

Research Paper

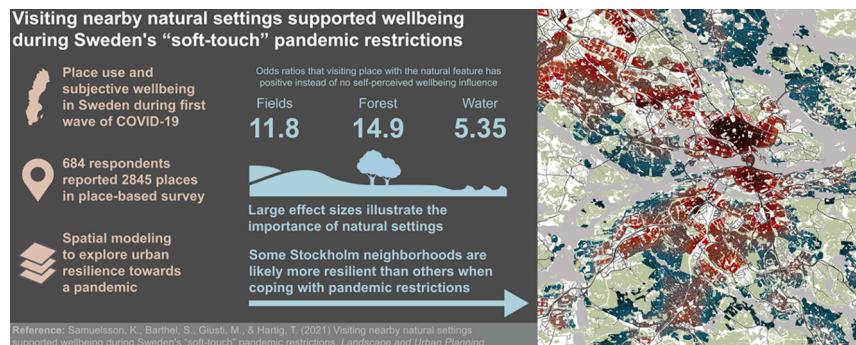
Visiting nearby natural settings supported wellbeing during Sweden's "soft-touch" pandemic restrictions

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HIGHLIGHTS

GRAPHICAL ABSTRACT

- Spatial modelling of place use and wellbeing in Sweden during COVID-19.
- Easy access to natural settings supports wellbeing under "soft-touch" restrictions.
- No evidence for a link between population density of visited places and wellbeing.
- Equitable access to natural settings can increase urban resilience towards pandemics.
- Strategies can synergize with climate change mitigation and biodiversity protection.



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ABSTRACT

The coronavirus pandemic entailed varying restrictions on access, movement and social behavior in populations around the world. Knowledge about how people coped with "soft-touch" restrictions can inform urban spatial planning strategies that enhance resilience against future pandemics. We analyzed data from an online place-based survey on 2845 places across Sweden that respondents abstained from visiting, visited with similar frequency, or visited more frequently in spring 2020 as compared to before the pandemic. In spatial logistic regression models, we relate geographical and sociodemographic properties of places (fields, forests, water, residential population density and daytime population density) to self-perceived changes in wellbeing from visiting the given place less or more often, respectively. Abstaining from visiting places with natural features located in areas of high residential density was associated with a self-perceived negative influence on wellbeing. Yet, fields, forests and water were strongly associated with places people claimed wellbeing benefits from during pandemic restrictions. The further a visited place was from the respondent's home, the more likely it was to have a positive wellbeing influence. As an illustrative case, we map our models onto the landscape of Stockholm, showing that some neighborhoods are likely more resilient than others when coping with pandemic restrictions. Both the most and least resilient neighborhoods span the socio-economic spectrum. Urban planning will do well

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to enable equitable, easy access to natural settings by foot or bike, to increase pandemic preparedness as well as support climate change mitigation and biodiversity protection.

1. Introduction

Urban residents' wellbeing is linked to experiencing different places in everyday life (Heller et al., 2020). Easy access to different places enables such experiential diversity on a neighborhood scale (Samuelsson, Colding, & Barthel, 2019). Access may however get restricted for various reasons. In 2020, urban dwellers worldwide altered patterns of daily place visits in response to the coronavirus pandemic (de Haas, Faber, & Hamersma, 2020; Venter, Barton, Gundersen, Figari, & Nowell, 2020). With the ensuing concentration of activities in their homes that people previously undertook elsewhere, like schooling or paid work, possibilities to periodically escape household confinement without risking infection have appeared especially important for maintaining wellbeing (Stieger, Lewetz, & Swami, 2020). We address these possibilities as place-based strategies for managing the demands of life and their psychological consequences, commonly referred to as coping (e.g. Korpela et al., 2018). We treat the possibilities for place-based coping as an aspect of urban resilience, or the ability of an urban system to adapt and continue to function in the face of disturbance (Meerow, Newell, & Stults, 2016). The experience with the COVID-19 pandemic calls attention to the ways in which urban resilience necessitates access to places that support people's efforts to cope, but without imposing dangerously increased risk of infection. Access to natural settings in particular has emerged as a likely component of this pandemic resilience (Venter et al., 2020).

Urban areas without opportunities for safe place-based coping could see more risky behavior and higher infection rates among some residents (Johnson, Hordley, Greenwell, & Evans, 2020) and greater social isolation among others (Okruszek, Aniszewska-Stańczuk, Piejka, Wiśniewska, & Żurek, 2020). Objective isolation can provoke loneliness (Hawley & Cacioppo, 2010), and a vicious cycle involving loneliness and anxiety (Cacioppo et al., 2006) may arise amid pandemic restrictions (Okruszek et al., 2020). Over months, distress can build up among those in lockdown (Gan et al., 2020) and continuing social isolation may increase the prevalence of depression (Holmes et al., 2020). The stringency of pandemic restrictions thus involves a tradeoff between limiting the spread of infection and limiting adverse mental health consequences over time. Less stringent strategies have allowed urban residents to visit nearby natural settings. Ample research indicates that such visits can engender psychological wellbeing by affording physical activity, social contacts and neighborhood social cohesion, relief from stress and cognitive fatigue, and a sense of connection with the surrounding world (e.g. Astell-Burt et al., 2021; Jennings & Bamkole, 2019; for reviews see Hartig, Mitchell, de Vries, & Frumkin, 2014; Markeych et al., 2017). Evidence is now rapidly amassing that visits to natural settings have helped urban residents sustain their wellbeing during pandemic restrictions (Johnson et al., 2020; Lesser & Nienhuis, 2020; Pouso et al., 2020; Venter et al., 2020).

Adding to this literature, we analyze a dataset of place use across Sweden during late April, May, and early June 2020. From that period and since, Sweden's response to the pandemic has frequently been described as "soft-touch" (or alternatively "light-touch") by international news media. While it is not obvious that this term is appropriate for characterizing the Swedish strategy or distinguishing it in international comparisons (Hale et al., 2021), we use it here to highlight that Sweden did not implement shelter-in-place policies, force businesses to close, or impose restrictions on the time people could spend out of the home. People were thus allowed to visit or abstain from visiting many places largely to the same extent as before the pandemic, without concern for punishment (for further details on the Swedish strategy, see Section 2.1). Our aim here is to explore how changes in place use

following such soft-touch restrictions relate to self-perceived changes in people's subjective wellbeing.

Subjective wellbeing is a multi-dimensional concept that encompasses life satisfaction, momentary experiences, and sense of purpose, but which differs from objective wellbeing (fulfilment of fixed needs) and preference satisfaction (fulfilment of wants and desires) (Dolan & Metcalfe, 2012). While leaving sense of purpose aside, we integrate experiential wellbeing and life satisfaction by asking people to rate how visiting or abstaining from visiting places has influenced their general feeling of wellbeing. Following Dodge, Daly, Huyton, and Sanders (2012), we view subjective wellbeing as a reflection of a balance between an individual's resource pool and challenges they face. This view of wellbeing resonates with a place-based approach (cf. Lewicka, 2011) and with the notion of urban resilience, as urban space and places can stand as resources that many individuals will simultaneously need to draw upon as they cope with a substantial challenge like a pandemic. This view also complements a classic view of psychological stress as a perceived excess of demands in relation to the resources needed for coping (Lazarus & Folkman, 1984).

An understanding of how changes in place use during soft-touch pandemic restrictions relate to changes in subjective wellbeing can inform spatial planning strategies that build resilience against future pandemics. Focusing on the environment around places people visited or abstained from visiting, we measure population density because Swedes were requested by authorities to limit nonessential interaction with other people and to maintain physical distance between each other in shops, restaurants and public space. Visiting places in high-density areas may negatively influence subjective wellbeing because of fear of infection, but abstaining from visiting places in such areas may negatively influence wellbeing if those places were used for social interaction or accessing urban services in pre-pandemic times. We also measure natural features around places visited since visiting natural settings appears to have been an important coping strategy for many people, especially urban inhabitants (see above). Lastly, we measure how far the places visited are from respondents' homes, because Swedes were requested to refrain from all nonessential travel. The analysis is divided into three parts. First, we provide a descriptive analysis of the sample and the places they visited or abstained from visiting. Second, using spatial regression models, we investigate the properties of places associated with positive or negative change in wellbeing from visiting or abstaining from visiting them. Third, as an illustrative case, we extrapolate from the regression models to produce a map of Stockholm that shows the proximity of different neighborhoods to places like those negatively or positively associated with wellbeing. We discuss the implications of our results for urban spatial planning strategies that consider environmental justice and preparedness towards future pandemics.

2. Methods

2.1. Case

The relative autonomy of Sweden's public agencies and local public authorities is established in the constitution (Jonung, 2020), resulting in the national response to the COVID-19 pandemic largely taking the form of guidelines revolving around individual responsibility (Petridou, 2020). Legal restrictions in Spring, 2020 were limited to restaurants and bars only serving food and drinks to seated guests (from March 24th onwards), public events not gathering more than 50 participants (from March 29th onwards), and elderly homes not accepting visitors (from March 31st onwards). High schools and universities moved classroom

teaching on-line, but preschools and elementary schools remained open. Working from home whenever possible was strongly recommended, as was avoidance of unnecessary travel by collective modes (buses, trains and planes). Extensive media coverage and ubiquitous signage in public places reminded people to maintain physical distance from others. Representatives from the public health authorities provided daily briefings through the major media and expressed that the measures would serve to flatten the curve of infections and so avoid an overwhelming burden on the health care system.

Sweden's soft-touch approach received much attention in the international media, in part because it aligned with politicized discussions around the world of pandemic restrictions as governmental infringement on individual freedoms. Representatives for the responsible Swedish governmental authorities took pains at an early stage to explain the thinking behind the country's approach, exemplified by a brief English-language film with the Minister for Health and Social Affairs, Lena Hallengren, and the Director General of the Public Health Agency, Johan Carlson (see [Folkhälsomyndigheten, 2020](#)). They make clear that the Swedish public health authorities anticipated that the pandemic would continue for an indefinite but probably long period; that their response needed to attend not only to morbidity and mortality from COVID-19 infection but also from other causes; and that the various measures adopted would therefore have to address a broad public health challenge of extended duration. Although not explicitly emphasized, the Swedish strategy thus allowed a substantial role for one of the historic pillars of public health promotion – urban parks and greenspaces ([Hartig et al., 2011](#); [Ward Thompson, 2011](#)).

Most of Sweden is sparsely populated, but the larger cities are considerably varied, with interspersion of inner-city closed blocks, modernistic apartment blocks, large housing estates with much green space between buildings, low-density detached housing, and large continuous natural areas. This is especially true of Stockholm, Sweden's capital and largest city. Together with the soft-touch restrictions, these circumstances make Sweden a useful case for understanding how people respond to a pandemic when they have considerable freedom to choose among different kinds of places to visit or abstain from visiting.

2.2. Survey, data collection and sample

Changes in people's place visits and their influence on wellbeing were assessed through an online public participation geographic information system (PPGIS) survey. PPGIS is a method whereby the public are invited to map experiential knowledge ([Brown & Kyttä, 2014](#)). The survey was developed using Maptionnaire (<https://maptionnaire.com/>) as a collaboration between KTH Royal Institute of Technology, the University of Gävle, and the municipalities of Stockholm, Gothenburg and Uppsala. Due to the rapidly evolving and uncertain situation around pandemic restrictions in the spring of 2020, and because the involved municipalities sought to quickly spread the survey to as many of their citizens as possible, a convenience sampling approach directed towards the public was used. The survey was aimed towards all citizens aged 15 and older with basic reading competence in Swedish, and it went online on April 28th, 2020. Information about it was published as a news item on the webpages of the University of Gävle, the Stockholm Resilience Centre and in the newsletter of the KTH School of Architecture and the Built Environment. Information was also published on Stockholm municipality's webpage for urban planning (<https://vaxer.stockholm>) and on Gothenburg municipality's main and urban planning webpages (<https://goteborg.se> and <https://stadsutveckling.goteborg.se/>). Because the survey was a collaboration between several parties, some questions did not pertain to the objectives of this particular study. We present the questions analyzed here below (for the full set of questions, see [Appendix A](#)).

We asked respondents to zoom in on their town on a map of Sweden and mark either a place they had visited less in recent weeks than before COVID-19, one they visited with similar frequency or one they had

visited more than before COVID-19. When respondents marked a place, we asked two follow-up questions. First, what attributes out of a pre-defined list (presented in [Fig. 4B](#)) characterized the place? Our purpose in providing the listed attributes was to capture common uses of places in a city that might have changed due to the pandemic. Respondents could also describe their use of places with their own words, but an analysis of these responses is outside the scope of this study. Second, we asked "How has your feeling of wellbeing been influenced by you visiting this place less/similarly/more as compared to before COVID-19?" The possible answers were "It has been positively influenced", "It has been negatively influenced" or "It has not been influenced". Respondents could mark as many places as they wished. We also asked respondents about their age group (15–19, 20–24, 25–34, 35–49, 50–64, 65–74 or 75+), gender (man, woman, other), occupation (working, student, unemployed, retired) and how many people were in their household (1, 2, 3–4, 5 and more). To analyze how far the visited places were from the respondents' homes, we asked them to indicate a point on the map within 100 m of their home. All questions were voluntary to answer.

After the information published in conjunction with the launch of the survey no further active attempts at recruitment were made. We retrieved data for analysis on June 15th because by then the number of daily respondents had been low for almost four weeks ([Fig. A1](#)). We filtered the data to contain only datapoints (places) within Sweden that were indicated by those respondents who had also provided a home point and their age, gender, occupation and household size. We also excluded 4 respondents who had recorded their gender as "other", because they were too few for reliable model parameter estimation.

2.3. Assigning predictor, control and outcome variables to places

[Fig. 1](#) provides a schematic overview showing how the predictor, control and outcome variables were assigned to places. Predictor variables reflecting environments around places visited were assigned in QGIS ([QGIS Development Team, 2015](#)). When measuring population density, we distinguished between the density of residents in an area (hereinafter residential density) and the density of people who had been working during the day in the area prior to the pandemic (employed or self-employed individuals from 16 years of age; hereinafter daytime population density). These data are provided by Statistics Sweden within 5984 demographic statistical units (DeSU) that range between 700 and 2700 inhabitants ([Statistics Sweden, 2020](#)). We used data on residents in 2018 and daytime population in 2017, the most recent years provided. We measured persons/km² within a 250-m radius of places. This distance was chosen because DeSUs in cities are often just a few hundred meters across, so measurements over areas defined by smaller radii would risk not accurately reflecting the environment around the place. Population density around a place was estimated by (1) calculating population densities within DeSUs, (2) buffering the identified place by 250 m, (3) creating intersection polygons for each overlapping area between a 250 m buffer and a DeSU, where an intersection polygon inherits the population density value of the DeSU it overlaps with, (4) weighting each intersection polygon by its proportion of the total buffer area around the place and multiplying the population density value with this weight, and (5) summing up the weighted population density values of all intersection polygons around the place to obtain a final estimation of population density.

When measuring natural land covers, we distinguished broadly between fields, forests, and water. These categories of land cover conceivably provide different resources for coping with a pandemic. We obtained national land cover data mapped on a 10 m resolution raster during the years 2017–2019 ([Swedish Environmental Protection Agency, 2020](#)). These data represent 25 land cover classes, from which we created the three variables. For fields, we used a single class, "open vegetated areas", which can include for example lawns in urban parks, courtyards or private gardens. For forest, we grouped data for seven

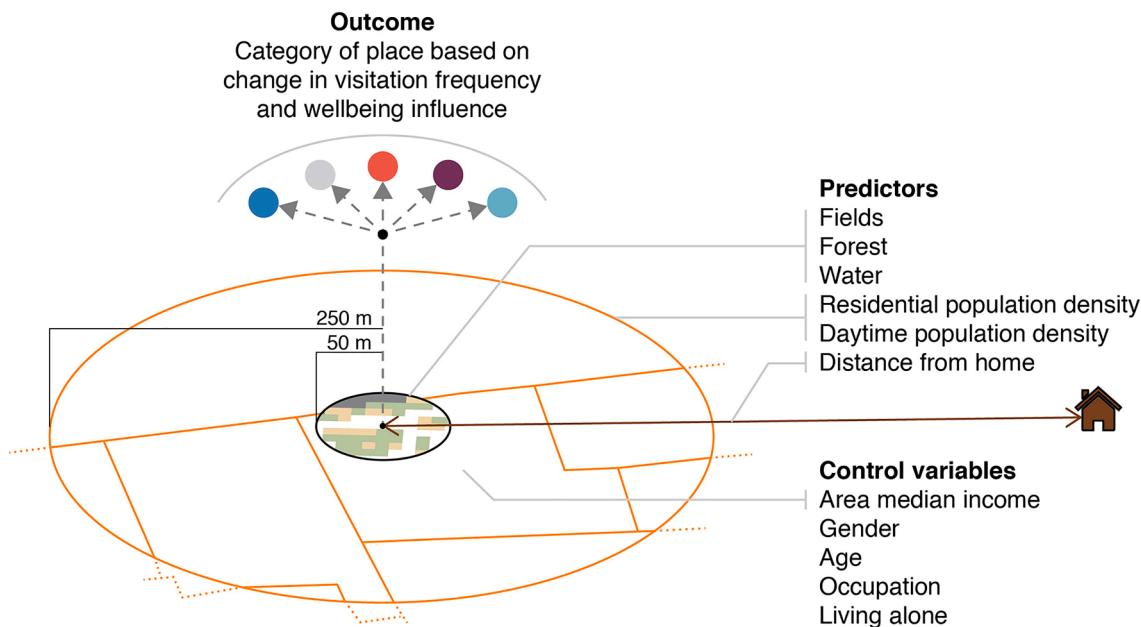


Fig. 1. Schematic overview identifying the predictor, control and outcome variables. Fields, forest and water are measured within a 50-m radius using land cover data on a raster (yellow, green and gray squares within the inner circle). Residential density and daytime population density are measured within a 250-m radius (the outer circle) by weighting overlaps with demographic statistical units (DeSUs) (borders given with orange lines). Distance from home is measured as Euclidian distance (brown arrow).

classes, mainly for large wooded areas but also including smaller wooded areas, for example within urban parks. For water, we grouped two classes, “lakes” and “sea”. The proportion of surface belonging to each variable was calculated within a 50-m radius of place visits. This distance was used because due to the spatial resolution of the land cover data it creates continuous differentiation between places that is spatially detailed. We did not consider forests on wetlands (eight classes) or agricultural land (one class) because although these classes contain vegetation, our focus was on physical more than visual access and these lands are not easily physically accessible for most people.

We calculated the Euclidian distances from the respondents’ home point to the places they identified. Euclidian distance provides a less accurate measurement of spatial accessibility than for example distance through the street network, but we chose it as a pragmatic option that could be implemented consistently across Sweden while still providing valuable indications of the importance of spatial proximity.

As a control variable, we added Statistics Sweden’s DeSU level median income data from 2017 to places. After assigning spatial variables to places, the remaining analysis described from here on was carried out in R (R Core Team, 2016) (see Appendix A for packages). Respondents’ gender, age, occupation and whether they were living alone were also used as control variables.

Combinations of change in visitation frequency and influence on wellbeing were assigned as outcome variable. To explore how abstaining from visiting places influences wellbeing we differentiated between Abstain-Negative (a negative influence on wellbeing from abstaining to visit) and Abstain-Nonnegative (no influence or a positive influence of abstaining to visit). We combined the no influence and positive influence reports because relatively few people reported a positive influence from abstaining from visiting places. To explore how visiting particular places influenced wellbeing, we differentiated between Visit-Negative (a negative influence on wellbeing from visiting), Visit-Neutral (no influence on wellbeing from visiting) and Visit-Positive (a positive influence on wellbeing from visiting).

2.4. Statistical modelling

Associations between geographical properties of places and their influence on wellbeing were explored through spatial mixed-effects logistic regression models (Zhang, 2002). We specified three models: Abstain-Negative places versus Abstain-Nonnegative places (model 1), Visit-Negative versus Visit-Neutral places (model 2), and Visit-Positive versus Visit-Neutral places (model 3).

Because DeSUs are constructed by Statistics Sweden to be relatively socio-economically homogenous, we grouped respondents based on home address DeSU and allowed intercepts to vary randomly between groups. Fields and forest were modeled as continuous variables whereas water was transformed into a binary variable with any presence within 50 m assigned the value 1. Residential and daytime population density were transformed to units of 10 000 s/km². Distance from home was logarithmically transformed because this variable was skewed. Most places were closer than 2 km from home, but some were tens of kilometers away (Fig. 3F), and it was important that the models properly accounted for variation in distances over the first few kilometers. We included age as a continuous variable (1 = youngest, 7 = oldest) and gender and occupation as categorical variables. For the number of people in the household, all values above one were grouped together, to differentiate those living alone from those that do not. This was included as a categorical variable. Variance inflation factors were calculated to ensure multicollinearity was not a problem (Table 2). All predictor and control variables were included in all models except occupation, which was excluded in model 2 to avoid overfitting.

To correct for substantial unmeasured spatial effects which could be present in cities, for example a negative wellbeing influence of visiting places close to bus and subway stops, we included spatial error terms as needed by first extracting residuals and linking them to place coordinates. Residual Moran’s I and its p-value were calculated at regular intervals from 100 m to 10 km circular neighborhoods. Spatial error terms were created at the neighborhood scales displaying the largest significant Moran’s I values, with all points within neighborhoods given equal weight. New regression models including the spatial error terms were fitted, and new residual Moran’s I values of these were calculated

(Fig. A3).

2.5. Mapping residential neighborhoods' proximity to places with negative and positive wellbeing influence

We extrapolated from models 2 and 3 to infer influence on wellbeing from landscapes surrounding residential areas and map the results. We chose to map Stockholm because most place data came from there and its landscape is varied. Raster files for fields, forest and water, previously used to assign independent variables, were cropped to the extent of Stockholm county. DeSU polygons were rasterized to the same extent and resolution. We applied moving window calculations with circular neighborhoods to calculate the mean of fields, forest and water, respectively, within 50 m radius of each raster cell, and the residential and daytime population density, respectively, within 250 m radius. The resulting values in the raster files were transformed to the units used in the regression. We performed inverse distance-weighted interpolation of values for distance to home and spatial error terms from mapped places within Stockholm county. This sequence of operations resulted in all predictors as specified in the regression models being represented on raster files of equal extent and resolution, allowing us to use the fixed effects estimations from the models to map the predicted outcomes of models 2 and 3 across the Stockholm landscape. Modal values for control variables were used for these predictions. We combined the log-odds predictions of both models into one map with scores on a scale from 0 to 1, akin to probabilities, by calculating Eqn 1

$$P = \frac{e^{\frac{LO_3 - LO_2}{2}}}{e^{\frac{LO_3 - LO_2}{2}} + 1} \quad (1)$$

where LO_2 and LO_3 are the predicted log-odds of the respective models 2 and 3 and P is the predicted combined score. Thus, places with a high probability of negative wellbeing influence obtain scores close to 0, those with a high probability of positive influence obtain scores close to 1 and those that are ambiguous or have a high probability of no influence on wellbeing obtain scores close to 0.5.

To illustrate accessibility or exposure from residential areas to places, we applied a moving window weighted summarization on the predicted scores with a Gaussian kernel with 2 km radius and 500 m standard deviation, since most of the places visited with similar or greater frequency than before COVID-19 are within 2 km of one's home (Fig. 3G). These scores, also on a scale from 0 to 1, reflect the environment surrounding each raster cell, with the influence of surrounding raster cells being greater if they are closer and decaying with increasing distance up until 2 km. Finally, a Stockholm county urban area map was used to obtain polygons of residential areas within which mean scores for P were calculated and mapped.

3. Results

3.1. Descriptive analysis of sample and places

The survey was answered by 684 respondents (Table 1), the majority of whom live in Stockholm municipality (64%) or elsewhere in Stockholm county (16%). Women (67%), people aged 25–49 (40%) and working individuals (79%) are overrepresented in the sample, especially when compared to all of Sweden but also when compared to Stockholm county (Table 1). The respondents reported 2845 places that they visited less, at the same frequency, or more often during pandemic restrictions versus before COVID-19 (Fig. 2). Respondents made fewer visits to places further away from home (median = 1.5 km) but increased their visits to places closer to home (median = 0.16 km; Fig. 3F), indicating generally diminishing home ranges (cf. Hasanzadeh, Broberg, & Kyttä, 2017) and increased movement within their own neighborhoods. Only 17 of the places visited similarly or more (0.9%) were >5 km from the home. People also reduced visits to areas where many people work

Table 1

Descriptive statistics for the sample ($N = 684$) and corresponding statistics for the populations of Sweden and Stockholm county (Statistics Sweden, 2021). The population statistics for gender, age, living alone and place of residence exclude people younger than 15 years of age to facilitate comparison with our sample. The percentages for occupation are of the sum of people that are working, unemployed, students or retired but excluding those that do not belong in any of these categories.

Respondent characteristic	Count (%)	% in Sweden	% in Stockholm county
<i>Gender</i>			
Woman	458 (67.0)	49.9	50.2
Man	226 (33.0)	50.1	49.8
<i>Age</i>			
15–24	19 (2.8)	13.5	13.2
25–34	187 (27.3)	17.1	19.3
35–49	257 (37.6)	22.9	26.2
50–64	169 (24.7)	22.0	21.6
65+	52 (7.6)	24.4	19.7
<i>Occupation</i>			
Working	539 (78.8)	64.7	68.3
Unemployed	17 (2.5)	5.2	5.0
Student	74 (10.8)	15.4	14.1
Retired	54 (7.9)	14.7	12.6
<i>Living alone</i>			
No	504 (73.7)	77.5	78.6
Yes	180 (26.3)	22.5	21.4
<i>Place of residence</i>			
Stockholm municipality	440 (64.3)	9.5	
Rest of Stockholm county	106 (15.5)	13.4	
Göteborg municipality	17 (2.5)	5.7	
Uppsala municipality	20 (2.9)	2.3	
Gävle municipality	57 (8.3)	1.0	
Other	44 (6.4)	68.2	

(median = 1061 persons/km² compared to median = 133 for places visited similarly or more often; Fig. 3E).

Based on combinations of visitation frequency and wellbeing influence, we defined five categories of places (Fig. 4A). The most commonly identified kind of place was Visit-Positive ($n = 857$), followed by Abstain-Negative ($n = 831$), Visit-Neutral ($n = 565$), Abstain-Nonnegative ($n = 381$) and lastly Visit-Negative ($n = 211$). These categories differed with respect to the features respondents assigned to them (Fig. 4B). Abstain-Negative places were often full of people; the respondent would have met family or friends there if not for the pandemic. Shops, restaurants or services were most common among Visit-Negative places, whereas Visit-Positive places were most commonly easily accessible and afforded seclusion.

3.2. Properties of environments associated with negative or positive changes in wellbeing

Model 1 showed that compared to Abstain-Nonnegative places, Abstain-Negative places predominantly feature forests (odds ratio (OR) = 7.74, 95% confidence interval (CI): 2.52–23.8), fields (OR = 7.86, 95% CI: 1.75–35.3) and high residential density (for every 10 000 people/km², OR = 1.26, 95% CI: 1.03–1.53) (Fig. 5A). These properties, together with respondent reports that they would meet family or friends in these places and/or that they are full of people (Fig. 4B), suggest that Abstain-Negative places include green areas normally used for socializing. We found no reliable association between self-perceived influence on wellbeing and daytime population density. This suggests that even though people abstain from visiting areas where many work (Fig. 3E), this does not typically entail a negative wellbeing influence.

Model 2 showed that compared to Visit-Neutral places, Visit-Negative places predominantly feature less forest (OR = 0.15, 95% CI: 0.05–0.44) (Fig. 5B). As people mostly abstain from visiting high daytime population density areas (Fig. 3E), there is much uncertainty in the estimation of this association (see the wide 95% CI in Fig. 5B). However, places across the residential population density spectrum are still visited

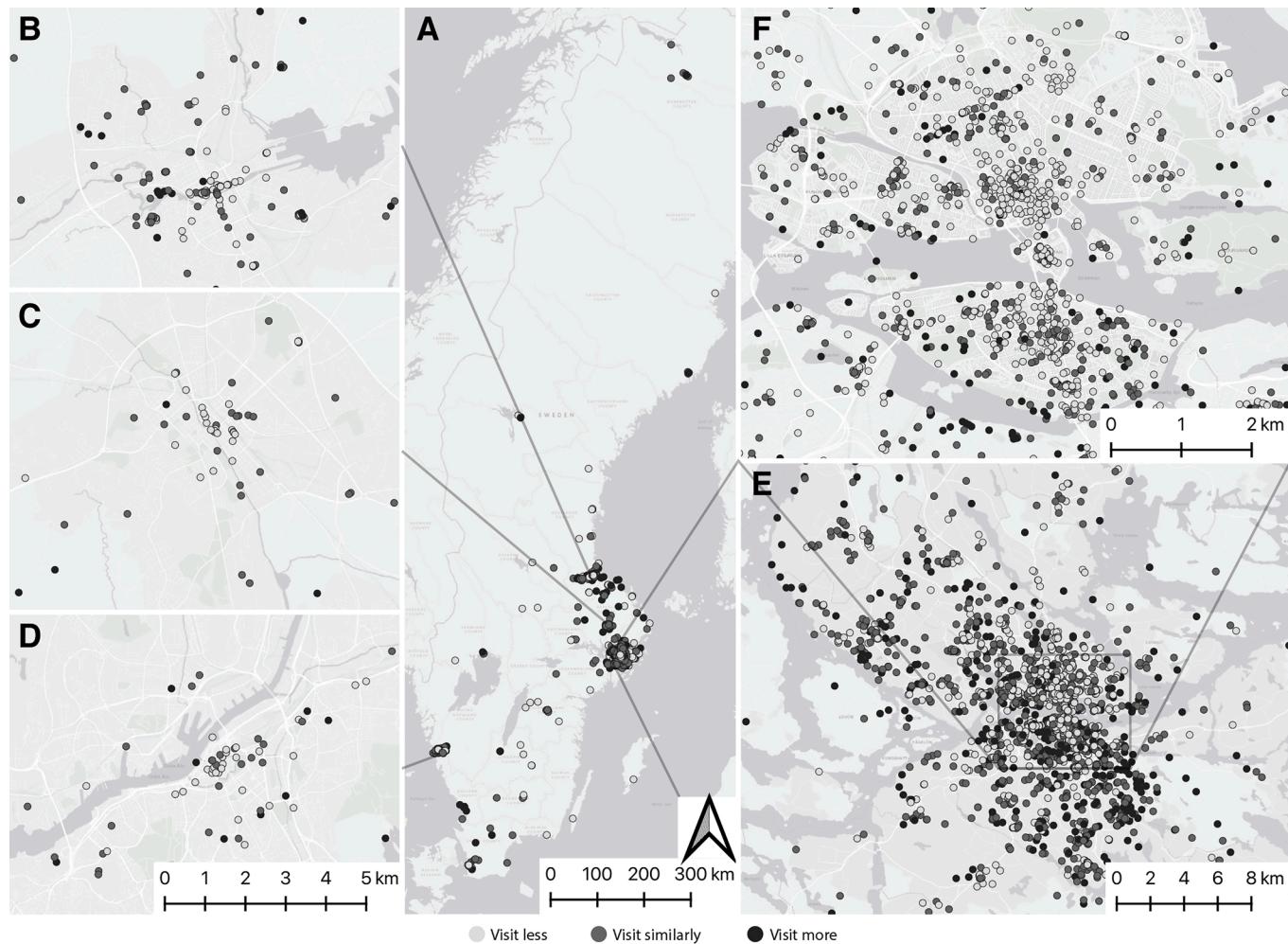


Fig. 2. Spatial distribution of places across Sweden. Each dot is a place marked by a respondent in the survey, with colors corresponding to visitation frequency. A. Sweden. B. Gävle. C. Uppsala. D. Gothenburg. E. Greater Stockholm. F. Central Stockholm. B-D are on the scale given in D.

(Fig. 3D) and here the OR is estimated with high confidence to be close to 1 (Fig. 5B). This suggests that Visit-Negative places are characterized more by lack of forest than high residential density.

Model 3 showed that compared to Visit-Neutral places, Visit-Positive places predominantly feature forest ($OR = 14.9$, 95% CI: 8.25–26.8), fields ($OR = 11.8$, 95% CI: 5.02–27.8) and presence of water ($OR = 5.35$, 95% CI: 2.85–10.1) (Fig. 5C). Increasing distance from home is also associated with Visit-Positive places (for each $\times 10$ distance unit, $OR = 1.12$, 95% CI: 1.00–1.24). This indicates that individuals that moved further than their proximate home surroundings were more likely to visit places they saw having a positive influence on their well-being. Parameters for residential and daytime population densities are similar to those of model 2. The 95% CI for daytime population density is again wide, while the OR of residential density is again close to 1.0 (Fig. 5C). This could indicate a tendency that areas where many work are more polarizing in that they often feature either Visit-Negative or Visit-Positive places, compared to areas that are mainly residential, where Visit-Neutral places are just as likely.

3.3. Illustration of residential neighborhoods' proximity to places with negative and positive wellbeing influence

Based on Models 2 and 3, we estimated how the landscape of Stockholm provides proximity to settings similar to those containing Visit-Positive and Visit-Negative places (Fig. 6, see Supplementary Fig. 1 for a high-resolution version). People living in the northern parts of

Stockholm's inner city appear most exposed to places like those our respondents reported have a negative influence while also having fewer places in their proximity like those reported to have a positive influence (area 2 in Fig. 6). Proximity to places supportive of wellbeing is highest in suburban neighborhoods bordering water or large natural areas, even though their residential densities can differ considerably from each other (areas 4 and 5 in Fig. 6). The south-western parts of the inner city score relatively high, being surrounded by water and several urban parks (area 3 in Fig. 6). On the other hand, some residential areas outside the inner city obtain low scores for proximity to places positive to visit (for example area 1 in Fig. 6). Notably, with neighborhood-level median income taken into account in the models, areas of both low- and high-proximity to places supportive of wellbeing appear to span the socio-economic spectrum.

4. Discussion

Geographical and sociodemographic properties of places have supported or challenged people's wellbeing during the COVID-19 pandemic. Our analysis corroborates previously reported associations with pandemic restrictions: that they diminish wellbeing among some groups more than others (Okruszek et al., 2020), that negative impacts can be mitigated by spending time outdoors (Stieger et al., 2020), and that urban dwellers turn more to natural settings if possible (Venter et al., 2020). In addition, we show that the spatial organization of the green and blue infrastructure and where people live and work provides

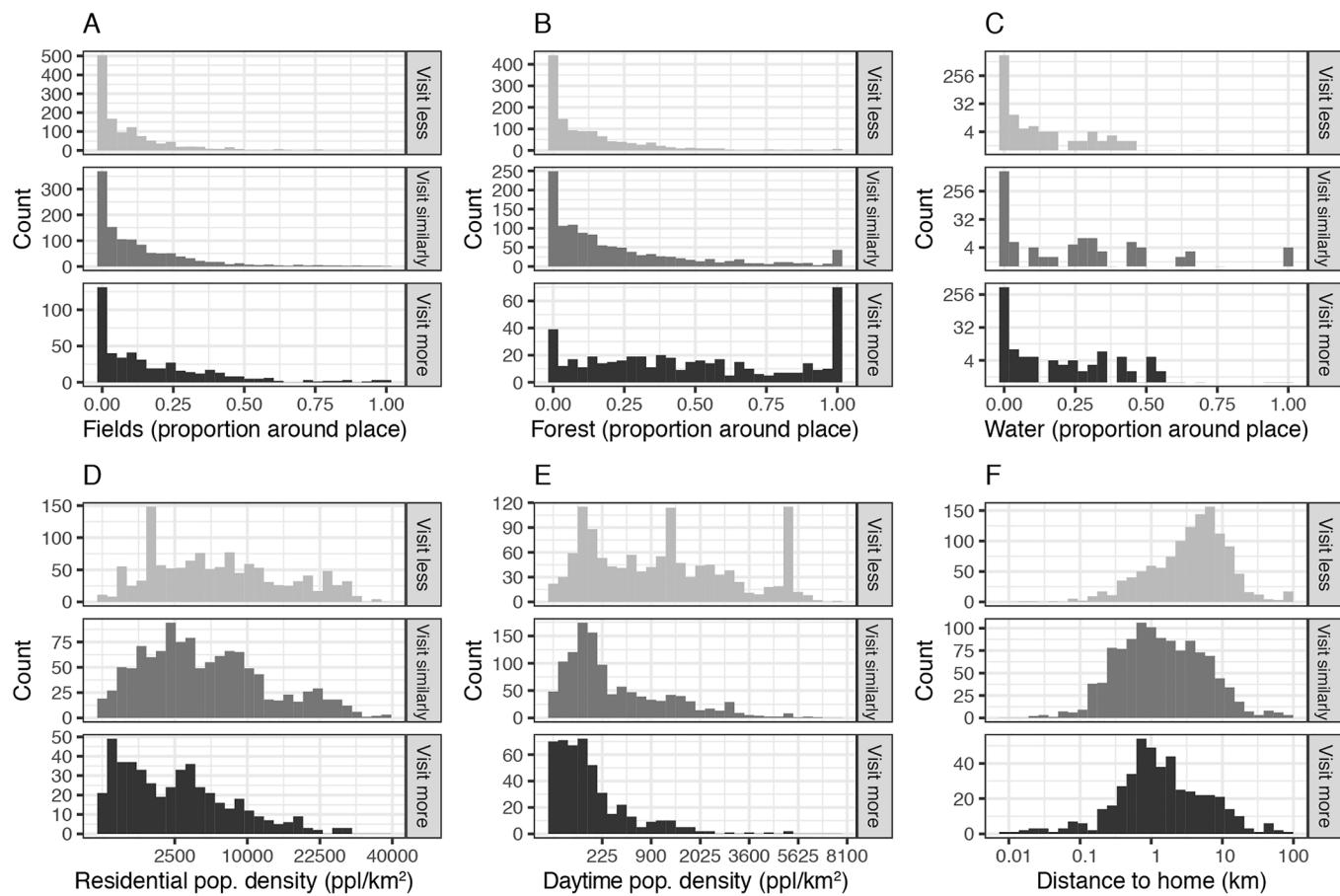


Fig. 3. Histograms of variables related to the environment around places visited less, similarly, and more, respectively, during pandemic restrictions as compared to before COVID-19. Fields, forest and water are measured within 50-m radius, while residential and daytime population are measured within a 250-m radius (see Fig. 1 for illustration). Variable units are given within brackets.

residents of some neighborhoods the ability to visit nearby places that support wellbeing, while others have to travel outside their neighborhood or are possibly left more vulnerable to negative effects of pandemic restrictions.

We found convincing evidence that specific land covers characterize places that support wellbeing under soft-touch pandemic restrictions, and hence play a part in urban resilience with respect to a pandemic. In all models, forests were the best predictor of places' influence on wellbeing. In addition, fields were strongly associated with Abstain-Negative and Visit-Positive places. The effect sizes associated with these land covers are particularly striking when considering that respondents were not limited to marking outdoor places, and illustrate the importance of having access to the outdoors for place-based coping. In Stockholm, forest areas are preferred to fields for psychologically restorative experiences in non-crisis times (Giusti & Samuelsson, 2020). However, that both forests and fields support wellbeing during this pandemic might be because restorative experiences are not the only experiences that people seek while coping with the pandemic and associated restrictions. For example, the settings within our fields category might lend themselves better to maintaining social relationships (Jennings & Bamkole, 2019), connection with the outside world, or physical activity, which other studies have found important during the current pandemic (Mutz & Gerke, 2020; Schnitzer, Schöttl, Kopp, & Barth, 2020). Visit-Positive places display a lot of variety in their features (Fig. 3B), further suggesting that different kinds of experience are important for maintaining wellbeing. These results speak to the value of having a variety of natural features accessible to urban residents. We did not find evidence that exposure to high-density areas mattered as much in terms of self-

reported wellbeing. That residential and daytime population densities were not associated with the influence on wellbeing of places visited similarly often or more could indicate that risks associated with difficulties in distancing are in general discounted, or that people knowingly accept these risks when searching for nature experiences (cf. O'Connell, Howard, & Hutson, 2020).

4.1. Limitations

This study has some limitations linked to our convenience sampling approach and the use of a single-language (Swedish) survey instrument. These choices may have influenced our results in two ways. First, our sample is not representative of the population of Sweden as a whole or of the Stockholm area in which most of the respondents lived, as indicated by the statistics in Table 1. Unrepresentative samples are likely to bias results more when the mapping activity involves expressing preferences rather than, as is the case here, providing simple descriptions (Brown, 2017). Nevertheless, we cannot rule out that the influence of place use on wellbeing among some groups is not represented in our sample. Aside from the overrepresentation of residents of Stockholm municipality, we observed an overrepresentation of women, people aged 25–49, and working people. While these variables are accounted for in our regression analysis, our sample could be unrepresentative in ways that we did not measure. For example, due to the survey being available only in Swedish it might have gathered relatively few responses among immigrants. Immigrants in Sweden have been found to be at elevated risk of mortality from COVID-19 (Drefahl et al., 2020), to which differing patterns of place use might be a contributing factor. Furthermore,

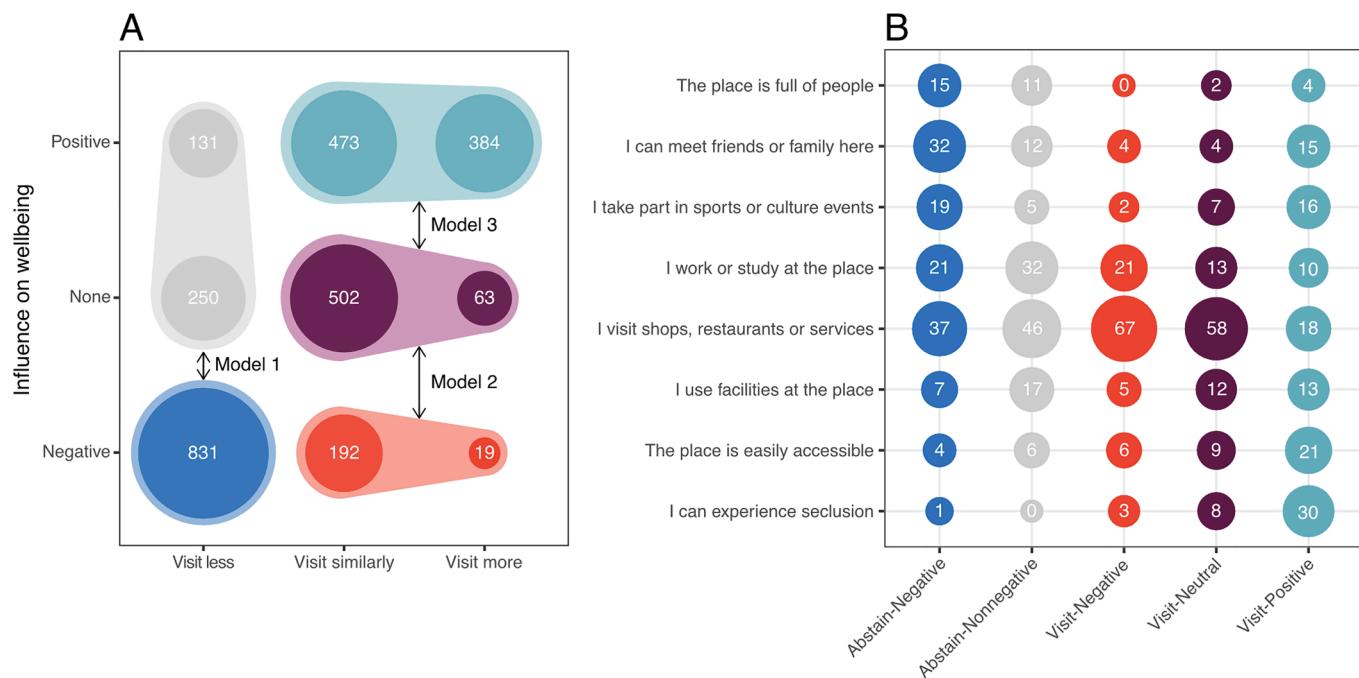


Fig. 4. (A) Matrix of place visits, with the number of places visited less ($n = 1333$), visited similarly ($n = 1323$), or visited more ($n = 518$), and their reported influence on wellbeing. We divide these into Abstain-Negative (blue), Abstain-Nonnegative (gray), Visit-Negative (red), Visit-Neutral (purple) and Visit-Positive (turquoise). The double-headed arrows indicate the kinds of places compared against each other in logistic regression models: Model 1 (Abstain-Negative versus Abstain-Nonnegative); Model 2 (Visit-Negative versus Visit-Neutral); Model 3 (Visit-Positive versus Visit-Neutral). (B) Matrix of the place categories and features of the places, with circle sizes and numbers within circles denoting the percentage of places within the category for which respondents reported the feature. For example, for 32% of Abstain-Negative places, respondents reported they would visit friends or family there if they did not abstain from visiting because of the pandemic.

Table 2

Odds ratios and 95% confidence intervals (Wald intervals) for fixed effects in regression models. Model 1 compares Abstain-Negative to Abstain-Nonnegative places, Model 2 compares Visit-Negative to Visit-Neutral places, and Model 3 compares Visit-Positive to Visit-Neutral places. The effects of being a student, unemployed or retired are compared against a baseline of working. These variables were not included in model 2 to avoid overfitting. Variance inflation factor (VIF) values well below 3 indicate multicollinearity among predictors was not a problem.

Variable	Model 1			Model 2			Model 3		
	OR	95% CI	VIF	OR	95% CI	VIF	OR	95% CI	VIF
Intercept	0.92	0.24–3.44		0.10	0.02–0.54		0.23	0.06–0.85	
<i>Environmental variables at place</i>									
Fields	7.86	1.75–35.3	1.29	0.23	0.05–1.11	1.08	11.8	5.02–27.8	1.12
Forest	7.74	2.52–23.8	1.25	0.15	0.05–0.44	1.10	14.9	8.25–26.8	1.21
Water	1.72	0.83–3.58	1.03	0.54	0.15–1.89	1.02	5.35	2.85–10.1	1.06
Residents (10 000/km ²)	1.26	1.03–1.53	1.06	1.10	0.77–1.57	1.42	0.99	0.75–1.31	1.46
Daytime population (10 000/km ²)	2.50	0.82–7.60	1.71	0.97	0.07–14.1	1.50	2.21	0.24–18.8	1.53
Distance to home ($\times 10$)	1.11	0.98–1.25	1.07	1.05	0.90–1.23	1.12	1.12	1.00–1.24	1.11
<i>Socio-economic variables at place</i>									
Median nbhd income (10 000 SEK/m)	0.98	0.95–1.02	1.50	1.04	0.99–1.09	1.17	1.04	1.01–1.08	1.11
<i>Demographic variables</i>									
Age group	1.10	0.88–1.37	1.38	0.98	0.76–1.27	1.04	0.84	0.66–1.05	1.67
Gender (woman)	0.88	0.60–1.27	1.06	2.34	1.39–3.94	1.04	1.40	0.97–2.04	1.07
Student	2.27	1.23–4.19	1.48	–	–	–	1.40	0.74–2.68	1.86
Unemployed	1.33	0.48–3.74	1.48	–	–	–	1.34	0.47–3.79	1.86
Retired	2.21	0.86–5.63	1.48	–	–	–	1.07	0.47–2.47	1.86
Living alone	1.26	0.83–1.92	1.08	0.72	0.42–1.23	1.03	0.77	0.52–1.15	1.10
<i>Spatial error terms</i>									
400 m	–	–	–	–	–	–	1.14	1.06–1.23	1.02

attention has been drawn to how the pandemic challenges wellbeing among essential workers – people that work in healthcare, schools, public transport or supermarkets (The Lancet, 2020). The survey collected relatively few Visit-Negative places, indicating that most people in our sample were not “forced” by work demands to visit places with a negative wellbeing influence for them; however, we do not know how many essential workers we had in our sample.

Second, the sampling strategy can impact data quality. PPGIS data quality is likely higher when respondents put effort into their mapping. Convenience samples have been found to perform better in this respect than internet panels but worse than random samples (Brown, 2017). We speculate that the extraordinary circumstances surrounding place use during the first wave of COVID-19 made it a topic that the public felt particularly engaged with at the time, so that the potential difference in

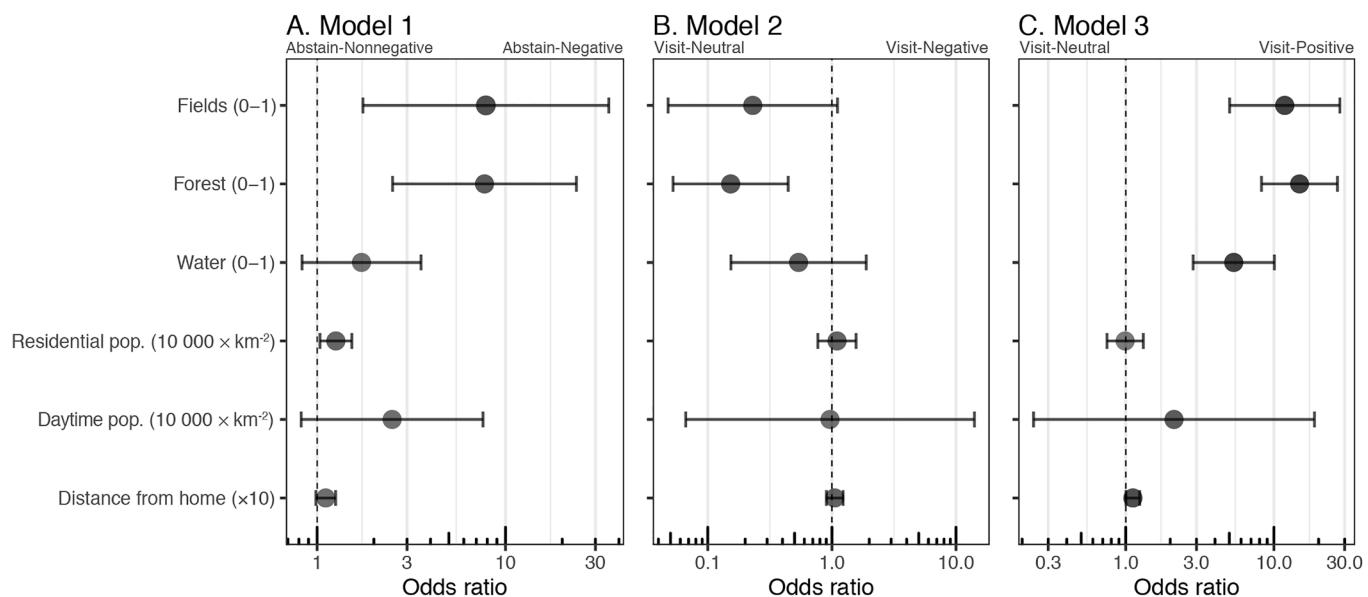


Fig. 5. Associations between geographical and sociodemographic properties of places and wellbeing outcomes of their use, as estimated in spatial logistic regression Model 1: Abstain-Negative versus Abstain-Nonnegative (A), Model 2: Visit-Negative versus Visit-Neutral (B) and Model 3: Visit-Positive versus Visit-Neutral (C). Associations are shown as odds ratios (dots) with 95% confidence intervals (bracketed lines). Units used in the models are given within brackets. (A) Abstaining from visiting places is more likely to have a negative influence on wellbeing when they have natural features and are in areas with many residents. (B) Visiting places similarly or more often is more likely to have a negative influence on wellbeing if they do not contain forest. (C) Visiting places similarly or more often is more likely to have a positive influence on wellbeing when they feature fields, forests and water.

data quality between convenience sampling and random sampling was low compared to other topics. Yet, these speculations can only be decisively answered by research that systematically examines sampling effects among studies done in the context of COVID-19.

Another limitation concerns the use of a one-time self-assessment to measure individuals' changes in wellbeing. Subjective wellbeing is often studied with validated instruments that use multiple items to capture different aspects of the latent construct. Analyzing respondents' direct assessments of how their use of places has influenced their wellbeing requires that they can correctly identify pathways between their place use and their wellbeing. Humans are notoriously poor at making health-related self-assessments (Dunning, Heath, & Suls, 2004). However, because patterns of daily place visits changed so profoundly in response to the pandemic, previously obscured pathways between place use and wellbeing could have become more apparent for many. Thus, we have reason to think that having the respondents identify the direction of the influence on well-being is on the whole reliable. Still, our design implies that we cannot estimate the magnitude of changes in subjective wellbeing, which would have been possible with repeated measures using validated wellbeing scales.

4.2. Spatial planning strategy for pandemic preparedness and urban resilience

The threat of future pandemics confronts researchers and professionals engaged in urban planning and design. Our results indicate that certain properties of the urban landscape aid coping with pandemic restrictions. Even though high-density environments display little association with influence on wellbeing from place visits, it is crucial that people keep apart to limit the spread of infection (Flaxman et al., 2020). This suggests that urban pandemic resilience can be strengthened by ensuring residents have equitable and uncrowded access to natural places. Only having access to small parks at the neighborhood scale seems insufficient in light of the increased park-use demand witnessed in some cities in 2020 (O'Connell et al., 2020). Green-blue infrastructure that permeates urban space can better help to ensure equitable distribution of opportunities for beneficial place experiences (Andersson

et al., 2019).

Our results illustrate how restricting one's home range can entail fewer possibilities for maintaining wellbeing through the use of particular settings. Having access to natural areas close to home can thus be seen as an environmental justice issue (Wolch, Byrne, & Newell, 2014). Unlike a study from the United States that found that low-income neighborhoods suffer most from lack of access to natural settings during COVID-19 (Spotswood et al., 2021), we found both high- and low-income neighborhoods in Stockholm are among those with poor access to places supporting wellbeing. Yet, residents of low-income neighborhoods are possibly left more vulnerable to negative effects of pandemic restrictions, as they may not have the means to travel for desired place experiences. However, increasing proximity to natural areas even in neighborhoods where many have the means to travel can be framed as an environmental justice issue when viewed in a countrywide context. When examining the environmental impact of urban travel behavior, leisure travel beyond the city has to be accounted for (Gren, Colding, Berghauer-Pont, & Marcus, 2019). Similarly, this pandemic has shown how many cities were not closed systems, although in Sweden and elsewhere rural residents often opposed a surge of urban residents looking to escape to the countryside (Malatzky, Gillespie, Couch, & Cosgrave, 2020).

Some authors speculate whether the COVID-19 pandemic may break the current city compaction trend (Batty, 2020; Nathan & Overman, 2020). Visiting distant places with private cars may provide similar wellbeing effects as traveling on foot or by bike; sprawling development might therefore help to build urban pandemic resilience. However, the coronavirus pandemic highlights a need for strategies that consider public health in conjunction with other major challenges that must engage urban spatial planning, such as mitigating climate change (Creutzig et al., 2016; Creutzig, Baiocchi, Bierkandt, Pichler, & Seto, 2015) and protecting biodiversity (Marselle et al., 2021; McDonald et al., 2020). Sprawling cities increase private car dependence (Seto et al., 2014) whereas walking and biking provide affordable mobility (Sharifi & Khavarian-Garmsir, 2020), making them more appealing transportation modes for planning strategies that jointly consider biodiversity protection, climate change mitigation, environmental

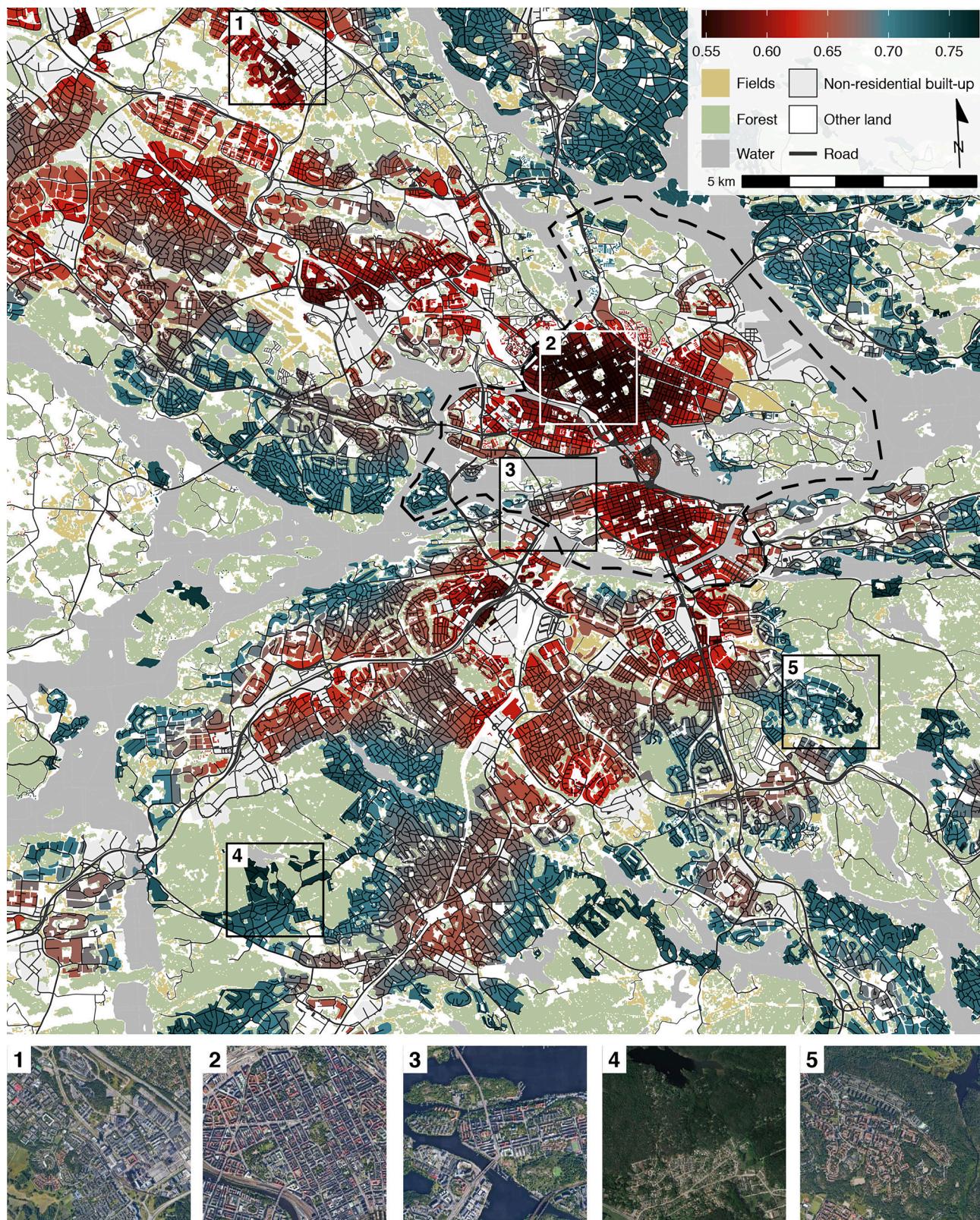


Fig. 6. Estimation of proximity to settings similar to those containing Visit-Positive and Visit-Negative places from residential areas in Stockholm. The dotted line demarcates the inner city. Proximity scores of residential areas are based on Models 2 and 3 combined with an accessibility analysis (see Methods for details), where scores close to 1 (dark blue) mean a high probability of positive influence from place visits in the surrounding neighborhood, while scores close to 0.5 (dark red) mean equal probabilities of positive and negative influence. Some non-residential land-covers are displayed in gray, white and green (see legend). The bottom row (1–5) shows Google Earth images of areas of particular interest. Kista (1) displays relatively low scores despite being outside the inner city. Vasastan (2), an inner-city district, displays the lowest scores. Hornstull (3) displays the highest scores within the inner city. Glömsta (4) and Bagarmossen (5) have very different urban forms and residential densities, but nevertheless both score high as they border large natural areas. See [Appendix A](#) for a high-resolution version of this figure.

justice and urban pandemic resilience. Our results encourage design that serves safe and equitable access on foot or by bike to places rich in natural features. Such design does not require a stance categorically for or against densification, but is rather in line with some existing policy, such as the 15-minute city model brought forward by Paris (Sisson, 2020). Spatially integrated spaces fill the function of socio-economic exchange and social interaction (Hillier, 2009), and these tend to also feature relatively high levels of residential and daytime population densities. On the other hand, green-blue infrastructure can contain secluded spaces that allow restorative experiences for many during non-crisis and crisis times alike (Coutts, 2016; Samuelsson et al., 2019). Mixing spatially integrated spaces with secluded natural spaces at the neighborhood scale could enable neighborhood-level densities high enough to promote walkability (Sarkar, Webster, & Gallacher, 2017) and provide the variability in experiences that is linked to positive affect in non-crisis times (Heller et al., 2020). This could be done while also retaining the spatial buffer capacity required during pandemics, when people have to keep further apart, and thus relieve visitors to smaller parks from feelings of crowding. The importance of easy access to different kinds of places might further amplify during a pandemic if governments include restrictions in the distance people can travel from their home, as was the case during the relatively hard lockdown conditions seen in some cities (Thiessen, 2020).

5. Conclusion

With continued globalization and urbanization, spatial planning must help prepare for future pandemics. This paper has presented insights for pandemic planning gained from studying place use across Sweden during the first wave of the coronavirus pandemic. Our results strongly suggest that easy access to natural settings supports wellbeing under a “soft-touch” regime of restrictions. We also found evidence that people’s wellbeing is negatively influenced by abstaining from visiting areas with high residential density; however, on the whole, population density did not display as strong associations to wellbeing as natural land covers. It is nonetheless still crucial that people keep apart to limit spread of infection. Thus, urban resilience inheres to properties of the spatial system that, among other things, enables access for everyone to natural settings without increased risk of infection. Our spatial analysis further reveals that both high- and low-income neighborhoods are among those who may suffer from poor accessibility of this kind. It is however useful to view the issue as one of environmental justice for all; although some urban residents can afford to travel to faraway natural settings, the public health response to a pandemic may limit even their mobility. Rich and poor alike can gain from efforts to ensure possibilities for visiting natural settings close to home. Urban planning will do well to enable equitable, easy access to natural settings by foot or bike, to increase pandemic preparedness as well as support climate change mitigation and biodiversity protection.

CRediT authorship contribution statement

Karl Samuelsson: Conceptualization, Methodology, Investigation, Software, Formal analysis, Visualization, Writing - original draft, Writing - review & editing, Project administration. **Stephan Barthel:** Conceptualization, Investigation, Writing - original draft, Writing - review & editing, Funding acquisition. **Matteo Giusti:** Conceptualization, Investigation, Writing - original draft, Writing - review & editing, Funding acquisition. **Terry Hartig:** Writing - original draft, Writing - review & editing.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.landurbplan.2021.104176>.

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