Public Greenspaces and Crime: an Analysis of Crime Timing and Public Greenspace Amenities

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Abstract: Public greenspace is a common feature in urban environments that can provide and promote social and physical well-being, yet they can also encourage deviant or criminal behaviour. The variability of greenspace form and function may influence opportunities for criminal behaviour yet researchers rarely distinguish greenspace by type. Further, greenspace form and function may disperse or concentrate crime into particular daily or weekly periods. Our study empirically constructs a typology of greenspace types from spatially integrated local council assets registers, crime incident, and cadastral data. We explore the extent that greenspace crime is a function of time, and the degree that greenspace types promote or hinder criminal opportunities. Our findings reveal that greenspace type influences the types and timings of crime. In line with routine activities theory, we find that that crime occurs during the temporal-spatial convergences of offenders, victims, and absent guardians, and that greenspace type influences these temporal-spatial convergences.

Introduction

Greenspace comprises a range of different settings including public parks, gardens, fields, ovals, and greenbelts. Greenspace remains a widespread design strategy for improving the environmental, health, and social conditions of cities. They provide unique health benefits for local residents including filtering and sequestering airborne and waterborne toxins (Yang et al., 2005); countering the urban heat island effect (Bowler et al. 2010; Kong et al. 2014; Feyisa et al. 2014; Li et al. 2012); and assisting in the development of immunity responses against allergies (Hanski et al. 2012). People living nearby greenspaces generally report heightened place attachment (McCunn and Gifford 2014; Kim and Kaplan 2004; Hur et al. 2010), greater social cohesion and trust (Mason 2010), and residential commitment (McCunn and Gifford 2014).

Greenspaces can also provide opportunities for anti-social and criminal behaviours. For example, greenspaces can create "social holes" that interrupt the flow if community social ties across the neighbourhood surface (Hipp et al. 2014), and thus reduce neighbourhood guardianship. Greenspace features can conceal consensual offenders – such as illegal drug users – from discovery and interruption (Felson and Groff 2010, p.35; Knutsson 1997; Hope 1982). Further, greenspaces can generate predatory crime by attracting and isolating potential victims for public nuisance crimes including pan-handling (Ellickson, 1996), and violent crimes including robbery and rape (Ceccato 2014; Groff and McCord 2012). Finally greenspaces provide "crime conduits" that convey offenders between other crime attractors (Crewe 2001). The offence itself is not the only outcome since legitimate greenspaces users may avoid greenspaces to avoid potential victimisation, which in turn ensures there are fewer guardians to ward away future offences. Further, legitimate greenspace users that avoid greenspace also forego many of the greenspace benefits previously described (Jorgensen, Ellis and Ruddell 2013; Sreetheran and van den Bosch 2014; Fisher and Nasar 1995; Schroeder, 1984).

While we know that greenspace can generate crime, there remains at least three gaps in understanding this greenspace-crime association. First, the literature on greenspace crime is mostly theoretical (Groff and McCord 2012). Further, only a handful of the available empirical studies observe city-wide variation rather than observing a single greenspace as a case study (see Anderson and West 2006; Crewe 2001; Groff and McCord 2012). Second, greenspaces vary in form and function yet the association between greenspace type and crime remains unknown (Clarke 2012). Knutsson's (1997) greenspace case study suggest that altering greenspace design can influence crime. They found that new greenspace amenities attracted further legitimate greenspace users that acted as place guardians. The extent to which greenspace design can influence crime across multiple settings remains unexplored. Last, the temporal dynamics of greenspace crime remains unknown. Greenspace visits occur within daily and weekly lifestyle routines, thus we would expect that there are particular routine periods when offenders can act when guardianship is low (Felson and Boba 2010). For example, juveniles may seize a low-risk

opportunity to offend between the parting of teacher supervision and the arrival of parental supervision after the workday (Herrmann et al. 2013; Groff and McCord 2012). Further, this daily period may no longer be low-risk on weekends when parent are home from work.

This study addresses these gaps by first spatially integrating crime incident data, council greenspace assets registers, and cadastral data into a single dataset. Using these data, we employ cluster analysis empirically classify citywide greenspace variation. Following, we employ chi-square analysis to determine whether greenspace type influences violent, theft, drug, public nuisance, and property damage crime within greenspace. Next, we employ circular statistics to explore whether greenspace type influences the timing and type of crime. Last, we plot the circular distributions of daily and weekly crime timing for observing when crime concentrates within greenspace types throughout the day and week.

Data & Methods

In Australia and elsewhere, greenspaces comprise public parks, gardens, fields, ovals, greenbelts, and reserves. Two key criteria that greenspaces universally share are natural ecology and public admittance, thus we employ the same criteria when selecting greenspace for our study (see Burgess et al. 1988; Comber et al. 2008; Coolen and Meesters 2012; Dinnie et al. 2013; Feyisa et al. 2014; Lachowycz and Jones 2013. This study examines the entire Brisbane Statistical Division (BSD), which is located near the South Eastern corner of Queensland, Australia (Figure 1). This region comprises five local councils that provide and maintain approximately 4,265 greenspaces. Recently, population growth in the region has exceeded the national rate by 39%, and thus the resultant rapid urbanisation has made urban space increasing contested (QTO of ESR 2011, p.14). Brisbane City occupies the centre of this region, and is the state capital.

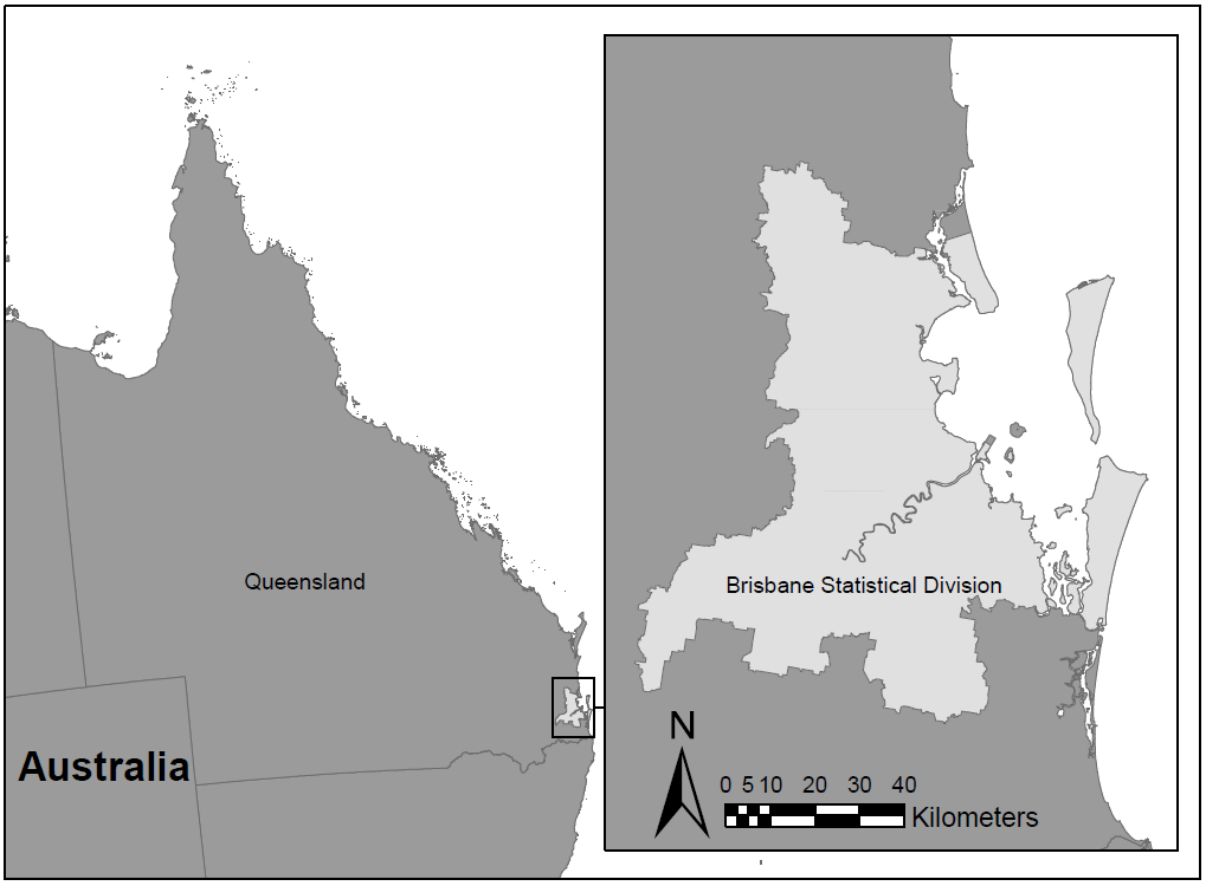

Figure 1 The Brisbane Statistical Division (BSD) within Queensland, Australia

For classifying greenspace and examining greenspace crime, this study spatially integrates the following four data sources:

Land Use
The Department of Natural Resources Management provides the Digital Cadastral Database and Queensland Valuations and Sales datasets that describe BSD land use. We employ this data for locating all 4,265 greenspaces throughout the BSD.

Greenspace Assets Registers
The Brisbane Statistical Division comprises five local councils that are Brisbane, Ipswich, Logan, Redlands, and Moreton Bay. Each council maintains an asset register of their amenities for insurance purposes, which combined reveal 25,952 greenspace amenities throughout the BSD. These amenities determine greenspace type.

Public Transport Stops
The Department of Transport and Main Roads provides the locations of 878 public transport stops—bus, ferry, and train—located within ten meters of a BSD greenspace. These stops are included as further greenspace amenities when determining greenspace type.

Crime
The Queensland Police Service provides the final dataset that describes the location, timing, and crime type for all reported crimes from 2007 until 2011. From this source, we extracted 9,545 crime incidents reported within greenspace, and that had a crime type of either violent, theft, drug, public nuisance, or property damage.

Data Preparation
Our data preparation required classifying greenspace and crime. Our first step was to collect all council amenities within greenspace and all public transport stops within ten meters of greenspace. These amenities were then classified by type using parsing program (Table 1). Following, we measured greenspace area and isoperimetric quotient to respectively capture greenspace size and roundness (Blasjo 2006) since larger greenspaces generally attract more visitors (Giles-Corti et al. 2005; Sugiyama et al. 2010), and elongated greenspaces often function as pathways rather than destinations which can influence crime (Crewe 2010). By comparing the presence of ten amenities, greenspace size and shape, a cluster analysis revealed that there was four general greenspace types found within the BSD[1]. Subsequently, a discriminant analysis revealed the unlikelihood of greenspace misclassification using the greenspace typologies ($p = 0.029$). From this point onwards, the greenspace types are labelled “amenity rich”, “sit or play”, “transport”, and “amenity poor” greenspaces to indicate to which set of amenities are likely located within the greenspace (Table 2)[2].

[1] Using Gower’s linkage method (1971) to compare both binary and continuous variables for degrees of similarity
[2] Using Calinski and Harabascz’s pseudo-F (1974) to determine the optimal number of clusters

Table 1 Amenity Types Reclassified using Keyword Parsing

Amenity Type	Keywords within the Amenity Description
Playground	"playground", "swing", "rocker (rota roca)", "spinner (supa nova)", "softfall", "pedal power", "play", "jungle gym", "giant revolving disk type e", "maze", "slide", "see-saw", "spring rocker", "digger", and "monorail"
Eating	"table", "bbq", "barbecue", and "firewood"
Seating	"furniture", "bench", and "seat"
Dog Off-Leash Area	"dog"
Managers	"museum/resource centre", "pcyc", "library", "visitor centre", "information booth", "information centres".
Formal Sports	"shot put", "hammer throw", "equestrian", "horse", "aussie rules", "afl", "sporting field", "stadium", "goal post", "goal", "club", "sporting clubhouse", "stand", "golf", "baseball", "cricket", "hockey", "rugby", "soccer", "basketball", "basketball_netball", "handball", "netball", "tennis", "volleyball", "sporting court", "basketball/netball", "boules court", and "lawn bowls/croquet green"
Informal Sports	"fitness exercise equipment", "upper body equipment", "exercise station", "bike", "bmx", "skate", "fitness exercise equipment", "upper body equipment", and "exercise station"
Enclosed Spaces	"shower", "toilet", and "change room"
Lights	"light"

Table 2 Proportion of Amenities in Each Greenspace Type

Cluster	**1**	**2**	**3**	**4**	**Total**
Name	"Amenity Rich"	"Sit or Play"	"Transport"	"Amenity Poor"	-
BBQs & Tables	77%	9%	0%	0%	12%
Buildings	31%	4%	0%	0%	5%
Dog Enclosure	6%	2%	0%	0%	1%
Managers	3%	0%	0%	0%	0%
Formal Sports	51%	9%	0%	0%	9%
Informal Sports	49%	32%	0%	0%	13%
Lights	58%	27%	0%	0%	13%
Playground	87%	49%	0%	0%	21%
Public Transport	26%	18%	100%	0%	13%
Seating	99%	66%	0%	0%	26%
Roundness (median)	0.52	0.51	0.47	0.47	0.49
Hectares (median)	1.74	0.56	0.87	0.62	0.71
Total	578	789	257	2,641	4,265

The last data preparation stage was to collect crime reported within greenspace. Out of 1,839,970 BSD crimes, 9,545 were reported within greenspace and belonged to one of the eleven crime types to be recoded as either violent, theft, drug, public nuisance, or property damage crime (Table 3). Crime timing was also recoded as two angular variables for circular statistics (see Brunsdon et al. 2007), thus one hour in the daily cycle of crime was equivalent to 15 degrees, and one hour in the weekly cycle of crime was equivalent to 2.1 degrees (Hawley 1950). Notably, we also captured seasonal cycles of crime but these did not yield any statistically significant findings thus they are not reported for this study.

Table 3 Crimes within Greenspaces Grouped by Type from QPS Crime Categories

QPS Crime Type	New Crime Type	Freq.
Homicide, Assault, and Robbery	Violent	927
Unlawful Entry, Other Theft, and Handling Stolen Goods	Property Theft	4,004
Drug Crime	Drug	1,083
Good Order Crime, and Liquor (excl. Drunkenness)	Public Nuisance	1,596
Arson, and Other Property Damage	Property Damage	1,935
Total		9,545

Analytical Approach

There are four stages to the analytic approach. First, we explore the association between greenspace type and crime type using a chi-square analysis. Second, we determine whether greenspace type influences the timing of crime by employing a circular t-test that compares cyclic distributions between greenspace types (see Wheeler and Watson 1964; Mardia 1972). Third, we explore if greenspace type influences the types of crime throughout the day and week by employing the same circular t-test but comparing crime types rather than greenspace types. Fourth, we plot and compare these circular distributions to observe when and where distributions diverge (Brunsdon et al. 2007)[3].

Results

Our first research question asked if crime varied across greenspace types. Our chi-square test revealed that crime opportunities did not occur randomly throughout the greenspace ($p < 0.01$; Table 4). In particular, sit or play greenspace attracted relatively more public nuisance crimes and fewer property theft and property damage crimes. Also, transport greenspace attracted relatively more public nuisance crime and amenity rich greenspace attracted relatively more theft.

Table 4 Crime Type by Greenspace Type

Crime Type	Amenity Rich		Sit or Play		Transport		Amenity Poor	
Violent	340	10%	129	7%	167	8%	291	11%
Property Theft	1,376	42%	616	35%	775	39%	1,237	49%
Drug	319	10%	291	17%	307	15%	166	7%
Public Nuisance	336	10%	460	26%	506	25%	294	12%
Property Damage	880	27%	261	15%	234	12%	560	22%
Total	3,251	100%	1,757	100%	1,989	100%	2,548	100%
Pearson chi2(12) = 683.3457 Pr = 0.000								

Next, we examined whether greenspace type influenced crime timing. Our circular t-tests revealed that greenspace type influenced the *daily* crime timing of all crime types ($p<0.01$; Table 5) except violent crime ($p = 0.12$). Also, our circular t-tests revealed that greenspace type influenced the weekly crime timing of all crime types including violent crime ($p<0.01$) but this time excluded property damage ($p = 0.33$).

[3] Cox (1998) provides all the circular STATA packages at http://econpapers.repec.org/software/bocbocode/s362501.htm except for the kernel density estimation programs that Isaías H. Salgado Ugarte provides upon request.

Table 5 Timing of Crime Variability by Greenspace Type

Crime type	Daily			Weekly		
	t	d.f.	P	t	d.f.	P
Violent	10.21	6	0.12	18.42	6	0.01
Theft	21.40	6	0.00	17.81	6	0.01
Drug	140.41	6	0.00	254.08	6	0.00
Public Nuisance	76.59	6	0.00	36.25	6	0.00
Property Damage	28.59	6	0.00	6.92	6	0.33

Following, we asked whether greenspace type influence crime type. Our circular t-tests revealed each greenspace type influenced crime type throughout the day ($p<0.01$; Table 6) and week ($p<0.01$).

Table 6 Timing of Crime Variability by Crime Type

Greenspace type	Daily			Weekly		
	t	d.f.	P	t	d.f.	P
Amenity Rich	92.52	8	0.00	30.38	8	0.00
Sit or Play	154.40	8	0.00	69.35	8	0.00
Transport	171.00	8	0.00	145.92	8	0.00
Amenity Poor	109.93	8	0.00	82.76	8	0.00

Afterwards, we plotted these circular distributions to observe when crime occurs within each greenspace type. Throughout the day, *theft* generally occurred from midday until 8pm; *drug* crime dispersed around 6pm within amenity rich and 1pm within the sit or play greenspaces; *public nuisance* crime concentrated around 5pm within amenity rich and transport greenspaces, and 9pm within sit or play greenspace; and *property damage* concentrated around midnight for all greenspace types but also 6pm within transport and amenity poor greenspaces (Figure 2). Throughout the week, *violent* crime concentrated towards the weekend except within the amenity rich greenspace, *theft* was relatively uniform throughout the week, *drug* crime concentrated towards Saturday afternoon within the sit or play and transport type greenspaces, and *public nuisance* crime concentrated towards the weekend except within amenity rich greenspace (Figure 3).

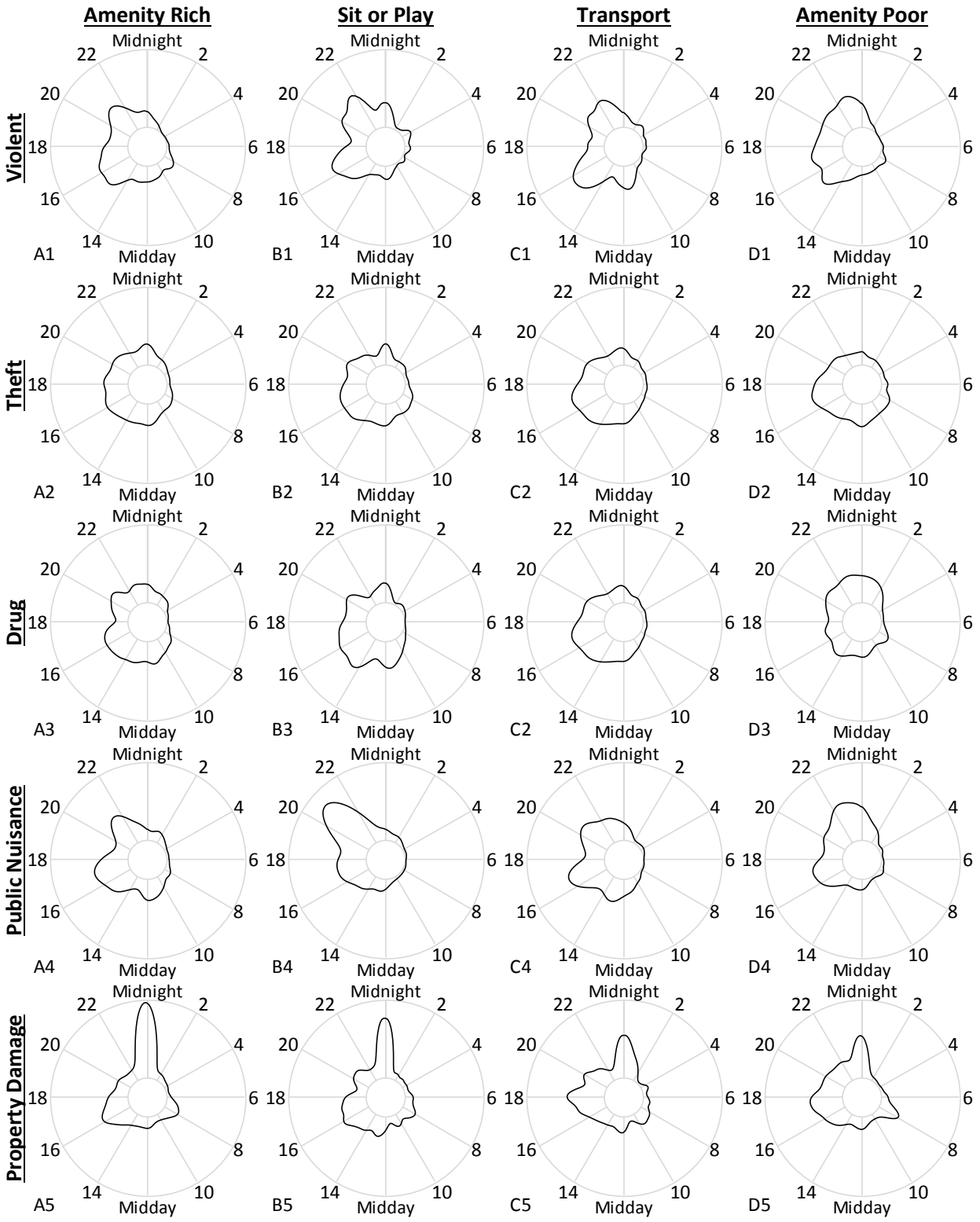

Figure 2 Circular Plots of Greenspace Types by Crime Type throughout the 24-hour Period (where spokes indicate 3-hour periods)

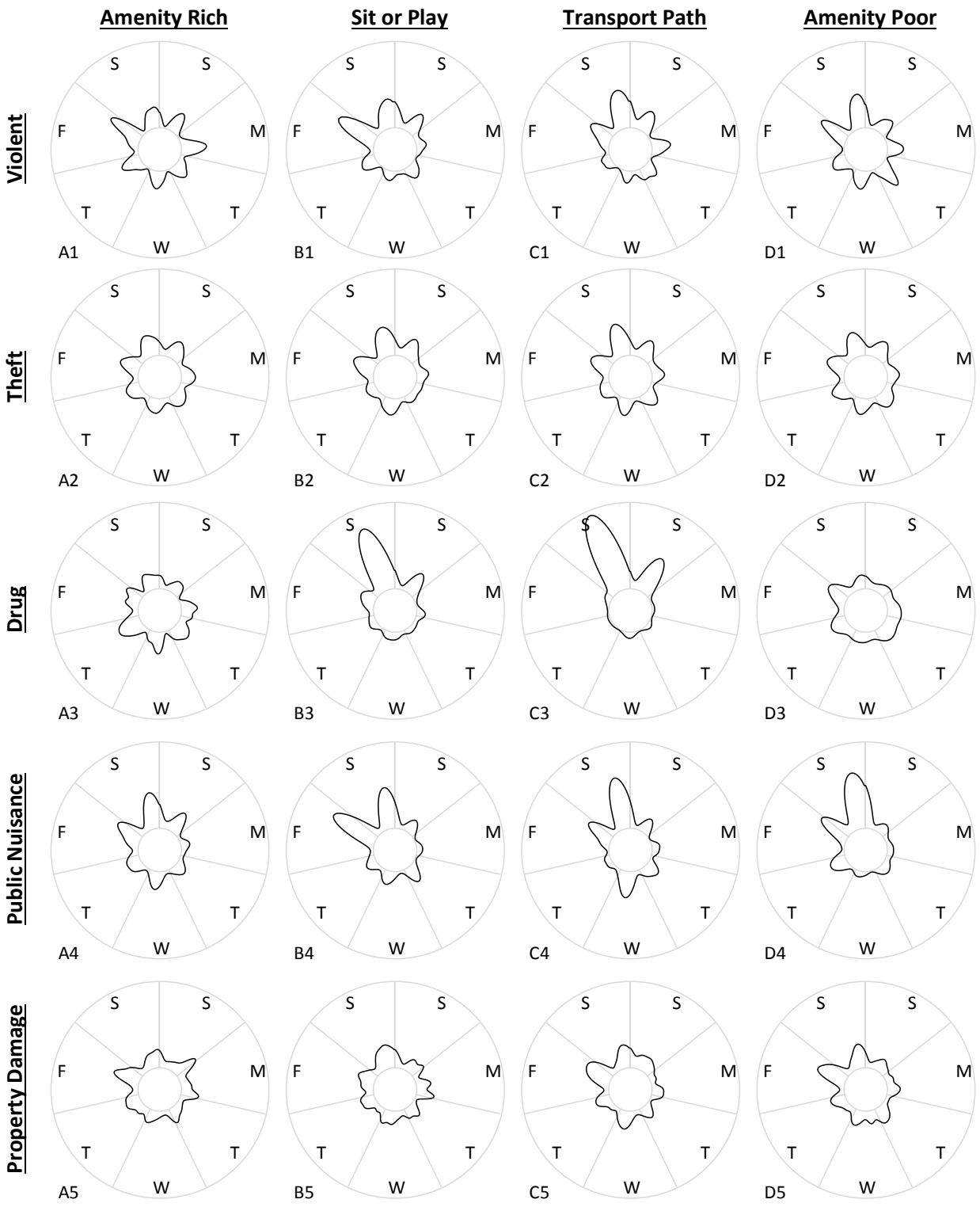

Figure 3 Circular Plots of Greenspace Types by Crime Type throughout the Weekly Period (where spokes indicate midnight)

Last, we overlayed several circular plots to compare crime between greenspace types, and to compare crime types within a greenspace type. Property damage concentrated around midnight within amenity rich greenspace but was more dispersed across the afternoon within amenity poor greenspace (Figure 4a). While property damage was concentrated around midnight within amenity rich greenspace, theft was relatively dispersed throughout the day within the same greenspace type (Figure 4b). Last, public nuisance crime concentrated towards the weekend within both sit or play, and transport greenspaces. The latter also revealed less concentration towards Friday and a unique concentration towards Wednesday (Figure 4c).

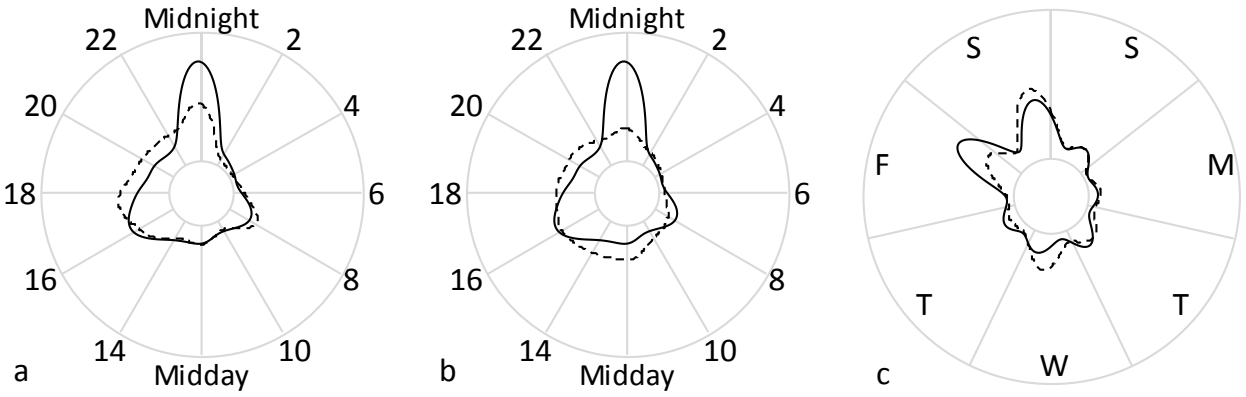

Figure 4. Circular plot overlays for comparing (a) property damage between amenity rich (line) and amenity poor (dash) greenspaces, (b) property damage (line) and theft (dash) within amenity rich greenspaces, and (c) public nuisance between sit or play (line) and transport (dash) greenspaces

Discussion & Conclusion

In urban environments, planners must maximise greenspace to ensure that all urban residents can receive the environmental, health, and social benefits associated with greenspace (Yang et al., 2005; Bowler et al. 2010; Kong et al. 2014; Feyisa et al. 2014; Li et al. 2012; Hanski et al. 2012; McCunn and Gifford 2014; Kim and Kaplan 2004; Hur et al. 2010; Mason 2010). With the rate of global urbanisation increasing, there is continual demand for access to beneficial and safe urban greenspace without reducing urban accessibility (Hipp et al. 2014; Knutsson 1997; Ellickson, 1996; Ceccato 2014; Groff and McCord 2012; Crewe 2001; Jorgensen, Ellis and Ruddell 2013; Sreetheran and van den Bosch 2014; Fisher and Nasar 1995; Schroeder, 1984). While some studies have systematically examined city-wide relationships between greenspace and crime (Hipp et al. 2014; Crewe 2001; Ceccato 2014; Groff and McCord 2012), this scholarship is still in its infancy. For example, we know little about whether greenspace type influences crime. Further, a large body of literature reveals that lifestyle routines influence crime temporal dynamics (Felson and Boba 2010), yet the role of greenspace within these lifestyle routines remain unobserved.

The central objectives of this study were two-fold. First, to spatially integrate a range of data sources to determine whether there are general greenspace types throughout the Brisbane Statistical Division. Second, to determine whether these greenspace types influenced the types and timings of crime. Our results reveal three key findings: (1) greenspace type influences crime type, (2) greenspace type influence crime timing, and (3) each greenspace type influences the timings of each crime type. These findings are strongly consistent with Routine Activities Theory that suggests crime opportunities are not randomly distributed across space and time (Cohen and Felson 1977). Further, these findings reveal that greenspace design has a role in shaping where there is opportunity for offending.

By comparing crime across greenspace types, we have found that greenspace design creates opportunities for specific types of criminal behaviour. For example, sit of play greenspace attracts relatively more public nuisance crime and less theft and property damage compared to other greenspace types. This particular greenspace type is primarily orientated towards children and their parents, thus would be thieves that do not resemble either may be sooner reported as public nuisance for violating a social norm (Goffman 1963). Similarly, transport greenspace has a clearly defined role—conveying

public transport users—which again may make it clear when a visitor is violating a social norm. In contrast, amenity rich greenspace can attract a variety of visitors thus making it difficult to distinguish thieves from other types of visitors, and thus explain why they contain relatively more theft. We would argue that certain greenspace types contain environmental cues that help determine when visitors are violating social norms and behaving in a criminal manner.

Further, by comparing crime timing across greenspace types, we have found that greenspace type may influence when lifestyle routines provide opportunities for offenders. For example, public nuisance crime was generally reported after dark, but the well-lit amenity rich greenspaces revealed less of an association with after dark. Jacobs (1964) previously argued that multi-use and well-lit greenspace extends the visits of legitimate greenspace visitors, and thus the period of greenspace guardianship that may explain the observed temporal dynamics. This greenspace type also revealed the highest concentration of property damage around midnight, which may suggest the earliest opportunity for uninterrupted property damage.

We argue that our findings offer a new evidence base to incorporate into Crime Prevention Through Environmental Design (CPTED; Taylor 2003). For example, designing greenspace with clearly encoded social norms may make it easier for guardians to distinguish legitimate greenspace users. Likewise, lighting may extend the period of guardianship and thus restrict opportunities for property damage. Last, our method is highly portable to other urban contexts that may yield further findings of how greenspace design influences crime.

While data availability did limit some of our analysis, further data may be become available for follow up studies. For example, data describing the longitudinal changes to greenspace amenities could isolate their causal role for crime opportunities, or the effectiveness of new crime prevention designs, policies, and laws. Further, data describing legitimate visitor behaviour or data describing nearby social structure may reveal fresh insight into the role of greenspace guardians (Ham et al. 2013; Sampson 2012). For example, Putnam (2007) found that residents tend to avoid public spaces and “hunker” at home within culturally diverse communities, thus we may find that greenspaces in these settings have fewer greenspace guardians.

While we have demonstrated two relatively novel methodologies for empirically classifying greenspaces and examining whether greenspace type influences crime, this is just the first step in teasing apart the time-space convergence between offenders, victims, and guardians. These methods can aid urban planners to reduce crime within public settings, policy makers to evaluate their impact in improving public safety, and policing services to orientate their resources around expected patterns of offending. With these priorities, they can reduce public expenditure while still providing safe place with many public benefits.

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