The outdoor environment as a means of tackling poor health and health inequalities

Final report (abridged version) on a research project funded by the Forestry Commission

Prepared by Professor Richard Mitchell

r.mitchell@clinmed.gla.ac.uk

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Table of contents

Background and Overview

The UK and other developed nations continue to face problems with rising rates of chronic diseases and apparently declining mental health. Allied to these are steady increases in health inequalities between population sub groups, particularly between those characterised by greater and less socio-economic disadvantage. Existing literature, drawn primarily from the UK, Netherlands and Sweden has suggested that either visual or physical access to green spaces may carry health benefits. There is evidence that populations to have access to green spaces have lower levels of morbidity and mortality from certain causes. A recent study in the UK also suggested that the health gap between more and less advantaged populations may be narrowed in areas which have a higher proportion of green space. Understandably, this kind of research finding has raised considerable levels of interest among a variety of groups. Politicians, health professionals, land managers and those with an interest in or passion for the natural world have all begun to talk about green spaces as potentially useful in the hunt for better public health, narrower health inequalities and preserved and enhanced green spaces.

However, this field of study remains in its infancy with many, many important questions about the relationship between health and access to green space, and how this relationship should be researched, still to be explored. This project was conceived to try and address some of these important questions.

The project details

The Forestry Commission funded a 12month project focused on developing research into the relationships between green space and population health. The project was originally intended to run from June 2008 to May 2009, but actually ran from July 2008 to end of August 2009. A research assistant (Thomas Astell-Burt) was recruited for the original 12 month period of funding, but unfortunately left early. We were fortunate to find a very experienced researcher who was able to work initially full time and then part time on finishing the work (Dr Liz Richardson). The slightly different skill set of the original researcher and the second researcher had implications for what we were able to achieve.

Initially, research effort focused on identifying suitable data sources for measuring green space and population health in the UK and securing access to them. Having clarified and refined was could be achieved with available data, a steering group meeting was held in November 2008 at which the research team presented revised aims and objectives for the work. The steering group approved the revisions, but noted that the team were being rather ambitious in the amount of work they intended to complete. A 5 week period of paternity leave for the project leader has delayed the final report!

In this report we explain the work undertaken and the outputs from the project.

The original aims of the project were these:

1. What is the association between access / exposure to greenspace and
   a. mental and physical health? (using measures of morbidity)
   b. mortality from specific causes of death? (where cause allows us to make inferences about *how* greenspace is influencing health because different diseases have different aetiologies)
   c. specific health behaviours? (such as physical activity and recreation)

2. Do these relationships vary according to the quality of greenspace?

We then intend to use this work to help us answer the third question

3. What data would be most useful for future research into the relationships between greenspace and health, but are currently missing?

In the period leading up to the start of the project, and shortly after its start, several factors led us re-focus of these aims. The new aims were approved by the project steering group. These factors were (a) the funding of a project with very similar aims by the Scottish Government Directorate for Rural and Environment Research (RERAD), (b) the successful development of a UK wide measure of green space availability as part of a project joint funded by several research councils (that project also led by Prof Mitchell), (c) the development of a collaboration between the research team and other leading academics from The Netherlands, Sweden and the USA. These developments meant that (i) part of the originally proposed work was being undertaken anyway by the RERAD project, (ii) the scope to analyse relationships between health and green space across the whole UK was dramatically increased and (iii) the possibility of comparing relationships between green space and health in the UK with those in other countries was extended. Since Prof Mitchell was involved in each of these developments and was also leading this FC funded project, it was decided (in consultation with Marcus Sangster) to seek synergy with the other projects. This led to a shift in the aims of the project which, following the steering group meeting in December 2008 were restated as follows:

1. A expansion of existing studies to include the entire UK and to
   a. Examine impact of data sets used to measure green space
   b. Focus on variation in association by causes of death
   c. Examine variations in association by economic / demographic group
2. An exploration the relationship between green space and mental health in the UK
3. An attempt to control for the influence of residential selection in the relationship between green space and health by using longitudinal data
4. Developing international comparisons with Europe and the USA

A brief summary of the methods and results for each of these tasks is presented below. In the report's appendix are copies of the academic papers which have been / will be submitted for peer review from this project.

Project results and achievements

1. **A expansion of existing studies to include the entire UK and to**

    a. **Examine impact of data sets used to measure green space**

The long-standing and widely held belief that natural environments are salutogenic (i.e. that they promote good health and healthy behaviours) has received recent and growing interest from epidemiologists. Several studies have suggested that access to (either visual or physical) green spaces such as parks, forests and woodlands carries health benefits. However, there has been little consideration of the extent to which these relationships between green space and health might vary, or might even be determined by, the indicators of 'exposure' to green spaces. Such studies all rely on environmental data that say where green spaces are, or how much green space there is in a neighbourhood. These data tend to differ in their origins, spatial resolution and definitions of what kinds of land cover are classified as 'green space'. It's a real possibility that the indicator of green space used could influence the results of epidemiological research. Most epidemiological analyses have relied upon single sources of data from which to derive general green space exposure variables within their respective study areas.

In this part of this project, we explored whether the kind of green space data we use makes a difference to the results we get in our analysis of the relationships between green space and health.

Our research questions were

> 1)   To what extent do green space indicators derived from different data sources tend to agree about the quantity of green space in a small area?

> 2)   Do associations between green space exposure and health vary according to the origins of the green space indicator and (by proxy) the type of green spaces captured by the indicator?

To do this, we derived 3 different measures of green space availability for the same areas in the UK. The first green space indicator was derived from the Coordination of Information on the Environment (CORINE), available from the European Environment Agency (EEA). CORINE is a decennially-released

land cover inventory of remotely-sensed satellite imagery spanning the whole of Europe. Its classification of land cover has 50 categories ranging from urban green spaces to dense urban fabric and industrial land use. CORINE is sensitive to larger green spaces such as parks. Smaller spaces that may contribute towards the overall ambient 'greenness' of neighbourhoods are not picked up by CORINE. We selected all CORINE land cover categories that identified natural, land-based (i.e. excluding water bodies) environment to produce an indicator of green space.

The second indicator was derived from the British Ordnance Survey's Master Map (OSMM). The OSMM is an extremely fine scaled source of geographic information for Britain only, containing over 450 million uniquely defined features at building and street level. OSMM is compiled and updated by ground and aerial surveys. We used 2 of OSMM's nine themes to defining green space: i) the terrain 'natural' subset, representing all natural (non-synthetic) topography; and ii) water (to include small 'blue spaces' such as river corridors). This dataset was capable of identifying very small green spaces and, in contrast to the CORINE based data, an indicator of the overall 'green ambience' or 'greenness' of small areas.

Our third indicator was a 'hybrid' designed to offer a middle ground between CORINE (sensitive to larger spaces only) and OSMM (sensitive to ambient greener). The Hybrid indicator was produced by the research team. We adjusted CORINE's estimates to increase sensitivity to smaller areas of green space, using data derived from OSMM and the UK census.

We carried out our analyses on four British cities of contrasting geography, population size and overall self-reported health. The cities were York, Exeter, Edinburgh and Glasgow. This was a purposeful sample which included a manageable number of small areas, cities that were known to us personally (enabling visual appraisal of the green space data sets), yet a range of city sizes, population densities and settings. We calculated the percentage of the land area of each small neighbourhood (ward) within each city that was identified as green space for each indicator. We compared the values of green space indicators for each ward using scatter plots, bar graphs and correlation. We examined any spatial patterns in agreement or disagreement between the indicators

We also looked at the relationships between the amount of green space identified in the neighbourhoods by each indicator, and the health of the population living there. We used two measures of health; self-reported poor health and the risk of mortality from any cause. The 2001 UK census provided the data on poor health. Anonymised, individual mortality records were obtained from the Office for National Statistics (ONS) and General Registrar Office Scotland GRO(S). The records covered every death registered and matched to a ward between 2001 – 2005. Since we know that how disadvantaged a population is holds a big influence on its health, and also that wealthier, more advantaged populations tend to live in greener neighbourhoods, we took account of how advantaged the populations in these neighbourhoods were. This was done using the Carstairs index, a widely used

and well validated indicator of area deprivation based on prevalence of overcrowding, unemployment among men, low social class, and not having a car. We also adjusted our analyses for population density, to allow for any influence settlement density not related to green space, for age and for sex.

Results showed

- that the three indicators of green space exposure showed strong agreement on the amounts of green space in the neighbourhoods
- a tendency for the CORINE data to find levels of green space close to zero in areas suggested to have higher levels of green space by the other two indicators
- that the amount of green space detected varied with socio-economic deprivation
- that CORINE estimated lower amounts of green space than OSMM and Hybrid at all levels of deprivation, but that this difference tended to be largest in the most disadvantaged neighbourhoods
- that the 3 indicators showed very similar associations with our two measures of population health; more green space was associated with lower risk of death, but not with the population's tendency to report poor health

What does this mean?

- the three indicators of green space showed reasonable agreement in terms of the quantities of green space detected in the neighbourhoods. Considering the big differences between the indicators in terms of the origins and sources, this was comforting. Given that the green spaces they are trying to detect are constant, however, it was perhaps not too surprising.
- CORINE had a tendency to indicate 'zero' green space for some areas shown by the other indicators to have higher levels and this was especially true for more deprived areas. Since CORINE tends to detect only larger green spaces, this probably reflects lower levels of 'ambient' greenery in poorer areas.
- since the relationship between green space and health in the neighbourhoods was the same whichever dataset we used it seems, in one sense, not to matter how green space is measured; we could have used any one of our indicators in an analysis of association between green space and health and got the same results.
- differences in sensitivity to different kinds of green space are important when related to the theories as to how green space is healthy. If contact with nature, rather than physical activity in it, is more significant for health, an indicator sensitive to ambient green space (such as road side trees, and small lawns) might be important. If the contact with green space necessary for health benefits requires larger spaces, either for exercise or more complete immersion in nature, larger parks or woodlands might be important, in which case CORINE would be useful.

- finally, the Hybrid dataset we created seems relatively accurate and useful. This is the only UK-wide, small-area green space data set available,

b. Focus on variation in association by causes of death

The existing studies on the health impacts of contact with nature have rarely considered a variety of health outcomes or considered how the health impacts might vary for different types of people. The most substantial part of this project attempted to explore both of these factors. It examined the relationship between the amount of green space in a neighbourhood (ward) and risk of death from a wide variety of causes, and looked at how these relationships varied by gender, affluence level and by country (contrasting those from Scotland, England and Wales).

Looking for differences in the relationship between green space and the risk of death according to the cause of death is important. Since we know how different types of disease develop and the factors that may cause them, we can use this information to learn something about *how* green space has a health impact. For example, if we observe that the risk of death from a disease which has being sedentary as a risk factor is lower in areas with green space, we might consider that green space is helping people stay healthy because it provides an opportunity to exercise. It's also an opportunity to further examine the problem we have with the fact that wealthier people (who tend also to be healthier) may be more likely to live in greener areas. If we saw an apparent relationship between a lower risk of disease known to be related to poverty and the amount of green space in a neighbourhood, but there was no plausible mechanism by which green space might influence that disease, we could deduce that the relationship is really due to the affluence of that area, and not the green space itself.

To do this work, we continued to use the Hybrid estimate of green space, discussed above, to capture how much green space there is in *urban* neighbourhoods (CAS ward) of the UK. Individual-level mortality records (including age, sex, cause of death and area of residence at death) were obtained from the Office for National Statistics (ONS) for England and Wales, the General Register Office for Scotland (GROS) and the Northern Ireland Statistics and Research Agency (NISRA). These records enabled us to count the number of deaths from specific causes, in each urban neighbourhood. When coupled with information on the numbers of people of different ages and sexes in the neighbourhood, this allowed the calculation of a risk of death from each cause. We could then assess the relationship between how much green space there was in a neighbourhood and the risk of death from each cause.

We looked at deaths from all causes, all cancers, lung cancer, colorectal cancer, prostate cancer for men, breast cancer for women, oesophageal cancer, skin cancer, cardiovascular disease and respiratory disease. We also looked at the rate at which residents of neighbourhoods report that their health is poor, and at the rate they report suffering from a long term illness that limits their activities. We took account of the level of affluence in the neighbourhoods using a measure of income deprivation which detects the degree to which the population living there is reliant on receipt of state benefits. We restricted these analyses to people aged 16 to 64 years old.

When we were doing this study, we made a discovery that the relationships between green space and health appeared to be different for men and women. We therefore continued this work analysing men and women separately.

Results showed that

- There was no protective effect of green space on women's risk of death from any cause, or of reporting poor health
- There were protective effects for men's risk of death from respiratory disease, cardiovascular disease and all cause mortality
- There were no protective effects of green space, for men or women, for the other causes of death examined

What does this mean?

- The protective effect of green space on men's risk of cardiovascular and respiratory disease was as expected. Both these diseases have stress and physical inactivity as risk factors and we would expect green space to have an impact on ameliorating these.
- The gender difference in the results was very, very surprising. One possible explanation is that men and women may experience and utilise the green space in different ways. There is evidence that women are often under-represented in public parks and are less likely to engage in vigorous activity while there.
- It is also possible that women's use of green space may be influenced by the quality of the green space to a greater degree than men's. Our data carried no measure of quality and this may be masking differences within women as a group, in terms of the health impacts of green space.
- Such differences have not been demonstrated before in the literature on health and green space.

c. Examine variations in association by economic / demographic group

We extended the analyses described above to determine if there was any difference in the relationships between green space and health for those resident in England, Wales and Scotland, between those who are relatively more and less affluent and for those at older ages.

Results showed that

- For men, the previously detected relationships between green space and lower risk of death from all causes, cardiovascular disease and respiratory disease were found in England and Wales, but not in Scotland.
- No protective effects for women were found within these countries
- Although England dominates the dataset in terms of the number of neighbourhoods (wards), there were fewer Welsh than Scottish wards so

the absence of significant results for Scotland was not due to lack of statistical power.

- Further investigation of the distribution of green space did suggest that Scottish urban wards tended to be less green that those in England and Wales, and this may partially explain the results. It is also possible that there is an impact of adverse climate, or of a different level of use of green space in Scotland. These factors could be usefully investigated in future work

- When exploring these associations by level of affluence, and by country the pattern of results starts to become unclear and this is probably due to relatively small numbers of places with the more unusual combinations of green space and affluence (such as very poor places with a lot of green space, and very affluent areas with very little green space). In general, for those causes of death which had been identified as having a relationship with green space, the results suggested a greater impact of green space on the least affluent groups (especially in Wales). There was a notable impact on the most affluent too however, with the 'middle' groups largely not exhibiting any impact.

What does this mean?

- The lack of an apparent protective effect of green space in Scotland is a key finding, and something of a puzzle. This will be further investigated in a RERAD funded project. It may be that the types of, and quantity of, green space in urban areas in Scotland may be different from that in England and Wales. It is also possible that any impacts of green space on this population are too small to be detected, when compared to the well known socio-economic and lifestyle influences which plague the Scottish population.

- When seeking differences in effect across groups defined by affluence, we observed the strongest effect on the poorest groups. However, the results were rather unstable and this probably represents the limit of our ability to research a relatively weak effect on health with relatively crude data. In turn, this suggests a need for more work with individual level data, and funding has been secured to do this.

2.   An exploration the relationship between green space and mental health in the UK and 3.   Control for selection by looking at longitudinal data

This is the part of the project which suffered most from the early departure of the Research Assistant. He developed access to the specialised data sets required and also had the methodological expertise necessary. The current situation is that a number of analyses have been run, but these are not yet in a position to be submitted to a journal. Further work on the methods used to analyse the data is required.

The data set we exploited for this work is the British Household Panel Study. This is a longitudinal data set (i.e. it follows the same sample of people over time). It has several advantages for our topic of interest. Since it follows the same people, year in year out, we are able to determine the sequence in which events happen. So, for example, we are able to observe whether wealthier groups are more likely to move to greener areas, or indeed poorer groups are more likely to move away from greener areas. We can also observe change in health status over time, which permits greater insight into the mechanisms by which green space might influence health. If, for example, those who are in poor health move to a greener area and their health recovers, that is greater evidence for a health impact of green space than can be obtained from data which simply show that people who live in greener areas are also healthier. A further advantage of these data is that they include measures of mental health. These include the well-used and respected 'General health questionnaire' or GHQ. A GHQ score of 4 or more is a readily accepted indicator of minor psychiatric morbidity. In simple terms, someone who scores 4 or more on the GHQ instrument is in need of clinical attention for poor mental health.

Through liaison with the academic team that run the BHPS we were able to attach our Hybrid measure of green space in a neighbourhood to the dataset. This means that we have connected a measure of the amount of green space in a respondent's neighbourhood to all the other information we know about them. The BHPS data also carry information on whether the respondent has access to a garden or not, allowing us to explore the impacts of different kinds of green space access. They also carry limited information on physical activity levels, allowing us to explore whether physical activity is the route by which green space seems associated with better health.

The BHPS data have permitted several insightful analyses, though as noted, these are not yet ready for publication.

Results showed that:

- residents of areas with a vary large proportion of green space are less likely to have poor mental health, as measured by the GHQ. This effect persists even after access to a garden is controlled for.

- this is not a 'graded' relationship however (i.e. one in which the risk of poor mental health reduces in a proportional to an increasing amount of green space). It is possible that such a relationship will emerge as our analyses improve.

- We did not observe any significant relationship between living in areas with more green space and an increased likelihood of taking exercise. In fact, once the level of exercise was adjusted for, it appeared that the strength of association between health and green space was increased. This, in turn, suggested that exercise might not be the key mechanism by which green space is associated with better health.

- we observed that those with poor mental health were more likely to move house, but that they were not more or less likely to move to a greener or less green area. Thus, in these data, we did not observe selective migration that would lead to a much sicker or healthier population being concentrated in less or more green areas.

Again, we stress that these are preliminary results

4 International comparisons with Europe and the USA

Collaboration was established with Prof Terry Hartig at Uppsala in Sweden, Dr Sjerp de Vries at Alterra in the The Netherlands and Prof Howard Frunkin at CDC in the USA. This group probably represents the leading researchers on green environments and health.

Our original idea was to use data from EUROSTAT to examine the relationships between green space and health in European cities. We spent a considerable amount of time investigating the data which purported to report indicators of green space quantity for a large number of cities across the EU, and to provide data on mortality rates from cardiovascular disease in the same locations. We were very disappointed to discover that the green space data were fundamentally flawed, with a large numbers of errors and implausible values. We also discovered a high degree of inflexibility in the health data, which meant that even if had we been able to find alternative green space data, the analyses would still not have worked properly. This was a very frustrating episode in the project!

Still keen to pursue the potential for international work, we investigated options for analysis in the USA, and had more success. In this study we were able to draw on a detailed land cover data set which allowed us to prepare two contrasting definitions of green space. These data were from the National Land Cover Database for 2001 (NLCD 2001). The first definition was 'green space', which included only vegetated open spaces, and excluded other surfaces such as water, sand or rock. The second measure was 'natural space', a wider measure which encompassed all open, undeveloped spaces, whether vegetated or not.

We used these data to quantify the amount of green space in US cities. We calculated a population-weighted mean green space percent for each of the 53 largest cities in the contiguous USA. A range of health status indicators for the year 2004 produced in a comparative format for the 54 largest USA cities were obtained from the National Association of County and City Health Officials. We extracted age-standardised rates for all-cause, heart disease, diabetes, pneumonia and influenza, all cancer and lung cancer mortality in 2004 for each city. The rates were age-adjusted to the year 2000 standard US population, using 2000 US Census figures. Following the approach already developed and discussed for the UK, heart disease, diabetes and all-cause mortality were included as causes of death with aetiological pathways that may be plausibly linked with green space through the protective effect of physical activity and the restorative effects of nature. Cancer mortality indicators were included as causes

of death we might expect to be only minimally related to green space, if at all. We also took account of the socioeconomic characteristics of these cities, using a measure of median household income, the ethnic composition of the city's population and air pollution levels.

Results showed that

- We found practically no evidence of a city-level protective relationship between green space and population health in the USA.
- We found some weak evidence that greater amounts of green space may be associated with *greater* risk of death from some causes

What does this mean?

- The results we have are surprising and interesting, but also probably strongly influenced by the methods we have used.
- By analysing at a city level we may have disguised variation in health within the cities, and also we have reduced the statistical power available (which reduces the ability to detect differences between cities with larger and smaller amounts of green space. The approach taken was the best possible with the data available, but we are aware that it is far from idea.
- The sequence of analyses we undertook did yield important and useful knowledge on how to measure green space in the USA and on the different results obtained when the methodology was adjusted. We are confident that an academic paper exploring the distribution of green space in urban USA will flow from the work. However, the research on associations with health will need considerably more development before it can be published.

Other outputs

We submitted an application for a Caledonian European Visiting Research Fellowship for Mr Thomas Astell-Burt to visit Uppsala in Sweden. The application was withdrawn as Thomas left the project before he would have been able to take up the Fellowship

Seminars / presentations made about this work:

- Is green space good for you? (University of Glasgow, Urban Studies seminar 20/03/09)
- Green space and health: the view from public health & epidemiology, (ESRC Outdoors Health Network Meeting, April 2009)
- Epidemiology of green space and health, (internal seminar series, University of Glasgow, May 2009)

- Does it matter how we measure green space for use in epidemiological studies? (International Symposium on Society and Resource Management, Vienna, 07/07/09)