Knight *et al. Environ Evid (2016) 5:3*
DOI 10.1186/s13750-016-0054-y

Environmental Evidence

SYSTEMATIC REVIEW PROTOCOL

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How effective is 'greening' of urban areas in reducing human exposure to ground-level ozone concentrations, UV exposure and the 'urban heat island effect'? A protocol to update a systematic review

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Abstract

Background: The impact of climate change on public health may occur through a number of main pathways including increased temperature, ground-level ozone levels and ultra-violet radiation, which have a range of consequences for human health. One strategy for adaptation to the predicted effects of climate change on health that has been proposed, is to 'green' urban areas, essentially by increasing the abundance and cover of vegetation. This protocol is for an update of a systematic review which aimed to address the question: How effective is 'greening' of urban areas in reducing human exposure to ground-level ozone concentrations, UV exposure and the 'urban heat island effect'?

Methods: A sensitive search of multiple databases and relevant journals for relevant published articles will be conducted. A search for relevant unpublished articles will be undertaken through an internet search and of websites of relevant organisations. Inclusion criteria will be applied at title, abstract and full-text. Repeatability checks of this screening process will be undertaken. Articles included at full-text will be critically appraised using a standardised checklist. A repeatability check will be made of this process. Pre-defined data items will be extracted from included articles. If appropriate, quantitative synthesis will be undertaken through meta-analysis and/or a narrative synthesis will be undertaken.

Keywords: Urban, Greening, Ground-level ozone, UV radiation, Heat-island

Background

The potential for climate change to impact on public health and the mechanisms through which this might occur has been increasingly explored since the publication of the Fourth Intergovernmental Panel on Climate Change report [5, 10, 16]. Recently, the 2015 Lancet Commission on climate change concluded that '…tackling climate change could be the greatest global health opportunity of the 21st century.' [18]. One consequence of climate change predicted by this report is an increase in the intensity, frequency and duration of extreme heat days; heatwaves, which would present a serious health risk. Increased temperatures can be particularly problematic in urban areas, where temperatures already tend to be a few degrees warmer than the surrounding countryside; a phenomenon termed the 'urban heat island effect' [13]. Concentrations of ground-level ozone are also predicted to increase, influenced by the effect of higher temperatures on ozone chemistry and the release of ozone precursors [12, 18]. Ground-level ozone levels can have considerable health impacts, in particular affecting respiratory diseases [16]. Increased exposure to UV radiation due to stratospheric ozone depletion and increased greenhouse gases also has a number of health

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consequences such as increased prevalence of skin cancer [1].

Strategies are needed for adaptation to the predicted effects of climate change on health. One strategy that has been proposed is to 'green' urban areas, essentially by increasing the abundance and cover of vegetation [6, 8, 11, 15, 18]. Vegetation, it is postulated, could counter some of the health consequences of climate change, in different ways. For instance, trees can provide shade, potentially reducing human exposure to high temperatures and UV radiation [7, 9, 14]. Vegetation may reduce ozone levels by absorbing and trapping ozone precursors and pollutants [12] and may allow adaptation to the urban heat island effect by increasing processes such as evapotranspiration and reflection of radiation [13]. This protocol is for an update of a systematic review which aimed to consider the evidence on the effectiveness of 'greening' interventions in the urban environment in reducing urban temperature, UV and ground-level ozone levels. The updated review will not consider the evidence underpinning the link between these environmental factors and health impact, which has already been extensively researched [18]. A simple logic model for this strategy is outlined in Fig 1. The updated review will cover the elements of the logic model which are coloured green.

This review was first published in 2010 [3]. The original review found a considerable number of studies that aimed to assess how land cover including parks, green areas and trees affect temperature and to some extent ozone (e.g., [2, 4, 17]; see other references within [3]). Studies using ground-level data collection mostly suggested that a green site could be cooler than a non-green site. A meta-analysis conducted on park temperatures estimated that an urban park is on average around 1 °C cooler than a built-up site in the day. A number of variables were identified that could affect this. However, these studies were mostly site comparisons that sampled relatively small numbers of green sites. Other studies suggested that some plants may contribute to ozone production and others demonstrated the complexity of interactions between ozone, its precursors and temperature. Few relevant UV studies were found. Similarly, we did not previously find any studies evaluating the effectiveness

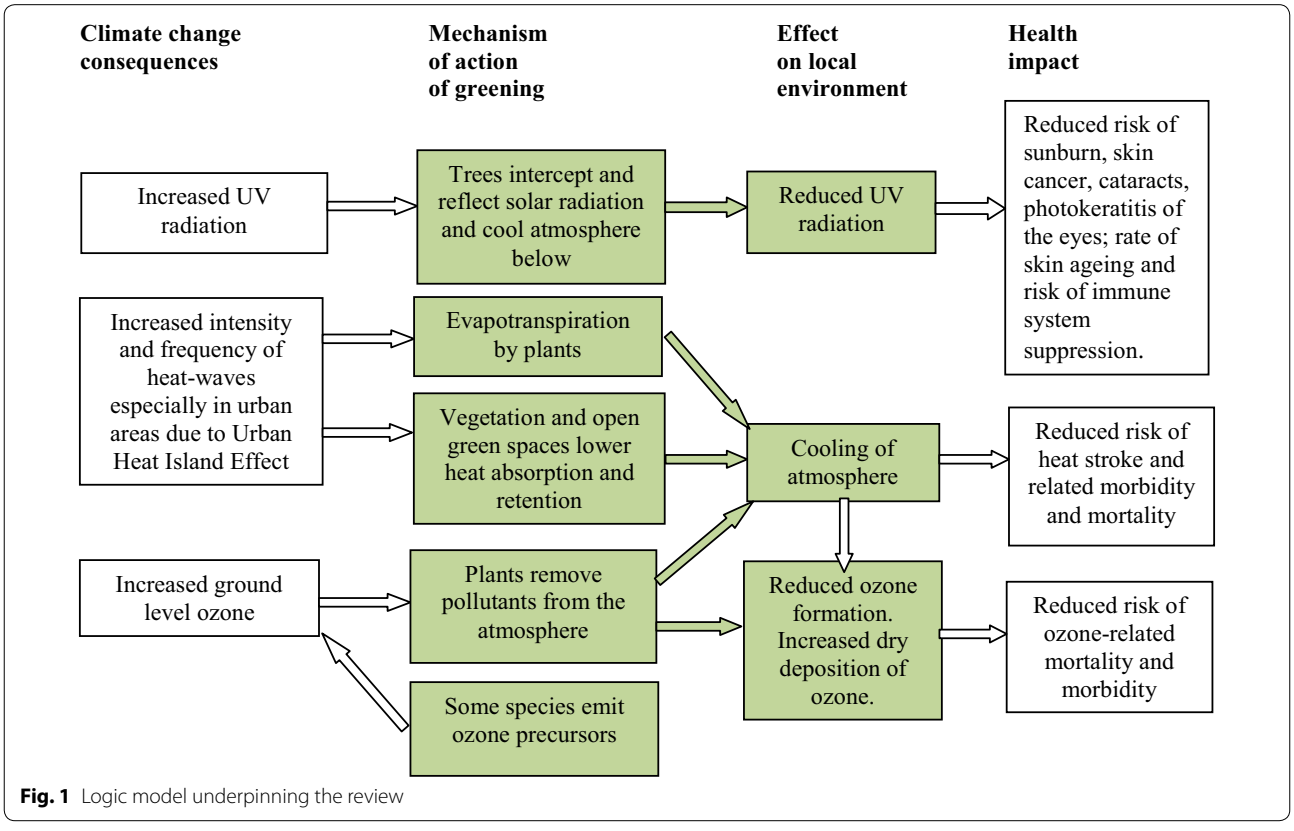

Fig. 1 Logic model underpinning the review

of an urban greening programme as part of a climate change adaptation strategy or investigating the direct effects of urban greening on human exposure to high temperatures, ozone or UV—or any health related consequences in the context of these variables. The impact of greening on nearby non-green areas was identified as a subject requiring more research. Scoping has revealed that since this original review a considerable number of relevant new papers have been published which have the potential to fill the gaps identified or to add further data to the meta-analysis. This suggests that an update would be useful.

This protocol is for an update of the original review [3], including recent literature. The original review was commissioned by Natural England and the involvement of stakeholders in question formulation is explained in the report on that review. The update will be undertaken following the Collaboration for Environmental Evidence Guidelines for Systematic Review in Environment Management (http://www.environmentalevidence.org).

Objective of the review

Primary question

How effective is 'greening' of urban areas in reducing human exposure to ground-level ozone concentrations, UV exposure and the 'urban heat island effect'?

Secondary questions

What is the best design—abundance, distribution and type of vegetation—for an urban greening programme?

What factors might modify the success of an urban greening programme? For instance, regional climate.

Methods

Search strategy

The search strategy will be based on that conducted for the original review but with improvements to include learning gained from the original review and to reflect developments in availability of potential sources and/or of searching technology.

A sensitive search of both published and unpublished sources will be conducted in order to capture as comprehensive and unbiased a sample of the relevant literature as possible. A three-step search strategy will be used in this review. An initial limited search of two key databases: Scopus and Medline will be undertaken followed by analysis of the text-words in relevant titles and abstracts, and of the index terms used to describe the papers.

A second search using all identified keywords and index terms will then be undertaken across all included databases. The third step will be reference list follow-up. The comprehensiveness of the search will be checked by examination of reference lists for any reviews found.

Papers published since December 2007 i.e. those published since the conclusion of the search for the original review, will be considered for inclusion in the review. No language limit will be applied. No document type or study type limits will be applied. No country limits will be applied.

Authors will be contacted for provision of any unpublished material, where suggested in an article, or missing data that may be relevant to the review.

Databases

The databases of different disciplines (environmental, ecological, public health) to be searched include:

1. Medline
2. Web of science
3. Geobase
4. PROQUEST database: Environmental sciences and pollution management sub-files (Bangor University)
5. CAB (Commonwealth Agricultural Bureau)
6. Directory of open access journals
7. Copac: joint catalogue of of academic libraries
8. Index to theses online
9. Greenfile
10. Geo ref preview database
11. AGRICOLA
12. BIOSIS
13. SCOPUS

Search terms

The searches will use free-text, keywords and subject indexing and combine the *Greening* and *Climate change* sets of terms. Search strings will be adapted for the different databases to allow for differing wild cards (*, $), word truncation (*) and proximity operators ("–", adj, (-)).

Initial search terms to be used:

Greening
Street* or Cities or City or Town* or "Built environment"
'Urban green*' 'Urban vegetat*
'Urban tree*'
'Urban open space*'
'Urban park*''Urban 'wood*'
'Urban forest*'
'Urban garden*'

Climate change
Climate
'Climate change'
'Heat island*'
Temperature*

Ultraviolet
UV*
Ozone
O_3
'Heat wave*'
Heatwave*
'Volatile organic compounds'
VOC*
'Nitrogen oxide*'
NOx
NO2

A second phase of the search will use additional search terms e.g. built environment, city, cities, towns, street trees, plants, planting.

Websites

Google and Google Scholar search engines will be used. Websites of relevant organisations will be searched (Appendix).

Other sources

Hand searching of electronic table of contents will be carried out for the following journals:

- Social Sciences in Forestry
- Urban Forestry and Urban Greening
- Landscape and Urban Planning
- Building and Environment

Article screening and study inclusion criteria

Citations captured from computerised databases will be imported into Endnote. In the first instance, the inclusion criteria will be applied to title only in order to remove spurious citations. Articles remaining after this filter will be screened by viewing abstracts and then full texts.

Hits from website searches will be filtered initially with the inclusion criteria on the title and abstract of articles (or introduction section if an abstract is not available). URLs for hits deemed relevant at title and abstract will be maintained within an Excel spreadsheet, and subsequently viewed at full text.

To assess and limit the effects of between-reviewer differences in determining relevance, at title, abstract and full-text stages, two reviewers will screen the same randomly selected sample of articles (sample size will depend on number of articles located by the search—a minimum of 10 % sample will be screened). The kappa statistic will be calculated, which measures the level of agreement between reviewers. If kappa is less than 0.6, the reviewers will discuss the discrepancies and clarify the interpretation of the inclusion criteria. Agreement will be reached through discussion. If necessary disagreements will be referred to a third reviewer. This may entail a modification in the criteria specification. Following this process one reviewer will then screen all items, applying the agreed new interpretation of, or modified, criteria. This process will be followed for both articles retrieved through the database and journal searches and those located through web-based searching.

Each article must satisfy each of the following criteria in order to be included after each filter. However, in cases of uncertainty, the reviewer will tend towards inclusion.

Relevant subject(s)

Urban temperatures, ground-level ozone or its main precursor concentrations (NOx and VOCs) and UV levels in any geographic location.

Human exposures to these variables or health-related outcomes in an environmental context of changes in these variables.

Types of intervention

Creation, enhancement or presence of green spaces in urban areas
Creation or enhancement of different types of urban greening

Enhancement of green spaces refers to any interventions that have changed the management of existing green spaces to increase the abundance of vegetation or area covered (e.g. additional planting). Green spaces would include any form of semi-natural environment (e.g. parks; green roofs) or plant species (e.g. trees) in urban areas. Urban areas would include any town or city including suburbs.

Types of outcome

Changes in quantitative measurements of the relevant subjects: temperature, ultraviolet (UV) and ground-level ozone or it's precursors.

Changes in human exposures to these variables or recorded health outcomes in the context of these variables.

Types of study design

Only studies which include a relevant comparator will be included.

Examples of comparators

Relevant comparisons that would be investigated by a study would include:

The presence of green space versus the absence of green space
Creation versus no creation of green spaces
Enhancement versus no enhancement of green spaces

Changes in recorded outcomes after creation or enhancement of green space

One type of urban greening versus a different type of urban greening

A list of articles excluded at full-text, with reasons for exclusion, will be compiled.

Study quality assessment

The methodology for this review will follow that of Bowler et al. [3]. The purpose of this process is to assess the risk of bias arising from study design or conduct and to identify confounding issues. The process will cover assessment and recording of details of the presence of a comparator (before/after intervention or control/intervention site), randomisation, identification and management of confounding factors, and replication. Studies which do not meet the minimum standard required in relation to unbiased sampling (e.g., random) and replication (e.g., sampling different sites at different times of day), will be excluded. One reviewer will appraise all included studies and a second reviewer will appraise a random sample of studies (size of sample will depend upon the number of included studies—a minimum of 10 % will be checked). The kappa statistic will be calculated and if less than 0.6, the reviewers will discuss the discrepancies. Agreement will be reached through discussion. If necessary disagreements will be referred to a third reviewer. All appraised studies will then be re-assessed by one reviewer in the light of the agreements reached. A summary of the findings of the study quality assessment will be compiled.

Data extraction strategy

Where possible, data will be extracted from each article and recorded in a spreadsheet. Data to be extracted will include the data on the outcomes, methodology and other factors that have been identified as reasons for heterogeneity. Data extraction forms will be the same as for the original review. Missing data (e.g. sample size or variance) will be calculated or inferred where possible from the summary statistics presented, or the authors contacted. Data will be extracted by one reviewer. A second reviewer will extract data from a random sample of articles (size of sample will depend upon the number of included studies—a minimum of 10 % will be checked). The consistency of data extraction will be examined and any reasons for variation identified. If necessary data extraction will be repeated to correct errors or inconsistencies. Extracted data files will be made available as additional files.

Potential effect modifiers or reasons for heterogeneity

Type of urban 'greening' and vegetation (low/high emitting vegetation)

Geographic location (latitude/altitude/longitude)

Degree of urbanisation (town or city, population density)

Human state/activity

Extremity of the event (e.g. duration and intensity of a heatwave).

Empirical/modelling/different types of modelling approaches

This list was compiled for the original systematic review following consultation with the stakeholder group set up for the review. The findings of the review do not suggest that it needs altering for this update.

Data synthesis

Random effects meta-analysis with calculation of Hedges *g* will be carried out on subsets of data, following the methodology of Bowler et al. [3] in order to update the meta-analysis conducted in the previous review. Sensitivity analysis will be run to explore the effects of including studies with different designs and methodological quality. Variation in effect sizes between studies will be explored using a priori reasons for heterogeneity. Specific attention will be given to the type of greening. The transferability of findings from studies under different climates will be considered.

In the previous review, quantitative synthesis was performed on only studies with comparators. Studies that were not suitable for meta-analysis were listed in appendices. We will follow the same procedure in the update.

Authors' contributions

TK and DB conceived the original systematic review. TK, DB and SP conceived the update of the systematic review. TK, DB and SP wrote this document with SK contributing to the search section. All authors read and approved the final manuscript.

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Acknowledgements

This project is supported by Public Health Wales by permitting TK, SP and SK to undertake the work without external funding. DB works at the Biodiversity and Climate Research Centre in Frankfurt, Germany and receives funding by the DFG. Bangor University will provide support with undertaking searches through enabling access to sources. We would like to acknowledge the assistance of Professor Andrew S. Pullin and Mrs. Dinah Roberts in providing feedback on drafts of this document.

Competing interests
The authors declare that they have no competing interests.

Appendix

The websites of the following organisations will be searched for relevant studies. This list will be expanded if further relevant organisations are identified.

California Energy Commission
California Environmental Protection Agency
Centre for Urban and Regional Ecology
Center for Urban Forest Research
Commission for Architecture and the Built Environment
Environment Agency
Environmental Protection Agency
European Environment Agency
Faculty of Public Health
Forest Research
Forestry Commission
Greenspace (including Greenspace Scotland)
Health Protection Agency
RIVM (Dutch National Institute for Public Health and the Environment)
National Trust
Natural England
Natural Resources Wales
Royal Society of Public Health
Scottish Executive
Scottish Environment Protection Agency
Scottish Natural Heritage
Stockholm Resilience Centre
Tyndall Centre for Climate Change Research
UK Climate Impacts Programme
UK MAB Urban Forum
The US Environment Protection Agency
US Department of Energy (DOE)
WHO

Received: 27 October 2015 Accepted: 28 January 2016
Published online: 26 February 2016

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