Benefits of urban parks

a systematic review. A report for IPFRA

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A systematic review

A Report for IFPRA

By

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Copenhagen & Alnarp, January 2013

Foreword

The International Federation of Parks and Recreation Administration (Ifpra, www.ifpra.org) is the unique international organisation that represents parks, recreation, amenity, cultural, leisure and related services. Among the federation's aims are the advancement of parks, recreation, cultural and leisure services through representation and the dissemination of information; and the promotion of relevant research. During the past few years, Ifpra has refocused its activities more towards urban parks, which e.g., led to the establishment of a World Urban Parks Initative together with a range of other national and international organisations. Moreover, Ifpra strengthened its scientific base by setting up as Science Task Force at the Ifpra World Congress in Hong Kong (autumn 2010), under the coordination of the new Ifpra Vice President for Science, Cecil Konijnendijk.

At the end of 2011, the Executive Committee of Ifpra decided to assign a review study of urban park benefits. This work was to be coordinated by the Science TF. In response, a research team of four, representing three different institutions, three different disciplines, and four different nationalities was set up. The research team carried out a systematic review of the scientific evidence for urban park benefits during most of 2012.

Copenhagen and Alnarp, January 2013

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Introduction

What do we know about urban park benefits?

Many scientific studies on urban green space start with stressing the multiple benefits of parks and other green areas (Lyytimäki and Sipilä, 2009). There is general agreement, at least within the green space sector, that urban parks are essential for liveable and sustainable cities and towns. But how much do we really know about these benefits? How strong is the scientific evidence for the different benefits of urban parks? Many of the assumptions used regarding decision-making involving urban parks are not stated clearly and are often based on limited or poor scientific evidence on the potential evidence (e.g., Pataki et al., 2011). This is a problem, as we live in a world where the demand for evidence-based decisions is increasing.

In order to provide a more qualified base for the International Federation of Parks and Recreation Administration's (Ifpra) activities in terms of promoting urban parks and their benefits, the present systematic review sets out to answer the question: What is the scientific evidence for different benefits of urban parks?

What is an urban park?

Urban green structures include a wide range of different components. Apart from parks, these include woodland, street tree and square plantings, cemeteries, private gardens, green roofs, community and allotment gardens, sports complexes, and so forth. For the purpose of this review, we defined 'urban park' as follows:

> Urban parks are defined as delineated open space areas, mostly dominated by vegetation and water, and generally reserved for public use. Urban parks are mostly larger, but can also have the shape of smaller 'pocket parks'. Urban parks are usually locally defined (by authorities) as 'parks'.

Study limitations

Extensive literature exists on the various benefits of urban green spaces in general, but not all of the studies have particularly addressed urban parks, even though parks are central components to urban green structures. Moreover, there seems to be tendency of study findings to be published at the local or national level, in reports or even 'grey' literature, rather than in publications that have undergone scientific scrutiny through the peer-review system. We could have decided to include all available evidence on urban park benefits, but the characteristic of systematic reviews is that only best available evidence published according to good scientific practice is considered. We realise that this will mean that we have missed a number of interesting studies and reports on urban park benefits, but this has meant less concessions to maintain the highest scientific standards. Moreover, the evidence emerging from this more rigid systematic review provides a much stronger case for promoting urban parks – that is, at least for those benefits for which sufficient scientific evidence exists.

We could also have included a wider range of green spaces, and not only urban parks. But we decided to exclude for example urban woodland or street trees in order to make the study more focused, and to adhere to Ifpra's mandate for specifically urban parks.

Finally, we decided to only consider articles published in the period 1 January 2000 through 1 April 2010. This choice could also be criticised, as relevant studies were published prior to this. We decided to focus on 'most current evidence', basing ourselves on our own knowledge and initial literature studies that showed an increase in 'urban park benefit studies' during the last decade or so.

Nature of the report
The present report has one clear focus: documentation of the current scientific evidence for urban park benefits. Thus it will be possible to say, after reading each of the results section for individual benefits, if the best available, most current scientific evidence for the benefit is weak, moderate or strong. The report provides some insight in specific subthemes and individual studies, but this is not its main focus. For details we refer to the individual papers, which are all listed after each of the results sections.

Categories of urban park benefits
In the frame of this report, 'benefit' is defined as something that promotes wellbeing (Merriam-Webster's, 2012). Thus in the case of urban park benefits, we are concerned with the services provided by the park that promote human or societal wellbeing, either directly or indirectly. According to Defra (2007), wellbeing is defined as a "positive, social and mental state; it is not just the absence of pain, discomfort and incapacity. It requires that basic needs are met, that individuals have a sense of purpose, that they feel able to achieve important personal goals and participate in society. It is enhanced by conditions that include supportive personal relationships, strong and inclusive communities, good health, financial and personal security, rewarding employment, and a healthy and attractive environment".

The author group agreed upon focusing on the major park benefit groups, considered to have the highest impact to society. Those were also derived from an initial literature search for general topics. The following potential benefits of urban parks were included:

- Human health and wellbeing, i.e. positive impacts of parks and park use on human health (both mental and physical) and wellbeing, either through direct or indirect effects such as recreation and leisure activities.
- Social cohesion / identity: the role of urban parks in strengthening social ties, relations and cohesion.
- Tourism: leisure visits outside of the own living or working environment, typically longer-term stays. Apart from potentially promoting the health and wellbeing of visitors, tourism is also of interest due to its contributions to the local economy.
- House prices: the value of urban parks as part of the living environment as reflected in higher real estate prices (for both houses and apartments).
- Biodiversity: the role of parks in harbouring and promoting biodiversity, and species diversity in particular. Biodiversity has a direct link to human wellbeing (e.g., through nature experience), while it also provides an important base for ecosystem functioning and thus a range of ecosystem services (e.g., Hooper at al., 2005).
- Air quality and carbon sequestration: positive impacts of urban parks in terms of reducing air pollutant levels and carbon sequestration.
- Water management: contributions of parks to stormwater / run off regulation.
- Cooling: the role of parks in the cooling of urban areas? (For this benefit category, we base ourselves on a recent systematic review by other authors).

For all of these benefits, we are especially interested to find out *whether parks promote the respective benefit more as compared to other urban land use, as well as other types of green spaces*.

In the terminology of the Millennium Ecosystem Assessment (MEA, 2005), the first four benefits fall under the group of 'cultural ecosystem services', while the final four are 'regulating ecosystem services'. Provisioning services, such as for example food and timber production, are not covered, partly as we evaluated these as less relevant in an urban park context.

Additional benefits could have been specifically addressed, for example relating to cultural-historical aspects, aesthetics and education. However the literature on these topics is not vast, and most of the aspects of these are covered under human health and social cohesion impacts.

Literature

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Methodology

Systematic review

This report is based on the results from a systematic review of selected peer-reviewed literature. A systematic review attempts to collate all empirical evidence that fits pre-specified eligibility criteria to answer a specific research question. It uses explicit, systematic methods that are selected in order to minimizing bias, thus providing reliable findings from which conclusions can be drawn and decisions made. The key characteristics of a systematic review are: (a) a clearly stated set of objectives with an explicit, reproducible methodology; (b) a systematic search that attempts to identify all studies that would meet the eligibility criteria; (c) an assessment of the validity of the findings of the included studies, for example through an evaluation of research methodology and assessment of risk of bias; and (d) systematic presentation, and synthesis, of the characteristics and findings of the included studies (Khan et al., 2003; Pullin and Stewart, 2006; Bowler et al., 2010)

The choice for a systematic review of the evidence implies that the study should be made as transparent as possible. It should be more or less replicable following our methods (i.e. same definitions, same search terms etc.). This increases the validity of the study (and consequently usefulness). All phases of the search process are documented for the sake of transparency.

The central research question for the systematic review was: *what is the current scientific evidence for different benefits of urban parks*?

Search process and inclusion criteria

Two widely recognised databases of peer-reviewed scientific publications were used, namely Web of Science and Scopus. These databases should cover all relevant literature on the topic. The search terms were considered among the categories 'Title, abstract, keywords' (Scopus) respectively 'Topic' (Web of Science).

After the initial search, two rounds of selection were undertaken. Firstly articles were included or excluded based on their title and abstract. The remaining papers were subsequently reviewed and evaluated for their relevance. In order for a publication to be included in the final dataset, it had to meet the following inclusion criteria:

- *Featured in one or both of the selected databases (Scopus and Web of Science), or added through 'snowballing'*. Snowballing means that relevant papers that did not feature in the original search could be found in the references of identified papers, and subsequently added. Snowballing has been applied very conservatively and only articles that could subsequently also be found in Scopus and/or Web of Science were included.
- *Published in the period January 2000 – 31 March 2012.* Clear focus was on the most current state of evidence.
- *Presenting scientific evidence on one or several pre-defined urban park benefits*. The benefit categories included are listed in the Introduction. For each respective benefit, specific secondary search terms were used and combined (by denoting 'AND' in the database search engine) with the primary search terms. The respective secondary search terms for each benefit are provided in the results section. For a few benefits, two sets of secondary search terms were combined to make a more targeted search possible.
- *Specifically looking at urban parks*. This means that green spaces studied had to fall within the definition of urban parks as given in the Introduction. In order to find relevant

papers in the two databases, a number of primary search terms were used, namely: "urban park*[1]", "city park*", "green space*" and "green area*").

- *Published in English.*
- *Presenting a (preferably) systematic review, meta-analysis or an original scientific study.* This means that, in principle, more conceptual papers and thematic reviews were excluded in order to meet the requirement that only best evidence and studies with appropriate scientific rigour were considered.

The protocol for the systematic review was developed jointly by the four researchers. We used a standardized data extraction sheet to ensure a controlled analysis and data-retrieve across the different benefits. In case of doubts and queries regarding whether to include an article or not this was resolved by consultancy from the other authors for consensus and decision.

Analysis of the results

The data registered and analysed for each of the selected publications is provided in Table 1. Apart from basic information about the publication and its authors, as well as the database(s) in which the publication was found, information was registered on study design, the benefits documented by the paper and the so-called primary end point variables (what was measured as an indicator for the benefit). The main relevant results (i.e. as pertaining to the specific benefit in focus) were listed, as was the geographical scope of the study (e.g., study undertaken at the level of one or more parks, one or more cities, countries, etc.). In addition we registered the number of sites or cases studied. Finally the strength of the evidence was assessed, and information was included about limitations of the studies and possible additional remarks.

Table 1. *Overview of the data extraction sheet.*

Title	Documented benefits
Authors	Primary end point variables
Journal	Main relevant results
Year	Geographic scope
Volume	Number of cases / sites studied
Issue	Single time or longitudinal study
Pages	Strength of the evidence
Found through Scopus, Web of Science, both (or snowballing)	Limitations of the study
Cites in Scopus resp. Web of Science	Other remarks
Study design	

Quality assessment

Quality grading of included studies indicates that every article is judged in accordance with a pre-defined protocol. This specifies the quality of the evidence by providing a numerical estimate of high, moderate, or low research quality studies for each outcome. Through this procedure a final average score of evidence is delivered. By such consequent and precise information across the outcomes the usefulness and implications of the material convert into valuable and useful measures for practitioners, decision-makers, and policies. This enables scientifically informed recommendations and a generic basis for guidelines.

Our protocol was inspired by the six quality assessment questions suggested by Bowler et al. (2010) as a main frame for assessing the strength of the evidence:

[1] '*' indicating "wild card", i.e. any ending of the word possible.

1) Did the study identify its target population or give sufficient information on the types of individuals/species? This determines the extent to which the study findings can be placed in context of the type of participant.
2) How did studies recruit participants? To make it a yes or no question: was self-selection bias controlled for in the study? 'Referred by a third party' was considered superior to 'self-referral' due to the possibility of self-selection bias, which affects the representativeness of the sample of the population.
3) Was randomisation used to allocate participants to groups, or in the case of a crossover trial, to decide the order of treatments? This affects whether there were any systematic differences between participants of intervention and comparator groups.
4) Were studies shown to be similar at base-line or were base-line differences accounted for in the analysis? This is important to be able to attribute measurable differences to the intervention.
5) Was the method of collecting data described and likely to be reliable and valid? This affects the confidence we can have in the results reflecting the intended measurement. N.B. here we also look at e.g., the issue of multiple cases/sites studied, single-moment or longitudinal studies, etc.
6) Were there any other differences between intervention and comparator groups that might explain differences in the data being measured? For example, if there were any differences between groups apart from environmental setting, this might explain any differences in the outcome rather than the effect of parks.

This review of benefits of urban parks analyses a wide range of benefits and studies represent a wide range of disciplines and methods. Humans are in focus, but studies also look at e.g., diversity of flora and fauna species. Therefore the above questions were not always easily applicable, for example because the large majority of the studies included were of observational rather than experimental nature. Moreover, where needed additional quality assessment criteria were added for specific benefits. These are specified in the respective benefit texts, under 'strength of the evidence'.

Literature

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Urban parks and direct and indirect health effects

Introduction to the benefit

Nature and green spaces contribute directly to public health by reducing stress and mental disorders (Ward Thompson et al., 2012; Annerstedt et al., 2012), increasing the effect of physical activity (Mitchell, 2012), reducing health inequalities (Mitchell and Popham, 2008), and increasing perception of life quality and self-reported general health (Maas et al., 2006; Stigsdotter et al., 2010). Indirect health effects are conveyed by providing arenas and opportunities for physical activity (Coombes et al., 2010), increasing satisfaction of living environment and social interactions (Björk et al., 2008; Maas et al., 2009), and by different modes of recreation (Weber and Anderson, 2010).

All these indicators correspond well to the definition of health established by the World Health Organization (WHO) (1946), including both physical, mental, and social components in the health concept. In addition the definition of public health (Winslow, 1920) even further emphasizes the efforts by society and communities for promoting health and preventing diseases. Thus, to support and improve public health varied actions are required by local administrators and policy makers. Within this field creating healthy urban environments is an important contribution. Considering the high level of global urbanization urban parks are imperative for maintaining and improving public health. This section demonstrates the scientific evidence for health effects, direct or indirect, from urban parks.

Search information

We included search terms on recreation or leisure activities since these were considered important to covering indirect health benefits. The secondary search terms were (as combined with the primary terms defining urban environment): leisure* OR recreat* OR visit* OR health* OR well-being OR wellbeing OR disease* OR disorder* OR morbidit* OR mortalit* OR illness* OR rehabilit* OR heal* OR “physical activit*”. The number of articles identified from the electronic search was 1285 in Web of Science and 709 in Scopus. The total number of initial hits is difficult to determine due to overlap between the two databases, but the titles and/or abstracts of at least 1000 or more articles were scanned. This resulted in 290 potentially eligible articles. After scrutinizing these papers we finally included 86 articles in the review that all fulfilled the inclusion criteria (see Appendix, Table A1). Papers on botanic gardens were not included, as these were considered special purpose green areas where botanical objectives often override public access and recreation. Neither were papers on specific items or qualities of parks included, only if they reported specified benefits of the park as such.

Key findings

The majority of the included studies used an observational cross-sectional research design, implying either survey- or register (n=10) data. The sample was either a cohort (n=6) or randomly or non-randomly selected participants for the specific study. Only a limited number of studies were longitudinal (n=3) with baseline and follow-up values and just one study was a single-blind randomized controlled trial. The number of participants varied much between the studies (ranging from 59 to 28.6 millions) as did the definition of environment, which was either subjectively or objectively assessed, something that usually infers some discrepancy (De Jong et al., 2011; Leslie et al., 2010). Nine studies were based on data from interviews and five studies used physiological health measures. Regarding specific populations nine studies addressed children or adolescents specifically, four studies were concerned with ethnic differences or particularly vulnerable populations, and two studies treated the issue of elderly people. The statistical analyses and adjustment for confounders showed varied degree of complexity and appropriateness. Studies containing specific biomarkers for evaluating health effects practiced for example Electroencephalography (EEG), Electromyography (EMG), heart-rate, cortisol, Body Mass Index (BMI) or growth curves. Subjective health measures or non-experimental studies used either register-data or national public health data; study-developed scales, questionnaires, observations or interviews; or frequently used, validated and reliable scales, such as General Health Questionnaire (GHQ-12) and Medical Outcomes Study Short Form (MOS SF-20). Physical measures to appraise physical activity, population distribution, or environment encompassed: accelerometers, System for Observing Play and Recreation in Communities (SOPARC), Behavioural Risk Factor Surveillance System (BRFSS), census tract data, General Position System (GPS), GIS, governmental-, national- or community- land cover data, self-ratings, or data sampling and modelling.

Several studies reported on more than one health indicator. The direct health benefits for which we found evidence on positive effects included psychological wellbeing(Tinsley et al., 2002; Hung and Cromption, 2006; Fuller et al., 2007; Gidlöf-Gunnarsson and Öhrström, 2007; Lafortezza et al., 2009; Abkar et al., 2010; Lee and Maheswaran, 2011; Stodolska et al., 2011;), reduced obesity (Nielsen and Hansen, 2007; Bell et al., 2008; Lovasi et al., 2011; Wolch et al., 2011; Toftager et al., 2011), reduced stress (Grahn and Stigsdotter, 2003; Hung and Chang, 2004; Nielsen and Hansen, 2007; Hansmann et al., 2010; Hussain et al., 2010; Korpela et al., 2010; Fan et al., 2011, Ward Thompson et al., 2012), self-perceived health (Hung and Chang, 2004; Payne et al., 2005; Maas et al., 2006, 2009; Lafortezza et al., 2009; Van Dillen et al., 2011), reduced headache (Hansmann et al., 2007), better mental health (Payne et al., 2005; Guite et al., 2006; Van Dillen et al., 2011), stroke mortality (Hu et al., 2008), concentration capacity (Hussain et al., 2010), quality of life (Hussain et al., 2010), reduced Attention Disorder Hyperactivity Disorder (ADHD) – symptoms (Taylor and Kuo, 2009), reduced cardiovascular symptoms and reduced mortality for respiratory disorders (Richardson and Mitchell, 2010), reduced health complaints (Van Dillen et al., 2011, Maas et al., 2009), overall mortality (Takano et al., 2002a), longevity (Takano et al., 2002b), birth weight and gestational age in low socioeconomic population (Dadvand et al., 2012), post-disaster recovery (Rung et al., 2011), and reduced cortisol levels (Ward Thompson et al., 2012). Health effects of parks on lung cancer or diabetes were studied in a few cases (Richardson et al., 2010, Richardson et al., 2011), but without finding any associations. The effect on reduced obesity also seems indeterminate with five articles reporting significant positive results, while seven articles report no effect.

The indirect health benefits were dominated by evidence for associations between access to parks or park use and increased physical activity (n=35), for reviews see for example Babey et al. (2008) or Kaczynski and Henderson (2007). Of the 35 studies eight could not demonstrate any significant relationship. Other indirect health effects for which evidence was found were: reduced levels of the air pollutants NO_2 and $PO_{2.5}$ (Su et al., 2011), reduced noise (Gidlöf-Gunnarsson and Öhrström, 2007; González-Oreja et al., 2010, Yang et al., 2011), increased recreation, community attachment, and social support (Elmqvist et al., 2004; Chen and Jim, 2008; Maas et al., 2009; Seeland et al., 2009; Ahmad et al., 2011, Arnberger and Eder, 2011; Arnberger and Eder, 2012; linked to the findings for the benefits of parks for promoting social cohesion provided in the next section) and cooling or thermal comfort to mitigate health consequences by exaggerated heat (Bowler et al., 2010, Mahmoud, 2011; see also the separate results for cooling benefits).

Only a few studies included comparative environments for controlled studies. These environments consisted of recreation centres, exercise facilities, and sports facilities (Kaczynski and Henderson, 2007), where parks were found to be more efficient in stimulating or promoting physical activity. However, another study showed a better effect on stress levels and restorative experiences by exercise and activity outdoor areas, waterside areas and urban woodlands compared to parks (Krenichyn, 2006). The latter study was of qualitative design though, while the former is a review study and hence providing stronger evidence for the suggested difference. Other examples were: non-park green neighbourhoods, where parks demonstrated higher levels of both social support and physical activity (Fan et al., 2011); two well-kept urban settings, more or less built, were relatively less efficient compared to a park setting to alleviating ADHD-symptoms (Taylor and Kuo, 2009); streetscape greenery showed the same positive effect on general health, health-related complaints, and general mental as parks (Van Dillen et al., 2011) as well as on longevity (Takano et al., 2002b) and obesity (Lovasi et al., 2011); proportion of gardens and green areas per total land area indicated similar effects on age-adjusted mortality as parks (Takano et al., 2002a).

Other variables that determined health related park use and activities were for example distance, facilities and amenities, general quality, park size and total tree canopy, species richness, time spent and frequency of visits to the park. There were also several studies suggesting a particular importance for ethnic minorities and immigrants as well as for adolescents (Cohen et al., 2007; Babey et al., 2008; Stodolska et al., 2011).

Conclusion and strength of the evidence

The quality assessment of the evidence for each output was made in accordance with the protocol described in the Method chapter of this report. Every outcome is evaluated respectively in a weighted analysis of the evidence, where also the number of studies on each benefit is considered in the concluding value.

- *Increased physical activity*. Most of the included studies on indirect health benefits related to associations between urban parks and physical activity. Taking this into consideration the evidence for this association should be valued as *strong*, in spite of the fact that also a few studies could not prove any effect.
- *Reduced obesity*. Taking all the factors into account, number of studies and quality of those, the evidence is *moderate to strong* for this outcome. This reflects, to some extent, the evidence for physical activity considering that those outcomes are related
- *Reduced stress*. Although several studies are addressing this outcome the evidence is only *moderate.*
- *Improved self-reported health and mental health.* The evidence for these aspects is *moderate.*
- *Opportunities for recreation, psychological wellbeing, and social support.* For these indirect outcomes the evidence is *weak to moderate.*
- *Reduced noise and cooling, and increased longevity.* The current evidence is *moderate*, but not enough controlled studies are made on the topic, why more research on these effects is needed before any certain conclusions can be drawn.
- *Reduced stroke mortality, reduction of ADHD-symptoms, and reduced cardiovascular/respiratory morbidity.* As each of these outcomes is represented by one high-quality study respectively, it is difficult to draw any conclusions on strength of the evidence. However, the findings to date suggest a potentially good effect, but more studies are needed in order to draw any conclusions or make any evidence grading.

Altogether the conclusion of this review is that there is sufficient evidence for parks as promoting health indirectly, particularly through increased physical activity. Another result of the review is that obesity, a main global problem, can probably also be reduced by access to parks. This seems to be particularly relevant for children. For the remaining promoted health benefits the tendency is positive and may form a basis for preliminary suggestions, but more research is needed before evidence-based recommendations can be applied.

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Urban parks and social cohesion

Introduction to the benefit
Urban parks have been viewed as an important part of urban and community development rather than just as settings for recreation and leisure. Urban parks have been suggested to facilitate social cohesion by creating space for social interactions (e.g., Coley et al., 1997; Kuo et al., 1998; Van Herzele and Wiedemann, 2003; Parr, 2007; Maas et al., 2009).

Social cohesion is defined as the extent to which a geographical place achieves 'community' in the sense of shared values, cooperation and interaction (Beckley, 1995). Public spaces such as urban parks are potentially of importance because they cater the opportunities for high levels of interaction between persons of different social and ethnic background (Lofland, 1998; Fainstein, 2005). For the development of local communities and social ties people have to be able to meet to establish relationship (Völker et al., 2007). In addition, interacting with others helps people to participate in society and to create feelings of acceptance (Putnam, 2000).

Globalization has resulted in increasing levels of migration over the past decades. This means some of the old, formerly rather homogenous nations are becoming more and more multicultural (Kærgård, 2010). This has raised political questions related to integration and social cohesion.

Most of the contacts between people will occur in places like local recreation facilities, schools, churches and parks (Kuo et al., 1998; Völker et al., 2007). The presence of trees (and shade) and grass in common spaces compared to barren spaces may attract residents to outdoor spaces, which enhances opportunities for the people to get connected (Coley et al., 1997).

Although several authors have highlighted the role of urban parks in social cohesion, not many of these claims have been supported by empirical evidence. This part of the systematic review therefore assesses articles presenting empirical evidence for the social cohesion benefits of urban parks.

Search information
In the search, the primary search terms as introduced in the Method chapter were combined with the following secondary search terms: "social ties" OR "social cohesion" OR "social capital" OR "social inclusion". This search generated 16 hits in Scopus and 3 in Web of Science. Evaluation of these 19 articles resulted in 4 articles to be included after omitting duplicates. To these, 1 article was added through snowballing (Ravenscroft and Markwell, 2000), leading to a total dataset of 5 articles (see Appendix, Table A2).

Key findings
Background information

Out of the five papers reviewed, two of the studies were undertaken in the Netherlands (Peters 2010, Peters et al., 2010), and one article each originated from Switzerland (Seeland et al., 2009), the UK (Ravenscroft and Markwell, 2010) and the USA (Fan et al., 2011). Four of the articles had the general public as their respondents, while two of the studies specifically focused on teenagers. Two other studies looked at teenagers. Four of the studies looked into the function of urban parks regarding social cohesion or integration among different ethnic groups and autochthones. In terms of methodology, most studied applied mixed methods, with one study taking a purely qualitative approach.

Urban parks as contributors to social inclusion and cohesion

Majority of the studies agreed that urban parks have more potential for social inclusion to occur than anywhere else because the easy access compared to other places in a city. Urban parks also provide facilities for leisure activities which attracts people to come. Social cohesion is enhanced when the people are engaged in an activity which connects them together e.g., organising an event, cycling, football.

Nevertheless, the social interaction which stimulates social cohesion among the people is mainly cursory and comprises informal interactions. Most of the people in the park have only a short chat with or just greet strangers, or they do not talk at all. Most of the time people visit the park with someone they know beforehand, e.g., friends or family members.

Most of the studies were based on observations of how people interact in urban parks, or on interviews which are focusing on finding out about the intention of social interaction and the meaning of the behaviour towards other people in the park. Only one study (Fan et al., 2011) used some form of indicators for measuring social cohesion, such as loneliness, feeling disliked and people being unfriendly, and subsequently generated models to explain the relationship between physical activity, social support and stress. However, none of the reviewed articles proved on the base of conclusive evidence that urban parks can enhance social cohesion.

Conclusion and strength of the evidence

The strength of the evidence of the respective papers was assessed based on e.g., the type of paper (with e.g., meta-analysis and systematic reviews representing the strongest evidence), rigidity of the scientific approach and the quality of the dataset e.g., in terms of number of respondents and randomization (as outlined in the quality assessment criteria presented in the Method chapter of this report). Four of the studies were evaluated as weak in terms of strength of the evidence provided, while only one was regarded as providing moderate evidence. Overall, it seems that the topic of how urban parks impact social cohesion has not been given much attention in the scientific literature, at least not since the year 2000.

In conclusion, there are some indications that parks promote social cohesion, but the strength of the evidence is *weak* due to the very small number of studies as well as the quality of those studies found.

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Urban parks and tourism

Introduction to the benefit

Urban parks do not only provide recreational settings to local residents. Also visitors from out-of-town will use these green spaces. In some cases, especially high-profile parks such as Central Park in New York are even major tourist attractions in their own right.

This section reviews articles that have looked at the role of urban parks in tourism. Authors have stated that green spaces, such an urban forest, can play an important role in attracting tourists to urban areas, e.g., by enhancing the attractiveness of cities and as a complement to other urban attractions (Majumdar et al., 2011). Wu et al. (2010) mention that within the field of eco-tourism, defined as responsible travel to natural areas that conserves the environment and improves the well-being of local people (TIES, 1990), there has been increasing attention to urban ecotourism, defined by the Urban Ecotourism Conference in 2004 as nature travel and conservation in a city environment. Probably due to their land limitations, especially many Asian island regions, including Singapore and Hong Kong, have promoted urban ecotourism actively, and have mixed it with urban tourism.

Search information

For the review of literature on the tourism aspect, the primary search terms as referring to urban parks were combined with the following secondary search terms: "touris*" OR "holiday*" OR "vacation*", in order to find articles that specifically addressed non-resident leisure use of parks.

The Scopus search resulted in 49 articles, of which 9 were considered to be (possibly) relevant based on an evaluation of titles and abstracts. The Web of Science search led to 33 articles, with 6 identified as (possibly) relevant. All of these were overlapping with the earlier Scopus search, thus leaving 9 articles for further analysis. Reading through these 9 articles led to a further exclusion of 2 papers, two of which dealt with the impacts of 'grey', inner-city living on leisure travel. Through snowballing, another relevant article was found (Deng et al., 2010). Thus, in all 8 articles were included (see Appendix, Table A3).

Key findings

Very few studies to date have specifically looked at how attractive urban parks are to tourists – and whether parks play a role in tourists' decision to travel to certain cities. For the case of the Indian city of Chandigarh, Chaudhry and Tewari (2010) interviewed 904 domestic tourists. More than $1/4^{th}$ of these considered urban parks and gardens as they main factor in making the city attractive, surpassing e.g., architecture and culture. The large majority of the tourists (89%) considered urban greenery very important from a tourism perspective. In a small-scale study of a Hong Kong park (Wong and Domroes, 2004), 28% of the interviewed tourists stressed that they enjoyed the parks of Hong Kong 'very much'. In a study of visitors to Savannah, Georgia, USA, Deng et al. (2010) found that the 306 respondents considered urban forests (including parks) as being the major contributor to the city's beauty, image, attractiveness and visitors' tourism experience, although for example historical attractions and amusement facilities ranked higher.

In their Delphi-study amongst 25 experts on ecotourism in Taiwan, Wu et al. (2010) found that 'environmental factors' were considered crucial to successful ecotourism.

Villella et al. (2006) studied visitation of the new Thames Barrier Park in London, which had tourism among its initial objectives. Nine percent of all visitors to the park came from outside London, and 2% from outside the UK, showing that local residents were by far the largest user group.

One could wonder whether tourists have different expectations from urban parks than local residents. Work on this topic was carried out in Kowloon Park of Hong Kong by Wong and Domroes (2004, 2005). In these studies, a rather small number of 36 tourists (61% of whom turned out to be first time visitors) were enrolled and their use and preferences were compared with those of local users. Tourist preferences were not that different from those of local users, for example in terms of liking open spaces, water, shady places, as well as places for strolling and sitting. Differences were noted in e.g., ways of getting to the park. Moreover, tourists were generally more satisfied with the park than local residents (Wong and Domroes, 2004). The authors also compared scores for visual qualities of the park, as well as so-called likeability indices (Wong and Domroes, 2005). Here differences between residents and tourists were noted, with tourists for example stating a higher preference for Chinese garden landscapes. With regards to the most-disliked scenes local residents were more sensitive to the utility aspect of the scenes and tourists to the overall upkeep of the park. Both groups expressed general preferences for greenery and water, and a dislike of built surfaces.

A study by LIaghati et al. (2010) showed that tourists to 'green' sites (including urban parks) in Tehran, Iran had different landscape preferences according to e.g., age and gender. However, this study has major weaknesses in terms of methodology – at least judging from the paper.

The study by Majumdar et al. (2011) in Savannah, Georgia, USA attempted to address the possible economic impacts of green spaces on urban tourism. In the study, tourists' willingness to pay for the city's urban forest (exemplified through for example parks, but also through e.g., street trees) was assessed. The study estimated the annual value of Savannah's urban forests to tourists to be in the range of 81 to 167 million USD, with a 95% confidence interval. The study also noted large differences in tourists' willingness to pay, with loyal and better off tourists being willing to pay more.

Conclusion and strength of the evidence

The strength of the evidence of the respective papers was assessed based on e.g., the type of paper (with e.g., meta-analysis and systematic reviews representing the strongest evidence), rigidity of the scientific approach and the quality of the dataset e.g., in terms of number of respondents and randomization (as outlined in the quality assessment criteria presented in the Method chapter of this report). Five of the studies were evaluated as weak in terms of strength of the evidence provides, while only two (Deng et al., 2010; Majumdar et al., 2011; both studies addressing green spaces in Savannah, Georgia) were regarded as providing moderate evidence. Overall, the topic of how urban parks impact tourism has not been given much attention in the scientific literature, at least not since the year 2000.

In conclusion, there are some indications that parks have touristic benefits, but the strength of the evidence is *weak*, due to the very small number of studies as well as the quality of those studies found. The study in Hong Kong, for example, had a very small and non-representative sample of tourists. The economic impact of parks on tourism was only addressed in the work by Majumdar et al. (2011) Savannah, Georgia. Although the evidence provided by this study outranks that of the other studies, the problem is that findings were not specifically related to urban parks, but rather to the city's entire 'urban forest'. This type of contingent valuation studies is also highly dependent on the local (economic) context.

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Urban parks and house prices

Introduction to the benefit

Different ways of estimating the economic value of nature have been explored over time. Especially in an urban setting, a way of indirectly assessing the economic value of green spaces is to study the impact of these spaces on house prices. If for example parks are valued by property buyers, this would be reflected in the premium they are willing to pay for the house or apartment. Quite a number of studies carried out, especially during 1990s.

In a (non-systematic) review of 30 studies that addressed the impact of parks on property prices, Crompton (2001) went as far back as the 1940s, while also looking at e.g., the property price increases due to the establishment of Central Park in New York. Among the 30 studies, the author found only 5 not supporting the proximity principle i.e. that having a park nearby raises property prices. He even mentions that a price increase of 20% seems a reasonable starting point. Other studies, such as the work by Luttik (2000) in the Netherlands found that overlooking attractive landscapes and water resulted in a price premium of 8-12 respectively 6-12%. Cho et al. (2008) studied the impact of forests on property prices in Knoxville City, USA and also found a positive impact on property prices caused by proximity of green spaces.

Here we only look at studies that have specifically included urban parks, rather than other types of green space.

Search information

The primary keywords were combined with two sets of secondary keywords: 1) “hous*” OR “dwelling*” OR “residen*” OR “propert*” as combined (‘AND’) with “hedonic*” OR “pric*” OR “valu*” OR “market*”. A search for these terms resulted in 173 articles in Scopus, and 86 in Web of Science. In both of these sets, 19 articles were evaluated as relevant based on title and abstract, while 14 articles were overlapping. Evaluation of the 24 articles led to the further exclusion of 4 (3 not relevant, 1 not available online). Through snowballing, 3 articles were added, resulting in a total of 23 articles studying the impact of urban parks on property prices (houses, apartments, residential plots) (see Appendix, Table A4).

Key findings

Background information

In terms of article authorship, 10 of the papers are written by experts from North America, 8 in Asia (China, Japan and Hong Kong), 6 in Europe (including the mentioned meta-analysis) and 1 in Australia.

The large majority of the studies included (n=19) applied a hedonic pricing approach to assess the impact of nearby parks on house prices. In hedonic pricing, sales data for properties are used and a model is built to disaggregate an observed price into a set of unobserved marginal implicit prices. Parts of the property value are related to different characteristics of the property and its surroundings. Typical property characteristics to include are, e.g., size, number of rooms, age of the property, while environmental characteristics can include location, proximity of important facilities such as schools and shops, but also green spaces. GIS modelling is used to assess the distance to for example the nearest park. Other methods applied by the studies include contingent valuation (e.g., willingness to pay and stated preference of homeowners) (n=4). One article, by Brander and Koetse (2011) comprised a meta-analysis of the economic value of open space. This meta-study assessed 20 contingent valuation studies (of which 3 on parks and green space) and 12 hedonic pricing studies (with 8 including parks).

The number of property sales included in the datasets ranged from 112 to 24862. Typically house prices were only studied in one city or city region, and only at one moment in time / time interval, rather than compared over time.

Parks mostly have a positive impact on property prices

The meta-analysis by Brander and Koetse (2011) concluded that open spaces in general, as well as specifically parks generally raise the value of nearby properties, be it houses or apartments. The large majority of the other articles and studied confirm these picture, although the precise impact on property value ranges widely among cities and countries. Therefore caution is needed when transferring results. The same study also compared urban parks with other types of green spaces and concludes that urban parks are more highly valued than for example forests and agricultural lands.

Not only property owners but also renters are affected, as Hoshino and Kuriyama (2010) found for one of Tokyo's wards. Their study of 2370 dwellings found a positive price effect (i.e. higher rents) when a nearby park was situated within 450 m. Medium-sized parks in particular led to higher increases. Park size is a factor, but studies indicate that even smaller green patches can have a positive influence. Kumagai and Yamada (2012) found a positive impact on land prices also for smaller green patches, although land prices increased proportionally with larger green patch coverage ratios.

Proximity is a key factor, as the price impact of nearby parks falls with increasing distance to the property. In their meta-analysis, Brander and Koetse (2011) found a 0.1% increase in house price with a 10 m decrease in distance from the park. Studies from Asia, Europe and North America confirm the principle that the value impact of parks increases with proximity. Kong et al. (2007) found higher house values for those properties with green space within a 300 m radius. In a study involving a large dataset of 16,000 property house sales, Tajima (2003) noted that a doubling of distance to parks led to a 6% drop in property price. A much cited study by Morancho (2003) of 810 residential dwellings in the Spanish city of Castellón found a drop in house price of 1800 EUR when moving 100 m away from the nearest green space. It has to be noted that the methodology for this study was not very well explained in the paper, so the findings need to be seen in the light of this. Sander and Polasky (2009) noted that a decreasing distance to the nearest open space, including parks, increases house sale prices in Ramsey County, Minnesota, USA.

Although Dehring and Dunse (2006) found proximity to parks raised prices of houses and flats in Aberdeen, they did not find an effect for lower density type housing. This could be due to e.g., the higher amount of private gardens in this type of housing.

Proximity to parks means that it is convenient to use the park for recreation purposes, but also that it possibly is visible from the house or apartment. Studied in the Chinese cities of Guangzhou and Shenzhen by Jim and Chen (2006, 2007; and Chen and Jim, 2010) showed that the visibility of urban parks is generally valued positively by property owners. A survey among 358 households in Shenzhen indicated an increase of close to 5% of house sale prices due to park visibility, with increased distance leading for a decrease in the price premium. In Guangzhou, the price increase found was 7.1%, with only water bodies scoring higher than parks. The positive impact of a green view was also found in central Melbourne, Australia, where building and industry led to negative impacts on property values (Bishop et al., 2004). In a study in Greece, the authors came to similar findings using a different methodology, namely a Fuzzy Delphi Approach involving rankings by local real estate experts. View to an urban park was expected to attract a price premium on property ranging from 8 to 30% (Damigos and Anyfantis, 2011).

Incidentally parks have a negative impact on property values
Several of the studies found some contradicting results and state that some factors can 'pull down' the positive effect of parks on property values. Troy and Grove (2008), for example, mention that crime rates in the neighbourhood are an important factor. In their study in Baltimore, Maryland, USA, they found that combined robbery and rape rates for a neighbourhood need to be below a certain threshold level (i.e. between 406 and 484% of the national average for these crimes). Chen and Jim (2010) found in their study in Shenzen, China that parks within 500 metres from the property did not have a significant impact on property prices, and highlighted potential negative effects such as noise by users, unruly behaviour, as well as crime. Kong et al. (2007) came to similar conclusions for Jinan, China, referring to negative impacts of parks in terms of noise and neon lights. In another Chinese city, Wuhan, while city level parks had a positive effect on house price, larger district level parks had not (Jiao and Liu, 2010). Noise is also mentioned as an explanation for some negative findings for larger-sized parks in Tokyo (Hoshino and Kuriyama, 2010). Cho et al. (2006) noted negative price effects of some parks in Knox County, Tennessee.

Conclusion and strength of the evidence
The strength of the evidence of the respective papers was assessed based on e.g., the type of paper (with e.g., meta-analysis and systematic reviews representing the strongest evidence), rigidity of the scientific approach and the quality of the dataset (as outlined in the quality assessment criteria presented in the Method chapter of this report). Most studies involved hedonic pricing, which means that 'proxy' values are used. Moreover, the sophistication of the explanatory model can differ. It was seen as strength if studies included data from multiple sites and not just one city. None of the studies had repeated measurements. A specific focus on urban parks and especially a comparison between the impact of parks and other types of green space was also seen as strength. Based on these criteria, one study as evaluated as strong, namely the meta-analysis by Brander and Koetse (2011), while 11 studies presented moderate to strong evidence and a further 6 moderate evidence that nearby parks provide benefits as reflected by higher property prices. The final six studies were evaluated as weak to moderately weak, e.g., due to unclear methodology or lack of scientific rigor.

Based on this quality assessment, there is *moderate to strong* evidence that urban parks have a positive impact on the value of nearby property (houses, apartments, land), although it is important to keep the limitations of the hedonic pricing methods – applied in the large majority of the studies - in mind. Parks have a greater impact on property values than other types of green spaces. The positive impact relates to both possibilities for recreational use and views over the parks. Positive impacts increase with proximity to the park and drops quite rapidly with increasing distance to the park. However, there are cases when parks do not have a positive impact, for example due to crime, noise and light pollution. Moreover, due to large differences in local conditions it is very difficult to generalise specific price increases as e.g., related to distance.

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Urban parks and biodiversity

Introduction to the benefit
During the past decade research on urban biodiversity has become momentous - not only because of the increasing impact of urbanization on natural ecosystems, but also because of the growing recognition of urban areas as hosts for innovative ways to conserve and promote biodiversity (Savard et al., 2000). The latter is illustrated by various global environmental conventions such as the 2002 World Summit on Sustainable Development, the 2007 Curitiba Declaration on Cities and Biodiversity, and the Global Partnership on Cities and Biodiversity launched by among others the United Nations Environment Programme (UNEP 2012). Researchers have stated that urban parks, due to their often high levels of habitat diversity and microhabitat heterogeneity, can constitute particularly important hotspots for biodiversity in the cityscape, albeit their primary role is recreational (e.g., Cornelis and Hermy, 2004).

This section reviews articles that have looked at the impact of urban parks on biodiversity in the cityscape. While the concept of biodiversity embraces both the ecosystem, the species, and the gene levels most research on urban biodiversity has focused on the species level, simply because it is well defined, quantifiable, and easily monitored (Farinha-Marques et al., 2011). Accordingly, we limit the review to this species dimension of biodiversity. We focus on species richness and omit species abundance, because the studies where abundance is included in diversity metrics tend to yield similar patterns (McKinney, 2008).

Search information
For the review of literature on aspects of species richness of urban parks, the primary search terms as referring to urban parks were combined with the secondary search terms “biodiversity” OR “species richness”.

The search generated 266 hits in Scopus and 175 hits in Web of Science. After screening of title and abstracts 66 potentially eligible papers were retrieved from Scopus and 56 from Web of Sciences. However, several of the papers overlapped between the two databases. Eventually 62 papers were included in the review (see Appendix, Table A5).

Key findings
Background information
The articles reported empirical research from 25 different countries, representing Europe (n=20), Asia (n=19), North America (n=13), South and Latin America (n=5), and Oceania (n=4), while one article involved researchers from different continents. On average each study examined 24.7 sites of which 17.7 were parks. As much as 76% of the studies examined one species group only (and mostly one fauna group), while only four studies examined both flora and fauna groups, all of which were conducted in Europe. Birds comprised the most examined species group, being covered in 48.4% of the studies (n=30). Invertebrates and vascular plants were also fairly commonly studied, included in 30.6% (n=19) respectively 27.4% (n=17) of the studies. In comparison, studies of mammals, amphibians, reptiles and bryophytes were limited in numbers (see Appendix, Table A5).

Parks often have higher species richness than other types of urban green space
In 14 studies the species richness levels of urban parks were compared to those in other types of specified green space including urban and peri-urban woodlands, gardens, green roofs, plantings along roadsides, residential areas, institutional grounds, derelict/ ruderal sites, seminatural

grassland and nature reserves in the urban hinterland. In 64.3% of these studies (n=9) urban parks were the most species rich type of urban green spaces (see Appendix, Fig. A1). This was true in two studies of birds (Kler, 2006; Carbo-Ramirez and Zuria, 2011) and one study of birds and mammals (Sorace, 2001). For vascular plants Liang et al. (2008) found parks to be more species rich than green belts and streets in Beijing, while Turner et al. (2005) concluded for Halifax, Canada that vascular plant species richness was higher in residential neighbourhoods than in forest plots within semi-natural urban parks, but this was due to a much higher representation of exotic species in the residential areas. For woody plants two out of three studies of plants found parks to be the more species rich than riverside green space and street niches (Jim and Chen, 2008, 2009). However, in a study of tree species diversity in Guangzhou, China institutional grounds contained more species than parks (Jim and Liu, 2001). For invertebrates Pacheco and Vasconcelos (2007) found parks to be the urban green space type that represented highest species diversity of ants in the city of Uberlândia, Brazil, but the species richness in urban parks was lower than in nature reserves. Tonietto et al. (2011) concluded that parks in Chicago, USA contained more bee species than other types of urban green space, with species richness being nearly at the same level as remnant of prairies. For isopod species in Budapest, the species richness in urban parks was lower than in old gardens and urban woodlands (Vilisics and Hornung, 2009). For butterflies, however, Koh and Sodhi (2004) found that those urban parks in Singapore that had adjoining forest had a higher number of species and abundance than forest remnants, while Öckinger et al. (2009) identified that both species richness and density of butterflies were higher in ruderal sites within Malmö, Sweden than in traditional and semi-natural parks. For bryophytes, Oishi (2012) concluded that species richness was higher in a Japanese garden compared to an urban park in the city of Kanazawa, Japan.

Exotic species are a major component of species richness in parks
Species richness comprises both native and exotic species. Information about the relative distribution between native and exotic species specifically in urban parks could be extracted from 15 studies (Appendix, Fig. A2). Seven of these concerned flora groups and nine examined fauna groups. Synthesis of the studies of plants shows that exotics accounted for a mean of 41.8% of woody species in urban parks (variation between 6.2% and 66.3% in three studies) and 42.6% of all vascular plants in urban parks (variation between 17.2% and 66.0% in four studies). Studies of fauna species groups generally reported exotics to account for lower shares compared to those reported for plants. Six studies examined the relationships for birds. They reported between 3.1% and 14% of the sighted bird species to be exotics, with an average of 8.1 %. For invertebrates, Tonietto et al. (2011) found that 17% of the bee species observed in urban parks of Chicago were exotics. Vilisics and Hornung (2009) reported 9.6% of the soil macrofauna in urban parks of Budapest, Hungary, to be exotics, while urban parks within the city of Uberlândia, Brazil, were apparently free of exotic ant species (Pacheco and Vaconcelos 2007).

Less urbanised, less isolated, larger and more diverse parks often harbour more native species
Several of the studies have looked into the reasons for certain green spaces harbouring higher species diversity. Multiple scales and spatial attributes interact in shaping the overall richness of species in urban parks, and many studies have adopted analyses and tests of confounding variables at different levels of spatial resolution. Fourteen studies applied the urban-rural gradient approach in analysis of confounding variables for species richness of urban parks. The results across these studies echoes that increased level of urbanisation causes decreased species richness and changes in the species assemblages of especially the fauna in urban parks towards more generalist species

(urban exploiters and urban adaptors) and exotics, while specialist species and other area sensitive species (urban avoiders) fade out. This was true for birds, bees, ants, beetles, butterflies but also vascular plants. (Atchison and Rodewald, 2006; Pacheco and Vasconcelos, 2007; Smith, 2007; Murgui, 2009; Hernandez et al., 2009; Jim and Chen, 2009; Vignoli et al., 2009; Öckinger et al., 2009; Magura et al., 2010; Biadun and Zmihorski, 2011; Lizeé et al., 2011; Konvika and Kadlec, 2011; MacGregor-Fors and Ortega-Àlvarez, 2011; Oliver et al., 2011). However, in many of the studies the loss of native species was masked by influx of exotic species and generalist species tolerating a wide range of habitat conditions, resulting in a stable number of species in parks along the gradient (e.g., Magura et al., 2010). The urban-rural gradient can also be regarded as a habitat-loss gradient (McKinney, 2002) where parks and other green space often feature as more or less isolated 'green islands' in an 'urban ocean' of built up structure. Isolation effects occur when the urban matrix is impermeable to dispersal (Garden et al., 2010). Of the papers reviewed, 20 studied isolation effects. As much as 19 of these were restricted to one fauna species groups. Birds were the most studied species group, with ten studies. Though research has been conducted in different regions of the world (see Appendix, Table A1) it consistently concludes that isolation influences urban bird species richness and assemblages negatively, but also that the effects of park size and the parks' habitat qualities override those of isolation in explaining bird species richness. In a study of 25 parks in Madrid, Spain, Fernandez-Juricic (2000) found that this was especially the case in older parks while isolation and urban matrix effects were more pronounced in younger parks due to their lower habitat diversity and complexity.

However, for invertebrate species, results showed the opposite relationships between park size and park isolation. Across eight studies the effects of isolation were exclusively found to override park size as a predictor for species richness of ants, bees, and butterflies (Koh and Sodhi, 2004; Yamaguchi, 2004; McFrederick and LeBuhn, 2006; Pacheco and Vasconcelos, 2007; Hernandez et al., 2009; Öckinger et al., 2009; Tonietto et al., 2011; Lizée et al., 2012). But, as for birds habitat diversity and qualities were found to be more important than isolation in determining overall species richness (McFrederick and LeBuhn, 2006; Tonietto et al., 2011). In fact, all studies that tested the effect of habitat diversity and qualities, irrespectively of the species group in focus, found a positive relationship between increased diversity of habitats and increased species richness.

Conclusion and strength of the evidence

The strength of evidence for the overall species richness levels of urban parks, was assessed e.g., based on the species group(s) in focus. Here plant species were regarded as a better surrogate species than individual fauna species groups (Bräuniger et al., 2010), and studies bridging both flora and fauna groups as representing the strongest evidence. Other evaluation criteria were based on those presented in the Method and for example related to the study's methodological set-up, the number of cities and parks and other green space types surveyed, and rigidity of the scientific approach. Based on these criteria, eight studies were evaluated as strong in regards of assessing the overall biodiversity of urban parks, and providing evidence for parks as biodiversity hotspots in urban areas. In addition, 15 studies provided moderate evidence and had their main limitation in studying only one fauna group. The limitation to one species group was also a main cause for 11 studies being evaluated as providing weak to moderate evidence when it comes to assessing overall species richness levels, and 28 studies being weak.

In conclusion, there is *strong evidence* that parks are biodiversity hotspots in the cityscape, being among the most species rich types of urban green spaces for all species groups that have been studied. When drawing results across the many studies, it is clear that substantial components of native species can persist, but also that very large shares of the plants species found in urban parks are exotics (often around 50%), while exotics constitute much less shares of fauna species groups. The large number of parks investigated and the wide geographical coverage of the studies, allows for generalisation of these conclusions at local as well as global scale.

As mentioned, many studies have adopted analyses and tests of confounding variables at different levels of spatial resolution. While this is widely regarded as a methodological strength (Savard et al., 2000; Angold et al., 2006; Werner and Zahner, 2010), the studies exclusively used an observational design which involved inventory and analysis of existing species richness and community attributes, rather than more controlled study designs such as experiments. This is not surprising given the types of intervention needed, something which sets obvious limits to the feasibility of conducting experimental work. Nevertheless, given the absence of experimental research, drawing results across studies, as done in this review, is important to enable general conclusions. The main constraint of research to date for assessment of the overall species richness of urban parks and its drivers is the limitation of individual studies to one or a few species groups, thus limiting the generalisation of results and their implementation in policy and practice.

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Urban parks, air quality and carbon sequestration

Introduction to the benefit

Air pollution is generally considered as a major concern in urban areas, and as being among the major risk factors contributing to the global burden of disease, with for example high levels of particulate matter (PM) air pollution being associated with excess mortality and morbidity in the urban population (Cavanagh et al., 2009). Air pollution relates to a wide range of pollutants, from PM to SOx and NOx, but als COx (important in terms of climate change mitigation). Cavanagh et al. (2009) state that various studies have identified the beneficial influence of urban vegetation on ambient air quality, although most of these studies infer the impact of tree coverage on urban air quality models rather than from experimental data (e.g., Yang et al., 2005; Nowak et al., 2006; Escobedo and Nowak, 2009), an exception being Freiman et al. (2006).

Paoletti et al. (2011) mention that pollution removal varies among cities depending on e.g., the amount of tree cover, with increased tree cover leading to greater total removal, but also for example the length of the in-leaf season and a range of meteorological variables that affect tree transpiration and deposition velocities. Cavanagh et al. (2009) elaborate on the specific role of urban trees in air pollution reduction, mentioning their effects in terms of intercepting atmospheric particles and absorbing various gaseous pollutants (also Yin et al., 2011). But trees can also lower air temperature through transpiration, which affects the photochemistry of ozone and reduces ozone production. The authors mention, however, that trees can actually also contribute to air pollution through the emission of so-called volatile organic compounds that can react in the atmosphere to form ozone in the presence of nitrogen oxides.

Although the impacts of urban trees thus have been studied rather extensively, at least through urban air quality models, there is indication that (experimental) research specifically on urban parks has been limited so far (Pataki et al., 2011; Yin et al., 2011). Parks often have high tree covers and can also have the character of woodland, which is relevant as the deposition of gaseous pollutants is typically greater in woodlands than in shorter vegetation (Paoletti et al., 2011). Makhelouf (2009) states that pollution concentrations are usually lower in parks than outside them, but to motorised traffic and human activity.

It is important to note that vegetation also can have negative impacts by emitting so-called volatile organic compounds that e.g., can enhance ozone pollution, and by being a source of allergens (e.g., Pataki et al., 2011).

Search information

The primary search terms related to urban parks were combined with two groups of secondary search terms: 1) “pollut*” OR “air quality” OR “particle*” OR “atmospheric*” OR “NO*” OR “SO*” OR “dust” OR “CO”, as combined with (2): “reduc*” OR “buffer*” OR “captur*” OR “lower*” OR “prevent*” OR “attenuat*”. The Scopus search resulted in 483 articles, with 17 identified as being potentially relevant based on title and abstract. The Web of Science search resulted in 101 articles, with 12 being potentially relevant. Out of these, 7 were overlapping, leading to 22 unique articles. A more thorough analysis of the articles led to exclusion of 14 articles (1 due to lack of availability). To the remaining 8 articles, 3 were added after snowballing, resulting in a total of 11 articles that explicitly look at the impacts of parks on air quality and carbon sequestration (see Appendix, Table A6).

Key findings

Parks contribute to reduction of air pollution

When excluding CO (which is dealt with below), 7 studies looked at the air pollution reduction effect of urban parks. All of these studies found that urban parks help remove air pollutants. Most of these studies were largely based on modelling work, applying for example biomass and air pollution uptake relations are described in the literature. Two of the studies apply the so-called UFORE model for studying air pollution uptake (Paoletti et al., 2011; Tallis et al., 2011). The work by Beckett et al. (2000) included physiological measurements of the particles captured by trees at five UK urban sites.

Five of the studies found that urban parks made substantial contributions to the removal of particles, including PM10 (Beckett et al., 2000; McDonald et al., 2007; Paoletti et al., 2011; Tallis et al., 2011; Yin et al., 2011), while four of the studies found that parks reduced the levels of other pollutants, including NOx and SOx (Jim and Chen, 2008; Makhelouf, 2009; Paoletti et al., 2011; Yin et al., 2011).

Paoletti et al. (2011) carried out a rare longitudinal study, applying the American UFORE model to look at air pollution reduction by the largest park in Florence, Italy, comparing data for 1984 and 2004. Results showed that the forest growth compensated the losses due to cuttings and damages by extreme climatic events, so that the overall amount of pollutants removed from the air did not change (and remained positive) from 1985 to 2004. Although the removal of pollutants per tree increased over time, the total amounts slightly decreased, still because of the reduction in the number of trees, so that the total amount of pollutants removed from the air in the eight plots showed just a small 5% reduction from 1985 to 2004. Modelling was also used by Yin et al. (2011, 2012) for studies in Shanghai, China. The authors used seasonal monitoring data of suspended particles (TSP), sulphur dioxide (SO2) and nitrogen dioxide (NO2) from six parks in the Pudong district of Shanghai district. Findings showed that vegetation in parks can remove large amount of airborne pollutants. It could be estimated by regression analysis that in summer, urban vegetation in Pudong District could contribute to 9.1% of TSP removal, 5.3% of SO2 and 2.6% of NO2 (Yin et al., 2011). The authors also stress, however, that the removal of air pollutants within urban vegetation patches is a complex process, which might be affected by various factors, from local atmospheric chemistry, meteorology, to leaf microstructure and cell physiology at the micro level.

The study by Jim and Chen (2008) for Guangzhou attempts to study the economic effect of air pollution reduction by urban parks, and the removal of SO2 and NO2 in particular.

Work by Lam et al. (2005) did not look at air pollutant removal, but rather at differences in air quality between parks and surrounding areas. The authors studied 70 parks in Hong Kong with a hybrid approach of air quality measurements and modelling. Results showed that air quality inside the parks was not substantially better than in the surrounding areas.

Contribution of parks to carbon sequestration

In the context of climate change, the sequestration of carbon by urban trees and other vegetation plays an important role. Five of the articles included COx removal by urban parks, agreeing that parks act as 'carbon sinks' (Jo, 2002; Makhelouf, 2009; Kordowski and Kuttler, 2010; Davies et al., 2011; Paoletti et al., 2011). Once again, most of the studies are based on modelling (of vegetation and pollution) rather than on on-site measurements. Kordowski and Kuttler (2010), however, measured carbon levels above a park in the city of Essen, Germany for a period of 14 months, deriving carbon fluxes in the area by modelling. The authors found a small carbon sequestration effect of the park over the period of an entire year. The rather low net sequestration can be attributed to the low but existent anthropogenic emissions from the single road crossing the area and from maintenance activities in the park (lawn mowing, gardening).

Davies et al. (2011) combined modelling work with actual on-site measurements of vegetation biomass. At the city wide scale, they found that an estimated 231 521 tonnes of carbon were stored within the above-ground vegetation of Leicester, equating to 3.16 kg C m2 of urban area, with 97.3% of this carbon pool being associated with trees rather than herbaceous and woody vegetation. Paoletti et al. (2011) found in their longitudinal analysis of the main park in Florence, Italy, that the average carbon storage per tree was similar in 1985 and 2004, but the reduction in the number of trees over time implied a 43% decrease in the carbon store of the whole forest. Also the annual carbon sequestration per tree was similar in the two years, with a 34% decrease in the total amount sequestered in 2004 relative to 1985.

Conclusion and strength of the evidence

The strength of the evidence of the respective papers was assessed based on e.g., the type of paper (with e.g., meta-analysis and systematic reviews representing the strongest evidence), rigidity of the scientific approach and the quality of the dataset (as outlined in the quality assessment criteria presented in the Method chapter of this report). For this specific benefit, it can be seen as a drawback that most studies rely on modelling rather than on on-site, physiological and meteorological measurements. It was seen as strength if studies included data from multiple sites and not just one city or park, and when the study was longitudinal rather than looking at one moment in time. Based on these criteria, only one study was assessed as providing moderate to strong evidence, namely Lam et al. (2005) who looked at air quality in 70 parks in Hong Kong, combined measurements and modelling, and compared air quality within the parks with the surrounding areas. Seven of the studies were assessed as providing moderate evidence, one weak to moderate, and one weak.

Based on this quality assessment, there is *weak to moderate* evidence that urban parks improve air quality by capturing pollutants such as SOx, NOx, COx and particles. In the case of COx, parks thus contribute to carbon sequestration. The body of evidence for individual air pollutants, however, is very limited (also Pataki et al., 2011). On the other hand, there is extensive literature on the impact of urban trees in general (i.e. not specifically looking at urban parks) and several of the studies included in the present review stress the important role of trees as compared to other woody and non-woody vegetation.

Literature

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Urban parks and water management

Introduction to the benefit

Water management is crucial to cities, particularly in times of climate change. Cities often import water from surrounding areas in addition to converting land cover from vegetated surfaces to buildings, pavement, and other impervious surfaces. This land-cover change radically alters the pathways and magnitude of water and pollution flows into, within, and out of urban systems. Surface water flooding describes the combined flooding in urban areas during heavy rainfall. As such, it includes pluvial flooding, sewer flooding, flooding from small open-channel and culverted urban watercourses, and overland flows from groundwater springs. Surface water flooding is predominantly caused by short duration intense rainfall, occurring locally (Fryd et al., 2011; Pataki et al., 2011).

Ecosystem-services-based approaches can help regulate the urban water cycle by reducing the amount of stormwater runoff and to improve water quality by removing pollutants from runoff. Bioswales, rain gardens, green roofs and other green infrastructure components can help reduce runoff e.g., due increased infiltration rates for non-paved surfaces. Increased infiltration would promote groundwater recharge and evapotranspiration from vegetated surfaces, and thus help to improve climatic conditions in the city (Pauleit and Duhme, 2000; Pataki et al. 2011). Urban landscapes with 50–90% impervious cover can lose 40–83% of rainfall to surface runoff (Pataki et al., 2011).

This part of the review focused on the role of parks in urban water management, with focus on evidence for reducing the amount of stormwater runoff.

Search information

The primary search terms related to urban parks were combined with the following secondary search terms: “stormwater*” OR “drain*” OR “flood*” OR “drink*” OR “runoff”. This search resulted in 127 articles found through Scopus and 68 in Web of Science. Based on title and abstract, initially 11 resp. 5 were maintained. A more thorough analysis of the remaining papers led to the including of 4 articles, to which 2 were added through snowballing, resulting in 6 relevant articles (see Appendix, Table A7).

Key findings

Background information

Five of the studies apply modelling to assess the water runoff impact of urban parks (Pauleit and Duhme, 2000; Kaźmierczak and Cavan, 2011; Peng et al., 2008; Gill et al., 2007; Zhang et al., 2012) while the remaining study used multi-criteria assessment (Kubal et al., 2009) for integrated flood risk assessment. All studies were conducted at the level of a city or city region, in Greater Manchester, UK (2 studies), Leipzig and Munich (Germany), and Beijing and Nanjing (China). In Nanjing, the CITYgreen model was used to assess a range of environmental services provided by the city’s urban green spaces (Peng et al., 2008).

Parks contribute to stormwater management

All studies find that urban parks (and urban green space in general) contribute to stormwater management, with focus on the higher water infiltration rates in urban green spaces as compared to other urban land use. However, the studies base themselves on previous research that demonstrated the positive impact of urban green space on management of floods and stormwater. For Munich, Pauleit and Duhme (2000) found a much lower average impervious surface share in green spaces as compared to other types of urban land use. Thus parks, wastelands, and farmlands significantly contributed to groundwater recharge with mean infiltration rates between 30 and 38%. Moreover, these areas have a much lower surface run off. Kubal et al. (2009) confirm this for Leipzig, stating that green cover plays a role in the limitation of flooding and thus recreational green space needs to be taken into account in decision-making on urban flood risk. The role of green space in limiting of flooding is also stressed by Kaźmierczak and Cavan (2011). In their study of Greater Manchester, the areas with a large proportion of land susceptible to surface water flooding tended to have less green space. Gill et al. (2007) also studied Greater Manchester and use their analyses to argue for more green space to make cities more resilient and adapted to climate change. In their model, adding green cover reduced stormwater run-off substantially. Moreover, the authors stress the important role of mature trees in the water cycle, e.g., through evapotranspiration. The work by Zhang et al. (2012) in Beijing found that 2494 cubic meters of potential runoff was reduced per hectare of green area and a total volume of 154 million cubic meters rainwater was stored in these urban green spaces, which almost corresponds to the annual water needs of the urban ecological landscape in Beijing. The authors also assessed the economic benefit of this function (which was found to be considerable and the equivalent of three-quarters of the maintenance costs of the city's green spaces).

Conclusion and strength of the evidence

The strength of the evidence of the respective papers was assessed based on e.g., the type of paper (with e.g., meta-analysis and systematic reviews representing the strongest evidence), rigidity of the scientific approach and the quality of the dataset (as outlined in the quality assessment criteria presented in the Method chapter of this report). For this specific benefit, it can be seen as a drawback that the studies rely on modelling rather than on on-site, physiological and meteorological measurements. It was seen as strength if studies included data from multiple sites and not just one city or park, and when the study was longitudinal rather than looking at one moment in time. However, none of the studies included longitudinal data.

Based on this quality assessment and only the studies listed here, there is *weak* evidence that urban parks contribute to the management of run-off / stormwater. However, the lower share of impervious surfaces in parks makes it obvious that infiltration rates are higher and a range of previous articles (see Pataki et al., 2011 for an overview) indicate that the runoff reduction benefit of parks is potentially very important. More on-site and experimental work specifically also for urban parks is needed to strengthen the evidence base and find out more about the mechanisms, the impact of differences in park size and structure, and so forth.

Literature

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Urban parks and cooling

Introduction to the benefit
Increased air temperatures can be expected to be particularly problematic in urban areas, where temperatures already tend to be higher than in the surrounding countryside (e.g., Oke, 1987). Climate change has a range of consequences for human health, including e.g., intensity and frequency of heat waves. Oke (1987) and others have studied the impact of urban vegetation in terms of their possible cooling effect. Mechanisms at work in cooling by trees and other vegetation include evapotranspiration – loss of water from plants as vapour into the atmosphere, which consumes energy from solar radiation and increasing latent rather than sensible heat, cooling the leaf and the temperature of the air surrounding the leaf. Shading from trees, which encompasses intercepting solar radiation and preventing the warming of the surface and air, is another mechanism, at work. Mechanisms depend critically on the type of vegetation (Bowler et al., 2010).

A systematic review of the cooling effects of urban greening, including specifically the category of urban parks, was recently undertaken by Bowler et al. (2010). This review also included a meta-analysis to statistically synthesise data on the temperature differences between urban parks and non-green urban areas to quantify the average cooling effect of a park across studies.

As this work was so recent, comprehensive and thorough, it was decided not to refrain from a new systematic review of the cooling effects of urban parks, but rather to refer to Bowler et al.'s main findings. It has to be noted, however, that these authors potentially included a larger range of databases and sources for their review.

Information about the search
Bowler et al. (2010) followed a stringent protocol and included only those studies that measured temperature at ground level in an urban area in any geographical location and that compared temperatures in a green site(s) and a non-green site(s). One of the categories included in the review was 'parks or green areas' (although the term 'parks and gardens' is also used sometimes). The authors identified in all 47 articles found for greening interventions of interest, including 24 for parks and green areas (with 125 parks included in general). However, it should be noted that only 11 of these studies were published during the time period studied in the present review (2000-2012), while the other 13 appeared during the 1980s and 1990s.

Key findings
Parks are cooler than the surrounding urban areas. In their meta-analysis, Bowler et al. (2010) found an average temperature reduction of 0.94 degrees C during the day, based on 26 effect sizes from 16 studies. At night the temperature difference was 1.15 degrees C (12 effect sizes from 7 studies). However, a significant variation was noted in the effect size among different parks both in the day and at night. Some initial support was found for a positive effect of park size on the estimated cooling effect. A study of 61 parks in Taipei city showed that parks over 3 ha are cooler than the surrounding urban area, while the temperature difference was much more variable for parks less than 3 ha (Chang et al., 2007). The cooling effect of parks varies also with the composition of the vegetation within the park, with e.g., the amount of (large) trees comprising an important factor.

Bowler et al. (2010) found very limited evidence (comprising only a few studies) for parks have any effect on the temperature of the wider surrounding area.

Conclusion and strength of the evidence

The strength of the evidence on the cooling effect of parks was assessed by Bowler et al. (2010). Based on this quality assessment, there is *moderate to strong* evidence that urban parks cool the environment, at least at the local scale. However most of the studies used an observational design and the authors note a lack of more rigorous study designs such as experiments. Therefore the impact of confounding variables needs to be kept in mind. Other factors to be kept in mind are that most studies only looked at single park and true replication was lacking. Moreover, there currently is *weak evidence* for the cooling effect of parks to extend beyond their boundaries.

Literature

Bowler, D.E., Buyung-Ali, L., Knight, T.M., Pullin, A.S., 2010. Urban greening to cool towns and cities: A systematic review of the empirical evidence. Landscape and Urban Planning 97, 147-155.

Chang, C.R., Li, M.H., Chang, S.D., 2007. A preliminary study on the local cool-island intensity of Taipei city parks. Landscape and Urban Planning 80, 386-395.

Oke, T.R., 1989. The micrometeorology of the urban forest. Philosophical Transactions of the Royal Society of London, Series B, Biological sciences 324, 335-349.

Conclusions

Table 2 provides an overview of this systematic review of the benefits of urban parks, based on peer-reviewed scientific publications during the time period 1 January 2000 until 1 April 2012. The table lists the benefit categories from those with the strongest to those with the weakest evidence base. In all, 201 articles were found to document one (or several) of the eight benefits of urban parks selected for this review. Additionally, by summarising the work by Bowler et al. (2010) on the cooling effect of urban parks, 24 articles were included indirectly.

Overall, it can be concluded that there is evidence for a range of benefits of urban parks, i.e. that we have sound scientific evidence that parks contribute to human and social wellbeing. This can be either directly (for example by making us more physically active) or indirectly (by their high biodiversity enhancing opportunities for nature experience and recreation). *Evidence is (moderate to) strong for the positive impacts of parks on 1) biodiversity (as measured through species richness); 2) property prices; 3) physical activity and reduced obesity; and 4) local cooling.* These benefits thus provide the strongest, scientifically supported arguments in favour of urban parks. For other health-related benefits, namely contributions to stress reduction and improved self-reported health and mental health; and indirect health effects through reduced noise and cooling, and increased longevity, the evidence base is moderate.

The matter of urban parks as a means to improving public health is a topic of the day with increasing actuality, given the global urbanization and an epidemic of non-communicable diseases, where people's living environment and lifestyles become of growing significance. These issues generate a focus on urban environments that can potentially contribute to healthy behaviours or even intrinsically create health effects. Another aspect is the augmenting health inequalities which is a major focus in health research and policies. In this perspective parks can be perceived as a possible planning tool to reduce environmental injustice, since it seems as if parks are especially important in deprived communities and for ethnic minorities. Subsequently urban planners should focus on high quality parks in such areas, where the case is currently that parks are scarce and often poorly maintained. Given e.g., the strong evidence for parks as promoting physical activity and reducing obesity, more thoughts should be given to how parks are planned and established with good opportunities and amenities for exerting varied kinds of physical activity, such as walking and biking.

It has also been proven that urban parks are biodiversity hotspots in urban areas. This does not only hold potential for attracting leisure seekers and tourists interested in nature, but also for using parks as areas for nature education and interpretation. Moreover, biodiversity is crucial for ecosystem functionality and thus for the ecosystem services provided by the paper. The review provides some evidence that the diversity of habitats and microhabitat heterogeneity contained in parks is the most decisive factor for the overall species richness and composition. Opportunities for biodiversity promotion in urban parks related to conscious habitat design and management therefore provide an interesting angle for the future that could contribute to the continued development of innovative ways to conserve and promote biodiversity in urban areas - not at least because the habitat qualities are largely within the control of park designers and managers. In regards for future research, adopting multi-species group approaches or coordination of study sites between studies of individual species groups can create important synergy effects that would advance the understanding of and evidence for the overall biodiversity of urban parks and its confounding variables.

Although especially the regulating ecosystem services of urban green space have been stressed during recent years, apart from cooling these services are not (yet) very well documented specifically for urban parks. The evidence base for contributions of parks to air pollution reduction and water regulation is weak (to moderate). The same can be said for the cultural services of contributing to tourism and social cohesion, where very limited sound scientific work has considered the specific role of urban parks.

Table 2. *Summary of main study findings. Benefits of urban parks are listed according to strength of the evidence (for the benefit category).*

Benefit category	**Nr. of articles**	**Main findings**	**Strength of the evidence**
Biodiversity	62	• Parks harbour higher species richness than other types of urban green space. *Note: part of this diversity is due to a large share of exotic species.*	• Strong
House prices	23	• Nearby parks mostly have a positive impact on property prices – thus demonstrating people's appreciation for parks in people's living environment	• Moderate to strong
Health and wellbeing	86	1. Parks contribute to increased physical activity and reduced obesity 2. Parks contribute to stress reduction and to improved self-reported health and mental health 3. Parks have indirect health effects through offering opportunities for recreation, psychological wellbeing, and social support 4. Parks have indirect health effects through reduced noise and cooling, and increased longevity *Note: only one high-quality study each on reduced stroke mortality, reduction of ADHD-symptoms, and reduced cardiovascular/respiratory morbidity – thus making it difficult to say something about strength of the evidence at this stage*	1. Strong (and moderate to strong for obesity) 2. Moderate 3. Weak to moderate 4. Moderate
Cooling	*24*[1]	• Parks contribute to cooling as they have lower day and night temperatures than surrounding areas.	• Moderate to strong
Air quality and carbon sequestration	11	• Parks contribute to air pollution removal. • Parks contribute to carbon sequestration.	• Weak to moderate
Water regulation	6	• Parks contribute to stormwater / run off management.	• Weak
Tourism	8	• Parks are attractive to tourists and are among their motivations to visit certain cities.	• Weak
Social cohesion	5	• Urban parks contribute to social inclusion and cohesion.	• Weak
Total	***225***[2]		

[1]Findings for cooling are entirely based on Bowler et al. (2010), who reviewed 24 studies specifically on urban parks. Out of these, 11 were published during the years 2000-2012.
[2]Of which 220 (+ Bowler et al., 2010) analysed by the researchers themselves.

Appendix

Table A1. *Overview of the evidence for the direct and indirect health effects of urban parks*

Article	Research design	Geographic scope	Main findings	Strength of the evidence
Ahmad et al. (2011)	Observational survey	Park (in Tabriz, Iran)	Appreciation of exploration of nature was the most preferred activity in parks	Weak to moderate
Akbar et al. (2010)	Observational study, questionnaire	Park (in Yazd, Iran)	Mental encounter is crucial contribution. "Relaxed", "refreshed" after visiting green space	Weak
Arnberger & Eder (2012)	Observational study, cross-sectional	City (Vienna, Austria)	Association between perceived supply and quality of green space and community attachment	Moderate
Babey et al. (2008)	Observational random-digit-dial survey study. Self-reported physical activity and access to park	Regional (California, USA)	Parks are particularly important for promoting physical activity among urban adolescents, less for rural. Adolescents with access to a safe park were less likely to be inactive.	Moderate
Bell et al. (2008)	Prospective cohort data, geocoded addresses	Regional (Marion County, Indiana, USA)	Higher greenness in urban green spaces significantly associated with lower BMI-scores at follow-up. Higher greenness also significantly associated with lower odds of increasing BMI-scores.	Strong
Boone-Heinonen et al. (2010)	Observational, register data, linked GIS	Cities (in USA)	Availability of major neighbourhood parks associated with higher participation in active sports, and in females wheel-based activity and reporting >5 Moderate to Vigorous Physical Activity bouts per week.	Moderate
Bowler et al. (2010a)	Systematic review	International	Meta-analysis showed that on average a park was 0.94°C cooler in the day. However, mostly based on observational studies of small number of green sites.	Strong

Article	Research design	Geographic scope	Main findings	Strength of the evidence
Bowler et al. (2010b)	Systematic review	International	Some evidence for positive benefit of a walk or run in a natural environment in comparison to synthetic environment. Also some support for greater attention in comparison. Less evidence of consistent difference in terms of blood pressure or cortisol.	Strong
Brockman et al. (2011)	Focus groups with primary school children	City (Bristol, UK)	Presence of urban green spaces facilitated children's active play	Moderate
Chen & Jim (2008)	Questionnaire survey, randomly chosen households; cost-benefit analyses	City (Zhuhai, China)	65.7% of respondents use public green spaces for leisure frequently.	Moderate
Chiesura (2004)	Observational, survey. Quantitative and qualitiative	Park (in Amsterdam, Netherlands)	Feelings of freedom, self-unity, luck, adventure, happiness were all experienced in the park. These were considered as highly important for people's wellbeing.	Low to moderate
Chung-do et al. (2011)	Observational, data from standardized collection	City (Honolulu, Hawaii, USA)	In Asian and Pacific areas 60% of users were sedentary, 26% engaged in moderate activities, 14% in vigorous activities. Men and boys were most active.	Moderate
Cochrane et al. (2009)	Multi-level regression analysis on observational data; cross-section	City (Stoke-on-Trent, UK)	Access to green space was important in explaining variation in physical activity, together with traffic, road casualties, and criminal damage	Weak to moderate
Cohen et al. (2006)	Cross-sectional study, middle-school girls	Cities (6 in USA)	Adolescent girls living near more parks, especially if parks have amenities conducive to walking and active features engage in more non-school metabolic equivalent-weighted moderate/vigorous physical activity than those with fewer parks. No causal inference could be drawn.	Moderate to strong
Cohen et al. (2007)	Observational studies, systematic direct observations, interviews	Parks (8, in Los Angeles, California, USA)	Park use and self-reported exercise level were predicted by proximity to park, especially in urban minority communities.	Weak to moderate

Article	Research design	Geographic scope	Main findings	Strength of the evidence
Coombes et al. (2010)	Data from Bristol Quality of Life in your Neighbourhood survey, GIS analysis.	Bristol, UK	Access to park, closest living had higher level of PA (corresponding to the recommended 30 min., 5 days per week). No effect on obesity when controlled for confounders.	Moderate
Cronan et al. (2008)	National, multiyear, multisite study of Latino Population. Onsite questionnaires.	Parks (in 3 cities in the USA)	Latinos use parks for physical activity repeatedly and also for social activities.	Weak
Cutts et al. (2009)	Observational, distribution of vulnerable populations in relation to parks and walkable streets.	City (Phoenix, Arizona, USA)	No relationship between obese population and lower access to green spaces. Benefits probably offset by social characteristics.	Moderate
Dadvand et al. (2012)	Cohort study	City (Barcelona, Spain)	None of the indicators of green exposure was associated with birth weight or gestational age. But there was such a relationship in the lower education group.	Moderate to strong
De Vries et al. (2007)	Cross-sectional study. Univariate and multivariate analyses	Neighbourhoods (10, in 6 cities, Netherlands)	Association between physical activity and proportion of green space in neighbourhood.	Moderate
Elmqvist et al. (2003)	Case study, narrative literature review	Stockholm, Sweden	Recreational use of parks in Stockholm is among the most important ecosystem services.	Weak
Epstein et al. (2006)	Cohort intervention study, within-subjects crossover design	Metropolitan area (Buffalo-Niagara Falls, USA)	During intervened more sedentary behaviour, access to parks increased youths' physical activity. As access to television and targeted sedentary behaviours are reduced, children chose how to allocate their increased leisure time.	Strong
Fan et al. (2011)	Community health survey, cross-sectional. Two-stage instrument variables regression modelling.	City (Chicago, USA)	Parks are associated with better social support than other neighbourhood green spaces, which have a negative association. Parks also increase physical activity.	Moderate
Fleischer & Tsur (2003)	Aggregated measures of recreational value of open spaces (travel cost expense method as proxy for willingness to pay)	Country (Israel)	Beaches generate the greatest economic value for recreation, parks are substitutable to some degree.	Moderate to strong

Article	Research design	Geographic scope	Main findings	Strength of the evidence
Foster et al. (2009)	GIS analysis, observational study, self-reported physical activity	City (Norwich, UK)	Access to green space was not related with walking for recreation.	Weak to moderate
Fuller et al. (2007)	Observational studies and semi-structured interviews	City (Sheffield, UK)	Significant correlation between species richness and psychological benefit, stronger relationship than for green-space area	Moderate
Gidlöf-Gunnarsson & Öhrström (2007)	Observational, cross-sectional. Questionnaire, self-perceived	Residential areas in Gothenburg and Stockholm, Sweden	”Better” availability to nearby green areas associated with well-being and daily behaviour and reduced long-term noise annoyances.	Moderate
Giles-Corti et al. (2005)	Observational study	City (Perth, Australia)	Access to attractive, large public open spaces was associated with higher levels of walking.	Moderate
González-Oreja et al. (2010)	Observational, field study	City (Puebla, Mexico)	Park size and total tree canopy sign reduced noise levels, irrespectively of park location and tree species composition.	Moderate to strong
Guite et al. (2006)	Observational, questionnaire, cross-sectional	City (district) (Greenwich, London, UK)	Association between dissatisfaction of urban green space and poor mental health.	Moderate
Hanibuchi et al. (2011)	Observational, cross-sectional study	Regional (multiple municipalities, Japan)	Presence of parks had positive association with frequency of sports activity, total walking time only few associations.	Moderate
Hansmann et al. (2007)	Field survey, cross-sectional, interviews	Parks (park and forest in Zurich, Switzerland)	Both city forest and park associated with 87% recovery ratio for stress, 52% reduction in headache, 40% enhancement of positive feeling well-balanced, Increased positive effects of length of visit and physical activity.	Moderate
Hillsdon et al. (2006)	Cross-sectional study, respondents from European Prospective Investigation into Cancer and Nutrition	City (Norwich, UK)	No association between neither access, size of park, quality of park and recreational physical activity	Moderate
Ho et al. (2005)	Observational, survey. Sampling according to ethnicity.	Metropolitan areas (2 in USA)	All ethnic groups described positive effects and scored them sign higher than negative effects; negative effect that scored highest (although low) was that parks attract crime and created unsafe conditions.	Weak

Article	Research design	Geographic scope	Main findings	Strength of the evidence
Hu et al. (2008)	Ecological geographical approach with stroke data at census tract level, modelling by dasymetric mapping	Region (Northwest Florida, USA)	High risk of stroke mortality was found in areas of low level of exposure to green space	High
Hung & Chang (2002)	Experimental, EEG, comparing photos of different landscape settings.	Lab setting (photos from US)	Natural recreational setting showed better pattern of EEG indicating positive mood, and relaxation, compared to urban parks. Otherwise no differences in physiological measures. For psychological measures all scores were sign higher for natural recreation setting.	Weak to moderate
Hung & Crompton (2006)	Semi-structured interviews, elderly respondents from both within and outside the park.	Park (in Hong Kong, China)	All the indirect benefits of the urban park were mentioned by the respondents.	Weak to moderate
Hussain et al. (2010)	Observational studies, interviews	Parks (2, in Faisalabad, Pakistan)	Association between all outcomes (e.g., less stress, tension) and park visits	Weak
Kaczynski & Henderson (2007)	Review (50 articles)	International	Difficult to draw conclusions about the importance of proximity to parks due to mixed results and wide variety of descriptors used to measure access and proximity. However, 80% of the articles showed some significant relationship between parks and physical activity	Moderate
Kaczynski & Henderson (2008)	Review (50 articles)	International	40% reported significant positive associations between parks and physical activity, 2% reported negative relationship, 18% were non-significant associations. 20 reported mixed findings, some positive relationships between parks and physical activity	Moderate
Korpela et al. (2010)	Observational, questionnaire	Cities (Helsinki and Tampere, Finland)	Restorative experiences and reduced stress were significantly more associated with exercise & activity in outdoor areas, waterside areas and urban woodlands than in parks.	Moderate

Article	Research design	Geographic scope	Main findings	Strength of the evidence
Krenichyn (2006)	Qualitative, semi-structured interviews	Park (Brooklyn, New York, USA)	The park provided support for all the mentioned benefits. Park considered as important nearby outdoor resource.	Weak
Lachowycz et al. (2012)	Observational data (cohort), GPS-and GIS-measuring of place and accelerometer for physical activity measuring	City (Bristol, UK)	Although the general activity level was low it showed that time spent on play and physical activity was approx. 50% in parks	Strong
Lafortezza et al. (2009)	Questionnaire, self-perceived heat stress	Parks (in Gateshead in the UK, Milano and Bari in Italy)	Longer and frequent visits to parks generate sign improvements of the outcomes in terms of reduced heat stress.	Moderate
Lee and Maheswaran (2011)	Review of academic and grey literature (35 articles included)	International	Weak evidence for relationship between health benefits and urban green spaces	Moderate
Lovasi et al. (2011)	Observational field study. Physiological measurements and geo-coded areas.	City (New York, USA)	Among other indicators such as street trees, park access was associated with smaller skinfold amongst urban preschool children.	Moderate
Maas et al. (2006)	Observational, cross-section, self-administered questionnaire	Country (Netherlands=	Percentage of Urban green areas is associated with perceived general health	Moderate
Maas et al. (2009)	Observational, national health survey data, health interview survey, national land cover data	Country (Netherlands)	People with more green in their neighbourhood (< 1 km) felt healthier, lesser number of health complaints, lower mental health problems. People with more green space felt less lonely and less experience of shortage of social support.	Moderate to high
Mahmoud (2011)	Observational study	Park (in Cairo, Egypt)	Different thermal comfort between different parts of the park; parks in general contribute to thermal comfort.	Weak
McCormack et al. (2010)	Systematic review (of qualitative studies)	International	Both physical and social features impact the use of parks.	Moderate
Mofawi et al. (2012)	Multilevel analyses of register data; BMI measured on site; GIS analysis of land data	Neighbourhood (of Cairo, Egypt)	No significant green space-BMI (obesity) association.	Moderate

Article	Research design	Geographic scope	Main findings	Strength of the evidence
Neuvonen et al. (2007)	Observational, self-reports in mailed questionnaire.	City (Helsinki, Finland)	Easier access and more green area in the city increased the number of visits.	Weak
Nielsen & Hansen (2007)	Observational survey	Country (Denmark)	Significant correlation between reduced obesity and reduced experienced stress, and distance to publicly accessible green areas.	Moderate
Özgüner (2011)	Observational survey study on site	Parks (in Isparta, Turkey)	People experience personal safety in parks, and experience benefits, such as sense of relaxation, calmness, peace and quiet, social interaction.	Weak to moderate
Orsega-Smith (2004)	Before-after observational, questionnaire and physiological measure	Parks (Cleveland Metroparks, USA)	Stress and lower systolic blood pressure significantly interacted with length of park stay. Direct relationship between park companionship and perceived physical health.	Moderate
Payne et al. (2005)	Exploratory, observational. Questionnaire, self-perceived health	City (Cleveland, USA)	Park users had sign higher perceived mental and physical health scores. Non-park users were sign more sedentary. People with parks in walking distance use them more frequently and are in better health and more physically active.	Moderate
Pearce & Madisson (2011)	Review	International	Likely that urban open space and street connectivity have positive effect on physical activity behaviour and related beneficial health outcomes. However low quality of many former studies, so no definite conclusions can be drawn.	Moderate
Potestio et al. (2009a)	Observational studies, BMI measurements, GIS analysis	City (Calgary, Canada)	No significant association between spatial access to parks and childhood overweight/obesity. Interpreted as specific for Calgary, very much dependent on car transport.	Strong
Potestio et al. (2009b)	Multivariate, multilevel analysis. Observational. Geocoding with GIS.	City (Calgary, Canada)	No association with access to parks and obesity. Maybe due to high level of car travel in Calgary, Canada.	Moderate to high

Article	Research design	Geographic scope	Main findings	Strength of the evidence
Potwarka et al. (2008)	Cohort study (children)	Neighbourhood of mid-sized city (Ontario, Canada)	No significant correlation between proximity to park space and healthy weight. But parks with playgrounds were correlated to healthy weight.	Moderate
Prince et al. (2011)	Cross-sectional study, based on data from International physical activity questionnaire; neighbourhood characteristics	City (Ottawa, Canada)	No significant effect on obesity in areas with more park areas.	Moderate
Quigg et al. (2010)	Cohort, intervention study (children aged 5 to 10)	Country (New Zealand)	No benefit was proven, only 2% of Total Daily Physical Activity occurred in parks with playgrounds	Strong
Richardson & Mitchell (2010)	Ecological approach, observational, 28.6 million adults, aged 16-64.	United Kingdom	Male cardiovascular disease and respiratory disease mortality decreased with increasing green space; no sign association for women.	Strong
Richardson et al. (2010)	Observational register study, GIS-data to make neighbourhood classifications.	Country (urban areas of New Zealand)	No sign association between usable or total green space and mortality, though inability to adjust for individual-level factors.	Moderate
Richardson et al. (2012)	Ecological cross-sectional study, land-use dataset for quantifying green space.	Cities (49 largest cities in USA)	No association btw greenness and suggested health benefits, probably overruled by other factors such as the tendency in US cities of association between green cities and higher levels of urban sprawl and car dependency. Mortality from all causes even higher in green cities.	Moderate to strong
Roemmich et al. (2006)	Cross-sectional observational analysis. Accelerometer measuring physical activity and GIS for neighbourhood characteristics.	County (Eric County, NY, USA)	Neighbourhoods with parks were associated with greater physical activity among kids	Moderate to strong
Reed & Price (2012)	Random controlled trial	County (in Michigan, USA)	No sign correlation between general physical activity and park visitors. Though for ethnic minorities (non-white) a sign correlation was found btw park use and PA.	Strong

Article	Research design	Geographic scope	Main findings	Strength of the evidence
Rung et al. (2011)	Observational interview study	City (New Orleans, Louisiana, USA)	Post-disaster visitors' main reasons for going to the park were escape and physical activity, more so than for non-disaster visitors. Hence parks may play a role in post-disaster recovery.	Weak to moderate
Seeland et al. (2009)	Empirical survey of pupils and teachers	City (Zurich, Switzerland)	Public urban spaces play important role for children and youths in making contact across cultures - prerequisite for social inclusion.	Weak to moderate
Shores & West (2010)	Observational, onsite, method: System for Observing Play and Recreation in Communities	Parks (4 urban, 4 rural, USA)	Rural parks were visited more often, but visitors to urban parks were more physically active.	Moderate
Stodolska et al. (2011)	Focus groups	City (Chicago, Illinois, USA)	Parks offer (health and other) benefits also to minority groups.	Weak
Su et al. (2011)	Field study, experimental pollution sampling and modelling; census tract data for socioeconomic and racial-ethnic variables.	City (Los Angeles, CA, USA)	Public parks had lowest pollutant concentrations of NO_2 and $PO_{2.5}$, but relatively high O_3. Evidence of socioeconomic and racial-ethnic gradients was found in air pollution exposure and inhalation doses in and around urban parks in Los Angeles.	Moderate to high
Takano et al. (2002a)	Observational by calculating relationships btw mortalities and urban indicators	City (Shanghai, China)	Age-adjusted mortalities were inversely related with a larger proportion of parks, gardens and green areas per total land area. This was one factor among many others.	Moderate
Takano et al. (2002b)	Cohort study, follow-up survey from records, longitudinal	City (Tokyo, Japan)	Probability of 5-year survival of senior citizens increased in accordance with green space for taking a stroll, parks, and tree lined streets near residence.	Moderate to high
Taylor and Kuo (2009)	Within subjects design, three different environments (city park and two other well-kept urban settings, more or less built), children.	City (unknown, USA)	20 minutes of park setting elevated attention performance of children with ADHD, no such effect in the other settings.	Strong

Article	Research design	Geographic scope	Main findings	Strength of the evidence
Tinsley et al. (2002)	Observational data from structured interviews of park visitors of different ethnicity	Park (in Chicago, Illinois, USA)	All groups described immediate sense of pleasure or gratification and non-pressing environment and activities as important features of the parks. Differences between ethnic groups in grading importance. Opportunity to be with others and to get vigorous physical activity also rated as important; opportunities for stress recovery slightly to moderately important.	Moderate
Toftager et al. (2011)	Cross-sectional national survey, observational; self-reported data for both distance and physical activity	Country (Denmark)	Relationship between moderate/vigorous physical activity during leisure time and distance to green space. Persons living more than 1 km from green space had higher odds of being obese (>30).	Moderate
Van Dillen et al. (2011)	Observational, cross-sectional, questionnaire, GIS	Country (80 urban neighbourhoods in the Netherlands)	Both quality and quantity of green space were correlated to general health, health-related complaints and general mental health	Moderate
Ward Thompson et al. (2012)	Exploratory stud; Saliva Cortisol sampling, GIS-based assessment of green spaces	City (Dundee, UK)	Sign relationships between self-reported stress, diurnal patterns of cortisol, and proportion green space in living environment. Percentage of green space is significant and independent predictor of circadian cortisol cycle and physical activity.	Strong
Wendel-Vos et al. (2004a)	Observational, self-administered questionnaire on demographic factors and physical activity, GIS analysis	City (Maastricht, Netherland)	No associations between parks and walking. Parks within 300 m radius was associated with bicycling for commuting purposes.	Moderate to strong
Witten et al. (2008)	Observational, cross-sectional survey; GIS-data on distance to parks and beaches.	Country (New Zealand)	No association between access to parks and BMI, sedentary behaviour or physical activity. Some evidence on relationship btw beach access and BMI and physical activity.	Moderate to strong

Article	Research design	Geographic scope	Main findings	Strength of the evidence
Wolch et al. (2011)	Longitudinal cohort, multilevel growth curve, GIS analysis	Regional (S. California, USA)	Significant negative relationship btw access to parks and BMI. Over half of the population had no access to parks within 500m. Sustained influence of parks on obesity.	Strong
Yang et al. (2011)	Observational with questionnaire and experimental study of EEG-responses	Lab setting (in Hangzhou, China)	90% of the participants believed that parks and urban plants contribute to noise reduction, 55% overrated the actual effect.	Moderate
Zenk et al. (2011)	Quasi-experimental pilot-study and exploratory observational design; GPS, GIS	City (Detroit, Michigan, USA)	Among many other variables, park land use in neighbourhood area and activity space was examined. No association between park use and physical activity, neither in neighbourhood nor activity area.	Moderate to strong

Table A2. *Overview of the evidence for the impact of urban parks on social cohesion.*

Article	Research design	Geographic scope	Main findings	Strength of the evidence
Fan et al. (2011)	Interviews, secondary data	City (Chicago, USA)	Neighbourhood green is found to encourage both social support and physical activity.	Moderate
Maas et al. (2009)	Interviews, secondary data	Country (Netherlands)	There appeared no significant relation between the percentage of green space and whether ot not people often contacted neighbours or friends in the neighbourhood.	Moderate
Peters (2010)	Observations, interviews	Parks (two parks in the Netherlands)	Although not many interethnic interactions occurred, people from various ethnic backgrounds valued being together in parks.	Moderate
Peters et al. (2010)	Survey, observations, interviews	City (Arnhem, Haarlem, Utrecht in the Netherlands)	Urban parks are sites where different ethnic groups mingle and where informal and cursory interactions can stimulate social cohesion.	Moderate
Ravenscroft & Markwell (2000)	Observations, interviews	Parks (8, in Reading, UK)	Youngster’s communication and recreation patterns can allow them to make friends in public green spaces. Some evidence to suggest that green spaces have the potential to cater for more than one ethnic group particularly where there are specialist facilities and equipment available for teenagers.	Moderate
Seeland et al. (2009)	Observations, interviews, focus groups	City (Zurich, Switzerland)	Public urban green spaces play an important role for children and youths in making contacts and friends across cultures.	Moderate

Table A3. *Overview of the evidence for the impact of urban parks on tourism.*

Article	Research design	Geographic scope	Main findings	Strength of the evidence
Chaudhry & Tewari (2010)	Survey, travel cost method	City (Chandigarh, India)	Urban ecotourism of importance, especially for domestic tourists. Green areas play a role in attracting tourists.	Weak to moderate
Deng et al. (2010)	Survey (on-site)	City (Savannah, Georgio, USA)	The results indicate that urban forests can positively and significantly contribute to the enrichment of tourist experience, e.g., as a supplement to cultural experiences.	Moderate
Liaghati et al. (2010)	Survey	City (Tehran, Iran)	Urban ecotourism occurring in Tehran – local landscapes of importance	Weak
Majumdar et al. (2011)	Contingent valuation, survey	City (Savannah, Georgia, USA)	According to the willingness to pay of tourists for the urban forests of the city, the annual economic value of these ranges from 81 to 167 million USD	Moderate
Villella et al. (2006)	Survey (on-site)	Park (London, UK)	Results suggested that the park had been as successful in attracting local and non-local users.	Weak
Wong & Domroes (2004)	Survey (on-site)	Park (in Kowloon, Hong Kong)	Kowloon park is among the most preferred parks, also among tourists; greenery as main component of appreciation	Weak
Wong & Domroes (2005)	Survey (on-site)	Park (in Kowloon, Hong Kong)	Scenic beauty of parks appreciated by both residents and tourists	Weak
Wu et al. (2010)	Delphi study	Country (Taiwan)	Green areas ranked among the factors for supporting urban ecotourism	Weak

Table A4. *Overview of the evidence for the impact of urban parks on house prices.*

Article	Research design	Geographic scope	Main findings	Strength of the evidence
Amrusch & Feilmayr (2009)	Hedonic pricing	City (Vienna, Austria)	Environmental factors (including open space) are valued by property owners	Weak to moderate
Anderson & West (2006)	Hedonic pricing	City region (Minneapolis-St. Paul, USA)	The value of proximity to open space is higher in neighborhoods that are dense, near the central business district, high-income, high-crime	Moderate to strong
Bark et al. (2011)	Hedonic pricing, landscape metrics	Watershed (Tucson area, AZ, USA)	Homeowners pay premiums for proximity to green space amenities	Moderate
Bishop et al. (2004)	Contingent valuation, GIS, visualisation	City (centre of Melbourne, Australia)	View of green space has positive impact on high-rice apartment prices	Moderate
Bolitzer & Netuzil (2000)	Hedonic pricing	City (Portland, Oregon, USA)	Proximity to an open space and open-space type can have a statistically significant effect on a home's sale price	Moderate to strong
Brander et al. (2011)	Meta-analysis (of hedonic pricing studies)	International	Positive relationship found between the value of open space and population density	Strong
Chen & Jim (2010)	Hedonic pricing	City (centre of Shenzhen, China)	Nearby parks higher prices of apartments, but private gardens have higher effect	Moderate
Cho et al. (2006)	Hedonic pricing, landscape metrics	Regional (Knox county, Tennessee USA)	Parks have a positive impact on property prices, but many factors influence the price effect	Moderate to strong
Damigos & Anyfantis (2011)	Fuzzy Delphi approach	Regional (Greater Athens, Greece)	A pleasant view could considerably increase the price of a house	Weak
Dehring & Dunse (2006)	Hedonic pricing, landscape metrics	City (Aberdeen, UK)	Flat price increase with proximity to open space, but not for lower density housing.	Moderate to strong
Hoshino & Kuriyama (2010)	Hedonic pricing	City district (Tokyo, Japan)	The effect of parks on property values varied with the buffer distance and park size	Moderate
Jiao & Liu (2010)	Hedonic pricing, geographic field modelling	City (Wuhan, China)	City level parks have significant amenity values, but district level parks do not	Moderate to strong
Jim & Chen (2006)	Hedonic pricing	City (Hong Kong, China)	View of green spaces raised housing price	Moderate

Article	Research design	Geographic scope	Main findings	Strength of the evidence
Jim & Chen (2007)	Hedonic pricing, stated preference	City (Guangzhou, China)	Good outdoor environment, including green space provision, proximity to parks, and views of green space and water has significant hedonic values.	Moderate to strong
Khorshiddoust (2009)	Hedonic pricing, contingent valuation	City (Tabriz, Iran)	Green spaces result in higher property prices / willingness to pay	Weak
Kong et al. (2007)	Hedonic pricing, landscape metris	City (Jinan, China)	Positive amenity impact of proximate urban green spaces on house prices	Moderate
Kumagai & Yamada (2008)	GIS analysis, relating house prices and green coverage	City (centre of Tokyo, Japan)	Correlation between house value and green coverage found	Weak
Lutzenhiser & Netusil (2001)	Hedonic pricing	City (Portland, OR, USA)	Positive impact of proximity to parks on property sales price (but urban parks less popular than natural area parks)	Moderate to strong
Morancho (2003)	Hedonic pricing	City (Castellon, Spain)	Inverse relationship between selling price of dwelling and distance from a green area	Weak
Qui et al. (2006)	Hedonic pricing, contingent valuation	Watershed (St. Louis metropolitan area, USA)	Residents' willingness to pay was consistent with the economic values of open space and proximity to streams embedded in existing home prices.	Weak to moderate
Sander & Polasky (2009)	Hedonic pricing, landscape metrics	Regional (Ramsey County, Minnesota, USA)	Environmental amenities, particularly views and open space access, impact prices. Parks have 2nd largest impact, after lakes	Moderate to strong
Tajima (2003)	Hedonic pricing, landscape metrics	City (Boston, USA)	Proximity to open space has positive impact on property value	Moderate to strong
Troy & Grove (2008)	Hedonic pricing, landscape metrics, crime statistics analysis	City (Baltimore, Maryland, USA)	Park proximity is positively valued by the housing market where the combined robbery and rape rates for a neighbourhood are below a certain threshold rate but negatively valued where above that threshold.	Moderate to strong

Table A5. *Studies used as data sources for this review, with specification of (from left to right) country; species group(s) studied; explanatory variables included in the analysis; number of sites and parks surveyed. N.B. the strength of the evidence in the individual papers has been assessed specifically for the aspect of overall species richness in the parks, i.e. not simply for the species groups in focus in the individual studies. n.a. = not applicable; Amph. = Amphibians; gra. = gradient.*

Author(s)	**Geographical Scope**	**Nr of sites**	**Nr of parks**	**Research Design**	**Birds**	**Invertebrates**	**Mammals**	**Amphi./Reptiles**	**Vascular plants**	**Woody plants**	**Bryophyte**	**Park - other sites**	**Native - exotic**	**Species-area**	**Isolation effects**	**Habitat qualities**	**Urban-rural gra.**	**Main findings**	**Strength of the evidence**
Bräuniger et al. (2010)	Germany, Halle/sale city	27	n.a.	Observational, field survey, species selected to represent different dispersal abilities	1	1			1		1			1	1			Park size was the best predictor for species richness, but also isolation and habitat qualities affected significantly. Vascular plant species richness explained total richness.	Strong
Hermy & Cornelis (2000)	City (Loppem, Belgium)	1	1	Develop monitoring method	1	1	1	1	1									Identification of 20 biodiversity indicators of urban parks.	n.a.
Cornelis & Hermy (2004)	Country (15 cities in Belgium)	15	15	Observational, field survey, biodiversity indicators	1			1	1					1		1		Park size could explain the variation in biodiversity. Number of habitat units, plant taxa and amphibian species all correlated with park area.	Strong
Gao et al. (2011)	City (Helsingborg, Sweden)	6	3	Observational, field survey, biotope classification	1		1		1							1		Vegetation structure and age influence the richness and abundance of the avian fauna and rabbits.	Moderate
Lizee et al. (2011)	City (Marseilles, France)	15	15	Observational, field survey, Principal Component Analysis	1	1											1	Park isolation acts as an environmental filter inducing a biotic homogenization through loss of specialist species and over-representation of generalist species.	Strong
Forrest & St. Clair (2009)	City (Edmonton, Canada)	1	1	Observational, field survey	1		1											Off-leash dogs have no effect on the diversity of birds and small mammals in urban parks.	Weak
Sorace (2001)	City (Rome, Italy)	3	2	Observation, point count field survey	1		1					1						Bird species richness was higher in an urban-agricultural park compared to urban park and peri-urban agricultural area, while richness of small mammal species was similar.	Weak
Carbó-Ramírez & Zuria (2011)	City (Pachuca City, Mexico)	19	6	Observation, field survey, winter and summer	1							1		1		1		Bird species richness was higher in parks than gardens and road strip corridors. Green space size was the most important variable for species richness in both summer and winter.	Weak
Kler (2006)	City (Ludhiana City, India)	13	4	Observation, field survey, only descriptive statistics	1							1						Only urban parks contained all bird species registered (n=29).	Weak

Author(s)	Geographical Scope	Nr of sites	Nr of parks	Research Design	Birds	Invertebrates	Mammals	Amphi./Reptiles	Vascular plants	Woody plants	Bryophyte	Park - other sites	Native - exotic	Species-area	Isolation effects	Habitat qualities	Urban-rural gra.	Main findings	Strength of the evidence
Vallejo et al. (2009)	City (Manila, Philippines)	4	2	Observation, field survey, TWINSPAN ordination and logistic regression	1								1	1		1		Four out of 70 bird species were exotics. Isolation degree determined species richness where uncommon and rare species preferred undisturbed areas and remnant vegetation.	Weak
Platt & Lill (2006)	City (Melbourne, Australia)	12	12	Observational, field survey on five occasions	1								1	1	1			Five of 51 bird species were exotics. Pedestrian traffic rate was not correlated with species richness. Isolation influenced species richness less than park area	Moderate
Fitzsimons et al. (2011)	City (Melbourne, Australia)	39	9	Observational, field survey, focus on remnant vegetation	1								1	1				Of 106 bird species 8 were exotics. Species richness was positively correlated with park size, and some species were either restricted to or more abundant in, larger parks.	Weak to Moderate
de Toledo et al. (2011)	City (Taubaté City, Brazil)	10	10	Observational, field survey, multiple regression	1								1		1	1		Two out of 64 bird species were exotics. Abundance and diversity of tree species were better predictors of bird diversity than isolation degree and park size.	Weak to moderate
Imai & Nakashizuka (2010)	City (Sendai City, Japan)	20	10	Observational, field survey, canonical correspondence analysis	1								1		1	1		Two of 31 bird species were exotics. Species richness decreased in highly urbanized areas. Insectivores and foliage foraging species contributed to species richness, but ground foraging species affected negatively.	Weak to moderate
Shwartz et al. (2008)	City (Tel Aviv, Israel)	1	1	Observational, point count surveys	1								1			1		Of 90 birds species 13 were exotics. Species richness was lowest in intensively managed park areas, but areas with intermediate management levels had higher or equal richness compared to unmanaged areas. Bird species richness was positively associated with the number of woody plant species.	Weak
Smith (2007)	Region (Ontario, Canada)	28	n.a.	Observational, field survey of remnant sites in urban and peri-urban areas	1									1	1	1	1	Bird species richness increased with site area, number of habitats, and pct. surrounding green space. Common birds dominated small areas; areas > 6.5 ha and more generally >20 ha supported sensitive species.	Moderate
Biaduń & Zmihorski (2011)	City (Biaduń City, Poland)	24	24	Observational, territory mapping during 26 years	1									1		1	1	Bird species richness increased with increasing tree age and park area, tree age being the most important factor. Distance to city centre negatively affected bird species richness. 0.2 bird species and 2.3 territories were lost per year from 1982 and 2007.	Strong
Oliver et al. (2011)	City region (Greater St. Louis area, USA)	20	20	Observational, based on NGO field surveys	1									1	1		1	The best predictors for resident bird species richness were park size and isolation degree. For migratory species, the best predictors were habitat diversity and developed area within the park.	Moderate
MacGregor-Fors & Ortega-Álvarez (2011)	City (Mexico City, Mexico)	5	5	Observational, field survey based on unlimited radius counts	1									1			1	Park size, ranging from 11.73 to 71.71 ha, did not show significant relationship with bird species richness. Bird species richness and composition fade out as the distance from border of the city increased.	Weak to moderate

Author(s)	Geographical Scope	Nr of sites	Nr of parks	Research Design	Birds	Invertebrates	Mammals	Amphi./Reptiles	Vascular plants	Woody plants	Bryophyte	Park - other sites	Native - exotic	Species-area	Isolation effects	Habitat qualities	Urban-rural gra.	Main findings	Strength of the evidence
Fernandez-Juricic (2000)	City (Madrid, Spain)	25	25	Observational, 6 field surveys within one seasons	1									1	1	1		Park age was a good indicator of habitat complexity. In old parks, bird species composition accumulated in an orderly fashion in relation to park age and area, while external factors were pronounced in young parks.	Strong
Chamberlain et al. (2007)	City region (Greater London area, UK)	277	n.a.	Observational, 12 field surveys evenly distributed over 2 summers and 2 winters	1									1	1	1		Site area was the most consistently variable related positively to bird species richness. The predicted rate of increase in species richness with site area was greatest at sites smaller than 10 ha. There were also positive effects of water bodies and rough grass.	Moderate
Evans et al. (2009)	UK	n.a.	n.a.	Review combined with analysis of data from national British breeding bird surveys	1									1	1	1		Habitat qualities were found to be more important than external ones in determining the species richness of urban birds. Urban bird responded positively to increased structural complexity and species richness of woody vegetation.	Moderate
Fernandez-Juricic & Jokimäki (2001)	Continent (Europe)	n.a.	n.a.	Review of main findings from European studies	1									1		1		Park area explained much of the bird species richness in larger city parks from southern to northern Europe, where parks of 10-35 ha contained all the bird species recorded in the entire urban region. Park age favoured colonization of bird species, because older parks had more complex habitat structure.	Strong
Khera et al. (2009)	City (Delhi, India)	19	19	Observation, field survey of bird and woody plant diversity	1									1		1		Bird species richness had a negative relationship with density of exotic woody species.	Moderate
Morrison & Chapman (2005)	City (Hartford CT, USA)	7	6	Observational, field survey	1									1		1		Park area, basal area, and the number of trees ≥ 50% dead accounted for over 90% of the variation in woodpecker densities in the parks.	Weak to moderate
Murgui (2007)	City (Valencia, Spain)	130	130	Observational, monthly field surveys during 1998 and 2004	1									1	1			Park area was found to override habitat diversity and park isolation in determine species richness of birds.	Moderate
MacGregor-Fors (2008)	City (Guadalajara, Spain)	8	3	Observation, field survey in urban plots	1											1		Old parks where trees are older generally contained higher bird species than younger parks. Species richness showed a positive relationship to tree species richness. In the plots with highest species richness, almost all birds used exclusively the exotic *Grevillea robusta*, indicating that some exotic tree species can retain high bird diversity.	Weak
Lin et al. (2008)	City (Taipei, Taiwan)	17	17	Observation, field survey	1											1		Overall there was higher bird species richness in higher greening level parks	Weak
Atchison & Rodewald (2006)	Region (Central Ohio, USA)	36	36	Observational, 3 field surveys in each of two winters	1												1	Species richness was positively related to urban development within 1 km. This may be partially explained by increased winter temperatures, numbers of birdfeeders near sites, and understory stem densities	Weak

Author(s)	Geographical Scope	Nr of sites	Nr of parks	Research Design	Birds	Invertebrates	Mammals	Amphi./Reptiles	Vascular plants	Woody plants	Bryophyte	Park - other sites	Native - exotic	Species-area	Isolation effects	Habitat qualities	Urban-rural gra.	Main findings	Strength of the evidence
Murgui (2009)	City (Valencia, Spain)	n.a.	n.a.	Observation, field surveys in winter and summer on two following years in urban plots	1												1	Across all seasons the species richness decreased around 40% in the city compared with the rural landscape. Bird richness and the abundance of most species were negatively related with the isolation and positively with parks and habitat diversity.	Weak
Pacheco & Vasconcelos (2007)	Biome (Cerrado biome, Brazil)	17	2	Observational, field survey with baited-pitfall traps, multiple linear regression		1						1	1	1	1	1	1	Among urban green spaces, parks supported the greatest number of native ant species and were free of exotic species. Larger parks contain most species.	Weak
Tonietto et al. (2011)	City (Chicago, USA)	18	6	Observational, field survey		1						1	1		1	1		Green-roof and prairie bee communities were distinct from each other, while those in parks were intermediate. Species richness increased with proportion of green space in the surroundings, but not in cases where turf grass dominated.	Moderate
Vilisics & Hornung (2009)	Country (Hungary)	100	18	Observational, field survey in diff. types of urban green space		1						1	1					Viable populations of indicator species of soil macrofauna were found in urban parks and gardens, but the presence of cosmopolitan and disturbance-tolerant species indicates an ongoing homogenization process	Weak
Öckinger et al. (2009)	Sweden, Malmö	20	12	Observational, field survey in urban and agricultural areas		1						1		1	1	1	1	Butterfly species richness was higher in early succession urban ruderal sites than in parks. Species richness was lower in urban habitats than in grassland remnants in agricultural areas. Species richness per site was positively correlated to connectivity, but not site area or any other local or landscape variables.	Moderate
Koh & Sodhi (2004)	Countries (China, Singapore)	39	20	Observational, field survey, random transect surveyed 3 times during the course of a year		1						1			1	1		Urban parks adjoining forest remnants had a higher number of butterfly species than forest remnants and isolated parks, indicating that urban parks should be situated as near as possible to a forest, in order to maximize their conservation value.	Moderate
Hernandez et al. (2009)	International	n.a.	n.a.	Review of 59 papers		1								1	1		1	Smaller urban parks and habitat fragments had lower bee species diversity than larger sites. Most studies found lower species diversity in urban areas compared to suburban areas and natural habitats. However bumble bees increased in urban areas and several studies reported higher abundance of cavity-nesting bee species in urban areas.	Moderate
Konvicka & Kadlec (2011)	City (Prague, Czech Republic)	25	4	Observational, field survey		1								1			1	Butterfly diversity was largest in sites far from the city centre, on alkaline bedrocks, south- to southwest oriented, and hosting high numbers of vegetation types and vascular plant species. Arboreal species persisted in urban parks, whereas common grassland species were absent.	Weak

Author(s)	Geographical Scope	Nr of sites	Nr of parks	Research Design	Birds	Invertebrates	Mammals	Amphi./Reptiles	Vascular plants	Woody plants	Bryophyte	Park - other sites	Native - exotic	Species-area	Isolation effects	Habitat qualities	Urban-rural gra.	Main findings	Strength of the evidence
Yamaguchi (2004)	Cities (Tokyo and Chiba, Japan)	98	98	Observational, field survey		1								1	1	1		Park area and age had a positive effect on the number of ant species. Parks in Tokyo contained fewer species than did comparable parks in Chiba (younger city), most likely because parks in Tokyo have been isolated for a longer time.	Weak
McFrederick & LeBuhn (2006)	City (San Francisco, CA, USA)	18	18	Observational, field survey		1								1	1	1		Bumble bee abundance was positively associated with parks that contained remnant fragments that have been largely unchanged. Park size did not predict bumble bee community structure.	Moderate
Lizée et al. (2012)	City (Marseille, France)	24	24	Observational, field survey and regression analysis		1								1	1			Found matrix effects (shape, complexity of the built patches) and distance from regional species pool (park isolation) to override park size in determine the variation in butterfly species richness in Parks of Marseille	Moderate
Clarke et al. (2008)	City (San Francisco, CA, USA)	24	24	Observational, field survey, pitfall traps		1								1				Smaller natural remnants in urban parks harboured ant populations that were just as diverse and robust as larger remnants	Weak
Matteson & Langellotto (2010)	City (New York, NY, USA)	18	18	Modelling		1									1	1		Habitat qualities were the most highly supported model for both bees and butterflies.	Weak
Emery & Emery (2004)	City (Sidney, Australia)	3	3	Observational, field survey of flying insects		1										1		The total and mean insect species richness did not differ significantly between parks with different levels of recreational use, indicating that the diversity of local vegetation that provided both food and shelter was the major determinant influencing insect diversity	Weak to moderate
Smith et al. (2006)	City (London, UK)	11	4	Observational, field survey, soil cores		1										1		The species densities of the studied soil invertebrates in the urban parks and gardens were comparable with those found in natural ecosystems	Weak
Magura et al. (2010)	International (Europe, Japan, Canada)	9	3	Use of published results from the Globalnet project		1											1	The rural faunas were more similar to the urban ones within the same location than similar urbanization stages were to each other, indicating that urbanization did not homogenize the taxonomic composition of ground beetle faunas across the studied locations.	Strong
Kitahara & Fujii (1997)	City (Tsukuba City, Japan)	3	3	Observational, field survey in newly designed parks and rural sites		1												Fewer butterfly species were found in a newly designed city park than in other areas, due to its man-modified habitat structure. The internal structure of the butterfly community in the new park was consistent with the 'quasi-equilibrium'' that appears during the colonization of an island.	Weak
Mahan & O'Connell (2005)	Region (Central Pennsylvania, USA)	8	7	Observational, field survey			1									1		Small mammal species richness was lowest in parks containing manicured habitats and surrounded by human-modified landscapes. However, parks managed for passive recreation supported mammalian assemblages that were similar in richness and diversity to mature riparian forest site	Weak to moderate

Author(s)	Geographical Scope	Nr of sites	Nr of parks	Research Design	Birds	Invertebrates	Mammals	Amphi./Reptiles	Vascular plants	Woody plants	Bryophyte	Park - other sites	Native - exotic	Species-area	Isolation effects	Habitat qualities	Urban-rural gra.	Main findings	Strength of the evidence
Vignoli et al. (2009)	City (Rome, Italy)	62	n.a.	Observational, field surveys in four transects from city centre to city border				1						1		1	1	Fragment size and wood size within each fragment correlated with the species richness of both amphibians and reptiles, with a clear threshold effect after 50 ha of wooded surface. The distance from the centre did not affect fragment species richness.	Weak
Liang et al. (2008)	City (Beijing, China)	63	15	Observational, field survey and spot remote sensing data					1			1			1	1		In total 47,6 % of the 544 vascular plant species were exotics (n=259). Plant diversity in greenbelts and streets was lower than in parks. Isolation affected plant diversity to a great extent negatively.	Weak to moderate
Li et al. (2006)	City (Beijing, China)	24	24	Observational, stratified random plot sampling					1				1	1		1		41% of all vascular plant species in urban parks were exotics. Only herbaceous species abundance was positively related to park area.	Weak to moderate
Säumel et al. (2010)	Europe	11	11	Analysis of historical documents combined with field surveys					1				1					The authors identify a trend at the European scale towards a common fashion of planting exotics during the 19th and 20 century park design and planting patterns; 66% of species on the planting lists were exotics. Thus far, 20% of the exotics planted in the studied parks have become naturalised and established far from the former sites of cultivation.	Weak to Moderate
Zhao et al. (2009)	City (Beijing, China)	53	53	Observational, field surveys five years apart using stratified random sampling					1				1					Among the vascular plants in urban parks, native species occupied 53.86% of the total. Landscape design, alien species introduction, and management were the main factors affecting the species composition and their spatial structure Beijing parks	Weak to moderate
DeCandido (2004)	City (New York, USA)	1	1	Observational, comparison of field data from 1947 and 1998					1							1		From 1947 to 1994, 25.5% of the native species were extirpated from Pelham Bay park, a rate of 2.9 species lost per year. Native species of the flora declined from 71.7% in 1947 to 59.6% in 1994-98. By comparison, the number of non-native species found increased by 39.7% since 1947. Each of the different habitats in the park had a greater proportion of alien species in 1994-1998 than in 1946-1947.	Strong
Turner et al .(2005)	City Halifax City, Canada)	17	4	Observational, field survey of woody plants					1			1	1					In general, the woody plant species richness was much higher in the residential areas, but these habitats were strongly dominated by non-indigenous species (77-87% exotics) whereas the natural and park habitats supported native taxa. Semi-natural parks had 79.7% natives.	Weak
Jim & Liu (2001)	City (Guangzhou, China)	35	21	Observational, field survey of woody plants						1		1	1	1				Park size correlated with richness and abundance of trees in parks. Of road side, institutional grounds, and urban parks, urban parks had the highest exotic-native ration with 1.27 (56 % exotics). Compared with the other urban forest types, parks had more pioneer and conifer species.	Weak

Author(s)	Geographical Scope	Nr of sites	Nr of parks	Research Design	Birds	Invertebrates	Mammals	Amphi./Reptiles	Vascular plants	Woody plants	Bryophyte	Park - other sites	Native - exotic	Species-area	Isolation effects	Habitat qualities	Urban-rural gra.	Main findings	Strength of the evidence
Jim & Chen (2009)	City (Taipei City, Taiwan)	32	10	Observational, field survey restricted to old trees						1		1				1	1	Among old significant trees in Taipei City, exotic species contributed 31 % of the total tree count. Urban parks with site heterogeneity and multiple functions accommodate the highest richness, even exceeding rural secondary forests.	Weak
Jim (2004)	City (Guangzhou, China)	n.a.	n.a.	Observational, field survey of heritage trees						1						1		Urban parks contained 22% of heritage trees in Guangzhou city, and all but one of the exotics species were found in parks. The low-stress growth condition and better arboricultural care resulted in higher species diversity and longer life span in parks	Weak
Jim & Chen (2008)	City (Taipei City, Taiwan)	30	10	Observational, field survey, only tree species						1		1						Urban parks had the higher richness of tree species compared to riverside parks and street, including urban endemic species.	Weak
Nagendra & Gopal (2011)	City (Bangalore, India)	40	40	Observational, field survey, stratified plots, only tree species						1			1			1		As much as 77% of trees in parks belonged to exotic species. Old parks had fewer but larger trees, and greater species diversity compared to recently established pars	Weak
Chen & Jim (2010)	City (Guangzhou, China)	n.a.	n.a.	Observational , full-scale field inventory						1								Vascular plant species richness in parks and urban green spaces was only slightly below urban-fringe secondary forests. Widespread adoption of western landscape style has brought exotic lawns and suppressed indigenous herbs.	Weak
Steward et al. (2004)	Christchurch, New Zealand	89	89	Observational, previous collected data						1								only 16,3% of trees planted in urban parks of Christchurch were native	Weak
Oishi (2012)	City (Kanazawa, Japan)	4	1	Observational, field survey of bryophytes, Multiple linear regression models							1	1				1		Bryophyte species richness was higher in a Japanese garden compared to secondary forest, an urban park and a lawn. Bryophyte species richness is related to the diversity of environments created by the design and maintenance practices.	Weak
SUM					**30**	**19**	**5**	**3**	**10**	**7**	**1**	**14**	**15**	**28**	**20**	**34**	**14**		

Vilisics and Hornung (2009)	Old gardens	Urban woodland	Isopod species	City centre	Natural woodland	Younger gardens
Öckinger et al. (2009)	Semi-natural grassland	Urban ruderal sites	Butterflies			
Koh and Sodhi			Butterflies	Urban woodland		
Tonietto et al. (2011)		Prairie remnants	Bees	Green roofs		
Pacheco and Vasconcelos (2007)		Nature reserve	Ants	Residential area	Commercial area	
Sorace (2001)			Birds and mammals	Peri-urban arable area		
Kler (2006)			Birds	Residential areas	Religious places	Market places
Carbó-Ramírez and Zuria (2011)			Birds	Gardens	streets	
Oishi (2012)		Japanese garden	Bryophytes			
Jim and Chen (2008)			Woody plants	River site green space	Street verges	
Jim and Chen (2009)			Woody plants	River site green space	Streets	
Jim and Liu (2001)		Institutional ground	Woody plants	Road side niches		
Liang et al. (2008)			Vascular plants	Green belts	Streets	
Turner et al. (2005)		Residential areas	Vascular plants			
			Urban Parks			

Fig. A1. *Relative species richness levels of urban parks compared to other site types, with decreasing diversity right to left. Urban green spaces are to the right of the black line and semi-natural and natural areas in the rural areas are to the left. The Grey filling indicate the urban green space type with highest species richness. The column with names of species group(s) indicate the position of urban parks and the species group(s) in focus of the individual studies.*

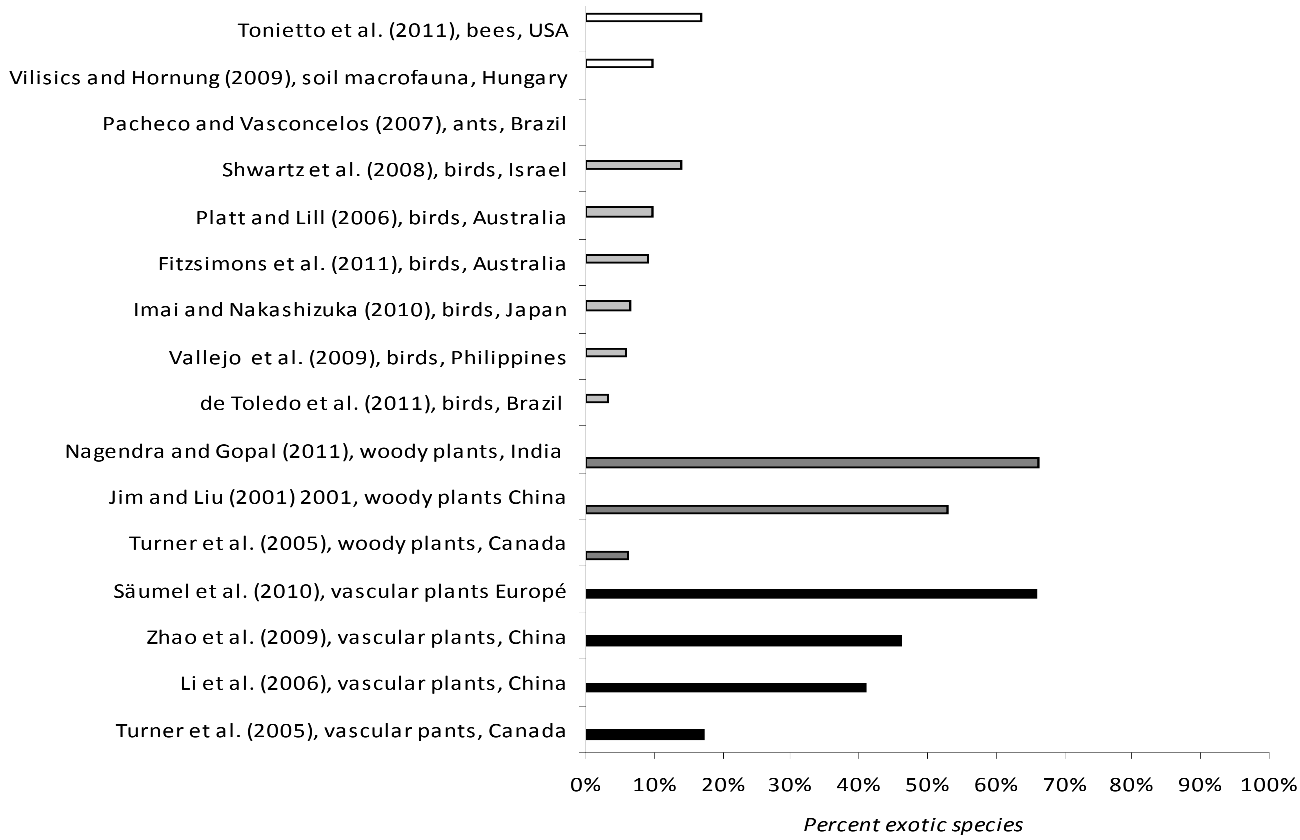

Fig. A2. *Share of exotic species of total species in parks: vascular plants (black), woody plants (dark grey), birds (light grey), invertebrates (white).*

Table A6. *Overview of the evidence for the impact of urban parks on air quality and carbon sequestration.*

Article	Research design	Geographic scope	Main findings	Strength of the evidence
Beckett et al. (2000)	Measurements of particulate uptake by trees	City (5 urban sites, including a park)	Significant quantities of particulate matter may be removed by trees of various age and size at a variety of urban locations.	Moderate
Davies et al. (2011)	Vegetation cover assessment, measuring of sample plots	City (Leicester, UK)	Carbon stored (3·16kgCm-2) in green spaces – largest part of this in trees	Moderate
Jim & Chen (2008)	Modelling and economic valuation	City (Guangzhou, China)	Annual removal of SO2, NO2 and total suspended particulates at about 312.03Mg. Estimate of economic impacts of this removal.	Weak
Jo (2002)	Modelling (carbon, vegetation)	City (3, including Chuncheon, South Korea)	Total C storage by urban green space (woody plants and soils) was estimated at approximately 139 kt, which equalled 56 5% of the C emissions from fossil fuel use	Moderate
Kordowski & Kuttler (2010)	Measurement of carbon fluxes	Park (in Essen, Germany)	Park acts as carbon sink, but only very small sink effect over the year	Weak to moderate
Lam et al. (2005)	Modelling and measurements	City (Hong Kong; 70 parks)	Air quality in parks better than at roadside, but not significantly different from ambient conditions	Moderate to strong
Makhelouf (2009)	Air pollution level measurements in the parks	City (Paris, France)	Green spaces are the least polluted spaces in the city	Weak
McDonald et al. (2007)	Modelling	City regions (West Midlands and Greater Glasgow, UK)	Change in land use (e.g., in terms of tree cover) impacts PM10 levels	Moderate
Paoletti et al. (2011)	Modelling and air pollution measurements on site	Park (in Milan, Italy)	Parks contributed to air pollution removal and carbon storage - important role of trees	Moderate
Peng et al. (2008)	Modelling	City (Nanjing, China)	Green spaces in Nanjing contribute to carbon storage	Moderate
Tallis et al. (2011)	Modelling	City region (London, UK)	Urban trees in London remove between 852 and 2121 tonnes of PM10	Moderate

Article	Research design	Geographic scope	Main findings	Strength of the evidence
Yin et al. (2011)	Modelling	District (6 parks in Pudong, Shanghai, China)	Parks remove TSP, SO_2, NO_2. Contribute e.g., 9.1% of TSP removal in Pudong district	Moderate

Table A7. *Overview of the evidence for the impact of urban parks on water management.*

Article	**Research design**	**Geographic scope**	**Main findings**	**Strength of the evidence**
Gill et al. (2007)	Modelling	City region (Greater Manchester)	Adding green cover to urban lands substantially reduced runoff. Mature trees play an important role in this	Moderate
Kaźmierczak & Cavan (2011)	Modelling	City region (Greater Manchester)	Areas with less green space are more susceptible to flooding	Weak to moderate
Kubal et al. (2009)	Multi-criteria assessment	City (Leipzig))	Important to integrate green spaces in decision making on urban flood and risk assessment	Weak
Pauleit & Duhme (2000)	Modelling	City (Munich)	Parks and other green spaces make important contributions to groundwater recharge and have substantially lower surface water runoff rates	Moderate
Peng et al. (2008)	Modelling	City (Nanjing)	Green spaces can help regulate stormwater runoff	Weak to moderate
Zhang et al. (2012)	Modelling	City level (Beijing)	Reduction of stormwater runoff and storage of rainwater in green areas. Economic benefit equals ¾ of management costs for city's green space	Weak to moderate