# Understanding the use of greenspace before and during the COVID-19 pandemic by using mobile phone app data

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**Abstract**

Engagement with natural areas has increased during the Covid-19 pandemic, and this may well form one of the enduring legacies of this time. A better understanding of human interactions with urban greenspace, and how patterns of use have changed, including inequalities of use, will be crucial for decision makers to adequately manage and direct resources within these natural spaces as we recover from the pandemic. Current evidence on use of natural spaces is limited and does not easily support site-specific analysis or with fine spatio-temporal distinctions. Coupled with difficulties on primary data gathered throughout the pandemic, there is a general knowledge gap on how changing behaviour has reshaped the use of natural areas and what inequalities have arisen in this dynamic. Through the case study of Glasgow's open spaces, with a specific focus on one urban park, we apply new forms of urban big data from mobile devices to show how the use of greenspace has changed through the restrictions imposed during Covid-19 pandemic. The research findings will help park managers, urban planners, and policymakers better design the recovery and renewal of our cities after the pandemic.

## 1 Introduction

Natural ecosystems, including urban green and blue spaces, are valued for diverse reasons. On the one hand, they are important for natural environment conservation and biodiversity (Haines-Young and Potschin-Young, 2018). On the other hand, they provide an array of valuable cultural ecosystem services by offering spaces for leisure and recreation which can promote mental and physical health and well-being (Nath, Zhe Han and Lechner, 2018). In a time of pandemic, the perceived benefits of natural spaces are amplified (Kleinschroth and Kowarik, 2020; Poortinga et al., 2021). Nature has been a source of physical and mental respite for many during the pandemic, with lockdown rules heightening the appreciation for local parks and greenspaces (Kleinschroth and Kowarik, 2020). While restrictions on movement may initially have reduced access to greenspace (Ugolini et al., 2020), appreciation for these natural spaces has grown (Ugolini et al., 2020; Poortinga et al., 2021), and the use of parks and public greenspaces has increased overall in comparison to previous years (Natural England, 2020; Office for National Statistics, 2021). Understanding public interactions with urban natural areas, and the factors that influence behaviours in these areas, can improve decision making on how to best preserve or enhance the benefits they provide to the communities who engage with them (Kabisch, Qureshi and Haase, 2015). Despite the rising importance of greenspace in public policy, the understanding of human–environment interaction in urban greenspace is incomplete (Kabisch, Qureshi and Haase, 2015) with shortfalls in traditional research methods. Traditionally, the survey questionnaire is the most common tool used to understand interaction with urban greenspace, conducted in person on-site or off-site through a telephone/internet survey (Kabisch, Qureshi and Haase, 2015). While fundamental to understand the wide-scale changes in preferences and social norms towards nature spaces, especially in critical times like these (Natural England, 2020; Office for National Statistics, 2021), the technique has several disadvantages for analysis at high resolution. Although providing a wide socio-demographic coverage, surveys often lack spatial-temporal details, can be highly aggregated, suffer from low response rate, and may not cover individual observations over a prolonged period of time. The broad focus and sampling strategy of survey-based techniques cannot provide the near real-time insights needed at a local level to inform management strategies. To better understand how patterns of greenspace use have shifted during the pandemic, and whether these represent a temporary phenomenon or a more durable shift or structural change, we can look towards new forms of urban big data. The global penetration of smartphones and the integration of Global Positioning System (GPS) technology in various portable devices generate large volumes of opportunistic behavioural data, which open a window into how people use natural spaces (Ilieva and McPhearson, 2018; Cui et al., 2021). In the context of urban greenspace, the last decade has seen rapid growth in the application of GPS data from mobile phones for the exploration of human-nature interactions in the city (Cui et al., 2021). Throughout the Covid-19 pandemic, researchers have sought to understand changes in the use of greenspace (Ugolini et al., 2020; Poortinga et al., 2021), however, response using mobile phone data has been limited to more general mobility patterns (Khataee et al., 2021). In terms of urban greenspace, urban big data from Strava and Google have been applied to explore human-nature interactions through the pandemic (Venter et al., 2020; Rice and Pan, 2021), however, at the time of writing, a clear gap exists in in the literature to utilise new forms of mobile phone data to shed light on the situation before and during pandemic. Through the case study of the City of Glasgow's open spaces, with a specific focus on the Alexandra Park, this research explores how new forms of urban big data can be used to better understand human-nature interactions through the changing restrictions caused by the Covid-19 pandemic.

# 2 Data and Methods

## 2.1 Data and study area

The mobile phone app data used in the analysis is location-based service data from Huq (https://huq.io/). This data is generated when a mobile phone application updates the location of a mobile device using a combination of available location sensors, such as Bluetooth, cellular tower, Wi-Fi, or GPS (Wang and Chen, 2018). The data features high resolution (typically 10s of metres), timestamped location information (geospatial coordinates) for individual mobile users captured periodically to reflect mobility and behaviour events covering the period 2019 to 2020 for activities within Glasgow, UK. The case study area consists of a large sample of over 300 major open spaces located in the City of Glasgow, UK. The spatial extent of the natural areas was made available by Glasgow City Council for use in this research and encompasses all major opens spaces, amenity spaces and parkland in the city. Geomni UKBuildings land use data was utilised to enrich the mobile data for the process of home location detection. The dataset represents the structure, characteristics, and use of commercial, public and residential buildings across the study area, available through the digimap services in the UK (https://digimap.edina.ac.uk/).

### 2.2 Data analysis

Using 2019 and 2020 mobile phone app data from the provider Huq, we extracted all GPS points (impressions) within Glasgow's open spaces. Since we had the unique user ID for each of the mobile phone app users, we were able to understand different users' movement patterns within the city. For one site of specific importance to local policy makers, the Alexandra Park, we also extracted the number of visits for the 2020 period and assessed the 7-day rolling average. For visitors to this site, we estimated a home region at the Scottish datazone level. We expanded the state of the art in home detection algorithms by first enriching the mobile phone app data with high resolution land use data from Geomni's UKBuildings layer. For each visitor to Alexandra Park, we enriched their mobile phone app data and analysed only impressions within residential space. Based on common activity heuristics techniques (Alexander et al., 2015), a user's home region was assumed as the region where they recorded the maximum number of active evenings in residential space during the study period; where an evening is assumed to be 8pm to 7am. Only users who returned a definitive home region were retained for further analysis. Finally, we assessed the number of impression/visits throughout the pandemic to Alexandra Park and explored where these visitors were coming from.

## 3 Results and Discussion

### 3.1 Mobile phone app data in Glasgow's open spaces

We extracted over 769,000 impressions across two years in Glasgow's open spaces (Figure 1). The sites with the most impressions were Kelvingrove Park, Glasgow Green and Pollock Country Park (Table 1). George Square and the Botanic Gardens are also present in the list. Parklands represent a much larger surface area than amenity and open space, and it is not surprising they dominate the list of top sites in terms of the number of impressions. The relatively smaller open and amenity spaces have less impressions overall but have a higher density of impressions which is also to be expected.

Table 1. Huq impressions in the top 4 open spaces (2019/2020).

| Name | Location | Impressions | Per ha |
|---|---|---|---|
| Kelvingrove Park | West End | 55497 | S1614 |
| Glasgow Green | Parkhead | 46508 | 875 |
| Pollock Country Park | Cardonald | 42299 | 300 |
| Small community park | Parkhead | 27499 | 53195 |

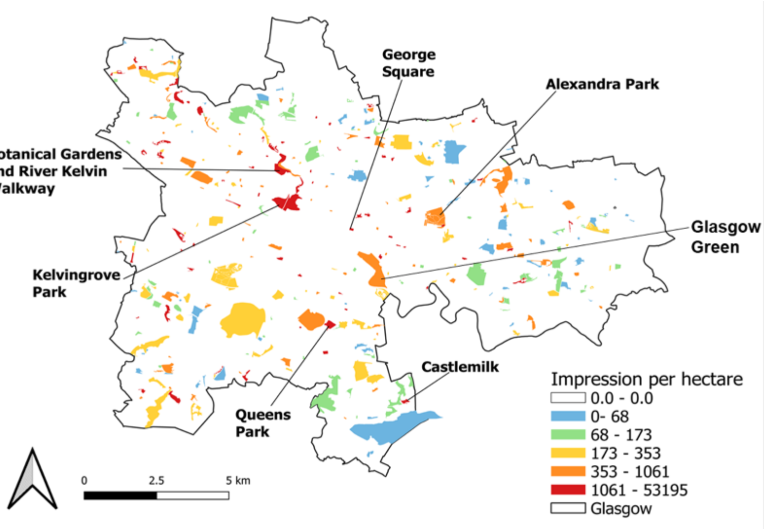
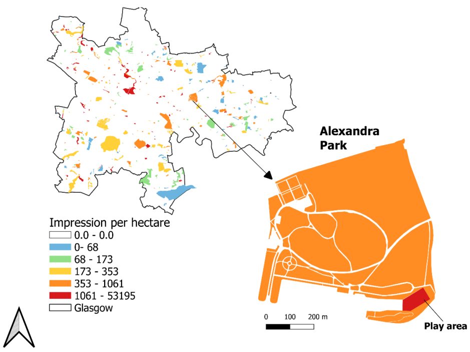
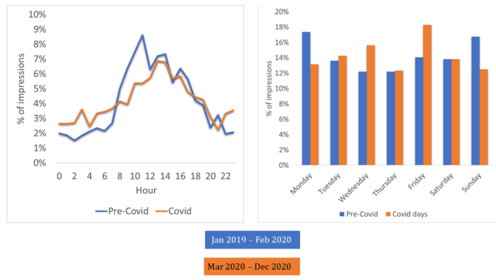



**Figure 1** Huq impressions in Glasgow's open spaces (2019/20)

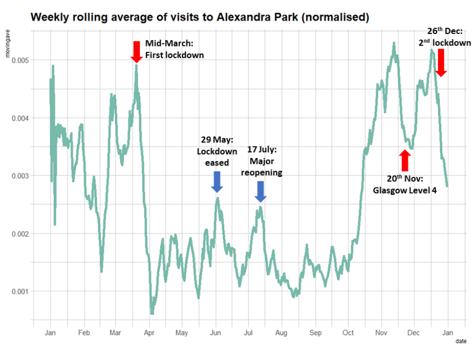



**(a)** Location of Alexandra Park

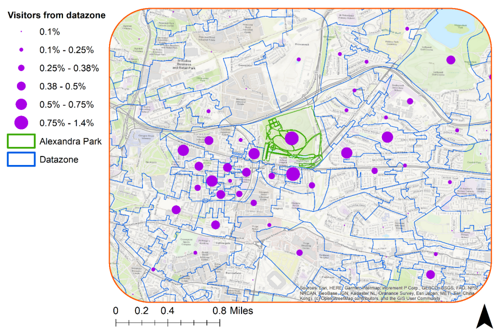



**(b)** Difference in impressions in Alexandra Park before and during Covid-19

**Figure 2** Location and impressions in study area




**(a)** visits to Alexandra Park (2020)




**(b)** Home location for Alexandra Park visitors

**Figure 3** Visits and home location of visitors to Alexandra Park

### 3.2 Changes in use of Alexandra Park during the pandemic

For one site of specific interest to policy makers, Alexandra Park (Figure 2), we tested some more detailed analysis in terms of the changes in use caused by the COVID-19 pandemic. Analysis shows some changes in the morning peak (shift from 10am to 12pm) at the park before and during the pandemic (Figure 2), with some differences in the daily number of impressions between the periods (Sunday and Monday peak rather than Friday peak). The introduction and lifting of various lockdown rules are reflected in the visitation patterns throughout 2020 (Figure 3). After the first lockdown was imposed in March 2020 there is a large drop in visits to the park which did not recover until the end of 2020, and a second national lockdown appears to reduce numbers again. The small reductions in visits following two lockdown easings in the Summer of 2020 could be caused by a substitution effect where the potential to engage in other activities replaces recreation in open space. In terms of who visits the park, Figure 3 shows the distribution of visitors based on their home region. We can clearly see that the surrounding residential neighbourhoods makes up a large portion of those visiting Alexandra Park which is to be expected given the various stay at home/stay local measures imposed throughout 2020.

### 3.3 Limitations and future directions

The research presented here should garner support for urban big data for human-nature interaction, but some limitations should be noted on the findings presented. While this type of mobile phone app data represents the near exact location of the device, with a higher spatial precision and higher granularity than other types of mobile phone app data such as call detail records (Wang, He and Leung, 2018), there remains some level of error in the GPS data. The analysis does not account for GPS points that may fall inside or outside of the open space boundary in error due to the limited accuracy attributed to the GPS point. Future research will overcome this by relying on stop detection techniques which looks at a user's impression in time sequence to ensure those passing by the open space are not mistakenly included as part of the analysis. In terms of representativeness of the data, these new forms of data carry the risk of bias through uneven population and demography coverage (elderly and vulnerable groups have lower mobile phone usage rate) while the details of dataset construction lie largely hidden, dependent on private providers. This may lead us to mis-diagnose problems and misdirect efforts to reduce inequalities, for example, or to produce results which are dataset-dependent rather than generalisable. In future work we will explore the inherent biases of mobile phone app data and develop correction techniques which achieve more representative population coverage for mobility research.

## 4 Conclusion

While the health and well-being benefits of greenspace access have been increasingly recognised, they have taken on even greater significance over the last 16 months due to the Covid-19 restrictions, which may form one of the enduring legacies of this time. This research sheds light on the changes in use of greenspace through the case study of Glasgow's open spaces and one urban park in particular, Alexandra Park, throughout the various Covid-19 related restrictions. Our findings show that the park was most visited by those in the surrounding area and that visitation patterns was impacted by the various lockdowns and stay at home orders throughout 2020.

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