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Environmental justice and outdoor recreation opportunities: A spatially explicit assessment in Oslo metropolitan area, Norway

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ABSTRACT

Urban and peri-urban green space provides multiple recreation opportunities with important benefits for physical and psychological well-being, but access to these benefits is often unequally distributed. Various methodologies to assess outdoor recreation opportunities exist, but they rarely take into consideration dimensions of environmental justice. The aim of this paper is to map and assess nature-based outdoor recreation opportunities with a focus on green space accessibility for different social groups, and discuss the results in light of of environmental justice. We use the Oslo metropolitan area, Norway, as a case study. We combine statistical analysis with spatial modelling to assess recreation preferences and distribution of nature-based recreation opportunities. We also analyse accessibility for different social groups, including children and the elderly, migrants and low-income households. Our results show that most people prefer large wooded green areas, high density of trees, and presence of water, although preferences differ depending on age and place of residence. Areas for daily recreation are accessible to the whole population in the study area, but they are unequally distributed, migrants and low-income households having relatively less access. Our methodology can also be applied in other cities and metropolitan areas to assess differences in accessibility to outdoor recreation opportunities. We discuss whether and to which extent these results illustrate a situation of environmental injustice. We conclude that the relation between access to green space and environmental justice can be complex, and that injustice may not automatically result from uneven access.

1. Introduction

Urban green space offers multiple nature-based recreational activities such as walking, running, bike riding, picnicking, animal sighting or sunbathing, providing many important benefits to physical and psychological well-being (Bolund and Hunhammar, 1999; Chiesura, 2004; Ernstson, 2013; Gómez-Baggethun et al., 2013; Gómez-Baggethun and Barton, 2013). For example, recreation in parks (Konijnendijk et al., 2013) and wildland (Thomsen et al., 2018) increases the opportunities for physical activity and, therefore, decreases the probability of health problems related with a sedentary lifestyle, such as obesity and diabetes. Documented psychological and social benefits of outdoor recreation include stress and anxiety reduction, but also positive effects on self-steem, sense of belonging and social cohesion (Konijnendijk et al., 2013; Thomsen et al., 2018), considered indicators of mental health (Jennings et al., 2016). Recreation opportunities strongly depend on green space proximity and accessibility (Coles and Bussey, 2000; Massoni et al., 2018; Paracchini et al., 2014; Voigt et al., 2014), but also on biotic and abiotic site conditions, on the presence of recreational facilities, and on people's preferences and values (Gómez-Baggethun et al., 2013; La Notte et al., 2017; Manning et al., 2011; Massoni et al., 2018; Voigt et al., 2014).

Environmental justice (EJ) has traditionally focused on health consequences associated with inequitable distribution of exposure to pollution and environmental hazards in low-income and minority individuals (Agyeman et al., 2016; Jennings et al., 2016; Kabisch and

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Haase, 2014). However, positive contributions of ecosystems to health and well-being is increasingly considered as an EJ issue (Jennings et al., 2016), including access to green space (Wolch et al., 2014; Zuniga-Teran and Gerlak, 2019) and the ecosystem services (ES) they provide (Ernstson, 2013; Gómez-Baggethun et al., 2013; Marshall and Gonzalez-Meler, 2016).

According to Schlosberg (2004), three different dimensions need to be discussed to address EJ: distributive, procedural and recognition. For the sake of our discussion, distributive justice refers to the fair distribution of the benefits from ecosystems (Ernstson, 2013), and it is commonly related to the concepts of inequality (i.e., the unequal distribution of benefits) and inequity (i.e., the social unfairness of the spatial distribution of benefits) (Zuniga-Teran and Gerlak, 2019). Procedural justice focuses on the 'fair integration of all affected groups into the planning and decision process of a public space' (Kabisch and Haase, 2014, p. 130). Finally, recognition means recognizing the different needs, demands, values and preferences of all social groups (Fraser, 1995). In this paper we focus on the distributive and recognition dimensions.

From a distributive point of view, many cities experience uneven opportunities for recreation, meaning that some social groups, such as migrants (Kabisch and Haase, 2014), low-income residents (Dai, 2011; Davis et al., 2012; Ernstson, 2013), and racial (Dai, 2011; Davis et al., 2012) and religious minorities (Comber et al., 2008), often have less recreational access. From a recognition perspective, preferences towards outdoor recreation can differ depending on age, gender, household income or cultural background (Byrne and Wolch, 2009). To include the recognition dimension of EJ, these differences between groups' recreation preferences should be considered in urban planning and green space design.

Various methodologies to assess and map recreation exist (Martínez-Harms and Balvanera, 2012; Wolff et al., 2015), but they rarely take into consideration dimensions of justice. When they do, outdoor recreation is mainly analysed through quantitative indicators such as green space per capita (Kabisch and Haase, 2014) or distance to green space (Comber et al., 2008; Dai, 2011; Davis et al., 2012), whereas quality of green space is rarely addressed. Other models to assess outdoor recreation combine quality with quantitative indicators to analyse accessibility, but they do not take into account differences in accessibility (distributive justice) and preferences (recognition) between social groups. That is the case of the Ecosystem Services Mapping Tool (ESTIMAP), 'a collection of spatially explicit models to support the mapping and modelling of ecosystem services at European scale' (Zulian et al., 2014, p. 2). ESTIMAP assesses potential supply, flow and demand of outdoor recreation opportunities (La Notte et al., 2017). In this paper we adapt the ESTIMAP model for outdoor recreation to map recreation opportunities in Oslo metropolitan area, Norway. We combine it with statistical analysis to assess the spatial distribution of and access to outdoor recreational opportunities in connection to population's preferences across social groups. We discuss our data in light of the distributive and recognition dimensions of EJ. Our main objective is to analyse if there are differences on preferences and inequalities on green space distribution depending on age, cultural background and income, and what the implications are for EJ.

2. Methods

2.1. Case study

Our case study is the metropolitan area of Oslo, Norway's capital (Fig. 1). Located in the southern part of Norway, Oslo's metropolitan area covers an area of 5732 km^2 and hosts 1,305,126 inhabitants (Statistics Norway, 2019). It comprises the counties of Oslo and Akershus and 23 municipalities (Oslo municipality and the 22 municipalities of Akershus county). Oslo constitutes the most densely populated urban core (681,067 inhabitants, 1597 people/km^2), while Akershus constitutes the peri-urban area. Oslo city is surrounded by forested hills known as Oslomarka. Blue and green areas (waterways, parks, recreation areas and green corridors) account for 21 % of the built zone (European Commission, 2019). Oslo-Akershus share a county administration with regional planning task.

Oslo is one of Europe's fastest growing capital cities (European Commission, 2019). Its population has increased by 30 % over the last 15 years, and the number of residents is expected to rise by more than 800,000 by 2040. Some 100,000 new homes are planned to be built over the next 15 years (Statistics Norway, 2019), which inevitable will result in higher pressure on green space. Furthermore, Oslo is a host to a growing cultural diversity. First and second generation immigrants account for 33 % of its population and this number is continuously increasing (Statistics Norway, 2019). Demographic trends and growing cultural diversity are challenges regarding unequal access to green space, which suggests that urban policy and planning will have to pay more attention to recreational opportunities and preferences across social groups.

2.2. Conceptual and methodological framework

To map outdoor recreation opportunities in Oslo metropolitan area we adapted ESTIMAP model version of Vallecillo et al. (2018). ESTIMAP assesses potential supply (i.e., the amount of the ecosystem service that can be provided or used), flow (i.e., actual use of outdoor recreation areas by population in a one-day trip) and demand (i.e., population needs for daily recreation) (La Notte et al., 2017). Our assessment focuses on terrestrial ecosystems, so recreation linked to water is only assessed in the terrestrial ecosystems that surround water bodies.

The literature on ES increasingly distinguishes among ES potential supply, capacity and flow (Baró et al., 2016; Hein et al., 2016; Villamagna et al., 2013). Potential supply is defined as the ecosystem's sustained ability to generate services irrespective of the demand for such services (Hein et al., 2016, p. 5). Capacity is' the ability of an ecosystem to generate a service under current condition and uses' (ibid, p. 4). It only emerges when there is demand for the service. Finally, flow is defined as' the amount of service received by people in a given time period' (ibid, p. 8). Recreation demand is defined by different authors in terms of potential or predicted visitation (Barton et al., 2019). The differences in quality or quantity occurring between the capacity, flow and demand of ES are often defined in terms of ES mismatches (Baró et al., 2015). For the sake of our discussion, 'met' and 'unmet demand', have been defined as the share of population living within a defined travel distance from areas for daily recreation ('met demand') or beyond ('unmet demand') (Vallecillo et al., 2018).

Applying the above mentioned definitions to ESTIMAP model for outdoor recreation, we mapped potential supply based on ecosystem biophysical characteristics, selected here on the basis of people's preferences in Oslo. Capacity was defined by cross tabulating the areas with high recreation potential and the distance from residential areas estimated by walking time, under the assumption (for simplification purposes) that there is no demand in distant spaces. Finally, potential demand was estimated based on the share of population living within two distance buffers from those areas: 10 and 30 min walk (Fig. 2). In this paper, we do not estimate flow because the mobility function proposed by Vallecillo et al. (2018) is based on studies carried out in the UK, and the assumptions may not represent the reality in Norway.

ESTIMAP was originally designed for an analysis at continental scale. Therefore, it was adapted to Oslo metropolitan area using higher resolution local datasets and available data about local preferences for outdoor recreation. We explain how we assess people's preferences for outdoor recreation, potential supply, capacity and demand in the following sub-sections.

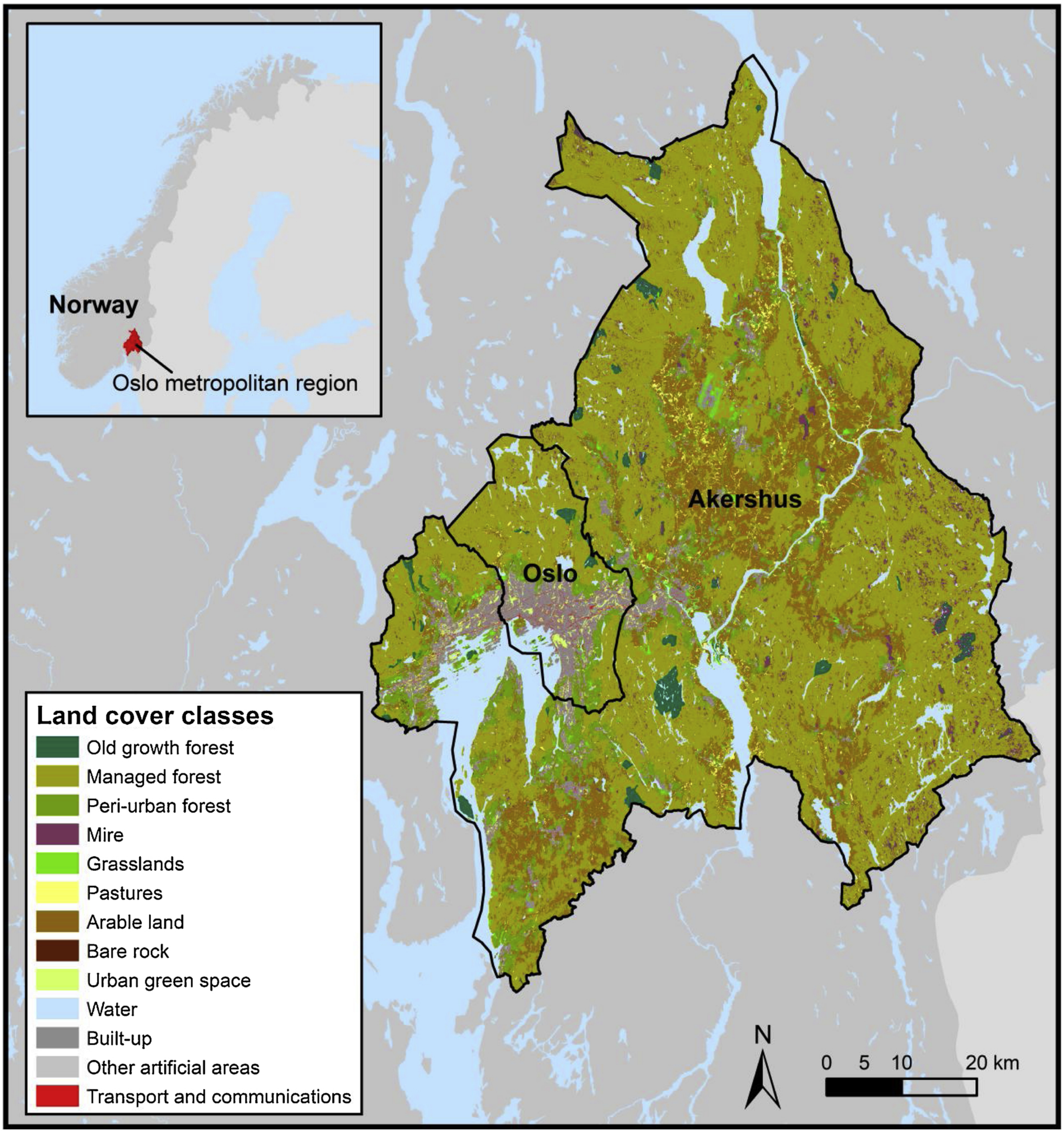

Fig. 1. Land cover classes in Oslo metropolitan area. Own elaboration based on land resource (Norwegian Institute for Bioeconomy Research, 2017), land use (Norwegian Mapping Authority, 2017a), protected sites (Norwegian Environment Agency, 2017) and urban settlements (Statistics Norway, 2016) datasets.

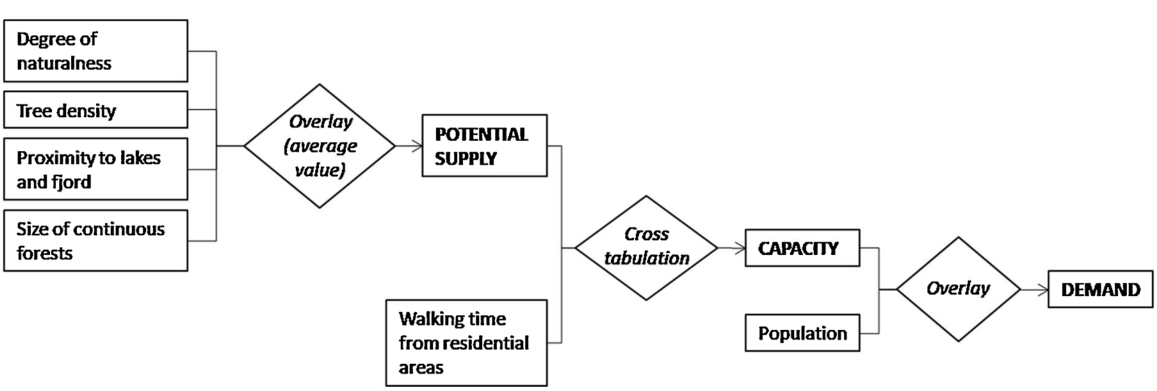

Fig. 2. ESTIMAP model for outdoor recreation in Oslo metropolitan area, modified from Vallecillo et al. (2018).

2.3. Preferences for outdoor recreation

To address outdoor recreation from the perspective of recognition (Fraser, 1995) we analyse if recreation preferences differ with socio-economic characteristics. Our data on people's preferences for outdoor recreation draws on results of an existing web-based population survey commissioned by the FP7 OpenNESS project, conducted by NORSTAT under coordination of the Norwegian Institute for Nature Research (NINA) in 2016. 1157 residents in Oslo municipality where pre-recruited for a NORSTAT panel, using random sample stratified to be proportional to population by city district. Respondents were asked to locate their residence and map their favourite recreation path and to characterise 31 biotic and abiotic characteristics and recreation facilities of their favourite path using a 7 point scale slider, 1 and 7 being opposed situations for the specific characteristic (see Table A.1 in Appendix A in Supplementary Data). For example, in 'degree of naturalness', the scale start point (1) corresponds to 'built areas', whereas the scale end point (7) is 'nature'. If a respondent chose 4, we interpret the response as if the respondent had a preference for an unlabelled midpoint between natural and built. Responses to these questions were interpreted as green space characteristics preferred by people for outdoor recreation. In this paper we only analyse characteristics and recreation facilities that could be mapped with local available data (see Table A.1 in Appendix A in Supplementary Data).

The following background socio-economic characteristics of the respondent were also obtained: age, gender, district, type of housing, origin, education level, household size, number of children under 18, years living in Oslo, occupation and personal income (see Figure A.1 in Appendix A in Supplementary Data). Other respondents' residence characteristics were subsequently calculated using Geographic Information Systems (GIS): grass cover and tree canopy percentage, normalized difference vegetation index (NDVI), and distance to fjord, freshwater, Oslomarka, graveyards, parks, sports, rivers, peri-urban forest and green space (see Table A.2 in Appendix A in Supplementary Data for details). While we mapped physical access to and qualities of green space for the whole metropolitan area, preference data were available only for Oslo. We combined the datasets to illustrate the potential for integrated analysis of EJ, recognising that preference variation in Oslo may not necessarily represent neighbouring Akershus.

We used principal component analysis (PCA) and redundancy analysis (RDA) to identify patterns of recreation preferences. PCA is a statistical technique to bring out strong patterns in large datasets, by reducing the dimensionality of such datasets and increasing interpretability (Jolliffe and Cadima, 2016). The graphical representation of PCA results is often used to make data easy to explore and visualize. Interpretation of the principal components (here on PCA axes) is based on finding which variables in the dataset are most strongly correlated with each component, i.e., which of these numbers are large in magnitude, the farthest from zero in either direction. RDA is also a method to extract and summarise the variation in a set of variables but in this case, variables are defined as sets of response and explanatory variables. The technique summarises linear relationships between components of response variables that are explained by a set of explanatory variables; RDA can be considered a constrained version of PCA (Buttigieg and Ramette, 2014).

First, we applied a PCA to establish patterns of correspondence among the recreation facilities and biotic and abiotic characteristics of green space. Second, we applied several RDA to analyse: i) the extent to which each of the respondents' socio-economic characteristics corresponded to their preferences for green space characteristics; ii) if Oslo respondents' preferences depended on the characteristics of their place of residence and iii) if the distance from respondents' residence to different natural elements has an influence on respondents' preferences. We used socio-economic characteristics and respondents' residence characteristics (see Table A.3 in Appendix A in Supplementary Data) as explanatory variables.

In all the analyses, responses '*do not know/not relevant'* were scored as the midpoint (4) on the scale. We performed the Principal Component Analysis (PCA) and RDA analyses with the CANOCO v.5 software (Lepš and Šmilauer, 2014). In all cases, responses (preferences) were centred, and the significance level of the correspondence was established by performing Monte Carlo permutation tests, 499 permutations (i.e., type I error probability in testing the hypothesis that the effect of the explanatory variable is zero) (Lepš and Šmilauer, 1999). With the RDA analyses, we extracted the first four canonical axes and obtained the following metrics: the percentage of the total variation in the response data set accounted for by the explanatory variable, the cumulative variation explained by the four canonical axes in the ordination, and the significance level of all axes according to the Monte Carlo permutation test.

2.4. Potential supply

Potential supply is defined here on the basis of ecosystem biotic and abiotic characteristics and recreation facilities, but excluding built infrastructures related with accessibility and capacity, such as roads and public transport stops and stations. We included a characteristic in the analysis if more than 50 % of the respondents assigned a score between 1–3 or 5–7, that is, when a clear preference or dis-preference was identified. Five characteristics fulfilled this requirement: degree of naturalness, tree density, proximity to lakes, size of continuous forest, and equipment rentals. Since most people answered that a presence of equipment rentals was not a reason to choose their favourite recreation path, this characteristic was not included in the analysis. Finally, we mapped four green space characteristics to define recreation potential: degree of naturalness, tree density, proximity to lakes and fjord, and size of continuous forest patches. We obtained one 10 m resolution raster map for each characteristic, where each raster cell has a score between 0 and 1, where 0 is a very low recreation potential and 1 is a very high recreation potential. The mapping and scoring methodology is explained in detail in Appendix A in Supplementary Data. The potential supply map was obtained by overlaying the four maps of green space characteristics and calculating an average value for each pixel.

2.5. Capacity

Capacity was determined from potential supply and distance from residential areas. To calculate distance from residential areas, we adopted Poelman's (2016) methodology to assess walking accessibility. In this study, we only consider pedestrian accessibility because it is the mode of transport most available to the whole population.

To map walking accessibility to recreation areas, we first created a pedestrian network that includes all paths and private, local and county roads, under the assumption that people walk through all of them, but not through European roads and motorways. We obtained the roads network from N50 Map Data (Norwegian Mapping Authority, 2017b). Second, to represent households, we chose residential buildings from land use dataset (Statistics Norway, 2017a) and computed centroids of each building polygon. To enable faster analysis, we removed those located closest to another centroid, keeping half of them. Poelman (2016) assessed accessibility by calculating the share of population that can reach green spaces through the pedestrian network in less than 10 min with a speed of 5 km/h. In the third step, we followed the same approach by identifying all sections of pedestrian network accessible within 10 min' walk (833 m) from selected centroids and in addition also all sections of pedestrian network accessible within 10 – 30 min' walk (834 m – 2.5 km). We created a 100 m buffer around both classes of identified accessible paths, assuming that people usually follow the paths and roads and can also diverge into the proximity of these paths to perform various recreation activities, but do not walk further away. Finally, we converted the resulting map to a 10 m resolution raster map where cells are classified in three classes: i) less than 10 min' walk, ii)

Table 1
Capacity classes.

	Recreation potential	
	0.4-0.6	>0.6
<=10 min	2	4
10-30 min	1	3

1. Medium potential - accessible
2. Medium potential – easily accessible
3. High potential - accessible
4. High potential – easily accessible

between 10 and 30 min' walk, and iii) more than 30 min' walk from any residential areas.

The final capacity map was then computed by a cross tabulation between the accessibility map and the potential supply map as specified in Table 1, similarly to the Recreation Opportunity Spectrum Map proposed by Paracchini et al. (2014). As we are only interested in recreation areas with capacity to provide recreation services, we did not map areas with low recreation potential (potential supply ≤0.4) (Baró et al., 2016) and/or that could not be reached in less than 30 min walking.

2.6. Potential demand

A measure of potential demand may be determined by the number of people living within daily commuting distance in the Oslo metropolitan area. However, we were specifically interested in distinguishing 'met' and 'unmet demand'. Areas for daily recreation were extracted from the capacity map as areas with potential supply >0.4 and reachable in 30 min walking. To quantify the number of inhabitants living near ('met demand') and far ('unmet demand') from areas for daily recreation (Vallecillo et al., 2018) we applied three distance buffers:

- Within 833 m from areas for daily recreation: at this distance, areas for daily recreation can be reached walking in less than 10 min (Poelman, 2016). We consider that at this distance most people have access to areas for outdoor recreation on a daily basis.
- Between 833 m and 2.5 km from areas for daily recreation: people living in this distance buffer can reach these recreation areas in a 30 min' walk or by a short bicycle ride. We assume that part of the population would visit recreation areas on a daily basis within these distances, but other people (e.g., people with mobility difficulties such as the elderly) would not visit them because the distance is too long.
- Beyond 2.5 km from areas for daily recreation: we consider population living beyond 2.5 km as unmet demand because at this distance it would take more than 30 min' walk to reach these recreation areas. People probably visit these areas during weekends, but not on a daily basis.

We calculated the percentage of population who lives within the three distance buffers using a 250 m population grid (Statistics Norway, 2017b). We computed a centroid of each square, assign it the square's value (number of people) and summed the values of all centroids that intersect with each distance buffer.

To analyse distributional equality we differentiated social groups according to three socio-economic characteristics: i) household income, ii) nationality, and iii) age. We chose household income and nationality because it has been demonstrated in several cities that people with low income and immigrant background generally have less access to green space (Dai, 2011; Davis et al., 2012; Ernstson, 2013; Kabisch and Haase, 2014). We considered the variable age because having recreation areas in the vicinity can be more important for the children and the elderly than for other age groups (Kabisch et al., 2017). We obtained age, nationalities and income data from Statistics Norway for 2017. We calculated the percentage of people under 14 and over 65 years, of migrants (people whose nationality is not Norwegian), and the average household income for each census tract. Since nationality and income data is only available at the municipality and urban districts level in Oslo, we assigned the municipality or district's value to the census tracts within them. We also calculated the percentage of areas for daily recreation (identified in the capacity map) in each census tract and carried out Bivariate Pearson correlations between them and each socio-economic variable to analyse if there are social groups with less access than others. We removed from the analysis the census tracts where there is not population.

3. Results

3.1. Preferences for outdoor recreation

The first principal component of the PCA (Fig. 3 A) captures 37.08 % of explained variation, and the second principal component 10.12 %. The first principal component is mainly defined by preferences for biotic characteristics. It suggests that people who prefer more natural areas with higher density and diversity of trees, higher continuity of forests, and more varied terrain, also prefer silence, areas far from roads and with little access by public transport. Two groups of preference variables, i.e., proximity to water on one side and absence of built facilities on the other, indicate preference groups that are poorly correlated with the main preference variables associated with the first principal component. The second principal component suggests that people who prefer proximity to water also prefer green space with recreation facilities such as signed paths, equipment rentals, restaurants, or sports grounds.

Only three socio-economic characteristics appear to be significantly associated with the respondents' preferences for green space characteristics: district (not-shown, explained variation 7%, pseudo-F = 6.1, P = 0.002), type of housing (explained variation 2.4 %, pseudo-F = 3.4, P = 0.002) and age (explained variation 1.2 %, pseudo-F = 4.0, P = 0.002) (Fig. 3, C and B, respectively). Other factors with statistical significance, such as years living in Oslo, explained a small proportion of the variability (≤1%). Education, region of origin, and income had no association with the respondents' preferences. In the case of age, the RDA ordination diagram (Fig. 3 B) shows a gradient: older people give higher values to most of the green space characteristics than younger people (under 40 years old). This indicates that older people prefer more natural areas near water surfaces, whereas younger people prefer more urban places with recreation facilities. The respondents' location also appears to be related with the answers. People who live in outlying districts and near peri-urban forests, prefer more natural areas, with presence of vegetation and water, and with few recreation facilities, whereas people who live in central districts prefer more urban places with recreation facilities. Also, respondents living in owned detached and semi-detached houses gave higher scores to most characteristics, including degree of naturalness, tree density and terrain diversity (Fig. 3 C). Finally, respondent's residence characteristics (NDVI, tree cover and grass cover) are not correlated with recreation preferences.

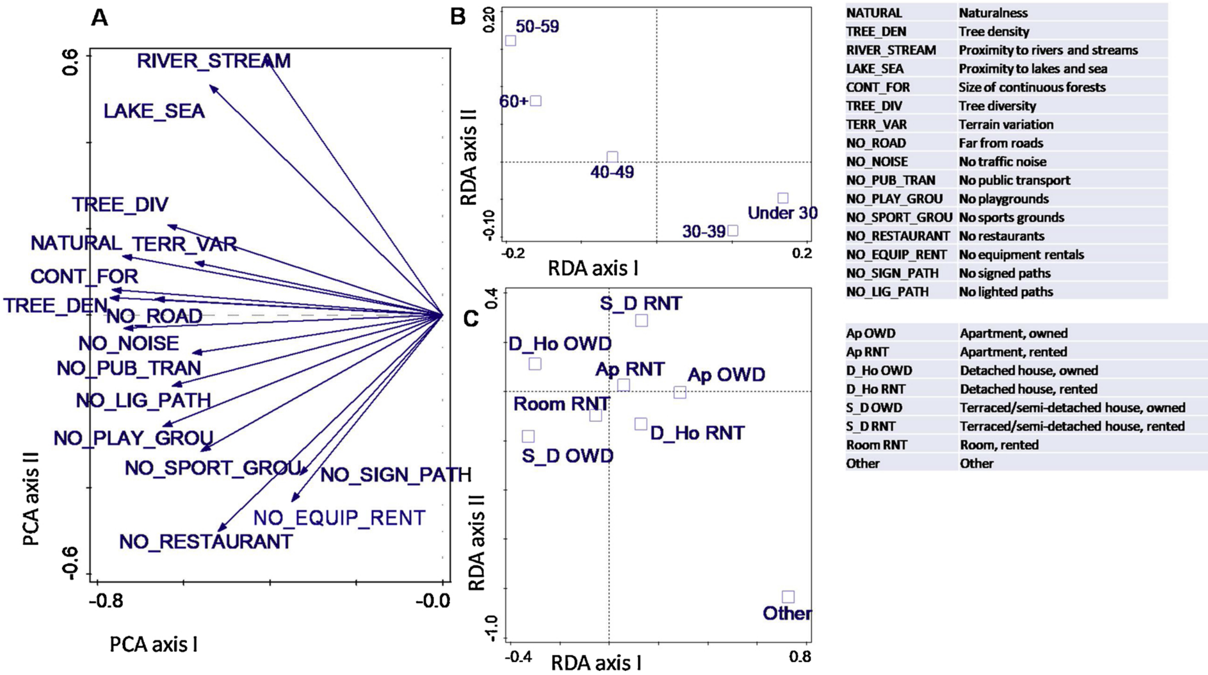

Fig. 3. (A) Preferences diagram plotted on axes I and II of the unconstrained ordination (PCA). The ordination score scaling is focused on standardized preference scores. The arrows point in the direction of the steepest increase of the values for the corresponding variable, and the length is a measure of the fit. The angle between arrows indicates the correlation between the preferences variables. (B and C) Summary of the variation in preference scoring interpreted by socio-economic factors, derived from constrained ordinations (RDA). Squares represent levels of age (B) and type of housing (C). The distance between the symbols approximates the average dissimilarity between the groups of respondents' preference scores measured by Euclidian distance.

3.2. Potential supply

More than 60 % of the study area (excluding surface water) has high and very high levels of recreation potential supply (>0.6), whereas areas with medium potential supply (0.4 – 0.6) cover only 7% of the study area (Fig. 4 A). Urban areas have generally low potential supply. Even most parks and green urban space do not reach a score of 0.4. Only larger urban green space with higher tree density and/or next to bodies of water obtained scores over 0.4. High or very high potential supply matches with large forests surrounding the urban areas and medium potential supply matches with forested areas in the urban-fringe.

3.3. Capacity

Areas accessible for daily recreation cover 18 % of the study area and are mainly located at the urban fringe, especially in Oslo and the southern municipalities of Akershus. Most of them are accessible (40 %) or easily accessible (38 %) areas with high potential for recreational supply (Fig. 4 B).

3.4. Potential demand

The majority of population has access to areas for outdoor recreation on a daily basis. Specifically, the entire population in Oslo and Akershus lives within a 30 min' walk and 93 % lives within a 10 min' walk from areas for daily recreation.

The distributions of population under 14 and over 65 years old, of migrants and by income level are shown in Fig. 5. Oslo municipality has a higher percentage of migrants and of lower income population compared to other municipalities. Bivariate Pearson correlations show that there is no correlation between age (Fig. 5 B) and percentage of areas for daily recreation (Fig. 5 A) on the level of census tract. However, the percentage of areas for daily recreation shows a significant negative correlation with percentage of migrants ($p < 0.01$, $r = -0.214$) (Fig. 5 D) and a significant positive correlation with income level ($p < 0.05$, $r = 0.045$) (Fig. 5 E). This means that in census tracts with higher percentage of migrants the percentage of areas for daily recreation is lower, and in census tracts with higher income level the percentage of areas for daily recreation is higher.

4. Discussion

The assessment of outdoor recreation opportunities in Oslo metropolitan area showed that most population has access, on a daily basis, to areas for daily recreation. However, the access is unequally distributed, with migrants and low-income inhabitants having relatively less access than other population groups. In section 4.1 we discuss these results in light of the distributive and recognition dimensions of EJ. Next, in section 4.2, we discuss the methodological limitations and opportunities of the ESTIMAP model to assess outdoor recreation at the local level.

4.1. Is unequal access to green space always an environmental justice issue?

Met demand for outdoor recreation in Oslo metropolitan area is very high (93 % in the 10 min' walk buffer, 100 % in the 30 min' walk buffer). However, migrants and low-income households have less access to areas for daily recreation than ethnic Norwegians and high-income households. Census tracts in Oslo municipality, with larger proportion of built-up areas, have a lower percentage of areas for daily recreation than the census tracts in Akershus municipalities, but also lower average income, and a higher percentage migrant population. This is a possible question of distributive justice with regards to green space access (Low, 2013), also identified in other cities around the world, such as Berlin (Kabisch and Haase, 2014), Cape Town (Ernstson, 2013), Chicago (Davis et al., 2012), Atlanta (Dai, 2011) or Leicester (Comber et al., 2008). Although migrants in Oslo seem to prefer neighbourhoods with green space (Søholt and Lynnebakke, 2015), ethnic residential segregation may also be the result of lower access to high-priced

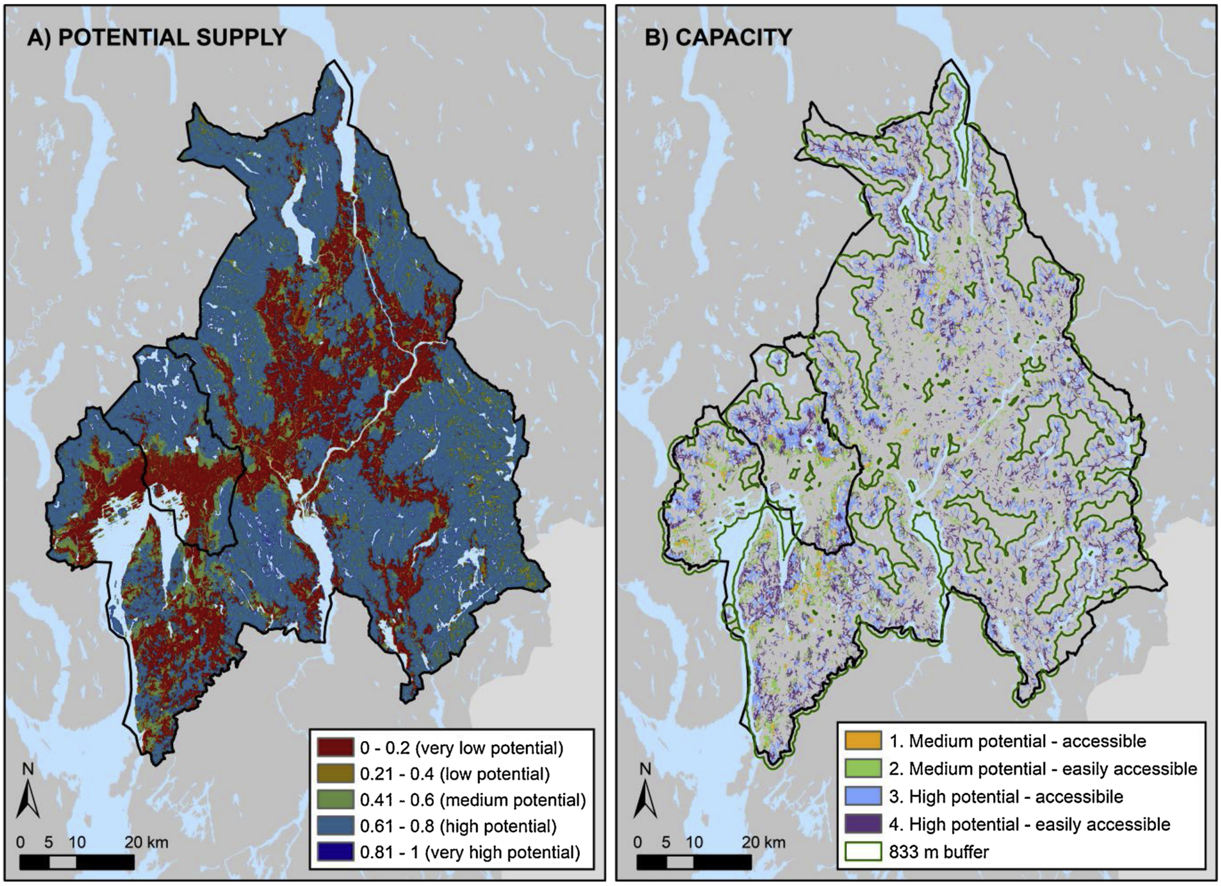

Fig. 4. Potential supply (A) and capacity (B) maps for outdoor recreation in Oslo metropolitan area.

housing market and other political and media factors (Andersson et al., 2017; Søholt and Lynnebakke, 2015).

Distributive justice or the fair distribution of benefits from ecosystems (Ernstson, 2013), is not the same as equal distribution of access to green space. Benefits depend on access, but also on recreation preferences and other urban amenities. The segregation we observe at the metropolitan scale of this study may also be a result of stronger preference among residents of migrant origin compared to ethnic Norwegian origin for 'everyday nature' of near residential urban environments over the peri-urban Marka forest (Skår et al., 2018). In our case study, living near the centre of the metropolitan area also confers a number of urban services and amenities which may compensate for relatively low green space access compared to peri-urban areas in Oslo and Akershus. For example, nearness to shops and other facilities and good access by public transport (Wolday et al., 2018) seem to be reasons that often prevail over nearness to green space. Furthermore, when met demand in absolute values is high, relative inequalities may not be interpreted as environmentally unjust.

In terms of recognition, our results show that recreation preferences are different for different age groups and people living in different neighbourhoods. Young people prefer more 'urban' areas for outdoor recreation, a finding that is in line with Massoni et al. (2018), who found that a majority of university students indicate a preference for 'more urban' parks. However, the ESTIMAP model used in this study does not assess recreation opportunities differentiated by the preferences of different age groups. Potential supply and capacity could be mapped for two preference age groups and compared with age distribution. Further preference analysis would evaluate what urban recreational amenities compensate for lower access to nature-based recreation, and the extent to which users perceived any injustice in relation to unequal access to green space. Furthermore, structural and functional diversity of green space, i.e. the variety of green space structures and the activities associated with them (Massoni et al., 2018), was not assessed in the ESTIMAP model due to data limitations. While our data on naturalness of land cover at metropolitan scale, and tree density and presence of facilities and infrastructure within land cover types captures different resolutions, our path preference data does not distinguish between the spatial resolution of naturalness. This may be important where recreation choice is a multi-stage choice (Day and Smith, 2017), e.g. deciding on type of recreation then destination choice by land cover type, then local path choice on-site.

A notable outcome is that recreation preferences are correlated with the place of residence. People who live in outlying districts, near to the peri-urban forests prefer more 'natural' recreation areas than those who live in the central districts. Massoni et al. (2018) also point out that the most common characteristics in urban parks in Oslo are generally the most preferred. Thus, both findings from these authors and from our own research suggest that population's preferences match the characteristics of green areas near the place they live. This suggests two possible situations: i) people's preferences adapt to the neighbourhoods they live in (habituation) or ii) people self-selected their home location based on their pre-existing preferences. In conclusion, people living in neighbourhoods with fewer areas or more managed green space for daily outdoor recreation cannot *ipso facto* be interpreted as unjustly unsatisfied demand if people have habituated to and/or self-selected their local habitat qualities. To further understand local preferences for green space more exploratory interview-based methods are required (Skår et al., 2018).

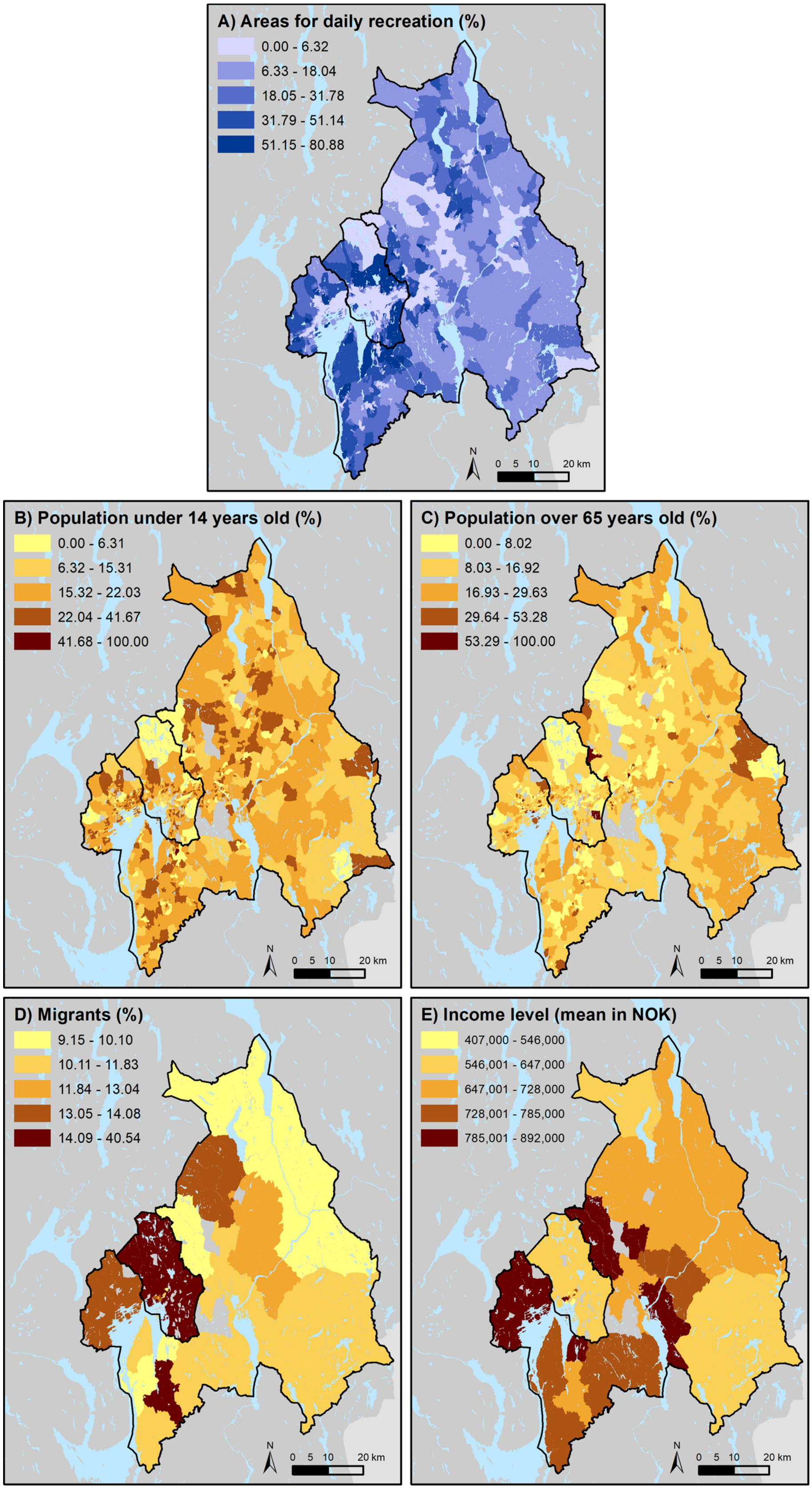

Fig. 5. Percentage of areas for daily recreation (capacity) (A), population under 14 years old (B), population over 65 years old (C), percentage of migrants (D) and mean household income (E) by census tract in Oslo metropolitan area. Census tracts with no population are in grey colour. Variables are classified following the Natural Breaks (Jenks) method.

4.2. Methodological limitations and opportunities for local assessments of outdoor recreation

In this paper we adapted ESTIMAP model for the case study of Oslo metropolitan area with local finer resolution data (10 m) than the European case study (Vallecillo et al., 2018). This limits comparison with other cities, but provides more precise results that are useful for urban and peri-urban planning. We think this methodology can be applied in other cities and metropolitan areas using their own local data. In this section we discuss the methodological limitations and opportunities of the applied methodology to locally assess outdoor recreation.

Degree of naturalness and presence of water are two characteristics usually included in ESTIMAP model to map recreation potential supply (Paracchini et al., 2014; Zulian et al., 2013) and our results validate the use of these two features. However, there are other preferred characteristics, such as tree density and size of continuous forest, which are not usually included in ESTIMAP models. Mapping them may be a difficult task at national or continental scales, but can be more easily done at urban and metropolitan scale, and therefore be included in local spatial modelling. Moreover, although survey answers are correlated and we can distinguish two preference groups in Oslo (people who prefer more 'natural' recreation areas and people who prefer more 'urban' areas), we cannot simplify this multi-criteria evaluation methodology of recreation potential to a few proxy variables. All the analysed green space characteristics define what is more 'natural' and what is more 'urban' and one or two characteristics are not able to represent the whole potential supply spectrum. Within a given socio-demographic there may be a range of preferences on a gradient from managed green space to wilderness, and the subjective interpretation of naturalness may vary across this gradient according to residents' local exposure to different levels of managed nature (Gundersen et al., 2019). Furthermore, preferences may differ by location, thus a previous assessment to select potential supply components would be recommended for each local case study.

Some authors only consider ecosystem biotic and abiotic characteristics in potential supply mapping (e.g. Casado-Arzuaga et al., 2013; La Notte et al., 2017) and they include manmade recreation facilities in a second step to assess, what they call, recreation opportunities. Casado-Arzuaga et al. (2013) assess recreation provision aggregating recreation potential and recreation opportunities, whereas La Notte et al. (2017) propose to aggregate these two components to estimate service flow. In contrast, Vallecillo et al. (2018) assess potential supply based on ecosystem properties and conditions, but also on human inputs such as roads and residential areas. We followed an intermediate approach. We considered that potential supply is defined by ecosystem biotic and abiotic characteristics and manmade recreation facilities, but proximity to roads and residential areas is used to assess capacity. Conceptual frameworks to assess outdoor recreation are fuzzy and differ from one study to another. In this paper we applied Hein et al.'s (2016) definitions and considered that manmade facilities increase potential supply. Recreation services from ecosystems is defined in CICES as 'the biotic and abiotic characteristics of open space that enable health, recuperation and enjoyment through outdoor activities' (Haines-Young and Potschin, 2017). Biotic and abiotic characteristics in urban areas may be perceived as relatively natural in condition, even though they are planted or constructed, determining potential supply, while manmade facilities may further increase capacity (e.g., water fountains, waste bins and restrooms). We find that the preference of acceptable outdoor recreation spaces is correlated with availability. In inner cities tree lined streets and avenues with wide pavements may be considered excellent for walking, jogging and biking. The ESTIMAP methodology (even employed at metropolitan level) does not have sufficient resolution to identify this type of accessibility or capacity (Fig. 4).

Population's preference information was obtained from a survey that was not specifically designed for this study. Respondents were asked to map their favourite recreation path and to characterise biotic and abiotic characteristics and recreation facilities of their favourite path. This conditions the interpretation of the results in two ways. First, the respondent's favourite path is more likely to be one near their homes. This would increase the likelihood that preferred characteristics are similar to the neighbourhood where they live. Second, we are only assessing potential supply for active recreation activities such as walking or running. We did not include characteristics chosen for passive recreation amenities (e.g., green views). Preferences for passive recreation amenities may be captured in hedonic property pricing methods (Barton et al., 2019). To capture habituation/adaptation of preferences to local habitat qualities, recreation choice panel data for each respondent, as done in Day and Smith (2017), could improve understanding of dynamic preferences in future studies.

Our results should also be interpreted in light of a number of data limitations and methodological assumptions. First, the metropolitan scale of analysis required us to standardise recreation opportunities across a number of municipalities, leading us to discard high resolution data on differential park qualities for e.g. Oslo, when comparable data was not available for smaller peri-urban municipalities. Second, the preferred green space attribute of urban tree canopy density was only included in the potential supply modelling of Oslo, because lacking data on individual trees in peri-urban municipalities of Akershus. Third, preference analysis by origin may be biased because migrants are underrepresented in the pre-recruited NORSTAT panel used for the survey. Fourth, the ESTIMAP model has been simplified because we do not have local data on observed recreation use (flow), or data to estimate carrying capacity, which may have an influence on met and unmet demand results. Finally, we assumed that all census tracts in each municipality or district have the same percentage of migrants and the same household income level, but they may differ across census tracts.

Finally, this research analysed outdoor recreation opportunities in Oslo metropolitan area through the lens of EJ. Mapping methodologies, such as ESTIMAP, are valuable tools for urban planning at regional and metropolitan scale, but they tend to overlook relevant characteristics of local green space that influence people's recreational choices. Mapping recreation demand in a way that accounts for local variation in site quality is important to account for recognition across social groups when informing urban green space management. Further research could focus on identifying which green spaces are preferred, for example, using participatory mapping (Nastase et al., 2019). These kind of methodologies may identify physical and psychological barriers which may diminish access for people living in some places or for specific social groups (Biernacka and Kronenberg, 2018) and may be used to corroborate if the areas for daily recreation identified in this study are also the most visited.

5. Conclusions

Based on our results we highlight two key planning and management recommendations for green space in Oslo metropolitan area in relation to distributional justice and recognition:

- In terms of distributive justice, although absolute levels of met demand are very high, quantity and/or quality of green space should be increased in densely populated built-up areas. We assessed access based on walking distances to areas for daily recreation but complementary indicators, such as green space per person (Kabisch and Haase, 2014), could indicate a lack of green space in Oslo central districts.
- From a recognition perspective, green space should be structurally and functionally diverse, so people with different recreation preferences have access to green space according to their preferences and values. In this case, a balanced combination between biotic and abiotic characteristics and built facilities would increase recreation

opportunities for different age groups.

Differences in relative access to green space have often been interpreted as a problem of EJ (e.g., Comber et al., 2008; Dai, 2011; Davis et al., 2012; Pham et al., 2012). The combination of inequality of physical access with equality in preferences is a potential indicator of environmental injustice because preferences are not adapted to different levels of access. However, the relative inequality in access to green space for selected socio-economic indicators needs to be evaluated in the context of (i) absolute levels of met demand which are so high that relative differences between groups may not be salient to inhabitants, (ii) self-selection and habituation to lower green space access making even salient inequalities of no emotional significance (because they are due to individuals own choices), and (iii) compensation of lower access to green space by other urban amenities and advantages (e.g. access to public transport). Hence, our research suggests that the relation between access to green space and EJ can be complex, and that injustice may not automatically result from uneven access.

CRediT authorship contribution statement

Marta Suárez: Conceptualization, Methodology, Formal analysis, Writing - original draft, Visualization. **David N. Barton:** Conceptualization, Methodology, Writing - review & editing. **Zofie Cimburova:** Methodology, Formal analysis, Visualization. **Graciela M. Rusch:** Formal analysis, Visualization, Writing - review & editing. **Erik Gómez-Baggethun:** Writing - review & editing. **Miren Onaindia:** Writing - review & editing.

Declaration of Competing Interest

The authors declare no conflict of interest.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.envsci.2020.03.014.

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