This has obvious benefits in terms of water conservation, however, certain issues raised in this report, such as the potential loss of aesthetic value and the reduced cooling effect of green space, are trade-offs with strong implications for human health, which must be explored. Coutts et al. (2012) express a similar concern in relation to energy use, when they state that the combined impact of droughts, water restrictions, xeric style gardens, and reduced vegetation health in urban areas will have a substantial impact on urban warming and future energy demands.

The next section draws on the ideas from the literature and investigates through an internet based survey the associations between the activities associated with different types of parks and reserves and where possible the watering of these parks and reserves.

3 Empirical investigation – the pilot study

This pilot study utilised an internet-based PPGIS platform developed by Brown & Weber (2011), which enabled participants to plot the spatial location of their park-based physical activities and benefits on a Google Map™ of Campbelltown Council. Through an associated online survey, the PPGIS website also allowed participants to provide personal health and socio-demographic data.

3.1 Study location

The City of Campbelltown encompasses eight suburbs in the inner eastern region of Adelaide, South Australia. The council area is predominantly residential, but also contains parklands, reserves, and some commercial areas. Geographically, Campbelltown is bounded in the north by the River Torrens, along which the 50km long Linear Park greenway was developed. To the east, the council is bounded by the Adelaide Hills, including conservation sites such as Black Hill Conservation Park. In addition to these naturally occurring areas of green space, the council area contains many small neighbourhood pocket parks, as well as a variety of reserves, ovals and sports fields. Compared to other areas of Adelaide, the eastern suburbs are characterised by relatively low-density housing and reasonably large residential allotments. Between the 1960s and 1980s, the population of Campbelltown grew dramatically from 15,000 to 43,000 people, and continued to rise at a much slower rate from the 1980s onwards. Recent population growth in Campbelltown has been attained through urban infill, rather than greenfield development, and as at 2011, the area housed a population of 48,165 people (ABS, 2011).

3.2 Study participants

Several methods were used to recruit participants to the internet-based PPGIS system. The City of Campbelltown, a partner in the pilot study, funded the distribution of a household recruitment brochure to all residences in the Council area (approximately 21,600 households). The bulk distribution was contracted to a local vendor who was to deliver the brochures over a two-day period. Due to Ethics Approval requirements, the study was only open to residents who were 14 years of age or older.

Following the distribution of the brochure, on-site convenience sampling intercepts were implemented at locations across the council are including Thorndon Park, Torrens Linear Park, The Gums and Daly Oval within the Council area. Individuals intercepted were provided with an invitation and encouraged to visit the PPGIS website to participate in the study. Additional recruitment methods were employed including posters, a paid newspaper advertisement, and promotion through the Campbelltown E-Newsletter. Posters with tear-off tabs containing the PPGIS website URL were placed on noticeboards in local shopping centres, at the Campbelltown Public Library, and at the University of South Australia's Magill Campus. A small paid advertisement was placed in the East Torrens Messenger Newspaper, and an announcement about the study was placed in the Council's monthly E-Newsletter, which is emailed to residents of the Council that have subscribed to the E-Newsletter. As part of the recruitment effort, an incentive of being entered into a draw for $500 was offered to participants.

3.3 PPGIS website

The PPGIS study website consisted of an opening screen for the study participant to request a unique access code, followed by a consent screen for participation. Upon consenting, the user was taken to a Google Maps™ interface instructing the participant to drag and drop different digital markers (icons) onto a map of the Campbelltown Council area (see Figure 1). The icons were located in three panels on the left of the screen. The first panel consisted of 13 physical activities commonly associated with parks and green spaces, the second panel consisted of 12 potential park benefits, and the third panel consisted of 12 potential actions that could be taken to help adapt local parks to climate change. The focus of this report is on the mapped physical activities and park benefits and the relationship between these and the irrigation patterns within Campbelltown parks.

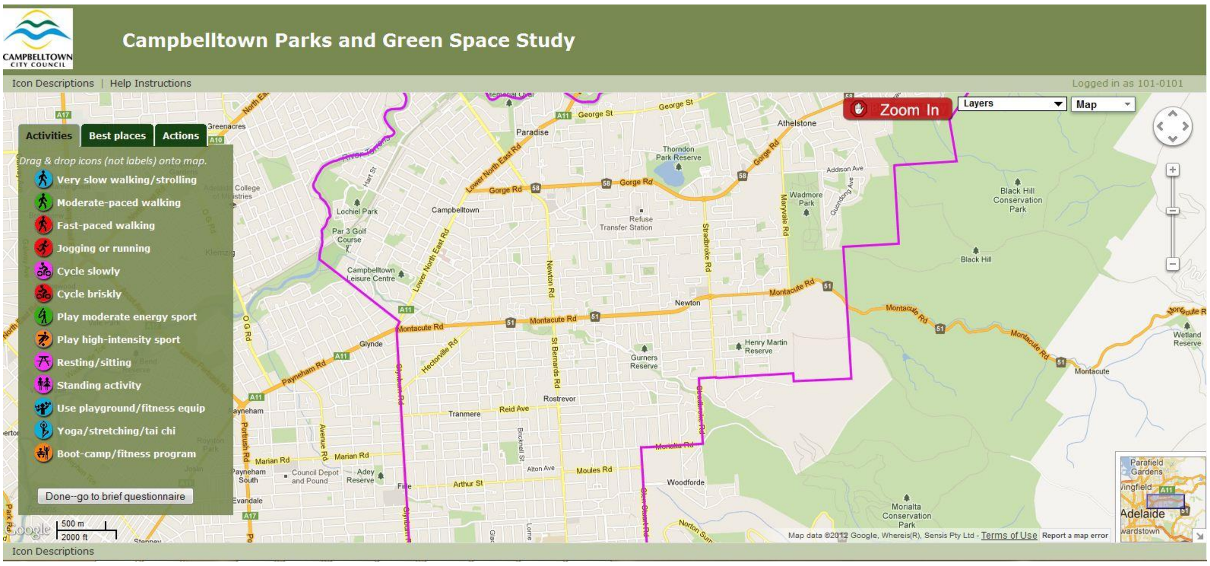

Figure 1. The Campbelltown PPGIS platform adapted from Brown & Weber (2011). The study site is outlined in purple on the map

The physical activities that could be mapped ranged from sedentary activities such as sitting, to running and playing sport (see Table 2). Each activity was aligned to a metabolic equivalent of task (MET) to assess the intensity of each activity. This allowed each one to be categorised as a low, moderate, or high intensity activity. Metabolic equivalents are a unit used to estimate the metabolic cost of physical activity, with the value of 1 MET being approximately equal to a person's resting energy expenditure, or resting metabolic rate (RMR). Activities can be categorized as multiples of resting energy expenditure. For example, fast walking is considered to be 4 METS because it requires an energy expenditure that is 4 times RMR (Welks, 2002).

Table 2. List of PPGIS markers for physical activities and park benefits used in the PPGIS study

Physical Activity	Intensity	Benefit	Domain
Very slow walking/strolling	Low	Enjoy nature	Environmental
Moderate-paced walking	Moderate	Get exercise/fitness	Physical
Fast-paced walking	Moderate	Escape stress	Mental
Jogging or running	High	Enjoy tranquillity	Mental

Physical Activity	Intensity	Benefit	Domain
Cycling slowly	Moderate	Spend time with friends	Social
Cycling briskly	High	Study/observe nature	Environmental
Moderate intensity sport	Moderate	Be around good people	Social
High intensity sport	High	Escape crowds	Mental
Resting/sitting	Low	Connect with family	Social
Standing activity	Low	Place to think/reflect	Mental
Using playground/fitness equipment	Moderate	Rest/relax	Mental
Yoga/stretching/tai chi	Low	Spending time outside	Environmental
Boot-camp or fitness program	High		

The park benefits that could be mapped (see Table 2) were aligned to the recreation experience preference items developed and validated by Driver and associates (Driver and Bassett, 1977; Driver and Knopf, 1976; Driver and Tocher, 1970; Driver et al. 1991; Manfredo et al. 1983). While Driver et al. (1991) identified 19 benefit domains, Weber and Anderson (2010) recommended a reduced set of benefits for Australian studies. This study focussed on those benefits Weber and Anderson (2010) found to be important to Australian park visitors, as shown in Table 2. The 12 benefits were logically organized into four benefit domains: physical, environmental, social, and mental health benefits.

3.4 Mapping process

Study participants were instructed to familiarise themselves with the set of spatial attributes (icons) and their definitions, and then place the icons relevant to their use of local parks on the Google Map™ of Campbelltown. To do this, participants were required to identify a specific location where they engage in an outdoor activity, such as jogging. They could then click on an icon signifying this activity, then drag and drop it onto the map location representing the place where they engaged in that activity or enjoyed that benefit. To ensure spatial precision in icon placement, the icons could only be placed when the participant had zoomed in to Google zoom level 17, which equates to approximately a 1:4500 map scale. Respondents were able to view the map using the standard Google roadmap display or could choose to switch to a satellite view of the area. Respondents were also able to annotate the markers they mapped to provide more specific information regarding why they had placed a marker in a specific location. Participants were encouraged to place at least 20 icons. Following the mapping activity, participants were directed to survey questions, which asked about their park use, their self-reported personal health characteristics, and selected socio-demographic information for comparison with census data.

3.5 Empirical results

3.5.1 Respondent demographics and park usage characteristics

A total of 242 people participated in the Campbelltown Council pilot study. Of those, 215 completed both parts of the PPGIS study (map and survey questions) and 27 completed only the map section. Respondents mapped 5469 icons for spatial analysis. To determine whether pilot study participants were representative of the general population of Campbelltown, their demographic variables were compared with census results for the Council area (ABS, 2011). About 58% of participants were female (ABS census=52%) with a median age of 41 (ABS census=42). About 43% of participants were in families with children (ABS census=45%). Thus, the study participants were close to representative of the general Campbelltown population in regard to these three demographic variables.

Study participants had lived in the Campbelltown area for periods ranging from less than a year to 47 years, with a mean residency of 16 years. About 56% of participants rated their knowledge of parks and reserves in Campbelltown as 'excellent' or 'good,' 32% rated their knowledge as 'average,' 12% rated their knowledge as 'below average' and only 2% rated their knowledge as 'poor'. About 65% of participants reported using Campbelltown parks at least once a week, with another 16% using the parks at least once every two weeks. Participants were also asked about their non-place specific frequency of engagement in the 13 physical activities as well as the duration of these activities. The most common physical activity was moderate-paced walking following by sitting and slow walking. The least common physical activity was 'boot camp' followed by yoga and high-intensity sport.

3.5.2 Associations between recreation and park attributes

Parks and reserves within the Council area were categorised into one of six park types, adapted from the NRPA park classification system (see Figure 2). Parks were also classified as being 'irrigated' or 'non-irrigated' based on data provided by Campbelltown Council.

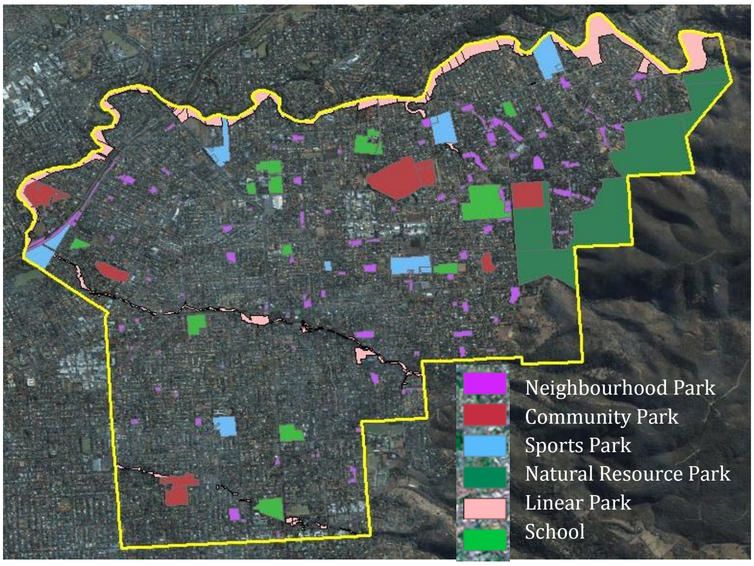

Figure 2. Map showing all green space within Campbelltown coded into six park classifications

The 13 physical activities and 12 benefits were spatially intersected with the parks located in the Council. A buffer of 10 ms was extended around each park boundary to include points that were likely intended for inclusion within the park. Physical activities not falling within any park boundary were classified as 'outside'. As discussed, the 13 physical activities were also classified into one of three physical activity intensity categories based on associated MET levels, and the 12 benefits were classified into one of four benefit domains.

Cross-tabulations were generated to show the relationship between:

- park type and the three activity intensity categories
- irrigation and the three activity intensity categories
- park type and the four benefit domains
- irrigation and the four benefit domains.

Chi-square statistics and standardized residuals were also calculated for these variables. Chi-square residuals provide a way to assess the strength of association between two categorical variables and is employed following a statistically significant chi-square result to determine which pair-wise categorical relationships most contribute to the overall significant association. Standardized residuals are a normalized score like a z score without units and if greater than +2.0, indicate significantly more activities or benefits than would be expected, while standardized residuals less than -2.0 indicate fewer activities or benefits than expected.

3.5.3 Physical activity as a function of park type

The physical activity markers (low, medium, and high intensity) were spatially intersected with parks located in the Council area and cross-tabulated. There was a statistically significant association between the intensity of physical activities and the urban park type, as shown in Table 3. The largest percentage of high intensity physical activity (about 60%) is associated with linear parks while the largest percentage of low intensity physical activity is associated with community parks (about 40%) and neighbourhood parks (about 23%). From the standardized chi-square residuals, low intensity physical activity is disproportionately associated with neighbourhood and community parks, while high intensity physical activity is disproportionately associated with linear parks and areas outside of park boundaries. As might be expected, low intensity physical activity is underrepresented in sports parks.

Table 3. Physical activity intensity by park type, showing the percentage of PPGIS markers

Park type	Low intensity	Medium intensity	High intensity	
Outside of park	6.2% [-1.2]	5.7%* [-2.5]	12.6%* [4.9]	7.5%
Neighbourhood	22.7%* [3.8]	18.4% [1.8]	6.7%* [-6.4]	16.5%
Community	39.6%* [10.0]	20.2% [-.9]	7.0%* [-8.2]	21.3%
Sports	6.3%* [-2.4]	9.7% [0.6]	10.7% [1.3]	9.2%
Natural	7.4% [1.9]	6.2% [0.9]	2.8%* [-3.2]	5.7%
Linear	16.6%* [-9.0]	38.8% [-.01]	59.9%* [8.8]	39.0%
School	1.1% [0.6]	1.0% [0.4]	0.4% [-1.2]	0.9%
Total markers	631 22.1%	1540 53.8%	690 24.1%	2861 100.0%

* Statistically significant [standardized chi-square residuals for each category]

3.5.4 Physical activity as a function of park irrigation

The physical activity markers were spatially intersected with parks located in the Council area and cross-tabulated. There was a statistically significant association (X^2=469.2, df=12, p < 0.00) between the type of physical activity and the irrigation of urban parks, as shown in Table 4. Most trail-based activities were strongly associated with non-irrigated green space, such as fast cycling (97%), slow cycling (80%), fast walking (80%), and moderate walking (79%). Not surprisingly, high intensity sport (88%) and moderate intensity sport (65%) were associated with irrigated green space. There appears to be a stronger association between activity type and irrigation, rather than physical intensity and irrigation.

Table 4. Physical activities by park irrigation, showing the number of PPGIS markers

Activity	Intensity	Irrigated	Non-irrigated	Total
Cycling fast	High	3.5%* [-9.6]	96.5%* [6.8]	342
Fast walking	High	20.0%* [-3.2]	80.0%* [2.3]	190
Fitness group/boot-camp	High	53.1% [1.9]	46.9% [-1.4]	32
High intensity sport	High	88.2%* [5.5]	11.8%* [-3.9]	34
Jogging/running	High	29.5%* [-0.9]	70.5% [0.7]	176
Moderate intensity sport	Moderate	65.1%* [5.7]	34.9%* [-4.0]	109
Moderate walking	Moderate	21.2%* [-5.3]	78.8%* [3.7]	612
Cycling slow	Moderate	19.6%* [-2.9]	80.4%* [2.1]	143
Playground equipment	Moderate	52.4%* [5.9]	47.6%* [-4.2]	334
Sitting/resting	Low	55.0%* [5.7]	45.0%* [-4.1]	240
Slow walking	Low	47.2%* [3.4]	52.8%* [-2.4]	212
Standing	Low	66.2%* [4.8]	33.8%* [-3.4]	74
Yoga/tai chi	Low	55.0% [1.7]	45.0%* [-1.2]	20
Total markers		845 33.6%	1673 66.4%	2518 100.0%

*Statistical significant results [standardized chi-square residuals for each category]

3.5.5 Benefits as a function of park type

The park benefit markers (*environmental*, *physical*, *social*, and *mental*) were spatially intersected with parks located in the Council area and cross-tabulated. There is a statistically significant association between park benefits and park type, as shown in Table 5. Community parks have the strongest association with environmental (33%), mental (34%), and social (49%) benefits, while linear parks have the strongest association with physical benefits (36%). From the standardized chi-square residuals, environmental benefits are disproportionately associated with *natural* parks, physical benefits are disproportionately associated with *sports*, *linear*, and *schools,* and social benefits are underrepresented in *natural* and *linear* parks.

Table 5. Park benefit domain by park type, showing the percentage of PPGIS markers and standardized chi-square residuals for each benefit domain

Park type	Environmental benefits	Physical benefits	Mental benefits	Social benefits	
Outside of park	5.2% [0.9]	4.4% [-0.1]	3.8% [-0.8]	4.2% [-0.2]	4.5%
Neighbourhood	15.0% [-0.6]	15.0% [-0.4]	15.8% -0.1]	18.6% [1.3]	15.9%
Community	32.5% [-0.9]	23.1% [-3.2]	33.7% [-.3]	48.5% [4.5]	34.6%
Sports	6.3% [-0.8]	11.4% [2.7]	5.9% -0.9]	6.8% [-0.2]	7.0%
Natural	14.8% [2.2]	8.1% [-1.8]	13.3% [0.9]	7.3% [-2.5]	11.9%
Linear	25.8% [0.3]	35.9% [3.5]	26.1% [0.4]	14.4% [-4.1]	25.2%
School	0.5% [-1.3]	2.2% [2.1]	1.4% [1.0]	0.3% [-1.3]	1.0%
Total markers	655 36.6%	273 15.3%	505 28.2%	355 19.9%	1788 100.0%

3.5.6 Benefits as a function of park irrigation

The park benefit markers (*environmental*, *physical*, *social*, and *mental*) were spatially intersected with parks located in the Council area and cross-tabulated. There is a statistically significant association between park benefits and park irrigation, as shown in Table 6. Irrigated parks have the strongest association with *social* benefits such as spending time with friends (64%), connecting with family (54%), and being around good people (70%). Non-irrigated parks have a strong association with *environmental* benefits such as enjoying nature (73%). From the standardized chi-square residuals, the environmental benefit of ’enjoying nature,’ is disproportionately associated with non-irrigated parks; and all social benefits are disproportionately associated with irrigated parks, as is the mental benefit of ’rest and relax’.

Table 6. Benefit domains by park irrigation, showing the percentage of PPGIS markers

Benefit	Domain	Irrigated	Non-irrigated	Total
Enjoy nature	Environmental	26.7%* [-3.3]	73.3%* [2.7]	270
Get exercise/fitness	Physical	31.4%* [-2.0]	68.6% [1.6]	245
Escape stress	Mental	37.1% [-0.4]	62.9% [0.3]	132
Enjoy tranquillity	Mental	26.7% [-0.8]	73.3% [0.6]	15
Spend time with friends	Social	64.2%* [4.1]	35.8%* [-3.3]	109
Study/observe nature	Environmental	27.5% [-1.9]	72.5% 1.6]	102
Be around good people	Social	69.6%* [3.6]	30.4%* [-2.9]	56
Escape crowds	Mental	31.9% [-1.4]	68.1% [1.1]	135
Connect with family	Social	54.0%* [2.7]	46.0%* [-2.2]	139
Place to think/reflect	Mental	44.6% [1.2]	55.4% [-1.0]	97
Rest and relax	Mental	55.7%* [2.3]	44.3% [-1.9]	79
Spending time outside	Environmental	44.6% [1.2]	55.4% [-1.0]	213
Total markers		628 39.4%	964 60.6%	1592 100.0%

* Statistically significant [standardized chi-square residuals for each category]

3.6 Discussion of results

This pilot study aimed to determine how different types of urban parks are used for physical activity, as well as their role in facilitating a range of non-physical human benefits. The study also sought to explore the influence of irrigation on park-based physical activity and benefit attainment and consider some of the potential implications of these findings for urban park systems, urban planning, and public health.

3.6.1 Associations between physical activity and park type

Linear parks are the most successful parks at facilitating high intensity physical activities such as walking, cycling and jogging. Linear parks and sports parks were the only park types that facilitated more high intensity physical activity than they did low intensity or sedentary activity. This is likely a result of the parks' design, as both are intended to facilitate exercise, with limited opportunities for more passive recreation options. The results revealed that community parks such as Thorndon Park were also successful at facilitating physical activity, however, the physical health benefit of the activities performed within linear parks exceeded those performed in community parks, which are often used for sedentary activities such as picnics and barbeques. Therefore, linear parks are thought to facilitate the greatest physical health benefit in Campbelltown Council. This supports previous research, which found that parks containing walking trails (of which Linear Park consists largely of) are more likely to facilitate physical activity (Kaczynski et al., 2008). Most of the high-intensity activities engaged in by participants were trail-based activities, such as walking and cycling.

One of the limitations of this study, was that it did not include children under the age of 14 years, for ethical reasons. It is possible that in community and neighbourhood parks, where high intensity physical activity was found to be much lower, that adults engage in stationary behaviour because they are supervising the play and recreation of their children, who were not accounted for in the pilot study. Future research should aim to include all segments of the population by using appropriate methods such as participant observation.

3.6.2 Associations between benefits and park type

Whilst there is an obvious relationship between physical activity and physical health benefits such as lower blood pressure, it is also important to consider the non-physical benefits that are attained by users of urban green space, such as relaxation. Respondents were asked to map the locations where they attained a range of different physical and non-physical benefits, ranging from exercise/fitness to family bonding and stress release. The most frequently mapped benefits were the enjoyment of nature and exercise/fitness, which are environmental and physical health benefits, respectively. Interestingly, both linear parks and community parks were comparable in terms of their success at facilitating environmental and mental health benefits. For example, both linear parks and community parks were popular locations for respondents to enjoy nature (an environmental benefit) and reduce stress (a mental health benefit). This supports the link between nature and human health that many previous studies have demonstrated (e.g. Maller et al., 2008).

In the field of urban ecology, Noss (1993) argued that linear green space, despite its important role in providing environmental corridors within fragmented landscapes, cannot be considered a substitute for large areas of green space. This study supports this argument from a human perspective. Linear parks and large community parks were comparable in their ability to facilitate some benefits, such as mental health benefits, however, in terms of physical health benefits, linear parks were found to excel, and in terms of social benefits, community parks were found to excel. As all benefit domains are of importance to society, it would appear that this need for a variety of green space configurations is applicable to people as well as other animal species.

3.6.3 Associations between physical activity and irrigation

The results showed a significant association between trail-based activities such as cycling and walking with non-irrigated parks. This is likely an indication of the importance of the Torrens Linear park, as discussed previously, rather than a reflection of the importance of irrigation. The majority of this park is not irrigated, however, it represents a substantial component of park-based physical activity within this community. Interestingly, the park also contains a body of water, the River Torrens. Studies have shown that people often prefer landscapes containing such features, however, whether this has an influence on residents' physical activity levels in Campbelltown cannot be concluded from this pilot study. The study did not control for park features such as bodies of water, a limitation that should not be overlooked in future studies.

As was expected, high intensity and moderate intensity sports were associated with irrigated green space. The introduction of the IPOS Code of Practice was strongly based on ensuring that sports fields remained 'fit for purpose,' and they are typically the most heavily irrigated type of green space in urban areas. Maintaining quality turf during the summer months requires substantial irrigation, and sports fields in Campbelltown are generally irrigated three to four times per week during dry weather (Boyle, G. 2013, pers. comm. 23 April). Thus, it was not surprising that sports would be associated with these spaces. The findings from this pilot study, whilst inconclusive, appear to indicate that there is a stronger association between activity type and irrigation, rather than physical intensity and irrigation. However, this may be indicative of the association between activity type and park type, as generally the type of park is what determines its watering regime.

3.6.4 Associations between benefits and irrigation

From the pilot study, irrigated parks have the strongest association with social benefits such as spending time with friends, connecting with family, and being around good people. This is an interesting finding, however, again it may be a reflection of park type, as it can be expected that the more popular, attractive parks within the Council area are those that receive irrigation. Without ceasing irrigation in a park that has a known level of use, and examining the effects of this on recreation, it cannot be concluded that irrigation is the source of the association between social benefits and certain areas of green space.

Non-irrigated parks demonstrated a strong association with environmental benefits such as enjoying nature, which may be due to the high level of use along the largely non-irrigated Linear Park. Interestingly, two of the key parks within the Council area for facilitating environmental benefits and mental health benefits were Torrens Linear Park and Thorndon Park. Whilst these two parks are of differing park type: linear park and community park; and whilst one is largely non-irrigated and one is largely irrigated; they do share one defining feature, and that is the presence of a body of water. Future studies should explore the importance of these features to park-based physical activity and benefit attainment in South Australia. The state's warm, dry weather could mean that rivers and reservoirs, such as those contained in these two parks, are of increased importance to the community.

4 Conclusions

The literature review and empirical investigation provide some insights into the benefits of urban greenspace. While only associations between irrigation and physical activity levels at this scale of research project, it provides a basis for recommending further research into the influence of irrigation on physical and mental health, controlling for differences in other attributes, such as park type, park size, and the presence of water bodies. In particular it is suggested that the experimental protocol in future research specifically control for different park types and irrigation levels, using paired park types across an LGA. This would necessarily require agreement from the Council to irrigate areas according to a carefully negotiated protocol to examine the changes in physical activity and overall park usage. This would allow the researchers to isolate the effect of irrigation on the population in terms of physical activity levels, benefit attainment, community satisfaction, etc. Non-irrigated green space could be re-irrigated to examine the importance of irrigation to park use.

In order to fully appreciate the health versus water trade-off, it may be worthwhile to investigate the importance of lush, green vegetation versus drought-tolerant vegetation to urban South Australians, and whether greater use of certain vegetation types by park managers impacts park use or benefit attainment.

The literature and empirical results suggest that there may be merit in linking green spaces using vegetated green corridors. This will help to facilitate greater physical activity, as well as contribute to the movement of wildlife within urban settings. As well, linear parks were shown to be an important physical health resource within Campbelltown. By connecting parks through trail networks, for example trails connecting key sites such as Thorndon Park and segments of Torrens Linear Park significant improvements in terms of physical health outcomes could potentially be achieved. These trails could facilitate a greater level of physical activity, as is already demonstrated by the large number of Campbelltown residents who participate in trail-based activities such as walking and cycling. Research into the number of people who use linear parks primarily for scenic enjoyment, as opposed to exercise or commuting to work could also be conducted. The findings of such a study will determine whether a single trail network will be sufficient, or if a dual network that combines two different types of trails, and therefore trail experiences, would be more effective. Such a network could consist of direct trails to the city and shopping areas, enabling rapid transit on bicycles, which would reduce the risk posed to walkers and joggers by cycling commuters, and at the same time would encourage more commuters because of the associated time savings. Implementing such a trail network could improve physical activity levels, and also holds important environmental benefits for native plant and animal species. Additionally, it could assist in reducing traffic congestion and carbon emissions by decreasing dependence on cars.

The literature review highlighted how the use of natural corridors, such as waterways, creeks and roadsides, to form linear parks could be maximised. Rails-to-Trails conversions and the High Line park in New York, which was an old elevated railway line converted to parkland, offer excellent examples of how disused corridors can be converted to popular green space. Increasing the overall 'greenness' of neighbourhoods may help to improve physical and mental health in urban communities.

It would be useful to investigate further the level of use that individual sports fields receive. Sports fields are one of the biggest consumers of water, and have been found to represent a disproportionate amount of green space in Australian communities. Although sports fields in general are highly important to certain segments of the population such as teenagers (Schebella, 2012), if individual ovals such as Campbelltown Memorial Oval are found to be under-utilised, they could be converted to another use, such as a community park, which has lower water demands and provides greater opportunity for irrigation using stormwater.

One of the learning from the the PPGIS map of Campbelltown (Figure 1) is that residents in the northern part of the council have greater access to urban green space than residents in the southern part of the council. There may be opportunities in the future for creative development of green space in the south. Acquisition of additional land may not be an option, so rather than setting aside large areas for parks, instead trees and plants could be planted along footpaths and in other developed areas to make pedestrian areas more attractive for physical activity. ‘Short cut corridors’ connecting popular destinations and suburban hubs to green spaces could also be encouraged.

Finally a last insight from the research is there may be scope for establishing small patches of greenspace that people interact with or pass by regularly as these areas can be important to mental health. Instead of allowing medians and small pocket parks to brown-off, there may be merit in replacing these lawn-covered areas with drought tolerant groundcover or small shrubs.

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