A Needs Assessment relating to the Provision of Natural Greenspace in areas with Low Levels of Physical Activity

Methodology

20 May 2016

Report to:

Kent Nature Partnership

Health & Nature Subgroup

A Needs Assessment relating to the Provision of Natural Greenspace in areas with Low Levels of Physical Activity

Methodology

Prepared by:

Teresa Bennett, Natural Values

Zoe Davies, Durrell Institute of Conservation and Ecology (DICE)

Susan Hodgson, Medical Research Council – Public Health England (MRC-PHE)

Centre for Environment and Health, Imperial College London

Tristan Pett, Durrell Institute of Conservation and Ecology (DICE)

Tony Witts, Kent and Medway Biological Records Centre (KMBRC)

20 May 2016

Contents

1. Introduction

This report is one in a series regarding the needs assessment in relation to provision of natural greenspace in areas with low levels of physical activity. It provides a detailed and transparent account of the methodological approach adopted, which will facilitate future updates or the application of the methods in other counties.

Throughout the report 'accessibility to greenspace' (including 'access of greenspace') refers to a site being accessible via some form of public right of way. However, this does not necessarily mean that the site is accessible to all sectors of society (e.g. individuals with a physical disability); accounting for the quality of the access route was beyond the scope of this project.

Greenspace is defined as *'places where human control and activities are not intensive so that a feeling of naturalness is allowed to predominate* '(as described by Natural England[1]). Greenspace includes '*all open space of public value, including not just land, but also areas of water such as rivers, canals, lakes and reservoirs which offer important opportunities for sport and recreation and can also act as a visual amenity*'[2].

Physical activity is defined on the basis of '*body movement that expends energy and raises the heart rate*'[3].

[1] Natural England (2010) *'Nature Nearby' Accessible Natural Greenspace Guidance.* http://webarchive.nationalarchives.gov.uk/20160323000001/http://publications.naturalengland.org.uk/publication/40004. Accessed 24/3/16.
[2] ODPM (2002) *Planning Policy Guidance 17: Planning for open space, sport and recreation*. HMSO
[3] Public Health England (2014) *Everybody active, every day: An evidence-based approach to physical activity*.

2. Geographical Information System (GIS) data processing and analysis

2.1 Spatial dataset preparation

Analysis of accessible natural greenspace provision across Kent required the use and manipulation of four types of spatial data (see Methodology Appendix A for full list):

- Boundary data
- Access data
- Greenspace data
- Kent population data

All spatial data were processed using ESRI ArcGIS 10.3.1 with EtGeo Wizards 11.2.

2.1.1 Boundary data

The spatial extent of the analyses comprised all land within the administrative boundary of Kent and therefore excluded the Medway Unitary Authority area. The study used 2011 Lower-layer Super Output Areas (LSOA) as the smallest geographic unit[4]. Each LSOA covers a minimum of 1,000 residents, with an average of 1,600, and their size is dependent on population density. LSOAs are the geographic building blocks of larger areas such as wards, districts and Clinical Commissioning Groups. The 2011 Rural-Urban Classification for Output Areas in England[5] was used to categorise each LSOA according to population density and settlement dispersal.

2.1.2 Access data

A key aspect of this study was to determine both the proximity and accessibility of greenspace to people. To achieve the latter, spatial datasets of Public Rights Of Way (PROW), Promoted Routes, Sustrans Routes and roadside footways[6] were collated. All routes were merged into a single dataset, after further processing of the footways data.

[4] https://data.gov.uk/dataset/lower_layer_super_output_area_lsoa_boundaries. Accessed 24/3/16.
[5] http://www.ons.gov.uk/ons/guide-method/geography/products/area-classifications/2011-rural-urban/index.html. Accessed 24/3/16.
[6] All supplied by Kent County Council (see Appendix A)

Urban footways were extracted from a dataset of all roads in Kent. Pavements, which did not cross roads or junctions, resulted in lots of short fragments. To better represent how people travel, gaps of less than 30 m between end points and nearby routes were closed. Where footways were present on both sides of a road within 10 m of each other, they were made into a single mid-line. These distances were chosen based on sampling gap sizes via the Ordnance Survey base map.

2.1.3 Greenspace data

Local authority open space audit layers were gathered from the twelve districts in Kent. Any dataset which was not projected in British National Grid was re-projected, and all datasets were tested for faulty geometry and repaired where necessary. All of the open space audit layers used Planning Policy Guidance 17 (PPG17) typologies[7] (see Methodology Appendix B). School playing fields were removed from the datasets as they are rarely publicly accessible.

County-wide datasets of greenspace relevant to the project (e.g. Local Nature Reserves, Kent Wildlife Trust reserves, Woodland Trust reserves, state owned woodlands, village greens and common land) were collated (see Methodology Appendix A for a full list). Any sites which are closed to the public were excluded. Not all greenspace of interest to this study is designated nature reserves or common land, so the 2012 Kent Habitat Survey data[8] were analysed to identify additional areas of unimproved or semi-improved grasslands, woodland and coastal habitats (above mean high-water) that should be included. These sites and the open space audit layers from each district were made into a single master greenspace layer.

Each publically accessible greenspace was categorised using naturalness levels (Box 1)[9], as no such differentiation is provided within the PPG17 typologies (Table 1). Naturalness levels are based on the 'feeling of naturalness' associated with a site[10]. Where a greenspace coincided spatially with woodland or a nature reserve, the naturalness score was modified in accordance to the guidance given in 'Nature Nearby' (e.g. a churchyard identified in the local authority data would be attributed to naturalness level 3, however, if the 2012 Kent Habitat Survey showed this site to have woodland present the level

[7] ODPM (2002) *Planning Policy Guidance 17: Planning for open space, sport and recreation*. HMSO
[8] http://www.archnature.eu/. Accessed 26/3/16.
[9] Natural England (2010) *'Nature Nearby' Accessible Natural Greenspace Guidance.*
[10] Ibid

would be raised to naturalness level 1). Improved farmland was not considered in this study, so level 4 was excluded from the analyses

Box 1: Naturalness Levels according to Natural England (2010) 'Nature Nearby' Accessible Natural Greenspace Guidance.

Categories for 'feeling of naturalness':

Level 1

- Nature conservation areas, including Sites of Special Scientific Interest
- Local sites, including local wildlife sites, Regionally Important Geological Sites
- Local Nature Reserves
- National Nature Reserves
- Woodland
- Remnant countryside (within urban and urban fringe areas)

Level 2

- Formal and informal open space
- Unimproved farmland
- Rivers and canals
- Unimproved grassland
- Disused/derelict land, mosaics of formal and informal areas of scrub etc
- Country parks
- Open access land

Level 3

- Allotments
- Church yards and cemeteries
- Formal recreation space

Level 4

- Improved farmland

Table 1: Naturalness levels in relation to PPG17 types.

PPG17 Type	Categorisation within naturalness level (see Box 1)	Naturalness level
Natural & semi-natural greenspace	• Designated sites and woodland • Other	1 2
Green corridors	• Designated sites and woodland • Other	1 2
Parks & gardens	• Formal & Informal Open Space • Country Parks	2 2
Outdoors sports facilities	• Formal Recreation Space	3
Amenity greenspace	• Formal Recreation Space	3
Provision for children and young people	• Formal Recreation Space	3
Allotments	• Allotments	3
Cemeteries	• Cemeteries	3

The master greenspace layer was derived from data captured using a range of spatial precisions. For example, in some instances whole sites were delineated, irrespective of internal complexities such as roads and buildings, while others had a high level of precision that separated out such features, resulting sites being fragmented into multiple polygons. As distance and size based metrics were used in this study to assess greenspace provision, it was important to combine all polygons associated with a site into a single contiguous polygon. Sampling within sites showed that closing gaps of up to 3 m would unify fragmented sites, but not erroneously join sites separated by major roads or railway lines.

Sites were frequently made up of a mix of naturalness levels and these differences needed to be maintained so they could be explored in the analyses of greenspace provision. To facilitate this, each naturalness level was selected in the master greenspace layer sequentially and exported into a new layer. The three naturalness level layers were then recombined into two new layers: (i) naturalness level 1, 2 & 3; and, (ii) naturalness level 1.

Naturalness level 1, 2 & 3 greenspace formed the main focus for this study. The rationale for this was that open spaces of all levels of naturalness provide opportunities for physical activity. Naturalness level 1 greenspace was also included in the analyses for comparison.

Natural England recommends a minimum area of 0.25 ha when mapping accessible greenspace[11] to identify opportunities to reduce greenspace provision deficiencies. Areas of greenspace with an area extent of less than 0.25 ha were therefore removed from each of the final combined naturalness layers. Once gaps between site fragments had been removed, the boundaries between adjacent polygons were dissolved to remove overlaps and create contiguous greenspace sites.

2.1.4 Determining site accessibility

Within the constraints of this study, it was not possible to assess whether or not each individual greenspace site is accessible to the public; therefore no site labelled as accessible is guaranteed to be open to the public. All local authority open space audit sites, with the exception of school playing fields (please see above) were assumed to be publically accessible. Any sites which were more than 10 m from an access route were excluded from further analyses. This tolerance was chosen because it accounts for the error associated with pulling footways and other overlapping paths into a single median line in the access route layer.

2.1.5 Kent population data

2.1.5.1 Population distribution data

The distribution of households within the LSOAs was not known and could not be assumed to be even across the area. The Office for National Statistics postcode database[12] gives a grid reference for the building closest to the geographic centre of all the buildings in a postcode. The postcodes were plotted in the GIS and those falling within Kent were extracted to a point data layer. Postcode level 2011 census population data were then joined to the points to provide the total number of people and occupied households in each postcode. On average there are 15.9 occupied households and 38.5 people per residential postcode in Kent. Any postcodes which did not include any residential households were deleted.

There is no direct relationship between postcode and LSOA boundaries, so each postcode needed to be attributed to the LSOA in which it is located. This could have

[11] Land Use Consultants (2008*) Understanding the relevance and application of the Access to Natural Green Space Standard*. Natural England.
[12] http://webarchive.nationalarchives.gov.uk/20160105160709/http://www.ons.gov.uk/ons/guide-method/geography/products/postcode-directories/-nspp-/index.html. Accessed 24/3/16.

introduced some error in population numbers as postcodes may include households located in an adjacent LSOA.

2.1.5.2 Deprivation data

Index of Multiple Deprivation (IMD) 2015[13] data were extracted for the 902 LSOAs in Kent.

2.1.5.3 Physical inactivity data

Physical activity is measured through the annual Sport England's Active People Survey[14]. Since 2012 the survey has included physical activity for health, and is now the national measure recognised by Public Health England and included in the Public Health Outcomes Framework. It reports population physical activity levels at County and District Council level so, for more spatially resolved estimates of physical activity, proxy measures are required.

Physical activity is reported in Experian Mosaic segments[15], a population profiling and segmentation tool used by Kent County Council (KCC). Experian assign activity levels to certain population segments and report the data at an Output Area spatial resolution, providing a more detailed interpretation of who is physically inactive and where. The underpinning information comes from a Target Group Index Survey[16], which includes the following question on physical activity: "How many hours per week do you take part in sport or other types of exercise, such as walking, jogging or going to the gym?". It should be noted that the question does not breakdown exercise by location. The physically active proportion of the population might, therefore, be using indoor facilities to exercise, rather than greenspace.

Nationally, data relating to almost 50 million people across the UK are used to build the Experian Mosaic segments. The number of respondents to the physical activity question in the Target Group Index Survey is unknown, but the sample size is assumed to be high enough for the results to be valid. Physically inactive people, as reported in Experian

[13] https://www.gov.uk/government/statistics/english-indices-of-deprivation-2015
[14] http://www.noo.org.uk/data_sources/physical_activity/activepeople. Accessed 24/3/16.
[15] http://www.experian.co.uk/marketing-services/products/mosaic-uk.html. Accessed 24/3/16.
[16] http://www.kantarmedia.com/global/our-solutions/consumer-and-audience-targeting/tgi-survey-data. Accessed 24/3/16.

Mosaic segments, are assumed match the Chief Medical Officers' definition of physical inactivity.

Due to commercial license restrictions, the five Experian Mosaic segments showing physical inactivity were grouped by KCC's Strategic Business Development & Intelligence and Public Health teams (Table 2).

Table 2: Physically inactive population figures for Kent derived from Experian Mosaic 2013 segment data

Inactive Segments	Kent Population (No. of people)	Kent Population (%)
Segment 1: Residents aged 55 and over on low incomes, often living in social housing	66,947	4.5
Segment 2: Younger Residents on Low Incomes Living in Social Housing (Aged 20-50)	15,758	1.1
Segment 3: Comfortably off singles and couples aged over 55	241,128	16.1
Segment 4: Families on low incomes with school age children, many living in areas of high deprivation	34,780	2.3
Segment 5: South Asian singles aged 55+ who own their own home	3,228	0.2
Total	**36,1841**	**24.2**

Experian Mosaic segments from 2013 that scored highly for low levels of physical activity or exercise participation were joined to the LSOA boundary layer, allowing the percentage of the population considered to be inactive to be estimated across the county by LSOA district and CCG.

2.2 Assessing greenspace provision

Two sets of accessibility standards were used to identify which postcodes have adequate greenspace provision: ANGSt[17] and Dover District Council accessibility standard[18] (Box 2). The analyses were repeated for two combinations of site naturalness: (i) naturalness level 1, 2 & 3; and, (ii) naturalness level 1.

[17] Natural England (2010) *'Nature Nearby' Accessible Natural Greenspace Guidance*.
[18] DDC Parks and Amenity Open Space Strategy 2013 & Land Allocations Local Plan 2015.

Box 2: Accessibility standards used in this study

ANGSt criteria:

- At least 1 site >2 ha within 300 m of where people live
- At least 1 site >20ha within 2 km of where people live
- At least 1 site >100ha within 5 km of where people live
- At least 1 site >500ha within 10 km of where people live

DDC accessibility standard:

- At least 1 site >0.4 ha within 300 m of where people live in urban locations or at least 1 site >2 ha within 1 km of where people live in rural locations

Accessible greenspace over the Kent border was not included in the analyses. Provision of accessible greenspace for LSOAs near the county border, therefore, will be an underestimate. The size of this underestimate will increase as the distances used in the accessibility standards become greater.

Three methods of assessing greenspace provision were explored:

- Service area.
- Buffer intersection.
- Allocation.

Each method has its pros and cons due to complexity of execution and the assumptions made. Following consultation with KCC, the service area method and results are presented as the core analyses.

2.2.1 Service area method

This method determines the potential distance travelled to access a greenspace, following the access route layer. A greenspace entry point was deemed to be any location where the access route layer intersected (allowing for 10 m error, see above) with the greenspace boundary. Where two or more greenspace entry points fell within 20 m of each other, a single consolidated entry point was generated at the geometric centre to reduce the computational complexity of the analyses.

Each separate analysis tested greenspace proximity/accessibility using the distances associated with the ANGSt and DDC standards. Where there was a break in the access route, the model assumed that travel via that route was not possible, even if the maximum travel distance has not been reached (hence high quality information on footways and paths was necessary).

The outputs from the models were lines representing the access routes that could be travelled from a greenspace entry point to the maximum distance for the accessibility standard being tested, and a polygon representing the area of influence of that line. The area of influence of the line was limited to a maximum of 100 m[19] to either side of the line. The postcodes which fell within the area of influence were considered to have met the standard. In densely populated areas, where access routes were closely packed, the model automatically avoided falsely including areas associated with access routes beyond the maximum travelling distance; this meant that only those postcodes whose centroids were very close to the route were included.

Limitations associated with using this method are summarised (Table 3).

Table 3: Assumptions and caveats to be taken into account in using the data from the service area method

Assumptions/caveats
• The model creates a polygon within which postcodes can be assessed to have access to greenspace within defined travelling distances along the path of a network and therefore relies on accurate route information. • The access route layer was found to be highly fragmented due to footways not meeting across road junctions and other routes ending short of road edges. These gaps were closed using a maximum tolerance of 30 m. This distance was chosen based on sampling gap sizes against the Ordnance Survey base map. • A greenspace entry point was deemed to be any location where the access route layer intersected (allowing for 10 m error) with the greenspace boundary. • Where two or more greenspace entry points fell within 20 m of each other, a single consolidated entry point was generated at the geometric centre to reduce the computational complexity of the analyses. • The postcode data, which is based on weighted-centroid points, did not necessarily coincide with the access route layer and so service area polygons were extended to 100 m either side of an access route to encompass and select postcodes within distance of greenspace entry

[19] This was the default value used in the software.

Assumptions/caveats
points. In urban areas, where the postcodes are more tightly packed, the weighted-centroid postcode points more closely match the location of the population than in rural areas where the population is more dispersed. Consequently, this approach is likely to under estimate greenspace provision in rural areas. • The access route layer consists of public rights of way and excludes the road network. Consequently, the method is likely to underestimate provision of accessible greenspace increasingly as the distances get larger. It also means that the method is less suitable when considering distance travelled other than on foot.

2.2.2 Buffer intersection

Buffer intersection is a Euclidean, or straight-line, method which assumes that greenspace is accessible to the public at any point around the edge of the site (Table 4). In each separate analysis, a buffer of the distance pertinent to the accessibility standard under scrutiny was placed around each area of greenspace. Any postcodes falling within the buffer were deemed to meet the standard

Table 4: Assumptions and caveats to be taken into account in using the data from the buffer intersection method

Assumptions/caveats
• This approach assumes that people take the shortest straight line route from postcode to the site, when in reality this is rarely the case. • The approach assumes the site can be entered anywhere along its edge, when for many sites there will be specific entry points, that may be some distance from the straight line route.

2.2.3 Allocation

The allocation method uses entry points to a greenspace, rather than assuming that a site can be entered at any point along its edge (Table 5). All postcodes that fall within the straight line distance pertinent to the proximity/accessibility standard under scrutiny from a greenspace entry point were reported as meeting the standard.

Table 5: Assumptions and caveats to be taken into account in using the data from the allocation method

Assumptions/caveats
• This approach assumes that people take the shortest straight line route from postcode to the site, when in reality this is rarely the case. • A greenspace entry point was deemed to be any location where the access route layer intersected (allowing for 10 m error) with the greenspace boundary. • Where two or more greenspace entry points fell within 20 m of each other, a single consolidated entry point was generated at the geometric centre to reduce the computational complexity of the analyses.

3. Statistical analyses

A form of regression analysis called generalised linear mixed modelling (GLMM) was used to identify potential variables that might explain differences in levels of physical inactivity between LSOA populations. In all models, inactivity was a two-vector response variable of the number of active, and inactive, people in an LSOA. To account for the fact that physical activity in the population was therefore a proportion a binomial error structure was employed. The models included three known predictors of physical inactivity from the scientific literature: (i) the proportion of the population over 65 years old (obtained from the 2011 census); (ii) the natural logarithm of the level of deprivation in the community (measured via the Index of Multiple Deprivation (IMD)); and, (iii) the proportion of the population who are non-white (obtained from 2011 census). Additionally, two of the ANGSt (areas over 2 ha within 300 m, and areas over 20 ha within 2 km), or the two DDC (urban areas over 0.4 ha within 300 m, and rural areas over 2 ha within 1 km) greenspace proximity/accessibility standards, were incorporated as potential predictors. Collinearity between explanatory variables was tested[20] for each analysis and deemed acceptable, as no variables had a variance inflation factor greater than three.

In the models, two 'random effects' were accounted for. The first of these was differences in rural/urban LSOA population density and size (via the 2011 Rural-Urban Classification for Output Areas)[21]. The second was LSOA identity, to control for overdispersion (greater variation in the dataset than would be expected by a binomial model)[22]. Two erroneous data points were removed prior to modelling[23].

An information-theoretic approach to model selection was used to compare all candidate models and identify the most parsimonious solution[24,25]. Only candidate models with a

[20] Zuur A.F., Ieno E.N., Walker N.J., Saveliev A.A., Smith G.M. (2009) *Mixed effects models and extensions in ecology with R*, Springer Verlag.
[21] The 2011 Rural/Urban Classification (RUC2011) is published by the ONS (http://www.ons.gov.uk/ons/guide-method/geography/products/area-classifications/2011-rural-urban/index.html).
[22] Browne, W.J, Subramanian S., Jones, V.K., and Goldstein, H. (2005) Variance partitioning in multilevel logistic models that exhibit overdispersion. Journal of the Royal Statistical Society: Series A (Statistics in Society) 168: 599-613.
[23] Two LSOAs (E01024563 Swale 015D and E01024683 Thanet 013B) were removed from dataset prior to conducting the analyses, as the number of inactive people was higher than the total population.
[24] Burnham, K.P. & Anderson, D.R. (2002) Model Selection and Multimodel Inference: A Practical Information-Theoretic Approach. Springer Verlag, New York.
[25] Whittingham, M.J., Stephens, P.A., Bradbury, R.B. & Freckleton, R.P. (2006) Why do we still use stepwise modelling in ecology and behaviour? Journal of Animal Ecology, 75, 1182–1189.

ΔAIC_c<4 (Akaike Information Criterion) were included in the model set used for model averaging and, as such, implausible models with low AIC weights were eliminated from the analysis solution[26,27]. Averaged parameter estimates (β), unconditional standard errors (SE), lower and upper 95% confidence intervals (LCI and UCI) and relative variable importance factors (RI) are reported for each GLMM.

The statistical analyses were conducted for naturalness level 1 green spaces, and then again for all naturalness level 1, 2 & 3 sites combined. Initially this was done for the county as a whole, before being repeated for urban and rural Kent separately.

The whole statistical procedure was carried out three times using green space provision as estimated by the following methods: (i) service area; (ii) buffer intersection; and, (iii) allocation. All statistical analyses were performed using R (version 3.2.3)[28] and GLMMs applied using the package lme4[29].

A fundamental limitation of this study is that green space proximity/accessibility across the county border was not assessed, even though some sites in neighbouring counties[30] may have permitted people living in Kent to meet the ANGSt and DDC standards. To test the impact that this may have had on the study results, a series of sensitivity analyses were conducted. This comprised repeatedly re-running the modelling procedure, each time removing the LSOAs in Kent bordering neighbouring counties at the distance intervals associated with the ANGSt and DDC standards.

[26] [26] Burnham, K.P. & Anderson, D.R. (2002) Model Selection and Multimodel Inference: A Practical Information-Theoretic Approach. Springer Verlag, New York.
[27] Bolker, B.M., Brooks, M.E., Clark, C.J., Geange, S.W., Poulsen, J.R., Stevens, M.H.H. et al. (2009) Generalized linear mixed models: a practical guide for ecology and evolution. Trends in Ecology & Evolution 24: 127–135.
[28] R Core Team (2015). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.
[29] Bates, D. Maechler, M. Bolker, B., & Walker S. (2015) Fitting Linear Mixed-Effects Models Using lme4. Journal of Statistical Software, 67(1), 1-48.
[30] Neighbouring counties covering Essex, East Sussex, Surrey, Greater London and Medway.

4. Prioritisation

Data on LSOAs were divided into five groups (Table 6) based on the level of physical inactivity within the population. The most physically inactive populations were deemed to be the highest priority for action.

Table 6: Physically inactive priority groupings

Proportion of population that is physically inactive	Priority
>80% population physically inactive	Physically inactive priority 1
>60%-80% inactive	Physically inactive priority 2
>40%-60% inactive	Physically inactive priority 3
>20%-40% inactive	Physically inactive priority 4
0%-20% inactive	Physically inactive priority 5

For each of the five physical inactivity priority groups, LSOA information (LSOA reference code, Kent LSOA name/reference, Ward name, CCG, Local Authority, Rural-Urban classification, IMD decile) were tabulated (as five matrices) along with the percentage population meeting accessibility criteria for greenspace within 300 m of home.

The percentage of the population meeting the standard of having a greenspace of at least 2 ha within 300 m of home (ANGSt) has been used as the main indicator of need for accessible greenspace in relation to physical inactivity within the prioritisation matrices. This standard was considered to be the most appropriate for assessing proximity of accessible greenspace for physical activity, based on evidence from the scientific literature suggesting that people are more likely to visit natural greenspace in close proximity to where they live[31,32,33].

The data were then categorised and colour coded (Table 7) according to the percentage of the population meeting the standards, in order to identify priorities for greenspace provision.

[31] Carter, M. and P. Horwitz (2014). "Beyond proximity: the importance of green space useability to self-reported health." *Ecohealth* **11**(3): 322-332.
[32] Dallimer, M., Davies, Z.G., Irvine, K.N., Maltby, L., Warren, P.H., Gaston, K.J. & Armsworth, P.R. (2014) What Personal and Environmental Factors Determine Frequency of Urban Greenspace Use? *International Journal of Environmental Research and Public Health,* 11: 7977-7992.
[33] Giles-Corti, B., Broomhall, M.H., Knuiman, M., Collins, C., Douglas, K., Ng, K., Lange, A. & Donovan, R.J. (2005) Increasing walking: how important is distance to, attractiveness, and size of public open space? *American Journal of Preventative Medicine* **28**(2): 169–176).

Table 7: Key to colour codes used in the prioritisation matrices

Percentage	Criteria
0% to 10%	% population meeting ANGSt for naturalness level 1, 2 & 3 greenspace of at least 2 ha site within 300 m of home using the service area method
0% to 10%	% population meeting the DDC accessibility standard for naturalness level 1, 2 & 3 sites using the service area method
>10% to 50%	% population meeting ANGSt for naturalness level 1, 2 & 3 greenspace of at least 2 ha site within 300 m of home using the service area method
>50% to 90%	% population meeting ANGSt for naturalness level 1, 2 & 3 greenspace of at least 2 ha site within 300 m of home using the service area method
>90% to 100%	% population meeting ANGSt for naturalness level 1, 2 & 3 greenspace of at least 2 ha site within 300 m of home using the service area method
>50%	% population meeting ANGSt for naturalness level 1, 2 & 3 greenspace of at least 2 ha site within 300 m of home using buffer intersection when that using the service area method is <50%

Within each matrix, LSOAs were initially ordered according to level of deprivation (a priority set by KNP), with the most deprived LSOAs listed first. Following this, LSOAs were ordered by the percentage of the population meeting the accessibility standards, with the lowest percentage population meeting standards listed first (Table 8).

Table 8: Accessibility standards used in ordering LSOAs within the prioritisation matrices.

Naturalness level 1, 2 & 3				Naturalness level 1	
Service area		Buffer intersection		Service area	Buffer intersection
ANGSt: % population within 300 m of >2 ha	DDC: % population within urban-rural standard	ANGSt: % population within 300 m of >2 ha	DDC: % population within urban-rural standard	ANGSt: % population within 300 m of >2 ha	ANGSt: % population within 300 m of >2 ha

The DDC accessibility standard (at least one site of at least 0.4 ha within 300 m in urban areas or at least 2 ha within 1 km in rural areas) was developed as pragmatic standard for provision of greenspace[34]. Across Dover, the mean size of accessible greenspace below 2 ha was found to be 0.4 ha in urban areas. In rural locations, with greater access

[34] DDC Parks and Amenity Open Space Strategy 2013 & Land Allocations Local Plan 2015.

to the countryside and areas of greenspace of at least 2 ha, a distance of 1 km (15 minutes walking time) rather than 2 km was considered more appropriate for the standard.

5. Effectiveness of methodology and suggested improvements

All methods used are repeatable. Buffer intersection was the least complex method in computational terms, followed by allocation and service area.

Each method has its strengths and weaknesses (Table 9).

Table 9: Strengths and weaknesses of the three methods

Method	Strengths	Weaknesses/Assumptions
Buffer intersection	• Simplicity of calculation.	• It assumes that people are able to take the shortest straight line route to travel to the site. • It assumes a greenspace can be accessed anywhere along its edge. • The number of people able to access sites within the ANGSt/DDC accessibility standard distances are likely to be overestimated, due to the two core assumptions.
Allocation	• Uses points of access to greenspace.	• It assumes that people are able to take the shortest straight line route to travel to the entry point of a greenspace. • The number of people able to access sites within the ANGSt/DDC accessibility standard distances are likely to be overestimated, due to this core assumption. • It assumes that the entry points to greenspace are accurate (these could be ground truthed to assess the associated degree of error).
Service area	• Most accurately reflects the routes used to travel to greenspace by foot. • Uses points of access to greenspace.	• It assumes that the entry points to greenspace are accurate (these could be ground truthed to assess the associated degree of error). • The provision of accessible greenspace is likely to be underestimated increasingly as the ANGSt distances get greater, due to exclusion of the road network; thus the method is less suitable when considering distance travelled other than on foot. • Less accurate for rural areas where the population covered by a postcode is more dispersed and therefore likely to underestimate greenspace provision.

To directly compare the results reported here to a repeat follow up study in the future, the same methodological approach would need to be followed. However, the following improvements could be made to all three methods:

i. Include accessible greenspace in areas bordering Kent, so that they are accounted for when assessing accessibility standards for LSOAs on/near the border. The access route layer would also need to be extended into areas bordering Kent if the service area method is to be used.
ii. Postcode polygons could be used to assess proximity to access routes. This would avoid the need to limit the area of influence in modelling the route for the service area method.
iii. The service area method could be developed by including the road network in the access route layer when assessing greenspace accessibility at distances of 2 km or further.
iv. Data on greenspace entry points could be improved by ground truthing a sample of sites (time did not permit this in this study).

Appendix A: Study datasets

Type	Dataset	Data owner	Notes
Boundary	Kent and Medway	Ordnance Survey	Open data licence
	Districts	Ordnance Survey	Open data licence
	Clinical Commissioning Group (CCG)	NHS England	Open Government Licence
	Lower-layer Super Output Area (LSOA)	Office for National Statistics	2011 iteration
Greenspace	Nationally designated sites (Sites of Special Scientific Interest and National Nature Reserves)	Natural England	Open Government Licence
	Local Nature Reserves	Natural England	Open Government Licence
	Kent Wildlife Trust Reserves	Kent Wildlife Trust	Held by KMBRC not to be shared, only publicly open sites included
	Local Wildlife Sites	Kent Wildlife Trust	Held by KMBRC not to be shared
	Woodland Trust Reserves	The Woodland Trust	Held by KMBRC not to be shared
	RSPB Reserves	Royal Society for the Protection of Birds	Held by KMBRC not to be shared
	National Trust properties	The National Trust	Held by KMBRC not to be shared
	Kent Habitat Survey	Kent County Council	BAP priority habitats, woodlands and non-tidal coastal habitats used. 2012 iteration
	Kent County Council Country Parks	Kent County Council	Country Parks, picnic sites and other accessible natural spaces
	Registered Historic Parks and Gardens	Kent County Council	Not all open to the public
	Millennium Greens	Natural England	Open Government Licence
	Doorstep Greens	Natural England	Open Government Licence
	Forestry Commission woodland	The Forestry Commission	Open Government Licence
	Common land	Kent County Council	
	Open access land	Natural England	Open Government Licence
	Village greens	Kent County Council	

Type	Dataset	Data owner	Notes
Access	Open space audit datasets		Not all PPG17 typologies were represented in all datasets (see Appendix B).
	Ashford	Ashford Borough Council	
	Canterbury	Canterbury City Council	
	Dartford	Dartford Borough Council	
	Dover	Dover District Council	
	Gravesham	Gravesham Borough Council	
	Maidstone	Maidstone Borough Council	
	Sevenoaks	Sevenoaks District Council	
	Shepway	Shepway District Council	
	Swale	Swale Borough Council	
	Thanet	Thanet District Council	
	Tonbridge & Malling	Tonbridge & Malling Borough Council	
	Tunbridge Wells	Tunbridge Wells Borough Council	
	Public Rights of Way	Kent County Council	
	Cycling routes	Kent County Council	
	Promoted cycle routes	Kent County Council	
	Roads with footways	Kent County Council	
Kent population data	Deprivation levels by LSOA	Department for Communities and Local Government	Open Government Licence
	Physical inactivity prevalence at Output Area	Kent County Council	
	Health datasets relating to conditions that may be improved by access to outdoor greenspace	Kent Health Observatory	
	Population at LSOA by, for example, age, sex, deprivation (IMD and domains) and ethnicity	Department for Communities and Local Government	
	Population data for postcodes	Office for National Statistics	Open Government Licence

Appendix B: Local Authority open space audit PPG17 greenspace categories

PPG17 Type	Ashford	Canterbury	Dartford	Dover	Gravesham	Maidstone	Sevenoaks	Shepway	Swale	Thanet	Tonbridge & Malling	Tunbridge Wells
Allotments	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Amenity Greenspace	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Churchyards & Cemeteries	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Green Corridors	Yes	Yes	No	No	No	No	Yes	Yes	No	Yes	No	No
Natural & Semi-natural Open Spaces	Yes	Yes	Yes	Yes*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Outdoors Sports Facilities	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes
Parks & Gardens	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Provision for Children and Young People	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes

*Note that Dover did not supply a Natural and Semi-natural Open Spaces layer as they construct theirs from national datasets i.e. Natural England's SSSI layer etc.