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The role of distance in peri-urban national park use: Who visits them and how far do they travel?

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Abstract

There is a sizable literature about the factors shaping park visitation and use – especially for urban parks, including (i) geographic (e.g. proximity), (ii) socio-cultural (e.g. population characteristics) and to a lesser extent, (iii) individual psychometric factors (e.g. attitudes and values). Yet comparatively little is known about how factors related to distance may affect peri-urban national park use, particularly outside the United States. This paper reports on research investigating distance-related factors affecting use of a peri-urban national park in Brisbane, Australia. This study found that older visitors live closer to the park while younger visitors travel further to use it. Surprisingly, travel distance did not vary with the type of recreational activities that users were conducting in the park. These results have implications for park planning and management including user demand for different recreational activities in peri-urban national parks. Results are useful for scholars using distance decay models to explain travel behavior, evidencing the empirical veracity of the model in different places and across different service types. The findings are especially important for geographers because they demonstrate that assumptions about uniform park catchments may be unsupported and need to be empirically validated.

Keywords:

Urban-rural fringe, park use, visitor, distance decay, travel patterns, gravity model

1. Introduction

More than two decades ago, Eldridge and Jones (1991) asserted that: ‘few concepts are more central to the discipline of geography than distance decay’. The basis of this assertion was that distance affects many spatial patterns, processes and relationships, and even underpins Tobler’s (1970) observations about the relatedness of things in space – often referred to as the ‘first law of geography’. Geographers have given attention to the explicit role of distance decay across a variety of human-environment interactions, such as travel-demand behaviour for facilities including food distribution centres (LeDoux & Vojnovic, 2014), casinos (Markham, Doran, & Young, 2014), and health care (McGrail & Humphreys, 2009). Distance decay effects have also been observed in demand for recreation and tourism facilities (e.g. Burton & Veal, 1971; Elson, 1979; Hooper, 2014; Lee & Schuett, 2014; Veal, 1987). And such effects have long been examined across diverse fields including business, marketing, leisure, and transport research (e.g. Brown, 1992; Cardozo, García-Palomares, & Gutiérrez, 2012; Huff, 1964; Reilly, 1931; Spinney & Millward, 2013; Vickerman, 1974). Although the relationship between urban park use and the distance that people travel to visit urban parks has generated substantial scholarly attention (Giles-Corti et al., 2005; Kaczynski, Potwarka, & Saelens, 2008a; McCormack et al., 2006b; Talen, 1997, 1998; Talen & Anselin, 1998), distance decay studies of facilities such as wildland recreation sites and protected areas are less common in geography specifically and other disciplines generally (Bateman & Langford, 1997; Hanink & White, 1999; Zhang et al., 1999). Therefore, studies of distance-decay for peri-urban parks warrant closer investigation.

Common sense suggests that people who live nearer to a park will visit it more often than those who live further away (Stanis, Schneider, & Anderson, 2009). This idea is known as the ‘proximity’ hypothesis (Van Dijk & Van der Wulp, 2010), and has received some attention in the leisure studies and geography literature, but not as much as might be expected (Byrne & Wolch, 2009). Similarly, the observation that overall park use declines with increasing distance from a park has also attracted attention (Dee & Liebman, 1970). This is typically held to be a function of a ‘distance decay’ (Gregory et al., 2009; Wu & Cai, 2006).

Some scholars suggest that distance is also an important component of a broader construct known as park ‘accessibility’, because distance from a park appears to be strongly correlated with other aspects of park use, such as the frequency of visitation, or the types of activities people undertake when they visit a park (Giles-Corti et al., 2005). Distance also plays a selective role, interacting with the socio-demographic characteristics of potential park visitors, differentiating those who can readily access parks and those who cannot (e.g. (dis)ability, sex, age, race, ethnicity) (Byrne & Wolch, 2009; Nicholls, 2001; Talen, 2010; Wolch, Byrne, & Newell, 2014); see also (McKercher, 2008; McKercher, Chan, & Lam, 2008; Spinney & Millward, 2013).

For instance, researchers have found that people who live closer to a park tend to visit more often, but visit for shorter periods of time compared to those who live further away (Hanink & White, 1999). They also seem to undertake different types of activities when in the park, such as daily exercise routines, dog-walking and spending time alone, which may only be partly related to park design (Golicnik & Ward Thompson, 2010; McCormack et al., 2006a; McCormack et al., 2010). Conversely, people who travel further to visit a park, especially larger regional and national parks, tend to stay longer, and undertake activities based on active recreation or socialising (Arnberger & Brandenburg, 2007). This has led some scholars to conclude that there are different 'travel thresholds' for different types of recreational activity (Spinney & Millward, 2013).

In this paper we examine the comparatively poorly understood issue of distance-based variations in peri-urban national park use. This is important because rapid urbanisation is reducing the amount of greenspace in many cities around the world, potentially leading to problems with physical and mental health, citizen wellbeing, and residents' understanding of the natural world (Roy, Byrne, & Pickering, 2012). As the amount of urban greenspace (e.g. parks) declines, and urban areas expand, these trends may increase pressure on peri-urban greenspaces, such as regional and national parks and other protected areas for recreational use (Arnberger & Brandenburg, 2007). The term 'peri-urban national parks', in the context of this paper, refers to those parks located in the urban-rural fringe of a city, which is defined as the area between the outer edge of continuous built-up residential areas of a city or town and the rural-production space, irrespective of density of people per unit area (Lawton & Weaver, 2008; Nelson, 1992; Taylor, 2011).[1] Our understanding of how distance affects travel to peri-urban greenspaces is limited.

There are broader public health and social and environmental justice implications associated with distance-based patterns of peri-urban park use. These include ethno-racial and socio-economic differentiation in who can access these important nature spaces, and potential

[1] Several methods are used to distinguish peri-urban spaces from urban and rural areas including population density, urban structure characteristics, landscape patterns and/or night-time satellite images (Allen, 2003; Grosvenor & O'Neill, 2014; Sutton, Cova, & Elvidge, 2006). However, context matters, with differences in city and country characteristics, can effect the accuracy of a given classification method for distinguish among urban, peri-urban and rural areas (Allen, 2003; Grosvenor & O'Neill, 2014). For example, the population density for the same unit area can vary greatly if the same number of people are housed in three story apartments or four to nine story apartments (Griffiths, 2009).

health consequences that stem from limited access (Byrne & Wolch, 2009; Dai, 2011; Wolch, Byrne, & Newell, 2014). Here, 'access' refers to "the ease with which a site or service may be reached or obtained" and has been found to be related to, among other things, objectively measured and perceived distance (Nicholls, 2001). By better understanding how travel patterns and distance affect park utilization, geographers can begin to devise strategies to assist park managers and urban planners in taking steps to redress social and environmental inequalities arising from differentiated park access and potentially to help improve transport options for more distant parks and greenspaces.

This paper examines the distance decay relationship between visitors' characteristics including socio-demographic and visitation patterns, the distance travelled to a park, and visitors' place of residence, for a large peri-urban national park in Australia. Specifically it addresses five inter-related questions: (1) who visits this park? (2) how far do they travel to the park? (3) how is visitation affected by distance? (4) does the distance travelled to the park vary with visitors' characteristics? and (5) does the spatial distribution of park visitors' place of residence vary with visitors' characteristics? The paper is divided into five sections. First we examine the concept of 'distance decay' and how it has been understood by geographers, before focusing on distance decay effects in park use. We then discuss the methods we used in this study, before analysing our results. Following this, we consider the policy implications of our findings, and provide recommendations for further research. Importantly, we have found an age-effect in peri-urban park visitation where older visitors live nearby, and younger visitors travel further to visit the park. We discuss the implications of this result in the discussion and conclusion sections of this paper.

1.1. Distance decay models

Distance decay models in geography originated from the mathematical ‘gravity’ model, which was used to represent spatial interactions and to denote the attenuation of a spatial relationship with increasing distance (Brown, 1992; Eldridge & Jones, 1991; Huff, 1964; Huff & Jenks, 1968; Reilly, 1931). Also called the ‘friction of distance’, the idea of distance decay is based on the notion that as distance from a destination increases, the frequency of visitation declines. These concepts are implicit in Tobler’s (1970) ‘first law of geography’, which states that everything is spatially related, but things that are spatially closer are more related than distant things (Gregory et al., 2009).

Scholars have identified four different distance decay curves, which have been used to explain spatial effects related to distance: exponential, classic, plateau and secondary peak curves (Figure 1). The exponential function of distance decay (Figure 1), where the strength of the interaction decreases dramatically with increasing distance, is arguably the most common form of this model (Gregory et al., 2009; Skov-Petersen, 2001). Importantly, scholars have observed that distance decay effects are not uniform, and are subject to spatial variation produced by “geographic differences in transport technology or network accessibility” (Eldridge & Jones, 1991, p. 501; see also Fotheringham & Pitts, 1995; Huff & Jenks, 1968). Moreover, distance decay effects are related not only to physical space, but also to socio-demographic factors (income, race, age) and psychometric factors (values, attitudes, perceptions) associated with socio-cultural spaces (Van Acker, Van Wee, & Witlox, 2010). It should be noted that distance decay models are different to travel cost models. The latter estimate the non-market value of a good or services (e.g. a park) based on the distance that users travel to access that good or service (e.g. Benson et al., 2013).

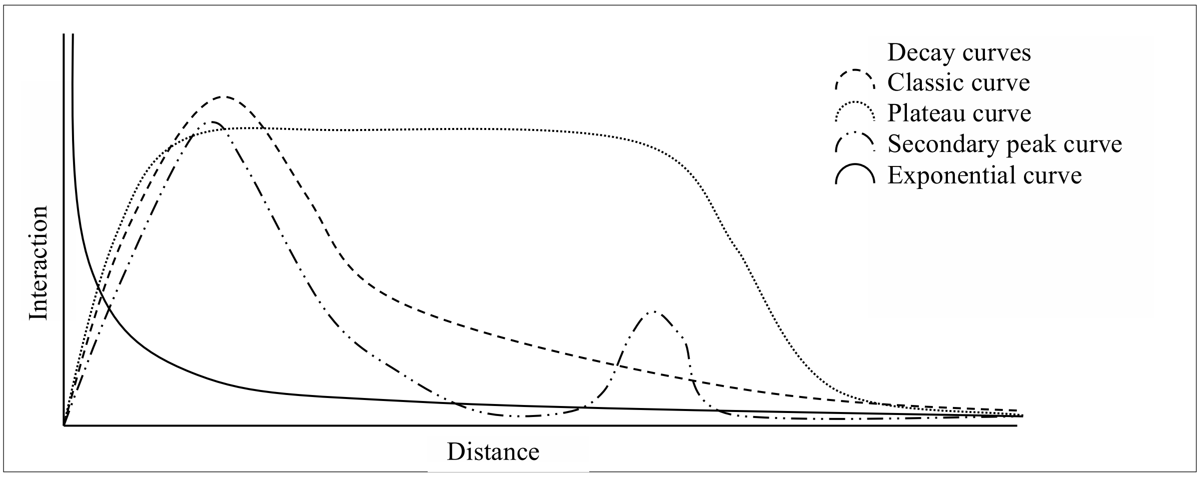

Figure 1. Different distance decay curves commonly used in Human Geography to represent spatial interactions. Diagram adapted from Gregory et al. (2009); McKercher (2008); and McKercher, Chan, and Lam (2008).

A wide variety of studies have investigated spatial effects related to distance decay. They include health care utilization (Arcury et al., 2005; Jia, Xierali, & Wang, 2015), hospital catchment travel times (McGrail & Humphreys, 2014; Schuurman et al., 2006), tourism (Hooper, 2014), and retail catchments (Brown, 1992; Reilly, 1931; Reynolds, 1953; Young, 1975). One area that has attracted considerable attention is recreation and tourism (Hall & Page, 2002). Studies examining suburban recreation and tourism demand and provision have found distance decay patterns where there are two peaks, or even a plateau pattern (Figure 1) (Hooper, 2014; McKercher, 2008; McKercher, Chan, & Lam, 2008; Wu & Cai, 2006). Researchers have found that “urban dwellers have a higher probability of participating in recreation near the city than going to remote locations” (Wu & Cai, 2006). An area that is receiving increasing attention is the effect of distance on travel patterns and park use (e.g. Zhang et al., 1999).

1.1.1. Distance and park use

Researchers have suggested three reasons why park use varies with distance: (1) the characteristics of a park, such as its naturalness or different services it offers can stimulate travel; (2) travelling to a distant park may provide a unique experience not offered by nearby parks; and (3) park visitors' motivations and preferences for specific activities may impel shorter or longer travel (Golicnik & Ward Thompson, 2010; Hanink & White, 1999; Haugen & Vilhelmson, 2013; Hooper, 2014).

Researchers have however, also found that socio-demographic factors can affect the distance that people are willing to travel to a particular park or recreational setting, including age, sex and income (Peschardt, Schipperijn, & Stigsdotter, 2012; Schipperijn et al., 2010; Spinney & Millward, 2013). A sizable body of research from the United States suggests that people who live closer to urban parks tend to be more affluent and older (Byrne & Wolch, 2009). The distance that people travel to a park has also been found to be related to other factors, such as frequency of visit, mode of transportation, time spent in the park, day of the visit and type of activity undertaken in the park (Byrne, Wolch, & Zhang, 2009).

Indeed, some scholars suggest that distance decay may vary according to different park sizes, features and facilities. For example, Low Choy and Prineas (2006) devised hypothetical distance decay curves for different types of parks. Local parks, they suggested, have peak travel distances under 400 m, district parks under 1 km, metropolitan parks under 5 km, regional parks under 10 km and national parks under 25 km.[2] Although research by Neuvonen et al. (2010) suggests that European national parks may have larger peak travel distances (up to 100 km), a distance decay model for parks has never been empirically

[2] Similar relationships have been postulated for multiple use recreational trails (Gobster, 1995; Lindsey, 1999).

validated. Our understanding of the role of distance in park use remains poor, especially for peri-urban national parks, and there is little work that examines distance decay of peri-urban national parks outside the United States (Hanink & White, 1999; Zhang et al., 1999). This paper seeks to address that knowledge gap.

2. Methods

2.1. Study area

Brisbane is the third largest city in Australia with a population of approximately 2 million residents (ABS, 2013). Centred along the Brisbane River, in the subtropical zone of south-eastern Australia, the city area covers around 138,000 ha (Figure 2). The median age for the population is 34 years old with around 45% of the population with a technical or university degree (ABS, 2014b). Three national parks are located in close proximity to the city. Together with 27 conservation parks and nature refuges, they cover an area of 43,170 ha (AGDE, 2012).

This research was conducted in the largest national park close to Brisbane: D'Aguilar National Park. This site area was declared a national park in 2009 to protect 40,000 ha of natural vegetation (DNPRSR, 2012; Rossi, Pickering, & Byrne, 2013). It contains an extensive network of multiple-use recreation trails and single-use walking trails (Rossi, Pickering, & Byrne, 2013). The 189 km of multiple-use trails in the park consist of management roads that are used for recreational activities including hiking, mountain biking and running (Fairfax, Dowling, & Neldner, 2012; Rossi, Pickering, & Byrne, 2012, 2013). Visitation to the surveyed trails in D'Aguilar National Park is lower than visitation for some popular trails and parks in the United States and Europe. For example, Wienerberg recreation area in Vienna receives around 1.24 million visits annually (Arnberger & Haider, 2005). For the surveyed trails in D'Aguilar National Park, there were an average of 15 ± 4 visits per day on weekdays and 79 ± 5 visits per day on weekends (Fairfax, Dowling, & Neldner, 2012) with an approximate annual estimation of over 12,000 visits.

The southern section of the park, where visitors were surveyed, is only 12 km from the centre of Brisbane City and hence is relatively accessible by car for many residents of Brisbane and the surrounding metropolitan areas (Figure 2). Rural properties close to the park have an average population density of 50 people per square kilometre, while urbanized areas close to the park have an average density of 2,100 people per square kilometre. In contrast to many cities in the United States, in Brisbane as with many other Australian cities, younger single people tend to live in the inner city – closer to jobs and amenities such as universities and cultural facilities, whereas older people increasingly live in middle ring suburbs as well as growing numbers in peri-urban areas, close to this park (Figure 3) (Bohnet & Moore, 2010; Chhetri, Stimson, & Western, 2009; Lim, 2013; McGuirk & Argent, 2011; Ragusa, 2010). This pattern has implications for park visitation.

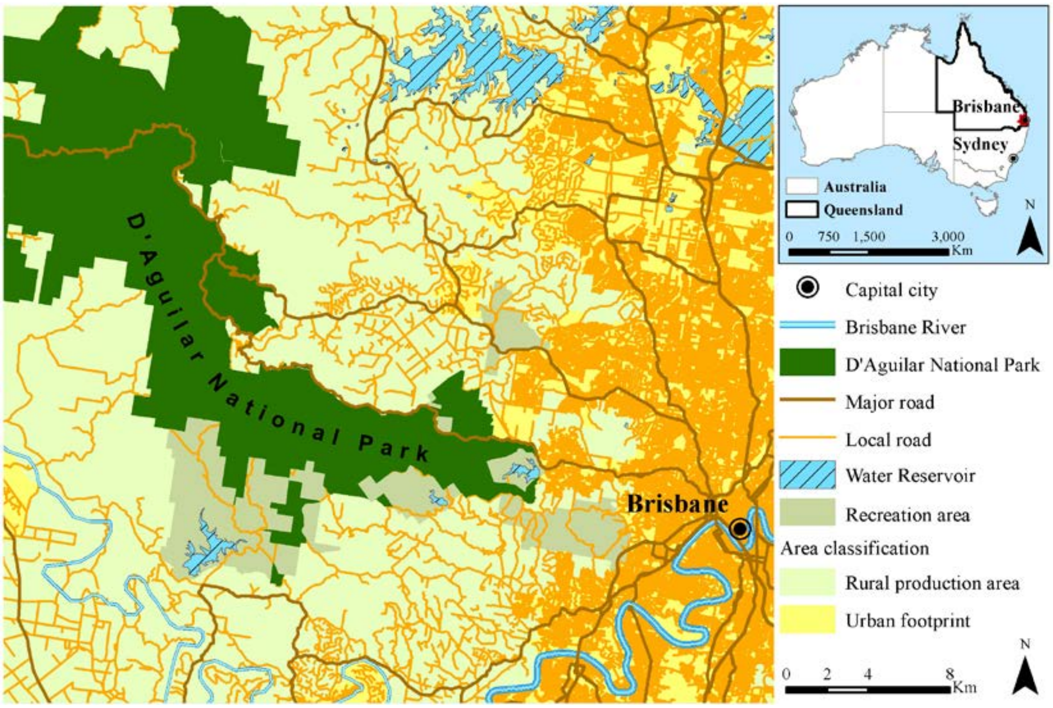

Figure 2. Location of the D‘Aguilar National Park in relation to Brisbane city and surrounding urban areas.

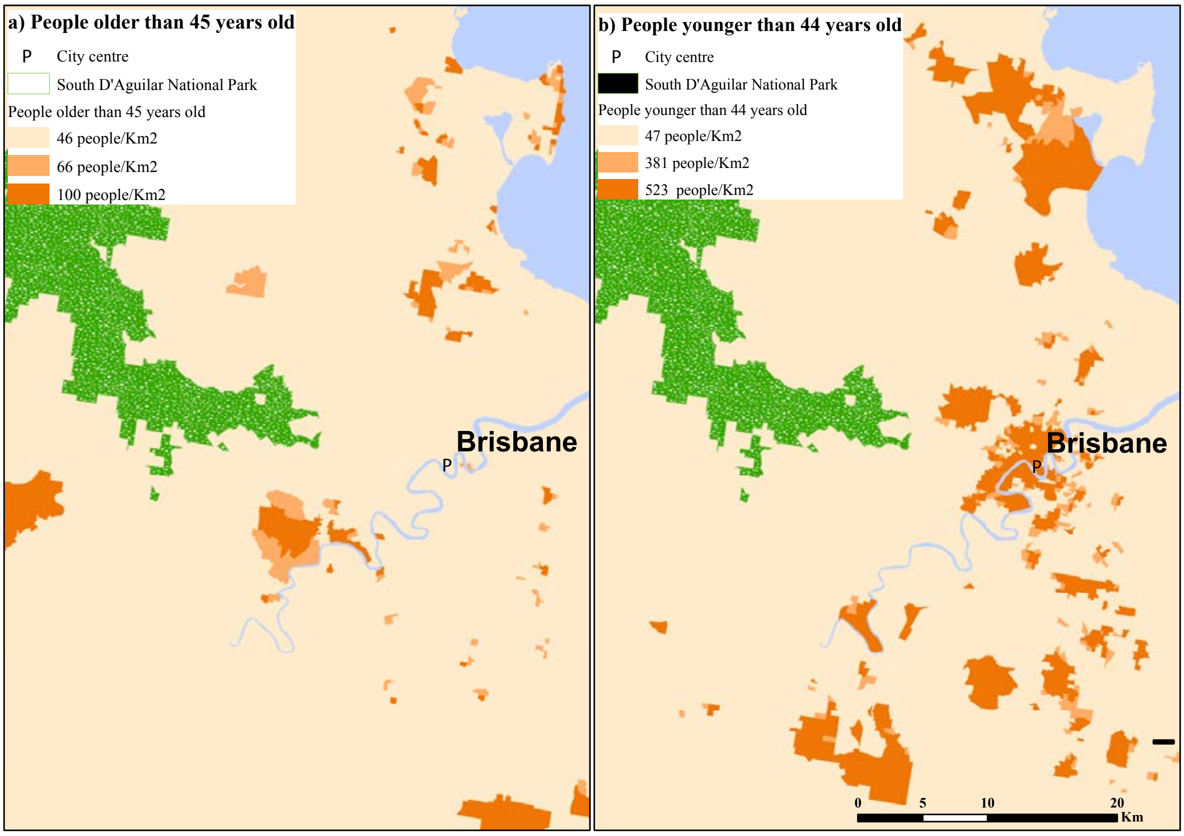

Figure 3. Spatial distribution of the Brisbane population based on residents' age using the Hot Spot analysis tool in ArcGIS, a) hot spot locations for people older than 45 years old, and b) hot spot locations for people younger than 44 years old.

2.2. Visitor survey

Information about who visits the park and where they live was obtained from an on-site survey of visitors conducted at the main park entrances closest to Brisbane City. On-site respondent-completed surveys are one of the most appropriate and commonly used methods for surveying park visitors (Veal, 2011). They have several advantages, for example: (i) they are comparatively inexpensive to conduct; (ii) have the potential to gather data on many visitors at the same time; and (iii) can provide data about community catchments for recreational amenities and parks (Veal, 2011). However, such surveys have some disadvantages too. They include the potential for low response rates and poorly completed questionnaires, when respondents self-complete without their answers being checked by the interviewer (e.g. missing a ‘skip prompt’) (Ewert, Chavez, & Magill, 1993; Fink, 2003; Veal, 2011).

To address these potential limitations, we took several steps including survey administrators checking all questionnaires to minimize errors or missing information. To ensure that measures were robust and reliable, the survey instrument was adapted from previous surveys used to examine visitation among peri-urban park visitors (Byrne, Wolch, & Zhang, 2009; Healy, 2009). To address potential pseudo-replication issues associated with temporal and seasonal variations in park use, data were collected during periods of high visitation (i.e. 22-24 April, 26 April, 30 April-2 May, 2011). This is a common approach when sampling visitors’ characteristics in protected areas that maximizes resources by obtaining a good sample size at lower cost (English, Zarnoch, & Kocis, 2004). It, also, enables researchers to maximize response rates where previous research indicates no seasonal (monthly) variation in visits (Fairfax, Dowling, and Neldner (2012). A previous trail camera monitoring survey conducted over one and half years (2009-2011) has shown that, for the trails surveyed, there is an average of 15 ± 4 visits on weekday days while on weekend days is 79 ± 5 thus, 84% of visits per day are on the weekend and public holidays. Overall weekend visits represent 67% of all visits to these trails, with the majority of visitation occurring early in the morning (Fairfax, Dowling, & Neldner, 2012). The questionnaire was approved by the home institution’s human subjects ethics committee following the Australian National Statement in Ethical Conduct in Human Research (ENV/19/10/HREC).

The survey instrument consisted of 24 questions, including closed-ended questions designed to collect information on visitor characteristics such as visitor demographics (sex, level of education and age) and park visitation patterns (activity, frequency and duration of visit, group size and type, mean of transportation). To assess where visitors to the park live and, therefore, the distance they travelled to use the park, visitors were asked to provide the closest street intersection to their usual place of residence and their postcode (zip code) (Lin & Lockwood, 2014). To comply with ethics procedures and privacy policies from the home institution (i.e. maintaining anonymity) residential addresses were not obtained.

All visitors arriving or leaving the park at the two main entrances to multiple-use trails were counted. In total, 508 people (including 47 children under 15 years old) visited the park during the survey period. Two interviewers approached all visitors older than 15 years of age and after introducing the project and obtaining respondents' consent, participants were provided with a self-completion questionnaire. A total of 234 out of the 461 adults, who were approached, completed the questionnaire in full, resulting in a 51% response rate.

2.3. Data analysis

Information from the surveys was entered and analysed in Excel, the Statistical Package for Social Science (SPSS version 22) and the Geographical Information System ArcGIS (version 10.1). To calculate how far visitors live from the park, a road network was developed using the South East Queensland road network shapefile (QDNRM, 2012) and the street intersection for each visitor was geocoded using ArcGIS. The geocoding was completed by matching respondents' street intersection with the road network intersection nodes. To calculate the distance from visitor's residences to the park, we used the Manhattan distance metric in the Closest Facility tool, with the resulting distance data added to the survey dataset for analysis.

To determine if the distance travelled to the park varied with visitor characteristics (socio-demographic and visitation patterns), a series of One-Way ANOVAs were performed. Socio-demographic data (sex, level of education and age) and visitation characteristics (activity, frequency and duration of visit, group size and type, mean of transportation) were used as independent variables and distance to the park as the dependent variable. For age, a non-parametric Kruskal Wallis test was employed because the data did not satisfy the assumptions of parametric tests.

For all the analyses, the variables *frequency of visit, day of visit* and *level of education* were condensed into two categories each. *Frequent* visitors are those who use the park weekly or more than twice a year, while *non-frequent* visitors use the park less than once a year. Categories for visit day were *weekend only* and *mixed day* which includes people visiting the park on weekdays and weekends. Categories for visitors’ level of education consisted of ‘*<vocational/technical’* including those holding primary or some secondary, secondary, vocational or technical studies, and ‘*tertiary/university’* which includes those with higher levels of education.

To determine if visitor characteristics were related to each other, and with how far visitors live from the park, a Categorical Principal Component Analysis (CATPCA) was conducted. Categorical Principal Component Analysis is analogous to Linear Principal Component Analysis (PCA), except that it is suitable for the analysis of categorical variables (nominal or ordinal) and non-linear relationships. In CATPCA variables’ categories are transformed into numerical values and then analysed as a conventional linear PCA (Linting et al., 2007; Manisera, Van der Kooij, & Dusseldorp, 2010). All visitor characteristic variables were included in the analysis. The distance that people live from the park was computed as a multiple nominal supplementary variable and all other variables as nominal. Subsequently, the variable 'level of education' was excluded for further analysis as the *Variance Accounted For* (VAF) value was very low (<0.2), suggesting limited contribution to the model (Linting & Van der Kooij, 2011).

To determine if there were spatial clusters among visitors who share the same characteristics, the Grouping Analysis tool in ArcGIS was used (ESRI, 2013). Only those variables identified in the ANOVAs and CATPCA analyses as associated with the distance that people travel to access the park were included. In addition, to identify if the spatial distribution of park visitor place of residence follows a similar pattern to that of the general community, data for Brisbane and surrounding areas were obtained from the most recent population census for Australia (ABS, 2014a) and entered into ArcGIS. Hot Spot analyses were conducted using census data to identify spatial clusters within the census data, based on the age of residents. To conduct the analysis, the smallest statistical area containing population age data was used with "polygon contiguity" in the Spatial Statistics, Hot Spot Analysis tool in ArcGIS. Distance band-width of 5 km (e.g. 0-5 km, 5-10 km, 10-15 km, 15-20 km) were used to calculate the proportion of people using the park based on the population of each distance band-width classified by age.

3. Results

3.1. Visitors' characteristics

Most respondents were male (71%), well educated (83%) and aged between 25 and 54 years old (86%). They tended to visit the park mainly on weekends (76%), engaging in a range of recreational activities. Hiking (39%), mountain biking (34%) and running (15%) were the most common activities. Most visited early in the morning with 93% of visitors using the park before midday. There were an average of 72.6 visitors per weekend/holiday using the trails. The data from our survey of visitors is consistent with a previous study by Fairfax, Dowling, and Neldner (2012) that found similar pattern of visitation with respect to timing of visitation, activity type and number of visitors/visits per weekend/holiday day. Visitors tended to visit the park very frequently (76%), typically travelling by car (76%), in groups of two or more people (89%) and spending more than two hours (75%) in the park (Table 1).

3.2. Distance effects upon visitation

As expected, the number of people who visited the park decreased with distance (Figure 4) but the peak of visitation was not for those living closest to the park, but rather for those living between 10 and 15 km away. As a result, people travelled 15 km on average to the park, although some people travelled much further, with five visitors travelling over 40 km. This distance effect is even greater when comparing younger and older people. People older than 45 years of age appear to be more sensitive to distance than younger people (Figure 4a).

When we calculated the proportion of the general population living at different distances to the park, we found that the proportion of people who visit the park declines markedly with distance, and that the pattern fits the exponential distance decay function (Figure 4b). Thus, the classic curve pattern of visitation based on the number of visitors is due to fewer people living within 10 km to the park, compared to those living 10 – 15 km away.

When the data was analysed based on age, we found that the distance decay pattern was not the same for younger and older visitors, as a proportion of the general population (Figure 4b). Older people living within 5 km of the park were more than twice as likely to visit the park as younger people in the same area. Although the proportion of people visiting the park declines markedly after 5 km, younger people living 10 km to 25 km from the park were more likely than their older neighbours to visit the park (Figure 4b).

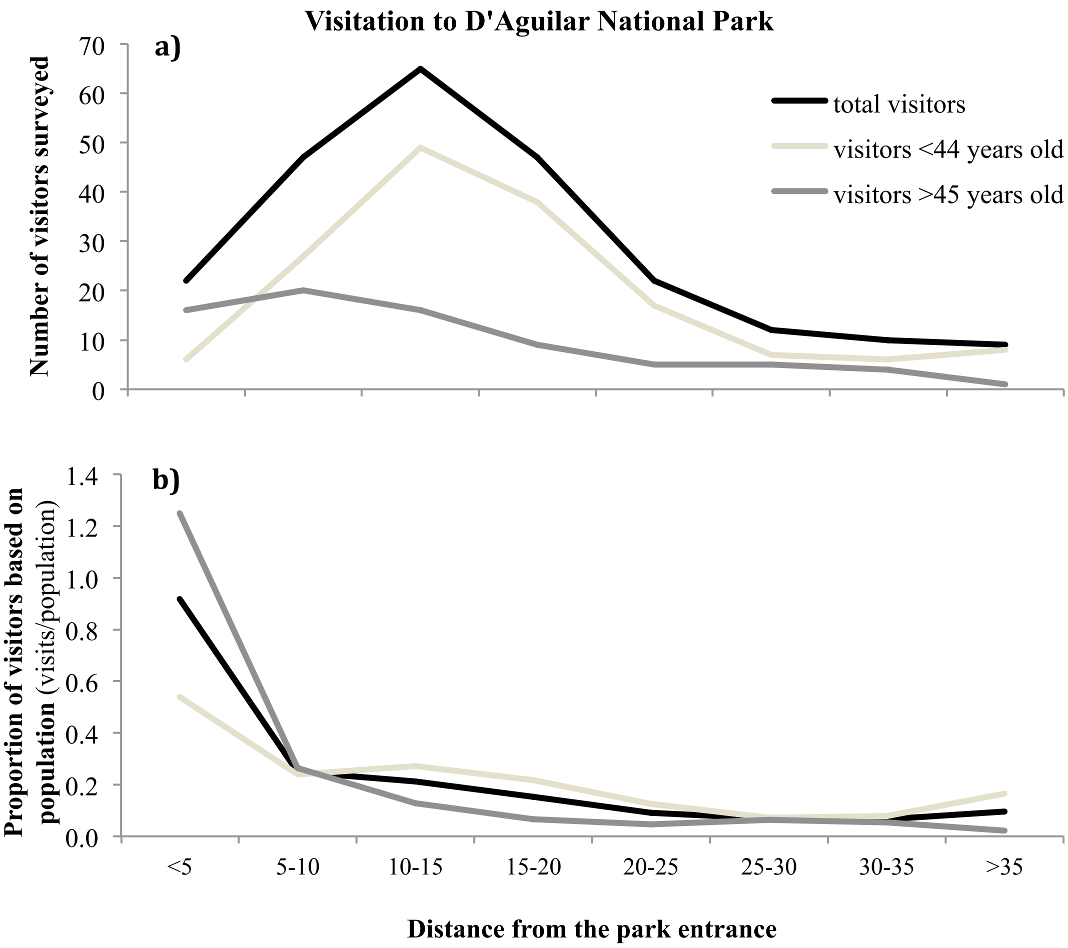

Figure 4. The a) number of visitors travelling different distances to visit D’Aguilar National Park, and the b) proportion of people living at different distances (e.g. 0-5 km, 5-10 km) from the park who visit the park.

3.2.1. Relationship between distance travelled and visitors’ characteristics

The distance that people travelled to the park was related to visitation and socio-demographic characteristics. This is apparent both from the CATPCA with a Cronbach’s alpha > 0.85 (Table 2 and Figure 5) and from One-Way ANOVA tests on individual characteristics (Table

1). The two components in the CATPCA analysis explained 46% of the total variance (Table 2). The first component, which represented those living more than 10 km away from the park was explained by group size and type, frequency and day of visit and means of transportation (Table 2). People travelling more than 10 km tended to be non-frequent visitors who travelled by car, in groups of more than three people, accompanied by friends, and visited the park mainly on weekends (Figure 5). The second component, which represented visitors travelling less than 10 km to the park, was mainly explained by age and time spent in the park (Table 2). People travelling shorter distances to the park tended to be older (> 45 years), and spent less than two hours in the park (Table 2 and Figure 5). Sex and the recreational activity undertaken in the park were not significantly related to the distance that people travelled to the park (Table 1 and Figure 5).

Table 1. Characteristics of visitors to south D'Aguilar National Park near Brisbane, Australia. This includes the results from One-Way ANOVAs comparing visitors' characteristics with the distance travelled to the park. * Non-parametric Kruskal Wallis (H) test was used as data did not comply with assumptions of parametric tests.

	Visitors' characteristics	Categories	*n*	Percentage of respondents	Mean kilometres to park	ANOVA
Visitation patterns	Frequency of visit	Frequent	177	76%	14 ± 0.64	F= 12.79, **p < 0.001**
		Non-frequent	57	24%	19 ± 1.25	
	Visit day	Weekend only	179	76%	16 ± 0.67	F= 14.07, **p < 0.001**
		Mixed days	55	24%	12 ± 1.06	
	Time spent	Less than 2 hrs	58	25%	9 ± 0.95	F= 31.53, **p < 0.001**
		Between 2 to 4 hrs	118	50%	16 ± 0.74	
		More than 4 hrs	58	25%	19 ± 1.24	
	Means of transportation	By car	177	76%	17 ± 0.68	F= 24.49, **p < 0.001**
		By other means	56	24%	11 ± 0.93	
	Group size	1 person	48	21%	11 ± 1.06	F= 9.15, **p < 0.001**
		2 persons	82	35%	14 ± 1.05	
		3-4 persons	73	31%	18 ± 0.91	
		>5 persons	31	13%	19 ± 1.79	
	Group type	Traveling alone	38	17%	12 ± 1.36	F= 4.0, **p < 0.05**
		Adult couple	34	15%	14 ± 1.90	
		With friends	110	48%	16 ± 0.82	
		Other	47	21%	15 ± 1.11	
	Main Activity	Mountain biking	78	34%	15 ± 1.02	F= 1.57, p > 0.05
		Hiking	91	39%	16 ± 0.88	
		Running	35	15%	15 ± 1.77	
		Other	28	12%	12 ± 1.69	
Socio-demographics	Sex	Male	167	71%	15 ± 0.68	F= 0.334, p > 0.05
		Female	67	29%	15 ± 1.17	
	Age*	<=24	15	6%	20 ± 3.36	H= 18.91, **p < 0.001**
		25-34	60	26%	16 ± 0.91	
		35-44	83	35%	16 ± 1.01	
		45-54	59	25%	14 ± 1.14	
		>=55	17	7%	10 ± 0.59	
	Education	<Vocational/technical	39	17%	20 ± 1.76	F= 13.43, **p < 0.001**
		Tertiary/University	193	83%	14 ± 0.59	

Table 2. Principal component loadings and variance accounted for (VAF) in the Categorical Principal Component Analysis. Loadings in bold indicate a good contribution of the variable to the component.

Variables loadings	Component 1	Component 2	VAF
Group size	**0.776**	-0.104	0.614
Group type	**0.739**	-0.072	0.552
Frequency of visit	**0.541**	0.088	0.300
Visit day	**0.527**	-0.188	0.313
Mean of transportation	**0.545**	0.272	0.371
Main activity	0.512	**0.683**	0.729
Time spent in the park	-0.433	**0.603**	0.551
Age	-0.403	**0.456**	0.370
Sex	0.251	**0.531**	0.345
Eigenvalue	2.691	1.453	4.145
% of variance explained	**30**	**16**	**46**

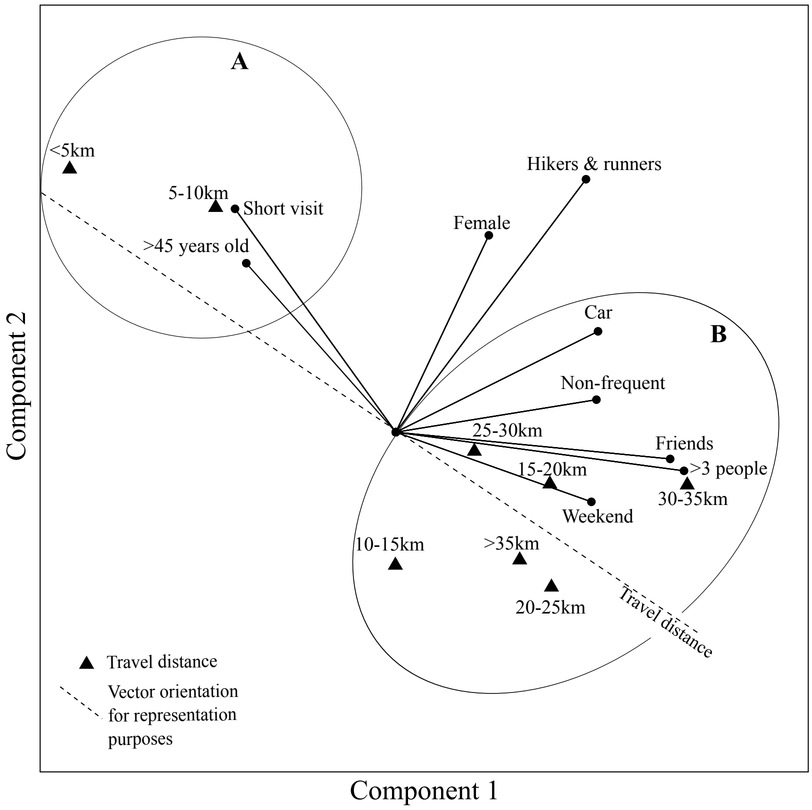

Figure 5. Categorical Principal Component Analysis of visitors' characteristics, visitation patterns and the distance travelled to visit D'Aguilar National Park. The projection of the variables shows the relationship among them and with distance. Variables close together are positive related (i.e. A = short travel distance and B = long travel distance) and variables at 90° angle are not related with distance (i.e. female and hiker & runners) (Linting et al., 2007).

3.2.2. Relationship between visitors' characteristics and where they live

When assessing *where* people live in relation to the park, rather than just how far away they live, three groups of visitors were identified (Figure 6). Visitors close to the park included those who live in rural areas to the south of the park (19 users), and those who lived in urban areas to the north-east of the park (30 users). These two groups differed in when they visited, and how they got to the park. Visitors from urban areas north-east of the park, visited the park mainly on weekends and tended not to travel by car to the park. In contrast, visitors from rural areas south of the park visited the park both on weekends and weekdays and mainly drove to the park (Figure 6). A third group consisted of visitors living further east of the park in urban areas close to the centre of the city. They differed from those living closer to the park in most socio-demographic and visitation characteristics (Figure 6). This city group was characterised by younger people who travelled by car to the park, often in groups of three or more people. They also tended to visit the park mostly on weekends and spent more than four hours in the park, but were not as frequent visitors as those living closer to the park.

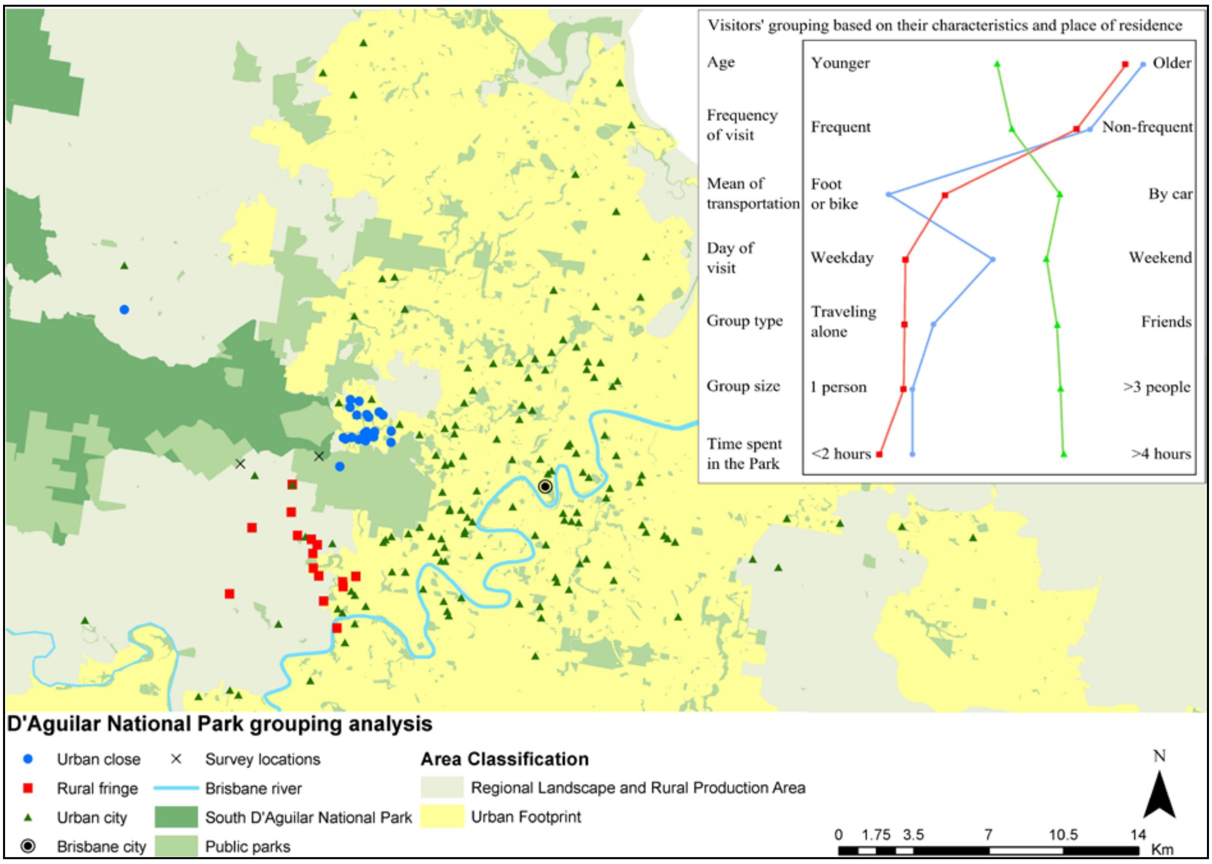

Figure 6. Residence location of the three groups of visitors to south D'Aguilar National Park identified in the grouping analysis by ArcGIS.

4. Discussion

4.1. Importance of the study

This study contributes to our knowledge about how distance decay affects park visitation, including the influence of visitor characteristics, especially age and to a lesser extent activity type. Most of the recent research on these issues has been conducted in publicly accessible urban green spaces such as urban parks (Byrne & Wolch, 2009), with comparatively less research for more naturalistic settings such as peri-urban national parks (Hanink & White, 1999). This is despite the fact that peri-urban national parks and their surroundings have often been placed under increased pressure due to rapid urban growth and concomitant outdoor recreation demand (Arnberger & Brandenburg, 2007; Frick, Degenhardt, & Buchecker, 2007). Determining visitor usage and travel patterns for such parks is important because it can greatly assist land managers in facility provision and demand-management for peri-urban sites, which in-turn affects the residential amenity of surrounding communities (Allen, 2003). In this study we found that the frequency and day of the visit vary, depending on how far away people live from the park. We also found that age affected the distance that people travelled to the park both in absolute terms and also as a proportion of the population. Unlike other studies (Spinney & Millward, 2013), the recreational activity that people were engaged in was not associated with the distance that they travelled to the park, and did not appear to affect park use.

4.2. Distance decay model and park visitation

The results of this study corroborate findings from previous studies on the effects of distance decay on park use and activity involvement (Haugen & Vilhelmson, 2013; Schipperijn et al., 2010; Spinney & Millward, 2013). To the best of our knowledge, this is one of the first studies to explicitly investigate distance decay effects upon the use of a peri-urban national park. It should be noted however, that the use of the exponential function of the distance decay model for assessing park visitation patterns is correct only when adjusted for the population living at different distances from the park. In absolute terms (number of visitors), the peak of visitation to D'Aguilar National Park was not for those living closest to the park, but rather for those living 10-15 km away.

We also found that in absolute numbers and as a proportion of the population, the effect of distance on visitation was strongly influenced by age. For example, older people (> 44 years old) living within 5 km of the park were more than twice as likely to visit the park as their younger neighbours, while younger people living 10 to 25 km from the park were more likely to visit the park than their older neighbours. As a result, the decay model for younger people as a proportion of the population was much flatter than it was for older people. These findings contrast with some previous studies investigating the use of parks by older people. Several studies have reported that as age increases, especially above 50 years of age, the overall level of park use declines (Bedimo-Rung, Mowen, & Cohen, 2005; Kemperman & Timmermans, 2006; Payne, Mowen, & Orsega-Smith, 2002). Scholars have also reported that the frequency of visits to parks also declines with age (though Payne et al. (2005) is a notable exception). Our findings complement those of some researchers, who have found that older people living in neighbourhoods with higher proportions of younger people are less likely to visit and use parks (Moore et al., 2010).

Age and distance also interacted with other aspects of visitation. For example, older visitors tended to visit the park more frequently, but for shorter visits during weekdays, as well as weekends. In contrast, younger people were less frequent visitors, but visited for longer, and mainly on weekends. So how can we explain these findings?

4.2.1. Age-related variations in travel distance?

The differences in travel distance with age and the resulting visitation pattern may be due to two reasons: (1) the type of recreational opportunities that the park provides for residents, and (2) the cost of travelling to the park (money or time) (Hanink & White, 1999). These findings suggest that D'Aguilar National Park may be acting as a *'user-oriented'* or local park for 'local' residents who live close to it. This is similar to a finding by Byrne, Wolch, and Zhang (2009) and Arnberger and Brandenburg (2007) who found that some large peri-urban parks may function as a local park for nearby residents. User-oriented settings like these parks are characterized by their proximity to users and are normally visited frequently for shorter periods of time (Hanink & White, 1999).

The opportunity to use the park may vary among those living close to the park, with older locals potentially having more opportunities to visit the park than their younger neighbours, who may have less leisure time due to work commitments and time constraints associated with raising families. It is also possible that one of the attractions for older people of living further from the centre of the city is being closer to nature. In many Australian cities, older people increasingly tend to live outside the densely populated inner city areas (Lim, 2013; McGuirk & Argent, 2011), and are attracted specifically to more rural and natural settings. This reflects more general amenity migration trends in Australia known as the tree-change phenomenon (Ragusa, 2010). Jorgensen and Steadman have also noted that older people may be more attached to places like national parks, especially if they have lived nearby for many years (Jorgensen & Stedman, 2006).

For younger people, living closer to Brisbane, the park may be acting as a *'resource-based'* destination providing recreational opportunities that are not available closer to the city. Resource-based parks are normally large natural settings, located further from the city where activities such as hiking are undertaken (Hanink & White, 1999). These areas are normally visited less frequently, but for longer periods of time per visit. Also, it is possible that people with 'nature oriented' values may be more likely to visit parks in Brisbane than those with more anthropocentric values, irrespective of the distance that they live from the park (Lin et al., 2014).

The spatial effects of travel distance also appear to affect the visitation patterns of younger people, who are predominantly travelling from the city, because travel cost and time availability are known to affect visitation patterns (Wu & Cai, 2006). For example, those visitors living in the inner city need more time to travel to the park than those living close to the park, due to factors such as traffic congestion, hence they tend to visit mostly on weekends, when they appear to be able to spend more time in the park.

4.2.2. Distance decay and activity type

We did not find any relationship between the distance travelled to the park and the activities that people engaged in, with no differences in the distance travelled between those going hiking, running or mountain biking. This differs from other studies which have found difference in the distance travelled to amenities based on recreational activities (Gobster, 1995; Spinney & Millward, 2013). For example, in a study on different types of trails in the Chicago metropolitan region (Gobster, 1995) trails further from the population centre (> 9 km) were more popular with cyclists than walkers or runners in comparison to trails close to the population centre.

The lack of differences in the distance travelled based on the activity could be due to the characteristics of this peri-urban park. D'Aguilar National Park may be acting as an activity destination area because it is the largest protected area in the Brisbane region and offers a range of recreational opportunities, including an extended network of multiple-use trails for hikers, runners and mountain bikers (Rossi, Pickering, & Byrne, 2013). It may therefore potentially attract different types of visitors to the park who come from a range of distances (Bedimo-Rung, Mowen, & Cohen, 2005; Kaczynski, Potwarka, & Saelens, 2008b; Neuvonen et al., 2010).

5. Conclusion

This study investigated the relationship between park use and travel distance in south D'Aguilar National Park, Brisbane, Australia. It sought to test assumptions about distance decay and park visitation and use for a peri-urban national park, addressing an important knowledge gap. Our study contributes to the broader understanding of park users' travel patterns, complementing the well-established literature on distance-decay functions for a variety of different types of human activities such as: outdoor recreation (Lee & Schuett, 2014); food distribution (LeDoux & Vojnovic, 2014); and healthcare services (McGrail & Humphreys, 2014). The study has produced three important findings.

First, we found that age played an important role. Older visitors living close to the park appeared to be significantly more likely to visit the park than older people living further away. For younger people, the effect of distance on visitation was still very important but it was not as pronounced. This is contrary to the findings of much of the park and recreation literature which has found that older people do not visit parks as often as younger people (but Kaczynski et al. (2009) found similar results to ours for urban parks). Second, we also found that distance decay does not produce one uniform 'park catchment' as has been postulated by Low Choy and Prineas (2006). Rather, distance interacts with the socio-demographic characteristics of visitors to produce multiple catchments – for example, age-based catchments and rural vs. urban catchments. Third, our finding that distance does not affect the type of activity undertaken in the park was unexpected, and also runs contrary to most recreation studies which have found an interaction effect between activity type and distance (e.g. Spinney & Millward, 2013).

We acknowledge that our study does have some limitations. For example, we did not collect data on the ethno-racial composition of park visitors. Research in the United States has found that visitation to national parks is ethno-racially differentiated, and that there appears to be an interaction effect between race/ethnicity and access to parks (Byrne, Wolch, & Zhang, 2009; Dai, 2011; Floyd, 1999). Nor did we address the potential effects of intervening opportunities. Kaczynski et al. (2009, p. 176), among others, have noted that "multiple proximal parks or an aggregate amount of park space nearby" could potentially affect distance decay functions in park visitation and use.

We also acknowledge the limitations common to intercept surveys for which, sometimes, samples may not be truly random and thus the margin of error is unknown (Fink, 2003; Veal, 2011). We sought to capture a large sample based on data from the trail monitoring cameras (Fairfax, Dowling, & Neldner, 2012) where counts and estimations indicate that 67% of visit to the trails are on weekends. Although surveys were not conducted on weekdays outside of school holidays, we did collect data on many visitors who use the trails on weekdays, with 24% of those surveyed by us on weekends, reporting that they also regularly visit the park on weekdays.

Although in the study conducted by Fairfax, Dowling, and Neldner (2012) there was no seasonal (monthly) variations in the type of recreational activity conducted on the trails, it is possible there could be some seasonal variation in visitors characteristics or travel patterns, and between weekdays and weekends. These issues should be taken into consideration when interpreting these results.

5.1. Directions for further research

Further research is needed to understand how distance decay influences activities undertaken in wilderness areas and national parks, particularly those close to cities. As urban populations swell, and urban greenspaces become more congested (Sister, Wolch, & Wilson, 2010), pressure will increase on peri-urban greenspaces and protected areas to provide recreational functions. Our study has shown that two trends are observable, at least in a large Australian city: (1) older people appear to choose to live closer to natural areas, using these areas as they might use a local park, and (2) younger people appear to be prepared to trade-off weekend visitation to parks in return for living closer to the cultural and economic attractions of inner city living. If these trends apply elsewhere, it suggests that peri-urban national parks and protected areas are likely to face increasing pressure to function as recreation areas for visitors with diverse needs and expectations. Future research should examine other parks in Brisbane – and elsewhere – to enable comparative analysis, enabling a more confidence in the findings we report here.

It is also possible that there could be increasing conflict in peri-urban parks if the population dynamics and travel patterns that we have reported here hold true in other cities internationally. Older and younger people are known to have different values, and different recreational needs, and it is possible that these could create future conflict, especially as the proportion of older residents is increasing in most cities in the developed world (Kemperman & Timmermans, 2006). For instance, Jacob and Schreyer (1980) and Vaske et al. (1995) have found different types of conflicts related to park use such as interpersonal or social value conflicts. Additional research is required to test this possibility, because it could have repercussions for park management in the longer term. The role of intervening opportunities also needs to be considered. Recent research suggests that if people do not have many options, they will travel further to access amenities like parks, but if there are more opportunities closer to home, travel distances can decline markedly (Haugen & Vilhelmson, 2013; Lin et al., 2014; Neuvonen et al., 2007). We could not test that hypothesis in our study and future research should address this limitation.

Future research would also do well to examine local communities near this and other national parks, to investigate what is motivating older people living near the park, and to determine what factors are motivating younger people living further away to visit the park. Future research should also consider the potential displacement effects of distance, by examining non-users. More research is required to better understand the effects of park crowding, and the role of time and income as constraints to park use, and how these variables interact with distance. Future research should also consider the role of visitors' motivations, attitudes (e.g. sense of place) and values in shaping park use – and how these interact with distance.

Time and budget limitations precluded a broader comparative approach to the results obtained from one peri-urban park. Further research including for more parks in Australia and other countries is required to better understand how distance decay influences visitation and use of natural areas more broadly. Such additional studies will help us to understand how the distance decay phenomenon applies to natural areas beyond D'Aguilar National Park.

Last, this research has practical implications for park managers due to their dual mandate for nature conservation while providing recreational opportunities to visitors. For example, the lack of difference in the travel distance based on the recreational activities highlights the demand for accommodating different recreational activities in peri-urban national parks in a way to avoid potential conflicts among users. It also emphasises the need to continue to provide large regional parks, as well as protected areas such as national parks, in the peri-urban area of cities.

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