Collaboration for Environmental Evidence
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CEE review 08-004

HOW EFFECTIVE IS 'GREENING' OF URBAN AREAS IN REDUCING HUMAN EXPOSURE TO GROUND LEVEL OZONE CONCENTRATIONS, UV EXPOSURE AND THE 'URBAN HEAT ISLAND EFFECT'?

Systematic Review Protocol

BOWLER, D., BUYUNG-ALI, L., KNIGHT, T. AND PULLIN, A.

Centre for Evidence Based Conservation - School of the Environment and Natural Resources - Bangor University – Bangor – Gwynedd - LL57 2BU

Correspondence: d.bowler@bangor.ac.uk
Telephone: +44 (0)1248 382953

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1. BACKGROUND

It is now widely accepted that climate change is occurring because of the accumulation of greenhouse gases in the atmosphere, which has arisen from the combustion of fossil fuels (IPCC, 2007). There has been growing interest in the potential mechanisms by which climate change might influence health (Confalonieri *et al*., 2007). In 2001, and updated in 2008, the UK Department of Health published a major report, 'Health Effects of Climate Change in the UK', which focused on the possible impacts of climate change on health (Department of Health and the Health Protection Agency, 2008). This report indicates that a significant impact of climate change on public health in the UK 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 predicted consequence of climate change is an increase in the intensity and frequency of heatwaves (RCEP, 2007). Heatwaves can present a serious health risk, for instance it has been predicted that there is a 1 in 40 chance that south-east England will have experienced a severe heatwave by 2012, resulting in 3000 immediate heat-related deaths (Dept of Health, 2008). 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' (Rosenzweig *et al*. 2006). 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 (RCEP, 2007). Ground level ozone levels can have considerable health impacts, in particular affecting respiratory diseases (Dept of Health, 2008). Increased exposure to UV radiation due to stratospheric ozone depletion and increased greenhouse gases also has a number of health consequences such as increased prevalence of skin cancer.

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 (Handley and Carter, 2006; Vandentorren *et al*., 2006; Gill *et al*., 2007). 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. Vegetation may reduce ozone levels by absorbing and trapping ozone precursors and pollutants (RCEP, 2007) and may allow adaptation to the urban heat island effect by increasing processes such as evotranspiration and reflection of radiation (Rosenzweig *et al*., 2006). This systematic review aims 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 review will not consider the evidence underpinning the link between these environmental factors and health impact, which has already been extensively researched (Dept of Health, 2008).

The methodology of a systematic review is designed to ensure the review conclusions are objective and based on the best evidence available (Khan *et al*., 2003; CRD, 2004). Comprehensive searching, of both published and unpublished literature, and the application of specific inclusion criteria are used to retrieve relevant studies without bias. Articles included in the review are critically appraised and their

findings summarised including a quantitative synthesis when appropriate. The findings of systematic reviews can guide the development of evidence-based policy and also highlight areas where current research is lacking.

2. OBJECTIVE OF THE REVIEW

2.1 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'?

3. METHODS

3.1 Search strategy

Relevant studies will be searched using multiple sources, covering both published and unpublished sources, in order to capture a comprehensive and unbiased sample of the relevant literature.

3.1.1. Databases

Keywords will be used to search a number of different databases. The search aims to include the following:

1) Medline
2) Science and social science citation index
3) ISI Proceedings
4) Geobase
5) Environmental sciences and pollution management sub-files (Bangor University)
6) Science Direct
7) CAB
8) Directory of Open Access Journals
9) Copac
10) Index to Theses Online
11) Knowledge Network for Biocomplexity
12) National Library for Public Health

No time, language or document type restrictions will be applied.

3.1.2. Search terms

Combinations of the following environment and climate change search terms (where * denotes a wild card) will be applied to these databases:

Semi-natural environment words:

Urban and green* (expand term as green, greening, greenspace, green space, green roofs if necessary)
Urban and vegetat*
Urban and tree*
Urban and open space*
Urban and (park or parks)
Urban and wood*
Urban and forest*
Urban and garden*

Climate change words:

Climate
"Climate change"
"Heat island*"
Temperature*
Ultraviolet/UV*
Ozone/O3
"Heat wave*" / Heatwave*
"Volatile organic compounds"/VOC*
"Nitrogen oxide*"/NOx/NO2

3.1.3. Web sites

These search words will also be used to search the internet, which may be particularly useful in locating unpublished material. This will be performed using the following web sites:

1) www.dogpile.com
2) www.google.com
3) www.scirus.com

The first 50 hits from each search will be checked for relevance. Links will be followed if the original hit indicates there may be relevant information on the website. Websites of specialist organisations will also be searched (listed in appendix A).

3.1.4 Other sources

References of studies included in the review, and in other reviews of relevant literature, will also be searched for any further relevant citations missed by the above search. 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.

3. 2 Study inclusion criteria

Inclusion criteria will be applied in order to identify the most relevant articles, from those captured by the search, for the review question.

Citations captured from computerised databases will be imported into an Endnote library. In the first instance, the inclusion criteria, which are identified below, will be applied to title only in order to remove spurious citations. Articles remaining after this filter will be filtered on viewing abstract and then full text.

Hits from web 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), and then at full text. 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, two reviewers will apply the inclusion criteria to at least 200 articles, at the title and abstract filter. 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. This may entail a modification in the criteria specification. After this discussion, one reviewer will apply the inclusion criteria to the rest of the citations.

Each article must pass each of the following criteria in order to be included after each filter. However, on 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 UVB 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.

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

The presence of a comparator will not be an inclusion criterion but this will form part of the appraisal in study quality assessment (see section 3.3).

3.3 Study quality assessment

The methodology of each article included in this review will be appraised and categorised e.g. the presence of a comparator (before/after intervention or control/intervention site), randomisation or confounding issues; and replication etc. to explore the effects of the study methodology (Stevens and Milne, 1997) on the findings. The study quality assessment methodology will be further developed once the articles included in the review have been identified.

3.4 Data extraction strategy

The availability of data will not be known until after applying the inclusion criteria. 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 piloted on a purposive sample of the articles, to represent the range of articles available, and amended if necessary to improve repeatability and efficiency. Missing data (e.g. sample size or variance) will be calculated or inferred where possible from the summary statistics presented, or the authors contacted.

Potential 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

3.5 Data synthesis

If extracted data are suitable for quantitative synthesis, we will aim to calculate effect sizes and carry out a meta-analysis. 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.

If insufficient data are extracted or data are mainly of low methodological quality (i.e. without a comparator), we will summarise the outcomes of studies in tables.

4. POTENTIAL CONFLICTS OF INTEREST AND SOURCES OF SUPPORT

None declared. This project is funded by Natural England (A UK governmental organisation).

5. REFERENCES

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Rosenzweig, C., Solecki, W.D. and Slosberg, R.B. (2006). Mitigating New York City's heay island with urban foresty, living roofs and light surfaces. Prepared for the New York State Energy Research and Development Authority.

Stevens, A., and Milne. R. (1997)**.** The effectiveness revolution and public health. In: G. Scally (ed). *Progress in public health*. Royal Society of Medicine Press, London. pp 197-225

Vandentorrn, S. et al. (2006) August 2003 Heat Wave in France: Risk Factors for death of elderly people living at home. European Journal of Public Health 6: 583-591.

6. APPENDIX A

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

Altostratus Inc
Air Quality Management Districts in the U.S.
California Energy Commission
California Air Resources Board
California Environmental Protection Agency
California Public Utlities Commission
California Resources Agency
Centre for Urban and Regional Ecology
Center for Urban Forest Research
Commission for Architecture and the Built Environment
CDC
Environment Agency
Environmental Protection Agency
EPA
European Environment Agency
Forest Research
Forestry Commission
Greater London Authority
Greenspace (including Greenspace Scotland)
Health Protection Agency
Houston Advanced Research Center
Intergovernmental Panel for Climate Change
Lawrence Berkeley National Laboratory
Parliamentary Office of Science and Technology
RIVM
National Aeronautics Space Administration
National Trust
Natural England
Scottish Executive
Scottish Environment Protection Agency
Scottish Natural Heritage
Tyndall Centre for Climate Change Research
UK Climate Impacts Programme
UK MAB Urban Forum
UK Public Health Association
The US Environment Protection Agency
US Department of Energy (DOE)
WHO