Density and displacement of users of urban greenspaces and routes

March 2024

Natural England Evidence Review NEER026

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Catalogue code: NEER026

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Keywords

Urban greenspace, urban trails, urban greenways, density, displacement, crowding, congestion, conflict, recreation

Acknowledgements

Thanks to Ian Baggott (CFP), Drew Bennellick (National Heritage Lottery Fund), Helen Bovey (Icarus), Paul Brindley (University of Sheffield), Jane Conway (Luton Borough Council), Lynn Crowe (Sheffield Hallam University), Julian Dobson (Urban Pollinators), Rachel Drew (parkrun), Alison Millward (Alison Millward Associates), Liz O'Brien (Forest Research), Chris Panter (Footprint Ecology) and Helen Townsend (Forestry Commission) for their responses to enquiries and their suggestions of possible sources of information.

Citation

Allison H. and Jones N.M. (2023) Density and displacement of users of urban greenspace and routes [NEER026]. Natural England.

Foreword

Natural England's purpose is to ensure that the natural environment is conserved, enhanced and managed for the benefit of present and future generations, thereby contributing to sustainable development and it includes promoting nature conservation and protecting biodiversity, securing the provision and improvement of facilities for the enjoyment of the natural environment and promoting access to the countryside and open spaces and encouraging open-air recreation. Sustainable Development requires management of the impacts of growth and housing development on the natural environment as well as delivering green infrastructure for the benefit of people and the natural environment.

Currently one of the ways Natural England addresses potential impacts from recreation on protected sites for nature conservation is by requiring local authorities to meet their statutory obligations by the use of strategic solutions. Each solution is bespoke but largely provide a mix of Suitable Alternative Natural Greenspace (SANG) and Strategic Access Management and Monitoring (SAMM). Natural England is seeking to improve our understanding of the evidence about the density of use by people of greenspace and green routes so that we, and others, can better understand the limits to the capacity of such sites.

This report is one in a series of three reports that were commissioned at similar times; the three reports are:

NEER026 Density and displacement of users of urban greenspaces and routes

NNER027 Provision and management of greenspaces and routes that generate additional use and enjoyment

RP04518 Compilation and review of evidence leading to SANG and SAMM provision

Natural England commission a range of reports from external contractors to provide evidence and advice to assist us in delivering our duties. The views in this report are those of the authors and do not necessarily represent those of Natural England.

1. Executive Summary

Introduction and study purpose

Urban greenspaces and green routes provide social and health benefits to those living and working in cities and towns but are often subject to high levels of use which can detract from those benefits. Crowding in such spaces can also be exacerbated by combinations of different recreational activities which may co-exist uneasily. Yet little is known about whether and to what extent users of urban greenspaces and routes are displaced due to conditions of high or low use.

This rapid evidence assessment was commissioned to identify evidence about whether displacement of users of urban greenspace and urban routes occurs due to high to low levels of use and to explore whether particular recreational activities also lead to and are susceptible to displacement.

Methods

Agreed search terms covering categories of urban greenspace, types of recreational use, terms relating to volume of usage, users and descriptors of urban environments were combined and searches were then run through multiple academic search engines. A total of 6100 initial hits were reduced to 194 studies and then to a final evidence base of 40 through a two-stage screening process. Grey literature was also identified through internet searches and expert elicitation and subjected to the same criteria-based assessment.

The nature of the evidence

Nearly three quarters of the 40 studies addressed urban greenspaces, and a quarter addressed urban green routes and trails. More than half looked at displacement and crowding in urban and peri-urban forests, the remainder covering urban greenspaces ranging from large city centre parks to small urban greenspaces on the edges of towns and small city centre urban greenspaces. Most studies were undertaken in Europe with some from North America and Asia. Less than a quarter examined interactions between specific user groups, and none looked at sedentary and minor activities, the dominant focus being on walkers, dog walkers, cyclists/mountain bikers and runners/joggers.

While more than half of the studies looked at crowding, and a quarter at displacement, only five addressed the relationship between the two. Four studies looked at the concept of social carrying capacity for recreational sites. Nearly three quarters of the studies used questionnaire data as their primary source or in combination with other observational sources. Multiple different and often non-comparable approaches were used to present data on user levels and crowding. While individual site-based studies were generally

robust and relevant, conclusions were often mixed and not generally consistent across multiple studies.

Key findings from the evidence

High density of urban greenspace use and displacement

There is some site-specific evidence which confirmed that displacement of users of crowded urban greenspaces does occur, though this is based on self-reported behaviour of a past decision to displace or future intention to displace. Displacement can be spatial, temporal or activity focused. No quantitative thresholds were observed or identified above which displacement is triggered.

Several studies also showed that actual visitor numbers were not necessarily a trigger for displacement because users of different urban greenspaces have different perceptions of crowding. A complex mix of social factors such as user group size, gender, prior experience of the site, culture, type of activity undertaken, place attachment, the presence of dogs on or off leashes, and social characteristics of the users themselves shape perceptions of whether a site is crowded. Some users are crowd-averse and may prefer lower user numbers, while others who are crowd-tolerant may see social contact and interaction with others as part of the recreational experience in urban greenspaces. A relatively low figure of 1 person/ha/hour has been suggested by Footprint Ecology as providing an optimal experience for visits to Suitable Alternative Natural Green Spaces.

Displacement created by specific recreational user groups

No evidence was identified which directly linked displacement of one user group by another. Crowding can nonetheless increase the potential for conflicts between recreational users which may predispose decisions to displace from a site, within a site or from one time of day to another. Certain groups are consistently reported as causing more disturbance to others (mountain bikers, cyclists, and dog walkers). However, dog walkers tend to seek out lower use times to allow dogs to roam off the leash.

Displacement of users from urban green routes

No evidence was found for displacement of users from urban green routes except at a micro scale to avoid conflicts such as collisions or to enhance their recreational experience within larger recreational settings such as urban forests. Nonetheless, high levels of use of urban green routes have been defined by transport studies using quantitative assessments and measurements of user flow rather than more qualitative perceived measures of crowding used in recreation studies about urban greenspaces.

Low levels of use of urban greenspace acting as a deterrent to users

No evidence was found showing that low levels of use *per se* are a deterrent to users; a small number of studies showed that low levels of use may be beneficial and preferred by certain groups. Nonetheless, some studies showed that low levels of use linked with dominance of certain user groups may well give rise to concerns for personal safety, especially by women.

Study limitations

The evidence used to develop this rapid assessment is partly reliant on a number of papers by a single author though this work is important in its use of multivariate analysis to understand the complexities of crowding and displacement. High reliance on the use of questionnaire-based surveys and self-reported rather than observational data together with self-exclusion of cyclists from data gathering was also a factor as was the short time available for expert elicitation.

Recommendations for further research

More site-based user monitoring in urban greenspaces is needed to understand the potential for displacement of users to other sites as well as some consistent methodology to study the multiple factors affecting crowding perceptions and social carrying capacity. Further research is required to understand more about the impacts of high levels of use of urban greenspace upon the health and well-being of users, and about how different user groups sharing the same urban greenspace affect each other's recreational experiences. Finally, gaining insights from those already displaced from using urban greenspaces and whether their response is a temporal or spatial one remains a challenge.

Recommendations for policy and practice

High and low levels of use of urban greenspaces present practical challenges for urban greenspace managers as well as urban planners. Managers need up to date information to be able to plan adequately for staffing, signage and improvements to recreational infrastructure taking account of the diversity of users sharing single urban greenspaces and the potential conflicts between user groups, especially dog walkers. For urban planners, understanding the effectiveness of displacement-based approaches such as Suitable Alternative Natural Greenspaces is key; they also need to anticipate adequate future urban greenspace provision in the face of social and environmental pressures such as urban densification and climate change which may exacerbate displacement and crowding.

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2. Background and introduction

2.1 Context

Urban greenspaces are recognised as being of great importance to healthy living, mental well-being, social interaction and community resilience, and the health and social benefits they provide are delivered through their frequent and regular use by those living in towns and cities (WHO, 2017).

Overall levels of use depend on a combination of urban greenspace provision influenced by availability, accessibility and attractiveness, fused with a mix of user preferences, motivations and demographics. Patterns of use will also change through time in response to wider interlinked social processes within the urban environment such as population growth, urban densification (increased housing density which can create pressures on existing urban greenspaces) (Wicki & Kaufmann, 2022) and gentrification (shifts in ethnic mixes, and changes in demographic and socio-economic status of urban communities, rather than changes in numbers of users *per se*) (Triguero-Mas and others, 2022). Urban green routes provide both recreational opportunities within cities as well as alternative commuting options for those wanting to use car-free and bus-free corridors, and their use will also be affected by similar factors.

Many studies addressing urban greenspace provision focus on themes such as the demographic profile, activities, preferences and motivations of urban greenspaces users, the standards of provision of the urban greenspaces themselves, and their links with active and healthy living. However, far fewer studies address one of the consequences of the successful delivery of attractive and accessible urban greenspaces, namely high levels of use by those keen to benefit from social spaces, contact with nature and opportunities for recreation and physical exercise which urban greenspaces offer. High levels of use of both urban greenspaces and green routes are often observed and reported, so at what point, if any, do high or even low levels of use, displace and deter other users?

2.1.1 Physical density and crowding

High levels of use within recreational sites and trails have been the subject of research for many decades in the recreational literature of North America especially in the context of tourism, national parks and ‘back country’ or wilderness settings (see reviews such as Shelby, Vaske & Heberlein, 1989; Vaske & Shelby 2008, Dogru-Dastan 2022).

A distinction between **density of people** on a site (a physical concept) and **crowding** (a psychological response to high numbers of people) was made by Gramann (1982). He also noted that crowding research in a US context had moved from consideration of physical density to a greater focus on a range of personal and social factors affecting perceptions of density which in turn may affect visitor experience and enjoyment. Westover (1989) explored the nature of the many interrelated factors affecting perceived

crowding in a recreational context which includes not only underlying site characteristics, but also demographic characteristics, recreational preferences, site familiarity and circumstances encountered on the visit.

By contrast with the volume of North American literature on crowding in recreational settings in remote and natural areas, there has been much less work undertaken on crowding in any setting in a European context. In a review of crowding in European forests, Arnberger & Mann (2008) found only 16 studies dealing with crowding since the 1980s. At last half of these studies focused on large rural recreational and productive forests, including many in Scotland and Wales (TNS Travel and Tourism, 2005; 2006; 2007; 2008). Until very recently, research on recreational crowding and coping strategies has not addressed urban settings, nor has urban greenspace research addressed recreation quality including crowding perceptions (Arnberger, 2012).

2.1.2 The concept of social carrying capacity

Some crowding studies, including recently those focused on urban recreational settings, have explored the concept of 'social carrying capacity' which complements the concept of ecological carrying capacity. Social carrying capacity is defined as the "level of use beyond which (recreational) experience parameters exceed acceptable levels" (Graefe, Vaske & Kuss, 1984). More users at a site mean more contacts between individuals; at some point those contacts may interfere with individuals' recreational goals, create potential conflicts, or create "excessive social stimulation", (Graefe, Vaske & Kuss, 1984) all of which combine to engender a perception of crowding which makes the recreational experience unacceptable, and which stimulates a number of possible behavioural responses.

Graefe, Vaske & Kuss also reported that levels of use only partly explained variations in visitor experience and crowding perceptions; in multiple studies of visitor satisfaction in natural and remote areas in the USA, actual use densities and perceptions of crowding were also mediated by other personal factors relating to their expectations, preferences, tolerances and prior experiences, the activities they pursue, behaviour of other visitors and the nature of the environment itself.

The social carrying capacity for a given site is not easily established since the concept presents both theoretical and practical challenges about its measurement (Marzetti & Mosetti, 2005). To apply it to a particular site may require the application of a combination of measurable management objectives such as upper limits for use by specific recreational groups and personal judgement. Bakhatiari (2014) suggested that the presence of recreation conflicts is one indicator that the social carrying capacity of recreation and tourism settings has been exceeded.

2.1.3 Urban greenspace provision guidelines

The concept of social carrying capacity (though not explicitly referred to as such) underpins proposed indicators and targets for urban greenspace provision developed by urban planners. Such metrics, which are based on a spatial measure of density of people

within an area of greenspace, imply that there are optimal and suboptimal levels of use in terms of physical density of users.

Several studies (e.g., Maes and others, 2019; Russo & Cirella, 2018) refer to a UN World Health Organization greenspace standard of 9m^2/per person (total greenspace rather than public greenspace). However, the key source quoted by these studies (WHO, 2010) contains no reference to the figure of 9m^2/per person at all, suggesting simply "the following parameters for assessing the performance of cities in providing citizens with adequate green and recreational areas: green and recreation space in recreational figures (sqm)…". Unfortunately, efforts by the authors to track down the source of this figure and the detailed evidence underpinning it have proved fruitless, and other experts who have also tried to validate the WHO figure have also not been able to validate its source. (Simone Borelli, 2023, personal communication).

Nonetheless many urban local authorities within England as well as elsewhere in the world have created guidance and targets based on a similar metric. Table 1 shows the spatial standards adopted by a selection of cities in m^2/per person and Table 2 shows actual provision of urban greenspace in m^2/per person calculated by mapping of urban greenspace and analysis of population data. Both tables are derived from studies and publications reviewed for this assessment and present data in m^2/per person and ha/1000 people to support comparisons across studies quoted later in this review.

Table 1. Spatial standards in city and national policies on urban greenspace provision (Note: some cells have been left blank)

	m^2/per person	ha/1000 people	Source
Cities			
Oslo, Norway	60.0	6.0	Venter and others,2021
Wolverhampton, England	43.8	4.4	City of Wolverhampton Council, 2018
Wigan, England	39.0	3.9	Wigan Borough Council, 2017
Amsterdam, Netherlands	24.0	2.4	Schrammeijer and others, 2022 – (NB figure is per household not per capita)
Berlin, Germany	6.0	0.6	Kabische & Haase 2014

	m^2/per person	ha/1000 people	Source
Countries			
Romania	26.0	2.6	Badiu and others, 2016
China	10.0	1.0	Shan, 2020
India	10.0	1.0	Lahoti, 2019
Italy	9.0	0.9	De Luca and others, 2021

The range of target and actual figures demonstrate how much variation there is in greenspace provision within and between different countries, which may be due to different sizes and configuration of cities as well as planning policy decisions and levels of ambition.

The metric assumes that every city inhabitant a) would use urban greenspace and b) would be occupying 'their' portion of urban greenspace at the same time; clearly this would never be true so users would always experience a more favourable per capita provision on any given urban greenspace visit.

Table 2. Examples of provision of city urban greenspace (reported data)

City	m^2/per person	ha/1000 people	Source
Portland, Oregon, USA	224.0	22.4	Trust for Public Land
Tampa, Florida, USA	129.0	12.9	Trust for Public Land
Detroit, Michigan, USA	78.0	7.8	Trust for Public Land
Rotherham, England	75.1	7.5	Sandwell Metropolitan Borough Council, 2022
Stoke-on-Trent, England	66.0	6.6	Sandwell Metropolitan Borough Council, 2022

City	m ^{2}/per person	ha/1000 people	Source
Coventry, England	36.9	3.7	Sandwell Metropolitan Borough Council, 2022
Sandwell Borough, England	36.0	3.6	Sandwell Metropolitan Borough Council, 2022
Southport, England	29.7	3.0	Sefton Council, 2008
Birmingham, England	28.0	2.8	Sandwell Metropolitan Borough Council, 2022
Brussels, Belgium	26.0	2.6	Phillips, Canter & Khan, 2021
Beijing, China	22.0	2.2	Zhang & Zhou, 2018
Chicago, Illinois	20.6	2.1	Trust for Public Land
New York City	19.0	1.9	Trust for Public Land
Hull, England	17.8	1.8	Sandwell Metropolitan Borough Council, 2022
Shanghai, China	13.1	1.3	Ullah, 2019
Ghangzhou, China	11.3	1.1	Shan, 2020
Leipzig, Germany	10.0	1.0	Kabische & Haase 2014
Mashhad, Iran	8.4	0.8	Mansouri Daneshvar, Khatami & Zahed (2017)
Xuzhou, China	7.8	0.8	Li, Huang & Ma 2021
Bucharest, Romania	3.5	0.4	Iojă and others, 2011
Granada, Spain	2.9	0.3	Adinolfi, Suárez-Cáceres, & Cariñanos, 2014

2.1.4 Displacement

One possible coping behaviour in response to experiencing crowding is displacement. Displacement activity (movement away from the source of the problem) can be spatial in nature (moving from one site to another) or temporal (shifting the time at which recreational activities are undertaken).

Displacement is one of several possible behavioural responses to deal with crowding. Others identified include emotional responses such as aggression directed towards other users due to actual or perceived conflicts between user groups competing for space and resources on site, or 'product displacement' responses whereby users recalibrate their expectations of a satisfactory experience according to the circumstances they find (Arnberger & Haider 2007a; Westover, 1989).

A further complication is that displacement is not only stimulated by and influenced by crowding, but also by a range of other non-crowding related factors ranging from physical conditions such as weather to the specific characteristics of the site (Westover,1989).

2.1.5 Measurement of user density and crowding

User and visitor survey data from which density estimates can be derived can be captured in many ways and presented in different formats. Panter & Liley (2016) identified seven broad approaches to data collection regarding visitors in the countryside; fixed point counts, direct observation, timelapse photography and CCTV, transects, GPS tracks, interview transcription and crowd-sourced/app data. To this list can be added aerial surveys including drones, a recently adopted technology.

These methods offer varying levels of accuracy of visitor numbers and also influence how the data can presented and the units of measurement. For example, crowd-sourced data from social media apps can be presented spatially to give a clear picture of hotspots of use where tracks overlap and converge within sites (e.g. Santos, 2016); however because such data comes from a self-selected group of population of users (i.e. those who use GPS activity trackers), absolute levels of use cannot be presented and instead values are often shown on a relative scale of 0-1 (from low to high) intensity. Other data using intensive visitor counts from multiple locations around a site can be used to create maps showing visitor pressure in people per unit/per hour/per day.

Other studies using fixed point counts or observation methods produce figures of usage for a whole site by counting visitors passing a fixed survey point and presenting data in temporal units (visitors per hour/per day or per year). A further approach of self-reported visit data from questionnaires such as daily, weekly monthly or annual visits per household or per individual is often reported in many demographically focused visitor surveys.

Such variations were discussed by Schägner and others (2017) while compiling a Europe wide data base of visitor survey information. They found that a lack of methodological

consistency as well as variations in study focus hampered comparability of different studies and data sharing of recreation visitor data and proposed a visitor survey standard.

Crowding studies are based on user surveys and questionnaire data but while most studies use a 9-point Likert scale (ranging from ‘not all crowded’ to ‘extremely crowded’) some use 4-, 5-, 6- or 7-point scales. These data are sometimes analysed in combination with independent variables such as demographic and site data but not for all studies. Arnberger & Mann (2008) in their review of crowding studies in European forests concluded that standardisation of crowding research is necessary because of the numerous methodological approaches and scales used and in order to gain better insights into crowding perceptions and commonalities and differences between study sites.

2.2 Research questions

This assessment addresses three interrelated questions about use and displacement of users of urban greenspace and urban green routes.

- Does (high) density (number of people per hectare or greenspace or per km of green route) of greenspaces in urban areas or close to urban areas, lead to displacement of users to other locations?
- Does the type of use of greenspaces in urban areas or close to urban areas, lead to displacement of users to other locations and which users/activities are most likely to be displaced to other locations?
- Is there an optimum density for users of greenspaces in urban areas (do too few users deter others)?

To address these questions, the search for evidence was based on the concepts of crowding and displacement discussed in *Section 2.1 Context*.

3. Method

3.1 Published literature

This section sets out the detailed methodology to address the two interrelated research questions for this project which is based on published guidance on quick scoping reviews and rapid evidence assessments (see Collins, Coughlin, Miller & Kirk, 2015). The steps in the process to identify and select available evidence are summarised in Figure 1.

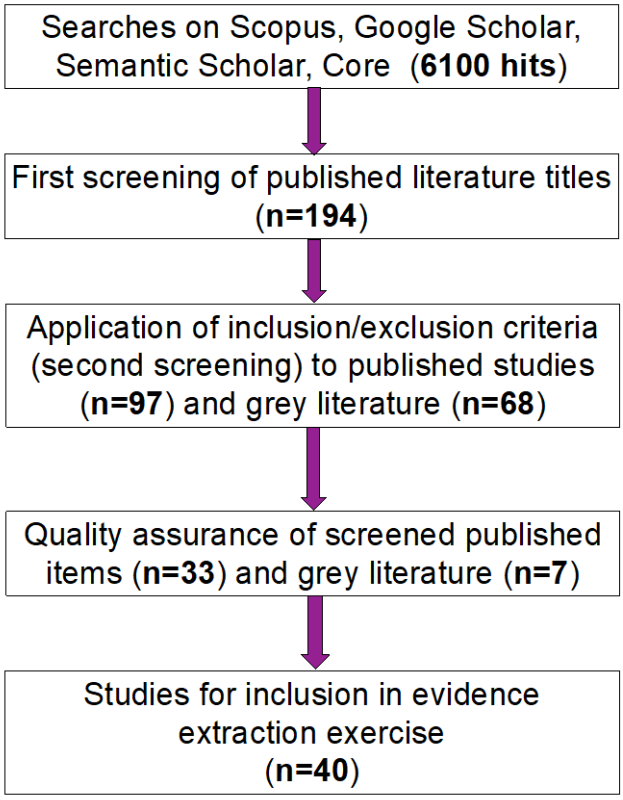

Figure 1. Summary of process to identify and select available evidence for assessment

Search terms were proposed to the Project Officer/Steering Group and amended following discussion. The search terms were divided into five key word groups as shown in Table 3. The terms urban greenspace and urban green routes are used in different ways and many synonyms are also used to describe urban greenspaces. Different countries have different typologies of urban greenspace and urban routes, but the terms used here reflect terms relevant to the UK. Searches were then run using the following search engines: Scopus, Google Scholar, Semantic Scholar, and CORE. Other search engines were also used as a background check; these included ResearchGate, BASE and Science.gov.

The five groups of search words were connected using Boolean operators AND, OR to create search strings. Searches were initially run using the full set in one combination.

However, these searches generated varying numbers of hits from 0 to millions depending on the search engine used, so search terms were streamlined or expanded in various combinations to reduce hits or increase hits where necessary. In Google Scholar, where tens of thousands of hits per search were recorded, search results were sorted by title relevance and the first ten pages of hits for each search were reviewed. In total 105 searches were run, and 6,100 potentially relevant titles were identified.

Table 3. Key word groups and search terms

Word groups	Search terms
Location descriptor	Urban, peri-urban, suburban, public, towns, cities, city
Terms for categories of urban greenspace and green routes	Greenspace, parks, green infrastructure, dog parks, nature reserves, informal greenspace, accessible natural greenspace, linear routes, green routes, footpaths, cycleways, urban trails, greenways, country parks, SANGs, cemeteries and burial grounds, greens, doorstep greens, millennium greens, regional parks, gardens
Terms for users:	Visitors, users, friends of, groups
Terms for levels/amount of use	Crowding, overcrowding, displacement, alternatives, density, use, conflict, volume, levels, numbers, surveys, counts, carrying capacity, optimum
Terms for types of recreational use:	Recreation, walking, dog walking, picnicking, biking, hiking, cycling, e-bikes, quad-bikes, mountain biking, horse-riding, BBQs, sun-bathing, visitor activities, informal education, guided events, natural play, tranquillity, cool refuge, bird/nature watching, fishing, art, community events, music, heritage/cultural events

Using the search results, an initial screening exercise was undertaken. Based on the titles alone, the following studies were excluded as being not relevant to the review or not possible to pursue given time constraints:

- Studies not in English
- Studies published before 1980
- Studies on human health benefits of urban greenspaces and green routes including papers on active living
- Studies relating to impacts of recreation upon nature itself
- Studies relating to the impact of COVID on use of urban greenspaces (COVID represents a set of atypical circumstances and the role of greenspaces in

pandemics is a separate review in itself; papers which used comparisons with pre-COVID use levels were however included for further screening)
- Studies on urban planning for greenspace provision rather than use
- Studies on urban densification
- Papers about recreation, crowding and displacement in wilderness in national parks or back country contexts (North American literature in particular)
- Papers about recreation, crowding and displacement in water sports (e.g., boating, sailing, kayaking) and winter sports (e.g., skiing, snowshoeing)
- Papers whose titles explicitly referred to preferences, behaviours and motivations regarding use or non-use of urban greenspace (a lot of this literature is about people's behaviours before they even arrive at areas of greenspace rather than their actions when they do; nonetheless, a lot of papers which did pass the initial screening exercise turned out to be preference and behaviour studies when examined in more detail and these were addressed at the inclusion/exclusion stage)

The results of this first stage screening exercise created a list of 189 published papers which at face value addressed visitor use of urban greenspaces and green routes and the concepts of crowding and displacement, 161 of which were assorted studies and 18 of which were potentially useful reviews and key conceptual/theoretical papers of various kinds based on their titles.

As a further check for relevant papers which may have been missed, selected papers from this list with the word displacement and/or crowding in the title were run through Connected Papers (www.connectedpapers.com), a visual tool which analyses papers according to their similarity, allowing strongly connected and very closely positioned papers to be identified even if they do not directly cite each other. This added a further five papers to create a total of 194 papers for the second stage screening exercise.

The papers identified from this first stage of screening were listed in an Excel spreadsheet and for each study a series of attributes were recorded directly linked to the various components of the research questions. (See Appendix 1 for list of attributes).

This list was then subject to a second stage screening exercise using inclusion/exclusion criteria agreed with the Project Officer/Steering Group. (See Appendix 2 for the inclusion/exclusion criteria). This reduced the list of papers to 97.

This reduced list was then subject to a quality assessment of each of the remaining papers. We focused particularly on relevance and robustness, and both were ranked on a scale of 1, 2 or 3 (low to high). For relevance we looked at whether the study's research questions were aligned to the questions explored in this evidence assessment and to what degree each study explored the interrelationships between user numbers at sites, perceptions of crowding and subsequent user displacement.

Our assessment of robustness took into account the clarity of presentation of the results, the method description, the design of any qualitative survey (for example, many studies

recognised the difficulty in obtaining a representative sample of cyclists compared with other user groups) and any obvious evidence of bias arising from the circumstances of publication. Studies which fell into the category whose results were confusingly presented, which gave little detailed information about the methods and approach used, whose provenance was unclear (for example, short conference papers sometimes summarised information in other papers without references to data sources or context of the study) or which showed some bias in the discussion of results were identified and excluded. Studies scoring 1 for either relevance or robustness were rejected outright. A total of 33 published papers were selected for inclusion.

The list of 18 reviews and key conceptual papers identified were not subject to the methodology described above. These were used as sources from which to identify studies which might be useful and as inputs and references for the introductory section of the review.

3.2 Grey literature and datasets

An adapted search strategy was adopted for grey literature, and datasets and searches were undertaken via several internet search-based engines and expert elicitation to produce an initial list for screening. These included:

- General internet searches using search terms identified in Table 3
- Internet searches of the publications pages of UK based consultancies known to be working in the field of visitor survey and research
- Internet searches of websites of urban local authorities in England (city councils, metropolitan councils)
- Approaches to experts in the field to briefly describe the project and seek their direction towards potential sources of information
- Identifying grey literature sources from published sources

From this approach 68 reports were identified as having possible relevance to the study. Most of these consisted of visitor surveys compiled from questionnaires and on-site visitor counts from a variety of sources but also included more general background material on urban green spaces and their use. The initial list of identified grey literature was assessed using the same inclusion/exclusion criteria and seven were subsequently added to the final list for inclusion. Combining both published and grey literature studies together meant that the final number of studies relating to displacement and crowding in urban and peri-urban greenspaces selected for inclusion was 40.

4. Synthesis of results

4.1 Volume and characteristics of the evidence base

The 40 studies identified can be characterised as follows:

- A total of 29 addressed urban greenspaces of various kinds and 11 specifically addressed trails, greenways or shared paths. Of the 11 trail studies, 5 looked at non-paved forest trails and tracks mainly of undefined widths and 6 at city shared use trails (surfaced and between 2-4m wide where widths given).
- The studies were split across different scales of urban environments: megacities (5) cities (32) and towns (6). (NB n>40 as some studies included comparative information from more than one city).
- The studies examined different kinds and sizes of urban greenspaces and green routes: urban forests (13), large peri-urban forests (10), large city centre parks (7), city shared use trails passing through various environments (6), natural greenspaces close to towns (4), small city centre urban greenspaces (2), peri-urban lakeside parks (1) and city centre botanic gardens (1). (NB n>40 as some studies included comparative information from more than one city).
- Most studies were on urban greenspaces and green routes in Europe (29) but some were from North America (7) and Asia (5). (NB n>40 as some studies undertook comparisons of sites from different parts of the world).
- Of the 29 European studies, 12 were from urban and peri-urban forests in and around Vienna with one author in common to all 12.
- More than half of the studies (25) used questionnaire survey data as their sole source of data on which to base analyses of past or intended behaviours, 14 used questionnaire survey data in combination with other sources (such as visitor counts or GPS tracking data). The remaining 5 only used direct observation data of user behaviour or derived spatial data. Only one study matched observed data with questionnaire derived data about user crowding perceptions.
- Less than a quarter (9) examined interactions between specific groups of users (the groups studied were walkers, dog walkers, cyclists/mountain bikers and runners).
- No studies explored the relationship between minority uses such as horse-riding and others or between sedentary activities such as picnicking, barbecues) and other users in terms of potential displacement.
- A total of 25 studies out of the 40 were focused on phenomenon of crowding as a subject of study, 10 on displacement and only 5 explicitly attempted to analyse the relationship between the two.
- Four studies examined the concept of social carrying capacity.

From this description, it can be seen that most studies are European focused with a high dependence on a single city and author for their perspectives. Studies were mostly reliant on user questionnaire data to probe user behaviour (both self-reported and intended)

rather than on empirical observational data. The studies are heterogenous in terms of scale and the urban greenspace types studied, though with a preponderance of analysis of urban and peri-urban forest sites.

4.2 What the evidence tells us

4.2.1 Research question 1

- Does (high) density (number of people per hectare or greenspace or per km of green route) of greenspaces in urban areas or close to urban areas, lead to displacement of users to other locations?

4.2.1.1. Displacement resulting from crowding

We found some evidence to support the proposition that urban greenspace users either have displaced or intend to displace to other sites due to perceived high levels of use and that users have adopted or intend to adopt coping behaviours including other forms of spatial and temporal displacement if they perceive sites to be crowded.

For example, a study of Wienerburg, a 120ha urban forest in Vienna (Arnberger, 2012) where the population within 15 minutes' walk has roughly doubled in the last four decades, showed that >50% of those interviewed felt that the site was crowded on Sundays and holidays. These users reported that they had adopted multiple coping behaviours in the past in response to crowding at the site; the most common was to move to another other parts of the site (intra-site displacement). Other coping behaviours were to visit at a less crowded time of the day (temporal displacement), reduce the length of visit, visit on a weekday rather than weekend visiting at a less crowded time of day, visit a different greenspace (inter-area displacement), put their dog on a leash, reduce the frequency of visits or finally change or suspend their chosen activity (activity displacement). Only 14% of the respondents reported that they had moved to a different area of greenspace while 56% had moved to a different part of the site. Less than 2% of respondents reported an emotional reaction (rather than a problem-focused reaction) to the perceived crowding at the site.

A similar study by Arnberger & Eder (2012a) in another urban forest in Vienna of 192ha (Ottakringerwald) also found that overall more than half the visitors perceived the forest as crowded on Sundays and that 44% reported adopting coping behaviours; of this group of 'copers' 14.5% said they had moved to other greenspaces, 37.3% had moved to other parts of the forest and 21.7% changed the time of their visit. Other behaviours included putting dogs on leashes and a few changed the activities they pursued. Weekday visitors were less tolerant of crowding than Sunday visitors. The different types of recreational displacement (temporal, spatial and activity choice) are illustrated in Figure 2.

A paper by Arnberger and others (2010b), again using the urban Wienerburg Forest in Vienna, is the only study we identified which integrates stated behavioural intent to

displace from a site due to crowding with empirical evidence of recorded visitor numbers. This study also addressed gender differences and walkers with and without dogs in some detail. Crowding tolerances of these groups derived from responses to the manipulated photo images of trail conditions were combined with visitor count data compiled over a year to estimate of the proportion of female and male visitors with and without dogs who therefore would likely displace from the site.

These results are summarised in Figures 3a and 3b. For example, conditions with more than 8 people visible on the trail occurred for only 1% of the year but 33 different days were affected mainly during Sundays and holidays and some summer evenings. They showed that displacement intentions differed by gender and activity; high use levels were a greater concern for all users than very low-use levels, especially for female dog walkers. However, while this study identifies key windows during the year when crowding becomes intolerable to certain user groups it does not go as far as identifying quantitative user density thresholds above which displacement takes place.

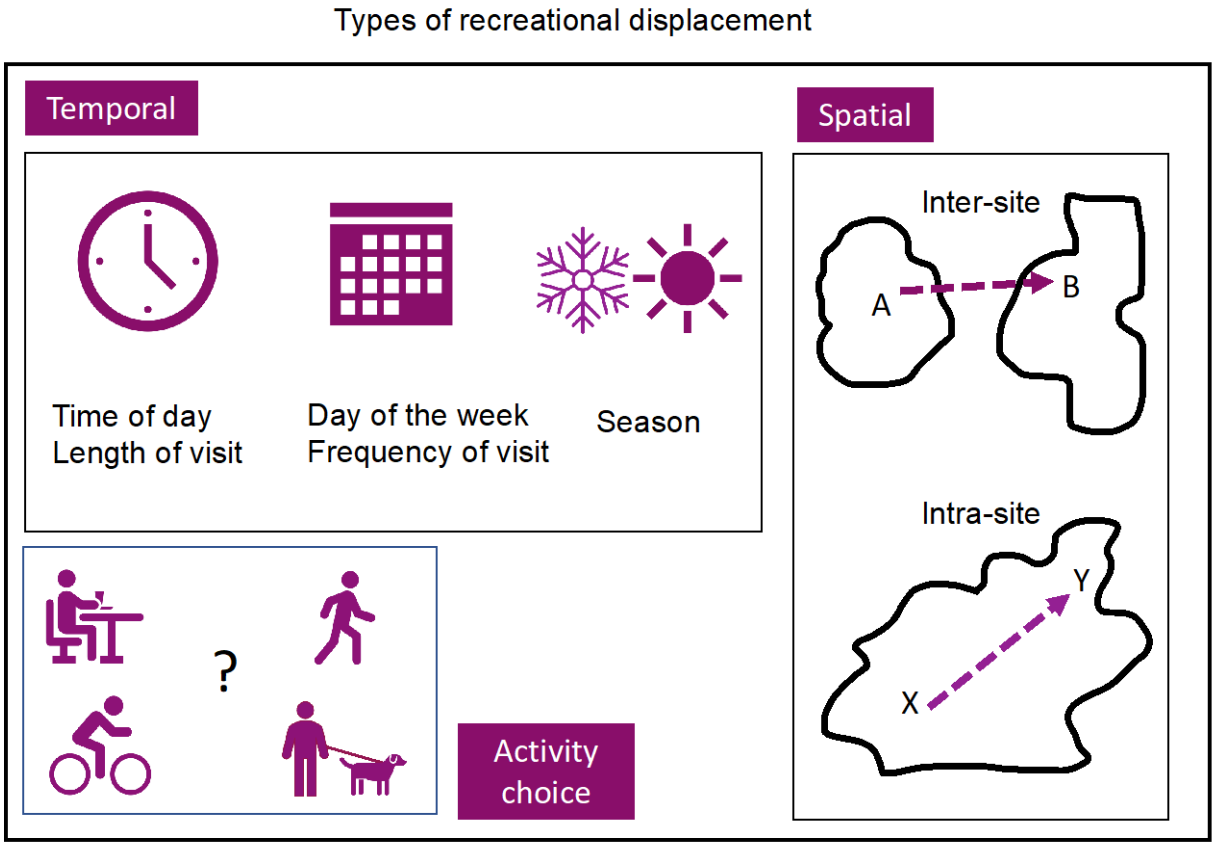

Figure 2. Main types of crowding-related user displacement from urban greenspaces

In Romania, the Craiova Botanic Gardens are a heavily visited urban greenspace within the city; Marinescu & Curcan (2020) showed that 65% of visitors perceived weekends to be very crowded; 54% reported temporal displacement of their use to different times, and 14% shifted their use from weekends to weekdays.

A study of the use of the 70 urban public parks in Leeds (Barker, Churchill & Crawford, 2018) using an on-line and postal survey identified that 26% of respondents avoided their main park at certain times of the day or week (i.e., temporal displacement). The reasons given were diverse; some related to crowding created by specific events or seasonal periods of heavy use but others related to concerns about personal safety after dark and the anti-social behaviour of other park users (including drinking and drug dealing, and dog walkers letting dogs off leashes).

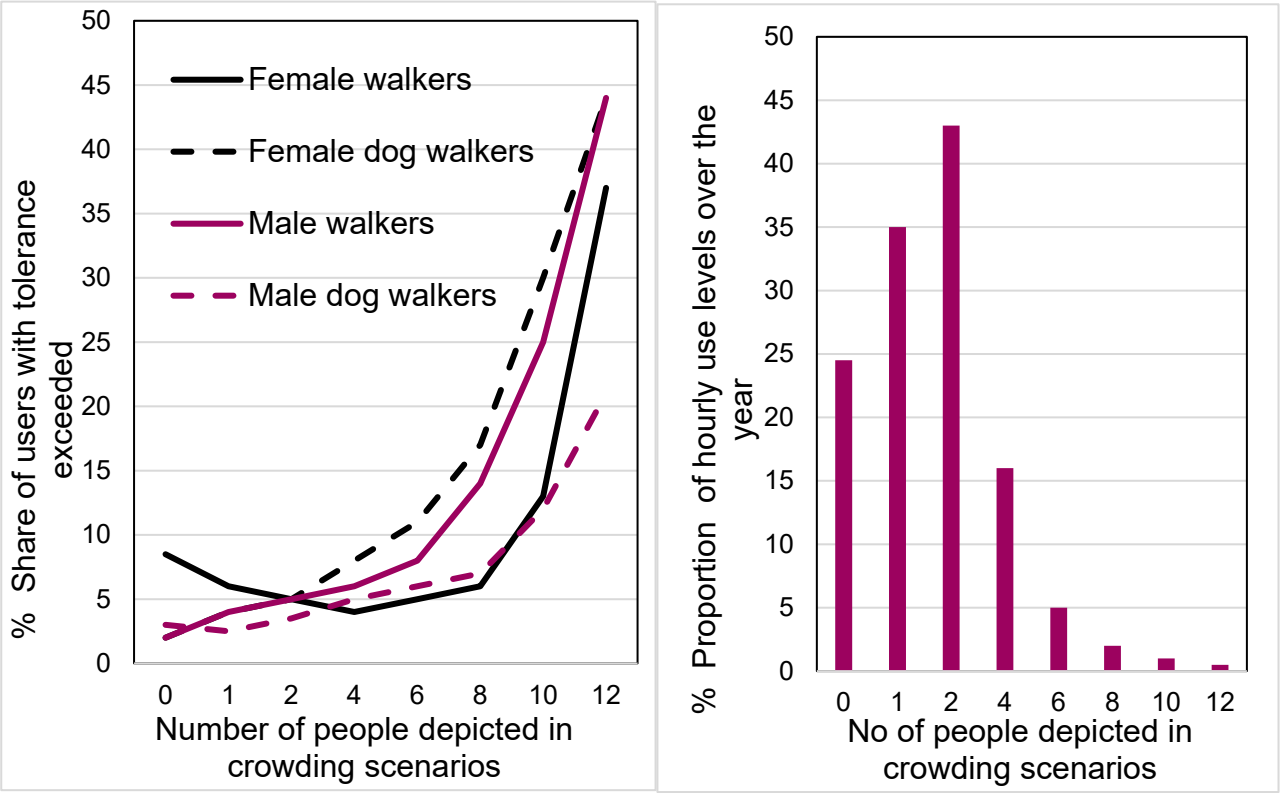

Figure 3a. Share of different user groups whose tolerance of crowding was exceeded by different scenarios of crowding and, Figure 3b. the % proportion of hourly use levels for each crowding scenario, based on actual visitor counts (redrawn from Arnberger and others 2010b)

4.2.1.2 Other reasons for displacement

We also found evidence to support other non-crowding related reasons for user displacement from urban greenspaces. These can be characterised as ‘detractors’ or contributors to negative recreational experiences.

In Ghangzhou, China, a study by Shan (2020) showed how marked temporal displacement of visitors in urban greenspaces can be. In this case climatic conditions lead some users to avoid high daytime temperatures in this subtropical city. Of the respondents 47% visited between the hours of 1800-2200 with only 19% visiting during the hours of

1000-1400. Shan suggested that heavy use at night may lead to crowding and reduced visitor satisfaction.

The Environmental Statement for the Sizewell C Project (EDF Energy, 2020) considered the potential effects on users of recreational sites in its vicinity caused by the construction of a new power station (such as changes to public rights of way and land take) and changes to the quality of perceived and actual recreational experiences (such as views, noise, air quality, traffic, and increased local population due to construction work). While the sites affected are principally in a rural location on the fringe of the small coastal town of Leiston, the in-depth analysis of potential displacement of visitors is worth referencing as an example of potential displacement due to major infrastructure developments. Interviews with visitors to several local greenspace sites showed that 29% would displace to other sites; of these, 60% would be prepared to travel up to 5 miles and the rest further afield. The study concluded that the displacement locations which users would likely visit were diverse and numerous, representing ‘a diffuse displacement of recreational activity’ across the area.

No studies were identified relating to the effect of car parking provision or car parking charges for urban greenspace; other evidence from rural situations has suggested that car parking fees can deter low income recreational users in the USA (Lambourn, 2017), though Weitowitz and others (2019) using data from a variety of rural nature conservation sites in the UK presented counter intuitive results (locations with parking fees are significantly busier) and indeterminate results (no clear relationship between parking areas with visitor facilities and numbers of people).

Fearnley & Liley’s study (2011) of visitor numbers to Suitable Alternative Natural Greenspaces (SANGs) on the edge of a number of North Kent towns also explored user attitudes to potential changes in their recreational experiences created by changes to rules about dogs on leashes and introduction of parking charges as well as increased visitor levels, and whether they would respond through temporal or spatial displacement. They showed that even if visitor numbers are not high, other factors affecting their experience would encourage users to displace and that users have markedly heterogenous preferences about what attracts or deters them from visiting different recreational areas.

4.2.1.3 Factors affecting crowding perceptions

Several of the studies we identified also showed that crowding perceptions varied not only with levels of use but to a series of other interrelated site-based and social factors as well.

A study by Westover & Collins (1987) undertaken in Potter Park, Lansing in Michigan USA found a clear relationship between perceived crowding and actual observed use levels though when few people were present, there was a tendency to report the park as crowded compared with areas with high use levels, suggesting that those who were more crowd-averse moved to less densely used areas. Arnberger & Heider (2007a) refer to the process of social succession whereby crowd-averse users who displace off site are subsequently replaced by crowd-tolerant users.

Arnberger & Haider (2007b) also compared actual measures of crowding (using observational data and on-site perceptions from visitor counts) with global measures (based on users' post-visit aggregated recollections of a site or series of sites). This distinction is important because many studies use global estimates when gathering data e.g., online and post-visit questionnaires rather than obtaining data on site. Global estimates from respondents in the Wienerburg area were consistently higher than actual measures; this was correlated with past experience of the site (specifically frequency of visits with crowding experiences on other days of the week and length of stay), possibly affected by recall of negative rather than positive recreational experiences. The study compared global and actual figures for specific times during a number of Sunday surveys but while the actual visitor counts fluctuated due to the dominance of short-term visits, the post-visit recall of users remained fairly constant. Arnberger & Haider concluded that frequent or long-term exposure to high use levels particularly on Sundays explains why the global measures are higher than the actual measures even at peak times of year.

Other studies have also explored social nuances of crowding perceptions. By showing respondents in the Wienerburg forest several manipulated photo images, Arnberger & Haider (2005) explored combinations of six social variables (number of visitors, user types, group size, distance of other users to the respondent, presence of dogs and direction of travel) representing different crowding scenarios along a trail to analyse the trade-offs between different factors affecting their recreational experience.

Three segments of users were identified according to levels of tolerance: crowd-tolerant, crowd-averse and crowd-indifferent groups. Common to all groups was a dislike of users in the foreground of the images, single users, fast moving users, the presence of dogs and high use levels. However clear differences were also evident; the crowd-averse group reacted more negatively to high use levels, to larger groups, to a mix of trail users and to users in the image foreground, whereas the crowd-tolerant group preferred some levels of social contact and a mix of trail users. All these variables in various combinations contributed the variances in the respondents' perception of crowding and present a complex and nuanced picture of the multiple factors at play.

This analysis was developed further by a follow up study again at the same site (Arnberger & Haider, 2007a) using the same scenarios to test whether a set of conditions were so intolerable to visitors that they would displace from the trail. This concluded that the propensity to displace is highest when visitors encounter more than six people and simultaneously inappropriate visitor behaviours occur, i.e., unleashed dogs, a mix of user types moving at different speeds, people in the foreground (violation of personal space), face to face encounters (rather than people moving at in the same direction) or a combination of any of these.

Mieno and others (2016) also looked at heterogeneity in social conditions of trail use urban forest, using respondents from Nopporo Forest in Sapporo Japan, by creating trail scenarios with varying numbers of walkers, hikers and joggers; the presence of dogs both leashed and unleashed; and the presence/absence of foragers. They identified two broad segments of respondents, an older group who were crowd-tolerant but not of foragers. The

second group were less tolerant of crowds especially excessive numbers. However, a larger number of people negatively affected the quality of recreational experience for all respondents but to a lesser extent than in a European context.

Those studies which analysed age as part of user demographic profiles showed that it accounted for very little of the variance in perceptions of crowding though Arnberger & Haider (2007b) showed that the presence of children in a group of users resulted in focus on the child and therefore in less sensitivity to the number of other users.

A study of trail users in the large Medvednica Nature Park on the outskirts of Zagreb by Sever & Verbič (2019) showed that trail users' perception of crowding was explained by a mix of site-based factors such as litter, visitor noise and road noise as well as by trail use levels.

Other studies have addressed place attachment as a factor in crowding perceptions. Eder & Arnberger (2012) in studying visitors to the Lobau Forest on the outskirts of Vienna found that almost 50% of users perceived Sundays as crowded and users with high local area knowledge perceived higher levels of Sunday crowding. They showed that place attachment (a concept in recreational research describing a positive emotional, symbolic or functional tie to a particular place) was not a good predictor of perception of crowding but prior experience (i.e., frequency of visits and familiarity) was. This was supported by a study by Sharp, Sharp & Miller (2015) who found that, for visitors to Kennesaw Mountain National Battlefield Park in Atlanta, there was no significant relationship between level of place attachment and the perception of crowding. The perception of crowding at this busy site was lower than expected according to Sharp, Sharp & Miller (2015) who concluded this may have been a combination of the presence of large numbers of frequent users whose tolerance of crowding is higher, or who may have displaced to other sites and times or rationalised their visit expectations.

Crowding perceptions and displacement also seem to be related to users' past experiences for some sites. For visitors to the forests of the heavily used Danube Floodplain National Park on the outskirts of Vienna, Arnberger & Brandenburg (2007) showed that local residents, regional visitors (within 100km) and tourists (from >100km and abroad) with different experience histories perceived crowding differently. Overall, 36% of respondents felt the park was generally crowded or crowded at specific times but this rose to 50% for local residents who visit the park frequently, 27% for urban visitors who visited less frequently and 19% for tourists (for whom ¾ were first time visitors). Furthermore, while 18% of all respondents said they modified their behaviours both spatially and temporally, 27% of local residents had done so but only 15% of regional visitors and 2% of tourists.

Of particular interest in this study is that 41% of local residents who felt crowded did not displace; possible reasons for this were lack of alternative sites, lack of transport, a readjustment of their expectations of the quality of their recreational experience or a high degree of place attachment, but these were not explored in this study.

However, past experience may not be reflected in perceptions of crowding everywhere. More than 90% of users of the urban and peri-urban forests of Heverlee and Meerdal Forest on the edge of Leuven in Belgium perceived crowding not to be a problem (Roovers, Hermy & Gulinck, 2002) though users satisfaction levels showed a preference for the less crowded of the two areas. Almost 100% of users had been to the forests before, so the relationship between past experience and perception of crowding here is weaker perhaps as a result of relatively low density of use levels.

Perceptions of crowding and therefore the potential to displace may also vary across cultures though this area of urban crowding research is virtually unexplored. Arnberger and others (2010a) compared trail preferences of users of two comparable urban forests, one in Vienna, Austria and one in Sapporo, Japan. Using image-based scenarios of different use levels of trails, they identified some statistically significant differences between the two groups and found that the Japanese respondents placed less importance on visitor numbers and tolerated higher densities, suggesting that they may be more accustomed to crowds.

Zhai, Baran & Wu (2018), in a study of urban parks in Shanghai using GPS trackers, showed that user groups pursuing different recreational objectives (e.g., playing with children, enjoying contact with nature and relaxing, and spending social time in family and friends groups) tended to distribute themselves in different configurations across the parks, though usually in hotspots. These choices may indicate an intention to avoid conflicts with groups with a different focus but also to align their activities with the facilities provided. These small-scale intra-site displacements reflect different group priorities; nature lovers are spatially more dispersed than family groups who choose to socialise in close proximity. They also noted different cultural preferences in use of urban greenspaces and their results indicated that Chinese users usually visit urban parks in small groups with families and friends.

The various factors (type of recreational environment, place attachment, prior experience, culture, gender, social characteristics, age group size, presence of dogs and type of activity) which may influence perceptions of crowding are illustrated in Figure 4.

4.2.1.4 Social carrying capacity

As noted in the introduction, the concept of social carrying capacity is defined as a level of use above which visitor experience is unacceptably compromised. Negative visitor experiences can include perceptions of crowding which may in turn trigger a coping behaviour such as displacement. We found four studies which have variously attempted to define social carrying capacity in urban greenspaces.

A study of a small but highly popular lakeside recreation area, Lake Podpeč, on the edge of Ljubljana in Slovenia (Marusič, Mihevc & Dremel, 2019) set out to identify the carrying capacity of the site. Using observational data to map users, they calculated that in areas of intensive use with frequent and sustained active or passive activities, the average land area per user was at least 30m^2, the equivalent of a circle with a radius of at least 3m.

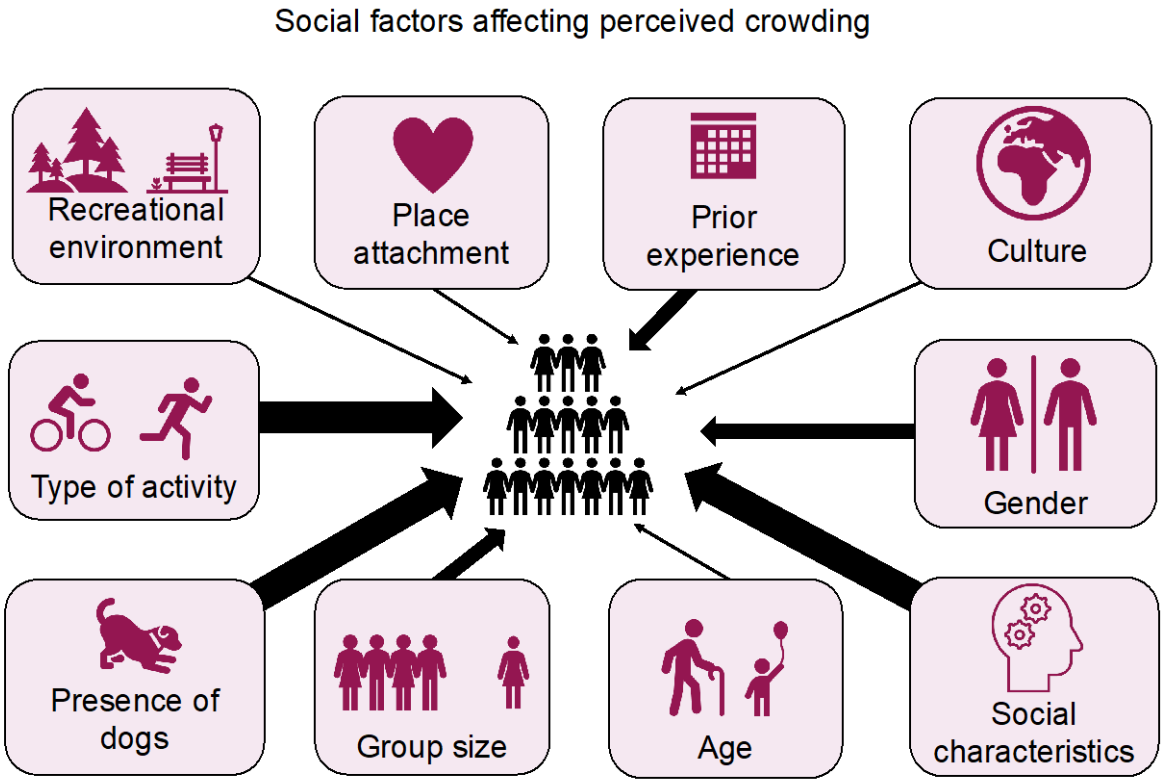

Figure 4. Social factors affecting perceived crowding (arrow thickness illustrates strength of relationship (weak; moderate; strong) based on evidence reviewed)

Mu and others (2021) analysed user activity patterns in relation to urban park features in three small intensively used parks in the old town area of Zhenghou City, China. They used an index of 'spatial vitality', a weighted average of four measures: diversity of age group, visitor density per hour, space usage intensity (per capita ground area) at the peak time and richness of activity types. Each park had a visitor capacity set by a park design code of approximately 130 people/ha although there was no explanation for how the figures had been determined. Visitor density in people/m^2 per hour peaked in one park at 0.048 (480 people/ha) and capacity was exceeded between 10am and 4pm on weekends.

In an England context, the only proposed measure of social carrying capacity for recreational spaces that we identified has been suggested by the Footprint Ecology consultancy. Their work has focused on SANGs (Suitable Alternative Natural Greenspaces). These need to be provided in circumstances where new residential developments close to Special Protection Areas and Special Areas for Conservation are anticipated to increase demand and create further ecological pressures on such sites. The agreed level of provision is 8ha/1000 people. In effect, SANG provision is a strategy to encourage recreational displacement of visitors away from ecologically sensitive sites through ensuring a supply of alternative greenspaces for recreation.

Monitoring the effectiveness of SANGs in providing displacement sites for visitors from SPAs has been undertaken through visitor surveys commissioned by local authorities to understand whether they are being used enough or indeed their capacity is being exceeded.

Based on data collected over several years in visitor surveys for SANGs and on professional judgement, Liley & Floyd (2013) and Cruickshanks & Liley (2014) considered that a figure of 1 person/ha/hour is a suitable measure of capacity for SANGs at which the SANG will "be reasonably busy" but "not feel too busy". SANGs are either created or designated from existing natural greenspaces and typically occur within or adjacent to small towns; while their character is not typical of more intensively managed and used city urban greenspaces, the examples included in Table 4 show that their use levels can be comparable with figures from studies of other kinds of urban greenspace.

Table 4. Examples of use density levels from urban greenspace crowding and displacement studies identified in this review

Town/City	Location/description	Size (ha)	User density (people/ha/day)	Source
Zagreb, Croatia	Medvednica Nature Park	17938	0.5 (annual average)	Sever & Verbič, 2018
Sapporo, Japan	Nopporo Forest, peri-urban forest	2050	0.93 (annual average)	Mieno, 2016
Vienna, Austria	Lobau, peri-urban forest	2400	1.2 (weekends)	Arnberger, 2006
Atlanta, USA	Kennesaw Mountain National Battlefield Park	1183	1.4 (annual average)	Sharp, 2016
Helsinki, Finland	Central Park, mixed natural greenspace	1100	5 (annual average)	Korpilo, 2018
Vienna, Austria	Ottakringer Wald, urban forest	194	5.7 (annual average)	Arnberger & Eder, 2007
Farnham, England	Farnham Park, natural greenspace in town (SANG)	85	6.3	Cruickshanks & Liley, 2014

Town/City	Location/description	Size (ha)	User density (people/ha/day)	Source
Uckfield, England	Uckfield Millennium Green, open greenspace (SANG)	8.9	10.4	Liley & Floyd, 2013
Shanghai, China	Gongqing Forest Park, city centre greenspace	125	36	Zhan, Baran & Wu, 2018
Vienna, Austria	Wienerburg, urban forest	120	36 (weekends)	Arnberger, 2006
Zhenghou, China	Wenbo Park, city centre urban park	3.21	40-220 (time dependent)	Mu, 2021
Zhenghou, China	Xuezi Park, city centre urban park	3.32	50-140 (time dependent)	Mu, 2021
Shanghai, China	Paotaiwan Forest Park, city centre greenspace	53	85	Zhan, Baran & Wu 2019
Craiova, Romania	Botanic Gardens, urban	17	85 (weekends)	Marinescu & Curcan 2021
Zhengzhou, China	Cultural Park, city centre park	6.74	180-480 (time dependent)	Mu, 2022
Ljubljana, Slovenia	Lake Podpeč, peri-urban lakeside open greenspace	0.8	333 (summer weekend)	Marusič, Mihevc & Dremel, 2019

Note: Figures per hour from Liley & Floyd (2013) and Cruickshanks & Liley (2014) multiplied by 12 (equivalent to annual average of 12 daylight hours/day) to provide comparable estimate with other studies).

4.2.1.5 Crowding on urban green routes and trails

None of the 11 studies we identified which examined trail use provide quantitative information about thresholds above which users of urban green routes (described using terms such as urban greenways and city shared-use trails) have been observed to or

intend to displace to other green routes. However, these studies do provide some evidence of overall levels of use and of the interactions and conflicts between different trail user groups which may be a predisposing factor to the initiation of coping behaviours such as displacement.

Although five of the trail studies identified were undertaken in the context of urban and peri-urban forests (Arnberger & Haider 2007a; Arnberger & Eder 2008; Arnberger and others 2010a; Mieno and others 2016; Sever & Verbič, 2019), forest trails are integral to visitor perceptions of crowding of the whole site; furthermore, where studies have focused on forest trails they also quote use density levels in terms of the whole site not in units of lengths of trails. In 4.2.1.3 *Factors affecting crowding perceptions* there is evidence for the occurrence of intra-site displacement by users of forest trails to allow for fulfilment of off-trail recreational experiences and also to avoid potential conflict with other users through collision.

This section therefore looks at studies addressing density of use and crowding of city and town shared-use trails, which are usually surfaced, and which pass through a range of urban greenspaces such as parks, along lake shores or along the path of former railway lines. These trails often serve both recreational and commuter use though not all studies made this distinction in their analyses. Standards-based and design literature from transportation research has also been identified as relevant here.

Gobster (1995) looked at recreational use of the greenway system within the Chicago metropolitan area and probed both its top positive and negative attributes; apart from rough surfaces (25%) 12% of respondents felt crowding was a negative issue on the greenway network overall.

By contrast, Johansen and others (2020) in a questionnaire study of three trails in the cities of Chicago, Dallas and Los Angeles found that perceived trail crowding was associated positively with trail use and suggested that trails with foot traffic are perceived as safe. He also suggested that increased social interactions, lead to positive social outcomes which help to increase future trail use.

A study from a 10-mile urban trail in Austin, Texas (Mount, 2014) used by both cyclists and walkers almost exclusively for recreation showed that subjectively derived (questionnaire data) and objectively derived (user counts) crowding measures were aligned for most users along different parts of the trail. Depending on the section of the trail under analysis users had markedly different preferences for whether they met more people or fewer people. However, the study did not go on to identify what if any coping behaviours users adopted to respond to these preferences.

Several studies allude to the relationship between user conflicts as a factor in perceived crowding along shared use trails. Delaney (2016) examined user interactions along the shared-use Bristol to Bath railway path and found that a surprisingly high number of interactions between pedestrians and cyclists (8.5%) involved negative interactions, either unfriendly verbal exchange or a near collision. Speed of cyclists was seen as a major

cause of these interactions. More than two thirds of users were commuting or other functional purposes with less than one third using the path for leisure.

A report for the Royal Parks in London on the implementation of speed calming measures aimed at cyclists along Mount Walk, a shared-use path through Kensington Gardens (Atkins, 2016) provided detailed insights into recreational and commuter pedestrian and cyclist levels of use and into the capacity of the route to accommodate both user groups. Cyclist flows and speeds peaked during commuter peak times during the week. It showed that speed calming measures (such as rumble strips and signs) had reduced potential for close interaction (potential collision or avoidance behaviour) between pedestrians and cyclists, although CCTV showed considerate behaviour between the two groups was almost always in evidence and 97.5% of cyclist interactions with pedestrians were conflict-free.

The report also undertook a pedestrian and cyclist space use assessment of Mount Walk to understand its capacity to accommodate the shared flows of two different user groups: cyclists and pedestrians. This was done using the Level of Service approach, which is widely used in transport planning as a way of setting standards of pedestrian capacity and comfort based on measurements of user flows on a scale of A-F (see Table 5) in combination with a recommended minimum path width of 3m for one cyclist and two pedestrians to pass side by side. It is a useful quantitative way of defining crowding on urban green routes in the absence of any other studies identified in this review.

The report created three scenarios for cyclist and pedestrian interactions based on typical patterns of use along Mount Walk. These scenarios are illustrated in Figure 5 which shows the configuration of users under each scenario. The report then calculated the maximum flows allowable under each assuming Level of Service B was acceptable. When matched against the actual measured flows, Level B was exceeded for a two-hour afternoon window at weekends under scenario 3 (three cyclists passing each other). This is at a point when pedestrian flows exceed 260 pedestrians per hour. Moving from Level B to C requires small scale pedestrian displacement or overspill off the path. Overall, and even given its high levels of use, the report concluded that at present Mount Walk provides a sufficient clear width for the observed flows allowing for natural adjustments by both cyclists and pedestrians along the route.

Pettengill, Lee and Manning (2012) also used the level of service approach in their comparative study of three greenways in northern New England which drew on both questionnaire-derived data and standards-based level of service (LOS) data established by US Highways Capacity Manual (see Figure 6). They sampled users (pedestrians and cyclists) of the urban bike path in the city of Burlington, Vermont USA to identify factors affecting their enjoyment of greenway travel (in particular density of use) and 32% of respondents said that density of other users and crowding was what they enjoyed least.

Table 5. Levels of service for pedestrians walking in small groups (Atkins, 2016)

Level of Service	Description	Flow per unit width, pedestrians/min/metre	
		Minimum	**Maximum**
A	Open	0.00	1.64
B	Impeded	1.64	9.84
C	Constrained	9.84	19.69
D	Congested	19.69	36.09
E	Crowded	36.09	59.06
F	Jammed	59.06	+

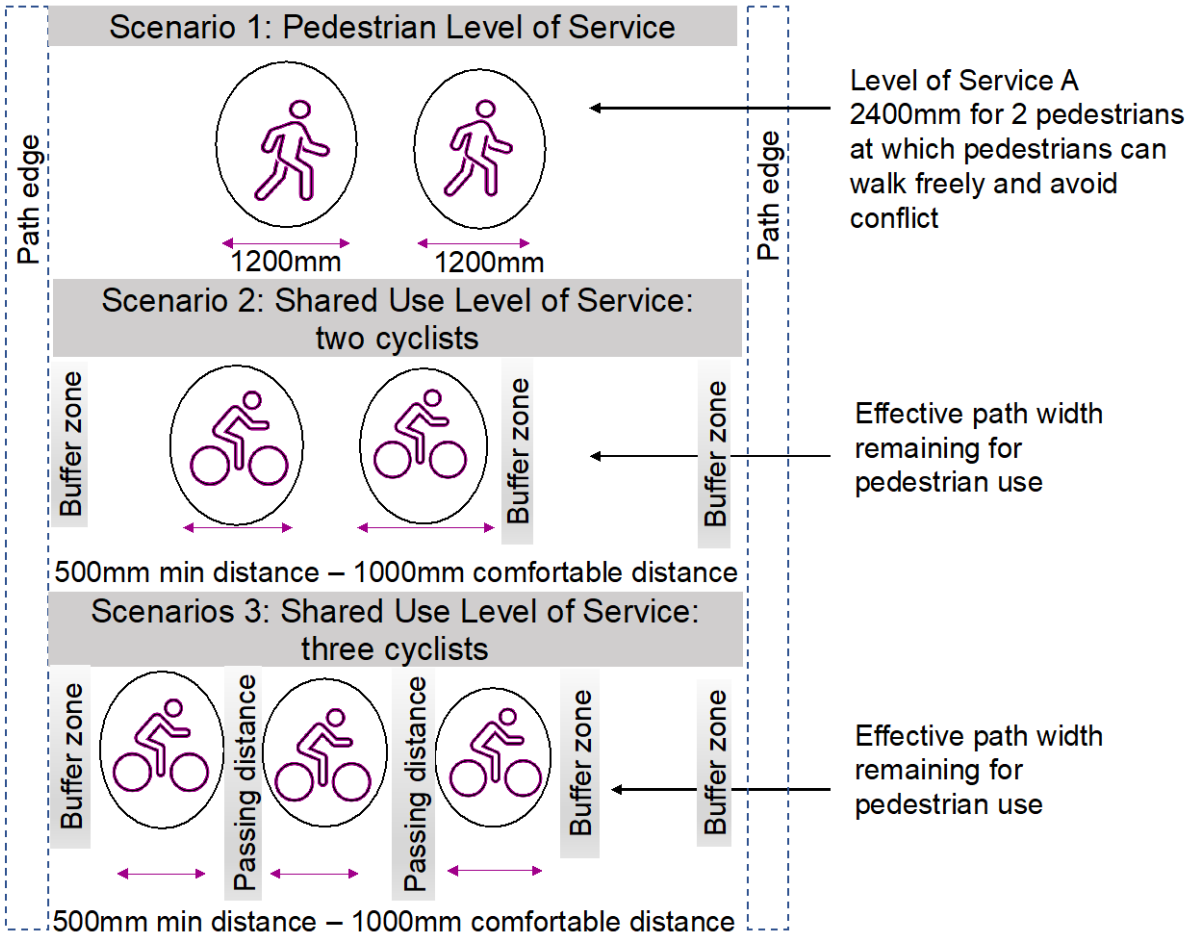

Figure 5. Space requirement for three user configurations of pedestrians and cyclists on Mount Walk, Kensington Gardens (adapted from Fig 105 in Atkins, 2016)

Using photos to simulate levels of use, ‘unacceptable’ levels for the Burlington bike trail (equating to Level of Service (LOS) E and F shown in Figure 6) were defined by respondents as 20 users per 300m^2 of path and ‘cautionary’ conditions (LOS C and D) were defined as 12-20 users/300m^2. Six users were perceived as acceptable (LOS A and B). Users of rural paths recorded lower figures showing that urban users are more tolerant of higher use conditions. The authors conclude that density of use is an important indicator of quality for greenway travel though potential displacement of users above unacceptable levels is not discussed.

Delaney (2016) quoted Dutch guidance that the upper limit for path sharing between cyclists and pedestrians is 200 pedestrians/hour/metre, above which negative impacts on journey experience occur.

The evidence base we found for analysis of crowding on urban green routes is very limited; however, some basic data on levels of use of surfaced shared-use urban green trails were identified and these are shown in Table 6 for comparative purposes.

Studies on the use of city shared-use trails provide a mix of qualitative questionnaire and empirical evidence about crowding and use levels. Where studies did give direct measurements of flows of pedestrian and cyclist traffic on urban green routes, direct comparison between them was not possible due to use of different units of measurement. Some studies used flow volume measures (such as people/min/ft, people/min/metre or people/hour/metre) others used density-based measurements (such as users per m^2 of path) or simple count measures (such as users/hour or day or users/km/day).

In summary, while the limited evidence available does suggest that crowding, as defined by levels of service standards, may occur when use is measured in thousands per day for city shared-use green routes and trails, there is no evidence in the literature reviewed in this study about inter-route displacement as a behavioural response, either intended or actual, by users of city shared-use green routes and trails.

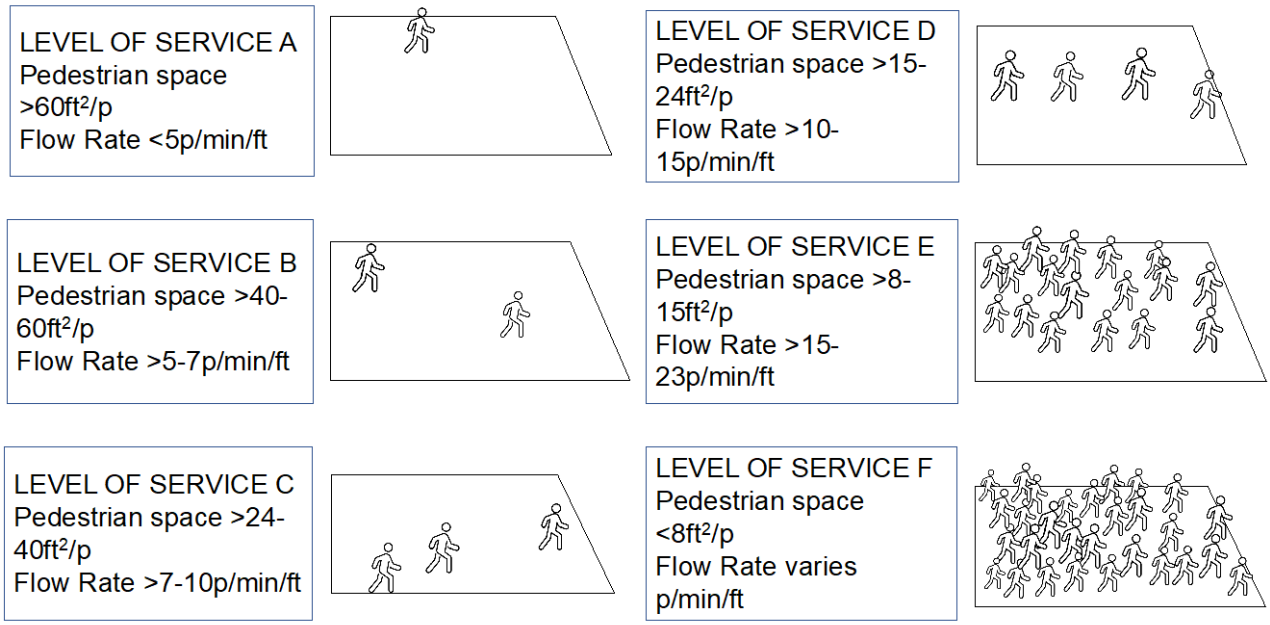

Figure 6. Level of Service (LOS) Framework for pedestrians in the US (adapted from Pettengill, Lee and Manning, 2012: original source Transportation Research Board, 2000). Description of LOS below taken directly from TRB, 2000):

- At LOS A, pedestrians move in desired paths without altering their movement in response to other pedestrians, walking speeds are freely selected and conflicts between pedestrians are unlikely.
- At LOS B there is sufficient area for pedestrians to select walking speeds freely, to bypass other pedestrians and to avoid crossing conflicts. At this level pedestrians begin to be aware of other pedestrians and to respond to their presence when selecting a walking path.
- At LOS C, space is sufficient area for normal walking speeds, and for bypassing other pedestrians in primarily unidirectional streams. Reverse direction or crossing movements can cause minor conflicts; speeds and flowrate are somewhat slower.
- At LOS D, freedom to select individual walking speed and to bypass other pedestrians is restricted. Crossing or reverse-flow movements face a high probability of conflict, requiring frequent changes in speed and position. There is reasonably fluid flow but friction and interaction between pedestrians is likely.
- At LOS E, virtually all pedestrians restrict their normal walking speed, frequently adjusting their gait. At the lower range, forward movement is possible only by shuffling. Space is not sufficient for passing slower pedestrians, Cross or reverse flow movements are possible only with extreme difficulties, Design volumes approach the limit of walkway capacity, with stoppages and interruptions to flow.
- At LOS F, all walking speeds are severely restricted, and forward progress is made only by shuffling. There is frequent unavoidable contact with other pedestrians. Cross and reverse flow movements are virtually impossible. Flow is sporadic and unstable. Space is more characteristic of queued than of moving pedestrians.

4.2.2 Research question 2

- Does the type of use (activities such as dog walking, BBQs, motorbikes etc) of greenspaces in urban areas or close to urban areas, lead to displacement of users to other locations and which users/activities are most likely to be displaced to other locations?

No studies were identified which directly attributed the activities of user groups to the inter-site displacement of other groups. However, nine studies were identified which looked at interactions and the potential for conflicts between recreational groups in peri-urban and urban greenspaces and on urban green routes; (potential conflict can be a predisposing factor which may trigger coping behaviours such as displacement though the studies identified tended to address these obliquely). Of the nine studies, seven used questionnaire-based evidence to identify where potential for conflicts might occur and only two (Arnberger & Eder 2008; Santos ,2016) used empirical data of interactions/conflicts between groups.

In a comparison of recreation use in two forests, (one urban (Wienerburg) and one peri-urban (Lobau) in Vienna) a study used video monitoring data over the course of a full year to explore interactions between four types of recreational activities, walkers, dog walkers, cyclists and joggers (all other categories comprised <1% of the total) and temporal patterns of potential for user conflicts (Arnberger, 2012).

The temporal daily pattern of each activity in each forest varied from weekdays to weekends and between each activity group. Peak use levels were identified on weekend afternoons where activities overlapped and used the forest resource at the same time, leading to a higher likelihood of potential user conflicts and perceived crowding levels. The study suggested that the almost complete absence of joggers during these peak use periods was a result of conflict reducing behaviour. At weekends joggers tended to use the forest between 9 -11 am and on workdays in the evening.

On workdays at one site, commuter cycling and walking peaked in late afternoon and evening, coinciding with recreational cycling and walking as well as routine activities such as jogging and dog walking. Conflict potential with fast moving cyclists was identified. Joggers reported conflict potential with dogwalkers during low-use periods when dog walkers tended to release their dogs from leashes.

While no displacement intentions or actual conflicts were recorded in this study, it identified sensitive time periods in which conflict potential between user groups is increased, a predisposing factor for displacement.

Table 6. User densities on selected urban green routes

City	Location/description	User flow data	Flows in users/per day	Source
Kensington Gardens, Mount Walk London	City centre urban park; shared-use trail, 0.8km	Average hourly pedestrian flow: 341 on Sundays, 234 on weekday;	Pedestrians: 4092 on Sunday; 2808 on a weekday;	Atkins 2016
As above	As above	Average hourly cyclist flow: 64 on Sundays, 256 on weekdays	Cyclists: 768 on Sunday; 3072 on a weekday	Atkins 2016
Trail at Lady Bird Lake, Austin Texas	Shared-use trail round perimeter of city centre lake; 16km	5821 on weekend day	5821	Mount 2014
Chicago Lakefront Trail Chicago	City shared-use trail running along shore of Lake Michigan through urban parks, 27km	8931 users across whole trail over 4 days	2,232 (all users)	Reynolds 2007
White Rock Trail, Lake Dallas	City shared-use trail running through urban parks and around lake shore, 24km	4 days of observation 6715 users across whole trail	1678 (all users)	Reynolds 2007
Los Angeles River Trail, Los Angeles	City shared-use trail running from residential areas to Long Beach Harbour, 30km	4 days of observation 2092 users across whole trail	523 (all users)	Reynolds 2007
Monon Trail, Indianapolis	City trail following abandon rail route through residential areas, 5km	379,500-445,600 estimated annual use	1,040-1,221 (all users)	Lindsay 1999

City	Location/description	User flow data	Flow in users/per day	Source
Canal Towpath Trail, Indianapolis	City trail following canal through residential and institutional areas, 8km	29,300-148,100	80-406 (all users)	Lindsay 1999
White River Trail, Indianapolis	City trail adjacent to White River through city greenspaces, 5km	27,500 - 53,200	75-146 (all users)	Lindsay 1999

A study of public use levels and patterns in the Lobau Forest over the course of a year which focused on dog walkers showed that dog walkers showed less variability in visitation over the year than those without dogs (Arnberger & Hinterberger, 2003). Daily peaks of dog walkers occurred in the early morning and early evening. During busy times when the site is busier, crowding leads to dog owners keeping their dogs on leashes as a coping behaviour to avoid conflict with other use groups. Dog walkers who want to release dogs from leashes do so in low-use times such as early mornings and workdays, demonstrating temporal displacement of their visits in response to their particular recreational preference.

Use of video monitoring allowed direct observation of user interactions in shared trails in the intensively used Wienerburg in Vienna (Arnberger & Eder, 2008). Over the course of a year, 0.45% of all observed visitors were involved in an interaction (change of behaviour) with other users. 92% of these were classified as displacement behaviour, such as shifting use to the other side of the trail or detouring to avoid collision with other users especially fast-moving users. Most interactions involved walkers and cyclists (35%) and 20% involved intra-activity between walkers, and 18% between walkers and joggers. Only 4% of interactions involved dog walkers even though nearly half of those questioned regarded dogs off the leash as the most annoying use of the area.

In a study in Altschwill Forest on the edge of Zurich, Kleiber (2001) identified eleven user groups through on-site interviews; half felt disturbed by one or more of the other user groups. The study further identified those groups who were most disturbing to and most disturbed by others. Dog walkers and cyclists were considered a problem by almost every other group; nature-lovers, those groups with playing children, and foragers were particularly disturbed by dogs and horse riders, while nature-lovers and dog owners were particularly disturbed by bikers. The degree to which such disturbance affected enjoyment of the visit was tested by applying a willingness to pay question; 20% of respondents disturbed by other users (i.e.,10% of all respondents) were willing to pay for the exclusion

of those groups; groups most willing to pay are readers/observers, picknickers and those with playing children.

A not dissimilar approach to analysing recreation conflicts in relation to displacement was taken by Bakhtiari, Jacobsen & Jensen (2014) for Danish forests. They compiled a matrix showing respondents' perceptions of which recreational groups disturb others or are disturbed by others, using data obtained through an internet-based questionnaire. Mountain bikers, horse riders, runners, group-runners, and dog walkers were the groups causing disturbance to other groups while those who felt most disturbed were those enjoying peace and nature, foraging, picnicking, biking and walking; horse riders, runners, group-runners and walkers also felt disturbed by other groups especially mountain bikers (who disturbed most groups) and some user groups experienced intra-group conflicts. Then, using a choice experiment approach they calculated the 'willingness to travel' of various groups to avoid conflicts and found that on average respondents were willing to travel 6km further to find a forest with 'few' visitors compared to a forest with 'many'.

Janowsky & Becker (2003) studied user groups (walkers with and without dogs, cyclists, joggers and horse riders) in the large urban forest of Stuttgart which has an extensive network of forest logging roads and trails. Different temporal patterns of use were identified for the three groups. Joggers were concentrated in the evenings during weekdays as were cyclists. User surveys identified the main potential areas of conflicts (see Table 7); mountain bikers create the greatest potential conflicts with other users. Joggers and walkers (without unleashed dogs) created the fewest potential conflicts. Joggers perceived walkers with dogs as a potential conflict but not the other way round.

Within Lisbon, Monsanto Forest Park, the city's largest greenspace, has 30km of trails and is heavily used by mountain bikers and runners. No absolute figures of trail use were presented in the study by Santos, Mendes & Vasco (2016) but they used volunteered geographical information (VGI) to map user routes within the park according to high, medium and low intensity and identify areas of conflicts between mountain bikers and hikers. High potential overlap conflicts included parts of the park originally designed for bikers but very high levels of use by walkers, runners and bikers have displaced some bikers on to adjacent roads.

A study of a 20km shared use path running from Bristol to Bath (Delaney, 2016) looked in depth at the behavioural and social interactions between cyclists and walkers on the move. The path is both a transport corridor and greenspace used both recreationally and for commuting and local travel in a ratio of 40:60. While >80% respondents felt comfortable sharing the path with other users, 52% reported frustrations with actions of other users. Cyclists were more frustrated by other users than pedestrians, and cyclists who use the path frequently were more frustrated than those who use it less often. Interviews showed that dog walkers and those walking with children were viewed as hazardous and unpredictable by cyclists. Delaney concluded that during peak times of park use "there is an underlying perception amongst pedestrian path users that cyclists dominate and have more right to the space. It appears that the bike dominates in a space

where the car is not present." This study identified potential user conflicts which in turn may trigger coping behaviours, but such behaviours were not discussed.

Table 7. Conflicts between user groups in an urban forest (Janowsky and Becker, 2003) (- no conflicts, + slight conflict, ++moderate conflict, +++heavy conflict) (Note: some cells have been left blank)

	Group causing disturbance							
Disturbed group	Hiker with dog	Hiker without	Walkers with dog	Walkers without dog	Cyclists	Mountain bikers	Horse riders	Joggers
Hikers with dog		-	-	-	+	++	+	-
Hikers without dogs	-		-	-	+	++	+	-
Walkers with dogs	-	-		-	++	+++	++	-
Walkers without dogs	-	-	-		++	+++	++	-
Cyclists	+++	-	+++	-		-	+	-
Mountain bikers	+++	-	+++	-	-		+	-
Horse riders	++	-	++	-	++	+++		-
Joggers	+++	-	+++	-	-	++	+++	

Korpilo and others (2018) examined the social factors affecting the spatial behaviour of runners, cyclists, mountain bikers, dog walkers and walkers using GPS data in Helsinki's Central Park, a diverse urban park and the largest single green area in the city. They showed that runners and cyclists adhered mostly to formal official trails, mountain bikers went off-trail in concentrated areas, and walkers and dogwalkers showed a dispersed pattern of off-trail use. About a quarter of all tracks recorded were outside the formal trail network. However only 5% of respondents went off trail to avoid other users, a low figure which was attributed by the authors to the size of Central Park in comparison with other studies. The primary motivation for dog walkers to leave the trails was to follow their dog and avoid other users.

From the studies by Santos, Mendes & Vasco (2016), Delaney (2016) and Korpilo and others (2018), displacement by trail users has been observed but this occurs only at an intra-site level often at a micro scale to avoid collisions/conflicts with other users while on the trails or to enhance recreational experiences especially for mountain bikers and dog walkers.

The nine studies discussed in this section 4.2.2 focused on interactions in various combinations between majority user groups in each urban greenspace setting, such as cycling, walking, walking with dogs, hiking, and mountain biking. Sedentary social activities such as picnicking or sitting with friends were mentioned only in passing. Minority user groups (such as Nordic walking, rollerblading, skateboarding), emergent user groups (such as e-bike and e-scooter users) and other motorised user groups (such as motorbikes and quad bikes) did not feature in any of the studies. Regular outdoor recreational events especially parkruns are hosted in many urban parks but there has been no research nor is any planned about possible displacement effects these events might create (Rachel Drew, 2023, personal communication).

The evidence presented here gives a picture of which users affect the recreational experience of others and therefore where potential conflicts may occur. However, there is insufficient evidence to determine whether and which particular recreational activities lead directly to and are susceptible to displacement.

4.2.3 Research question 3

- Is there an optimum density of users in greenspace in urban areas (do too few users deter others)?

The evidence relating to low levels of use and their potentially deterrent effect upon users is based primarily on perceived concerns for personal safety derived from questionnaire derived data.

In their year-long study of user levels in the Wienerburg urban forest in Vienna, Arnberger and others (2010b) asked specific questions about perceptions of safety; 59% of women users without dogs and 47% with dogs stated that they did not visit during dusk compared with 36% and 27% of men respectively. Periods of very low-use accounted for 20% of all daylight hours during the year while hours with heavy use accounted for less that 1%; they concluded that over a year, low-use levels when integrated with available daylight affect a substantial number of users and reduced the potential periods for forest use for female walkers with and without dogs. Nonetheless, some women dog walkers stated that they shifted their use to low density trail conditions to allow their dogs off the leash, thus avoiding conflicts with other users.

This study confirmed that gender is an important factor in shaping perceptions of personal safety and is supported by a study of women’s and girls’ perceptions of how safe they felt in parks in Leeds (Barker and others, 2022). They concluded that women and girls conflated low levels of the use of parks with concerns about personal safety and that

women and girls believed that well-used parks during the day are safer because of the principle of safety in numbers which leads to increased passive surveillance and opportunities to seek help if needed. Fostering a sense of ‘busyness’ in the parks through organised activities was a key recommendation of the report.

Other demographic groups may also be susceptible to perceptions that urban green spaces are unsafe, not necessarily because of low levels of use but as a result of a combination of use-related factors. According to Eason and others (2020), “groups may exclude themselves from green spaces if they feel the space is dominated by one particular group (for example, if a park is overwhelmingly used by young people) or if they feel unsafe (for example, when a space is poorly maintained or attracts antisocial behaviour).” Without safe parks to visit as the context for social contact with like-minded groups, including migrant and ethnic minority groups, social isolation can be exacerbated.

A study in St Louis Missouri (Hipp, 2013) found a complex set of factors at play when investigating why two city parks in low-income communities of colour were underused (though this term is not defined). It identified a range of reasons from park maintenance, park design, lack of personal time, personal safety concerns, lack of amenities, park opening hours, and the payment of fees for some facilities.

However, for some groups low levels of use are compatible with their desired experience of urban greenspaces. Arnberger & Eder (2015) showed that in Vienna those people who may seek out urban greenspace as a form of stress relief prefer low-use levels and that high use levels and user conflicts reduce the capacity of greenspaces for stress reduction.

None of the small numbers of studies we identified define a specific level of under-use of urban greenspaces which can trigger a shift from use to non-use; all the studies are based on analysis of intended and actual behaviours derived from individual and group-influenced perceptions of safety. The studies present mixed evidence: too few users can deter users concerned with personal safety, but so can non-compatible user groups and too many users, suggesting that low use of urban greenspace may be a function of multiple perceptions, preferences and barriers. These conclusions require further investigation.

4.2.4 Evidence evaluation

The evidence we found is based on individual case studies from sites primarily from Europe. The focus on Europe suggests their results have some relevance in an England context. However, the heterogenous nature of the individual study sites means generalised conclusions about the perception of crowding and levels of displacement are hard to draw.

A reliance on individual case studies combined with different approaches to data collection about user levels and the different ways of presenting information about crowding also make direct comparisons between different studies difficult, and the results in the evidence identified present a mixed picture. For example, the use of multi-variate analysis of user

responses in several studies shows that no single universal factor (including user density) explains variances in responses by users to the question of what affects perception of crowding. However, some common factors emerge across many studies suggesting that there is some broad consistency (with varying degrees of correlation) in factors such as past experience (visit frequency) of sites, the type of activities pursued by site users, social characteristics of users (their preferences for social contact in urban greenspaces) and the presence of dogs.

We also found that studies from different academic disciplines take contrasting approaches to the question of use levels. Recreational studies focus on user perception of crowding in urban greenspaces and trails differ considerably in approach from transportation studies which focus about capacity on pedestrian and cycle trails using empirical data to examine user flows in terms of standards and levels of service. These contrasting kinds of studies make it difficult to integrate their conclusions, but point towards some potential collaboration in addressing the questions posed in this report.

5. Conclusions

5.1 Key findings

5.1.1 Levels of use of urban greenspaces and displacement

The evidence identified in this assessment provides some preliminary findings regarding user displacement from urban greenspaces due to high and low levels of use.

It confirms that displacement of users due to high levels of use from one urban greenspace to another does take place, though no empirically derived thresholds beyond which displacement takes place have been identified.

Several studies show that displacement is a complex phenomenon which has both a spatial and temporal element to it. Users may displace not only from one site to another but in the case of large sites they can move within sites, for example from a busy honeypot entrance to a more remote area. Temporal responses to high levels of use include changing the time of day, the day of the week, or even season of their visit as well as adjusting the frequency and length of visits. A far smaller effect of activity displacement in response to crowding also exists. Studies of displacement rely on perception data about self-reported historic spatial and temporal displacement or the intention to displace, and none reported observed displacement.

A number of studies showed that high levels of actual use and users' perceptions of crowding at a site are sometimes not aligned and also confirmed that perceived crowding varies according to a number of factors either indirectly related or unrelated to use levels. These range from the physical characteristics of the site; the recreational activities and behaviours of other site users; place attachment; prior experience of the site; demographic characteristics such as age, gender, cultural background; and social characteristics (e.g., users may be naturally crowd-tolerant, for whom certain levels of social contact during use of urban greenspace is both acceptable or even desirable, or alternatively users may be crowd-averse).

Social heterogeneity means that while broad segments of crowd-tolerant, crowd-indifferent and crowd-averse users can often be identified through multi-variate analysis of survey data, even these groups are not homogenous, and the profile of users may vary from site to site and from activity to activity. One study attempted to define the relationship between the crowding tolerance of different types of users and the time during a year when those tolerances were exceeded based on actual visitor numbers. This showed that perceptions of crowding are therefore variable and personal – to put it colloquially, for a given individual there may be a 'Goldilocks zone' in which the number of users is perceived as not too many, nor too few, but 'just right'.

While no quantitative thresholds were identified from the literature above which displacement may occur, some studies addressed the concept of social carrying capacity for recreational sites, which suggests there is a level beyond which users' recreational experiences are unacceptably compromised. Footprint Ecology suggested a social carrying capacity for natural greenspaces around towns in England occurs at a density of 1 person/ha/hour (roughly equivalent to 10/ha/day).

This review also identified studies showing that high use levels and perceptions of crowding can trigger other behavioural responses or 'coping behaviours' as well as problem focused behaviours such as displacement. These behaviours can also include such as emotional responses such as a variety of forms of aggression towards other users or realignment of expectations of the recreational experience they are encountering.

A diagrammatic representation of these findings showing the multiple influences over an individual's decision to leave a site or not are illustrated in Figure 7. This shows how the site characteristics (the physical nature of the site), site detractors (such as litter, facilities, and demographics of visitors), the onsite behaviours of visitors (such as choice of activities or inter-user conflicts), visitor social profiles and chosen coping behaviours all interconnect to shape decisions about whether or not to displace.

Low levels of use may also be a factor in a decision to displace from a site as a small number of studies have shown. While studies using survey data show low levels of use are strongly linked with feelings of fear and concern for personal safety, a small number of studies have also shown that low levels of use in urban greenspace are desirable for certain activities (e.g., walking dogs off leashes) and to meet social expectations.

5.1.2 Levels of use of urban green routes and displacement

Studies of use of urban green routes concentrated exclusively on the interactions between pedestrians and cyclists. Examples of actual or intended displacement by either group from one green route to another have not been reported in any studies reviewed. Why inter-route displacement has not been identified is not clear: it could be that studies have not seen this as a valid research question, or it may be that tolerance of crowding on such routes is affected by limited options for displacement from linear routes except onto adjoining roads with traffic. Displacement reported from the evidence reviewed takes the form of microscale intra-route displacements or adjustments to behaviour to avoid collisions with other users or to enhance their recreational experience.

Those studies about crowding on urban green routes emphasise that urban green routes are used not only for recreation but also for commuting, particularly by cyclists. For cyclist commuters, minimising journey time to work is often an objective so the speed of their journeys is greater than for recreational use. Conflict potential occurs when recreational and commuting uses coincide in space and time.

5.1.3 User group effects of displacement

This review found no evidence that specific user groups directly displace other user groups to different sites. However, there are some consistently reported interactions between users of urban greenspace; these can affect perceptions of crowding by certain groups and therefore potentially to a decision to displace. For example, several studies consistently identified dog walkers who wish to let their dogs off the leash as contributing to perceptions of crowding, thereby creating potential conflicts with multiple user groups. Mountain bike users and cyclists are also key groups which disturb other users. The effects of interactions between minority and sedentary pursuits in urban greenspaces have however not been studied.

5.1.4 Challenges of measurement

The studies we reviewed mainly concentrated on understanding the demographics and motivations of urban greenspace users rather than on measuring the numbers using them; in other words, we know much more about who is using urban greenspaces than how many, and much more about why they use them than why they don't.

Moreover, varied and non-standardised approaches to measurement and reporting of results relating to the three key concepts of displacement, crowding and social carrying capacity have not allowed any meaningful comparisons between studies and drawing of conclusions beyond individual sites, a finding which confirms the view of Arnberger & Mann, 2008.

Furthermore, displacement studies use self-reported behaviour drawn almost always from on-site intercept interviews in which the user states they have displaced in the past or intend to do so in future. The disconnect between human intentions and actions means that the intention to displace may not always lead to actual displacement. On-site respondents by definition have not displaced to another site, though they may have displaced temporally; we found no examples of studies addressing observational measurement of actual displacement.

Some studies on health and active living in urban greenspaces have attempted to identify non-users in order to understand barriers to greenspace use, but research questions relating to non-use specifically due to displacement have not been identified in any of the studies reviewed here. Obstacles to firstly identifying and then engaging with non-users of urban greenspace to understand if they are genuinely displaced or have no interest in their use are considerable (Alison Millward, 2023, personal communication).

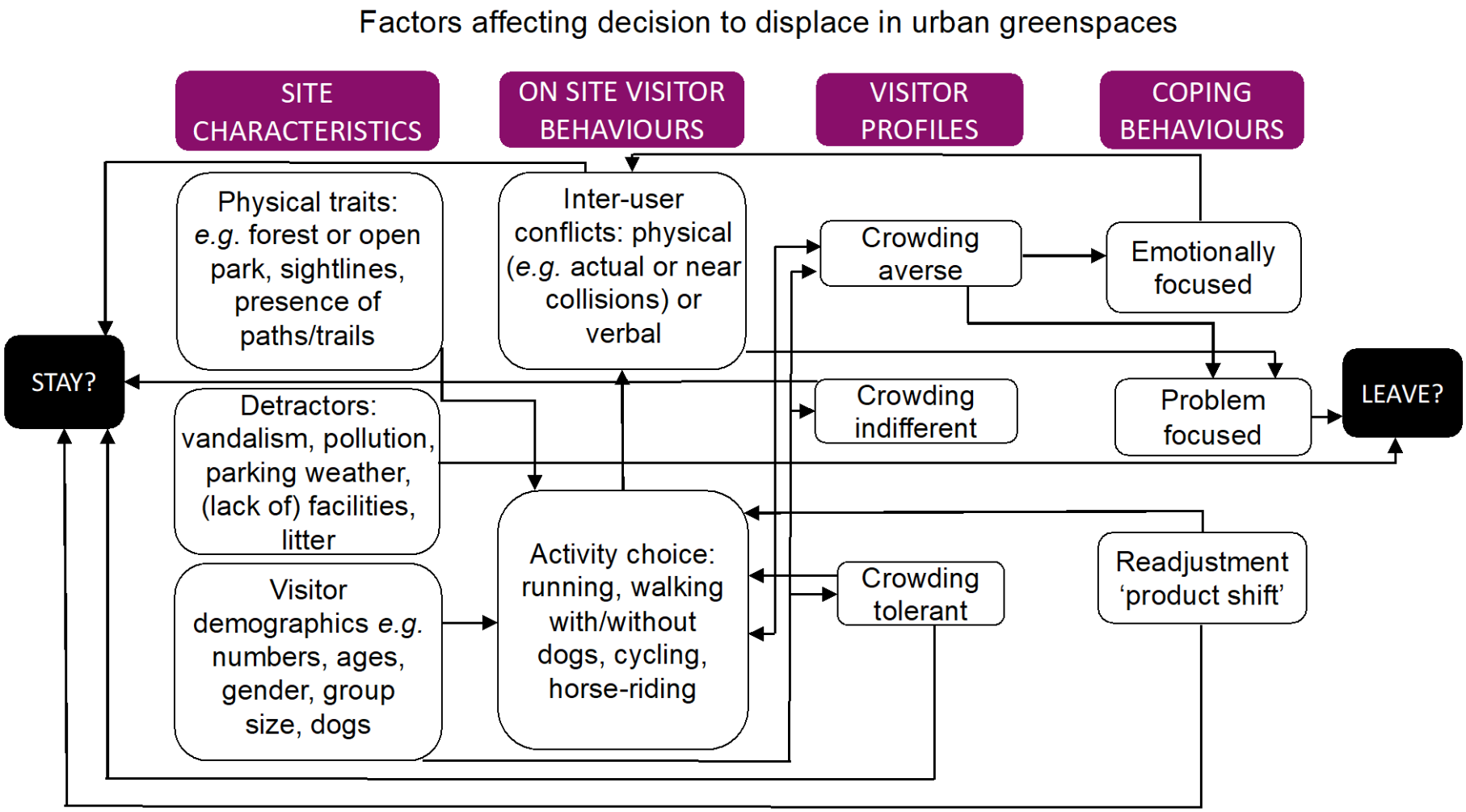

Figure 7. Summary of main factors affecting decisions to displace from urban greenspaces

5.2 Study limitations

Some limitations should be noted about this review. In particular, the body of reviewed evidence itself has some shortcomings. There is a large reliance on studies from a particular city (Vienna) and one author (Arnberger). The relevance and robustness of these studies was high, drawing on multi-variate analysis to explore the complexities of crowding and displacement and without this body of work this review would have been considerably weaker; however, there is a possibility that some of the conclusions drawn from these studies may not be wholly applicable to the UK given that these studies all focus on urban forests rather than other kinds of urban greenspace. This also applies to the results from those studies in Asia where social tolerances of crowding and social norms connected with use of outdoor spaces differ to some degree from European societies as suggested in the evidence reviewed.

In addition, direct comparison of data between studies was not usually possible given the different approaches to measuring visitor numbers and user density. Studies reviewed were heavily dependent on questionnaires administered through on-site surveys as well as on-line to generate data and several studies in urban and peri-urban forest settings mentioned that cyclists' views, and to a lesser extent runners/joggers' views were underrepresented in their samples given the nature of their activity.

The project also began with the assumption that a lot of visitor survey reports are unpublished and not readily available. While some unpublished reports are in the public domain and online, some were accessible only through organisations' own files, and required contact with experts to retrieve them. Expert elicitation interviews were restricted due to the time available to complete the review.

5.3 Implications for future monitoring and research focusing on evidence gaps

A number of gaps in knowledge have become evident.

- Site-focused monitoring of visitor numbers at urban greenspace sites is needed to answer basic questions about levels and patterns of visitor use. This is particularly important where density-related guidelines on the provision of greenspace have been adopted in planning guidance (for example, as has been done for SANGs) to ensure that greenspaces do not become too crowded.
- Standardised methodologies for crowding research and displacement studies are needed especially those which can combine perception-based data with monitoring of actual user numbers.
- A set of simple recreational quality indicators is needed to understand if the social carrying capacity of areas of urban greenspace in terms of visitor density/recreational quality has been reached.

- While considerable work has been done on the impact of high use levels on the ecological value of natural greenspaces including those in urban areas, it is unclear how high use levels of urban greenspaces might interfere with the physical and mental wellbeing effects and other cultural ecosystem services and social benefits such as contact with nature, recreational opportunities which accrue from urban greenspace.
- Cultural differences underpinning social preferences and perceptions of crowding of urban greenspace users are an under-explored area but important to understand in the context of multi-cultural societies sharing the same urban greenspace resource.
- Evidence for interactions and potential conflict as a predisposing factor to displacement has focused on pedestrians and cyclist user groups. Further investigation into interactions between these groups, minority activities (such as Nordic walking and e-scooters for example) and sedentary activities focused on social interactions would be highly relevant in the context of urban greenspaces.
- In particular, evidence about the degree to which noisy use of urban greenspace contributes to crowding perceptions and so deters and displaces certain groups of users especially those seeking quiet and stress relief has not been explored to our knowledge.
- Collaboration efforts between recreational researchers and transport design researchers could bring together insights into crowding and coping behaviours with an in-depth understanding of levels of service, user flows and management of speed on urban green routes especially city shared use and other non-motorized green routes.
- The phenomenon of inter-site displacement along urban green routes has not been identified from this review so further exploration of whether this is a true evidence gap would be valuable as would investigations of what coping behaviours are triggered by crowding on urban green routes.
- Identifying and studying non-users of urban greenspaces would help to understand whether they had been displaced or deterred from using them.
- The patterns of temporal displacement in the use of urban greenspaces already noted in relation to subtropical climates could become more pronounced in temperate regions of the world because of changing climatic conditions. Given the well-known cooling effects created by urban greenspaces especially in summer in temperate zones, what potential effects might climate change have on levels of use in future and especially on temporal displacement.
- Finally, we suggest that there are some broader questions about social equity and displacement of urban greenspace users which need defining and addressing. A paucity of urban greenspace provision combined with population pressure created by urban densification may affect users' perceptions of crowding and levels of use of urban greenspace, which may have consequences for increasing social inequalities amongst city inhabitants.

5.4 Implications for policy and practice

High and low levels of use of urban greenspaces present practical challenges for urban greenspace managers and urban planners. In this final section we set out some of the most pressing of these emerging from the evidence presented in this assessment,

- The adoption of new low cost and efficient methods for assessing user density levels in urban greenspaces such as aerial surveys and mobility data should be considered by recreational managers to address underlying lack of information for decision-making.
- Information about differing patterns of use by different recreational groups throughout the day and the week is important in managing urban greenspaces so that resources for staffing, signage and improvements to recreational infrastructure can be effectively deployed at the most appropriate times. In addition, such information has the potential to pre-empt and inform the management of conflicts between different user groups.
- Google has a facility labelled “popular times” which shows the level of use of named places including greenspaces day by day and hour by hour. (It takes information from people who have automatically opted in to “Google Location History”.) Urban greenspace managers and users alike may find this information useful.
- The diversity of users who may often share a single urban greenspace needs greater recognition in management planning to take account of different social characteristics, different expectations of interactions with others and different levels of recreational satisfaction. Zoning of activities and provision of trails for high use and low use activities may help to achieve this at some sites.
- Changes to recreational experiences requiring dogs to be on leads or banning the use of certain trails by mountain bikers, may stimulate unforeseen displacement behaviour to other sites; such decisions should be made in the context of other nearby urban greenspaces.
- The importance of past experience in perceptions of crowding has relevance for local residents who use sites frequently; their involvement in planning and management of their local urban greenspaces could be one way of reducing perceptions of crowding and enhancing their user experience of the site in question.
- Potential conflict between dog walkers and other users in urban greenspaces is being addressed in some areas by the creation of dedicated areas within urban greenspaces or dedicated dog parks. The success of this provision for urban dog walkers has not yet been fully assessed compared with other measures such as requiring all dogs to be on leashes.
- High levels of use in urban greenspaces not only have social consequences for users but also ecological consequences by reducing areas where wildlife can remain undisturbed. This applies to displacement both within sites if users are moving away from honeypot areas or between sites where users are substituting use of one site for another.
- In the context of England, the provision of Suitable Alternative Natural Greenspace is part of planning strategy to encourage recreational displacement of visitors from

sensitive sites such as SPAs and SACs. However, while SANGs provide the local places where such displacement is deemed to be less ecologically sensitive, proactive measures to encourage such displacement from SPAs to SANGS may need to be taken and subsequently monitored to ensure use does not exceed acceptable levels.

- While urban densification can create some environmental advantages such as reduced carbon emissions, urban planners should ensure that adequate urban greenspace compensation for densification and gentrification of urban areas is undertaken to avoid undue pressure on remaining greenspaces and detrimental health and well-being effects on local residents.
- Ensuring adequate urban greenspace compensation is particularly important in the context of a changing climate as the importance of urban greenspace in providing shade will increase. Overall planning of urban greenspace provision must also ensure that potential displacement due to high levels of use or indeed other reasons does not lead to social inequalities preventing access to the climatic amelioration effects of urban greenspaces.

6. References

NB: Studies in bold denote inclusion in the core evidence base of 40 studies.

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7. Glossary

Crowding - a psychological response to high numbers of people.

Displacement - the act of individuals removing themselves from a problem situation (i.e., crowding).

GPS - Global Positioning System - a satellite-based radio navigation system owned by the US government.

Likert scale - the most widely used approach to scaling responses in survey research; respondents specify their level of agreement or disagreement on a symmetric agree-disagree scale for a series of statements.

Place attachment - a concept in recreational research describing a positive emotional, symbolic or functional tie to a particular place.

SANG - Suitable Alternative Natural Greenspace; a recreational site created to attract residents of new developments away from designated sites such as Special Protection Areas and Special Areas of Conservation that are protected for their high biodiversity value and which are sensitive to recreational pressures and activities.

Social carrying capacity - the level of use beyond which (recreational) experience parameters exceed acceptable levels.

Spatial vitality - a weighted average of four visitor measures: diversity of age group, visitor density per hour, space usage intensity (per capita ground area) at the peak time and richness of activity types.

Special Areas for Conservation –protected areas in the UK which are important high quality conservation sites designated under the Conservation of Habitats and Species Regulations 2017 in England and Wales

Special Protection Areas – protected areas for birds in the UK classified under the Conservation of Habitats and Species Regulations 2017 in England and Wales

Urban densification – increasing density of people living in urban areas.

Urban gentrification – shifts in the socio-economic status and demographics of urban communities.

VGI - Volunteered Geographic Information; geospatial content generated for free by volunteers using mapping systems available on the internet.

8. Appendices

8.1 Appendix 1 - Attributes recorded for the 194 assorted studies identified from the first screening exercise

ATTRIBUTES
Country of study
Location of study
Name of urban area
Type of urban area: (e.g., town, city, mega-city)
Size of greenspace studied (ha) OR Length/width of green routes (km)
Type of greenspace
Type of green route
Timescale over which data collected
Study addresses greenspace and routes in combination (Yes/No)
Data collection methods (e.g., physical counts, automatic counts, video, drones, social media, GPS tracking, questionnaires)
Activities of major recreational user groups included in study e.g., hiking, walking, dog walking, cycling, mountain biking, other) Is study focusing on mixed or single group?
Types of users analysed (e.g., unspecified, specific groups e.g., young, elderly, ethnic minorities, women, focus on intersectionality)
Quantitative data on user levels presented: (Yes/No)
Qualitative data on user perceptions of use particularly crowding levels: (Yes/No)
How user density is recorded: (e.g., counts past a fixed point, visitors per hour)
Study explicitly mentions/addresses crowding, displacement, barriers
Study explicitly addresses reference to size/provision of greenspace linked to population numbers (numbers/ha, numbers within walking distance)
Study addresses optimal user numbers: (Yes/No)
Miscellaneous observations/comments:

8.2 Appendix 2 - Inclusion/exclusion criteria for the second stage screening

ATTRIBUTES	INCLUSION	EXCLUSION
Country of study	Europe, North America, South Asia, Australasia	None (but obvious cultural differences to be noted)
Location of study	City, urban, peri-urban, urban-proximate (defined as within 5-10km of city/town edge)	Wilderness and 'back country' areas of USA, protected areas in rural locations
Size of greenspace/dimension of urban routes	Area/length given in hectares/km	No size/length mentioned
Type of greenspace	All	Blue space (i.e., lakes, beaches, coastal areas) but greenspaces containing waterbodies included)
Type of green route	All (e.g. greenways, urban trails)	Blue routes (rivers, canals) but include green routes which run alongside blue routes
Timescale over which data collected (a few weeks/a season, a year, multiple years)	All	No exclusions
Data collection methods (physical counts, automatic counts, video, drones, social media, GPS tracking, questionnaires)	All	None (NB some methods only provide relative data on density of use and questionnaire studies give data perceptions of crowding rather than absolute figures)
Data collected explores visitor density, perceptions of crowding, displacement, social carrying capacity	Yes	No

Types of users analysed (unspecified, specific groups e.g., young, elderly, ethnic minorities, women, focus on intersectionality)	Any including single focus studies e.g., adolescents/the elderly, women	None
Types of activities	Land-based recreation activities e.g., walking, dog walking, jogging, running mountain biking, (no studies identified on picnicking, nature observation, e-bikes, motorbikes)	Watersports such as boating, canoeing, kayaking; winter sports such as skiing and snowshoeing
Accessibility of paper	All online accessible papers	No online version identified/only accessible behind paywalls
Relevance	Study research questions aligned to the research questions for this evidence assessment; study addressed interrelationships between user numbers at sites, perceptions of crowding and subsequent user displacement.	Study research questions not obviously aligned to this assessment; relationship between user numbers, crowding and displacement not addressed
Robustness	Clearly presented results and method description, representative samples in qualitative surveys; no obvious evidence of bias arising from the circumstances of publication.	Confusingly presented results, little detailed information about the methods and approach used; bias in the discussion of results

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