Chapter 7

General Discussion
MAIN FINDINGS

Evidence for associations between green space and general health outcomes

The first aim of this thesis was to synthesize the evidence for an association between objectively measured or self-reported green space in the residential environment and perceived mental health, all-cause mortality and general health (Chapter 2). The results of the evidence synthesis, which took into account methodological quality and consistency of the studies under review, showed strong evidence for a positive association between the objectively measured quantity of green space or greenness in the immediate residential environment and perceived mental health. Obviously, adults who live in green environments reported better mental health than adults who live in less green environments. With regard to the associations between the objectively measured quantity of green space and the other two health outcomes, the evidence was judged as strong for all-cause mortality, and moderate for perceived general health. The few reviewed studies that used other measures of green space quantity (e.g. presence or number of green spaces) and quality (perceived as well as objectively measured) provided inconclusive evidence.

The review revealed the following knowledge gaps. Firstly, few studies have explored differences in the associations for different population subgroups (i.e. effect modification). Some of them provided indications that people with low social economic status benefit more from green space in the living environment than people with high social economic status. For other population subgroups, such as age groups and gender, there is inconclusive evidence. Secondly, most of the studies were conducted in Northwest European countries. To explore whether the conclusions from the review can be generalized to other countries with different urban and land use planning and different lifestyles due to different cultures and climates, more epidemiological studies are needed. Another important recommendation for further research was that sophisticated measures of exposure to green space should be developed to provide more insight into exposure-effect relationships. Most studies identified in the review focussed on (objective of subjective) quantity measures of green space as proxies of exposure. Few studies have investigated whether use of green space might be an important exposure pathway. Finally, it should be noted that the cross-sectional design of most of the included studies impedes causal inferences. Therefore, the results should be interpreted with caution.

Inspired by the strength of the evidence for an association between green space quantity and mental health, the next challenge of this thesis was to identify mediators and modifiers of this association. In particular, this thesis focussed on the role of the use of green space in that association, because this was identified in the review as an important knowledge gap.
Exploring effect modification and mediation

The second aim of the thesis was to explore effect modification and underlying mechanisms using cross-sectional data collected across four European cities in different regions: Northwest (Doetinchem in the Netherlands, Stoke-on-Trent in England); South (Barcelona in Spain); East (Kaunas in Lithuania). Three studies were conducted to answer the following research questions:

i. How strong is the association between time spent on visiting green space and mental health; do cultural, climatic, demographic and motivational factors modify the association?

ii. Do indicators of physical activity and social contacts mediate the association between time spent on visiting green spaces and mental health?

iii. Does time spent on visiting green space mediate the association between the level of residential greenness and mental health?

**Association between time spent visiting green space and mental health: effect modification**

To answer the first research question, multilevel regression analyses were conducted that used pooled data and data by city. The results showed positive associations between total time spent visiting green space and perceived mental health and vitality in the pooled data, as well as across the four cities (Chapter 3). This suggests robust relationships independent of cultural and climatic differences between the four cities, although the associations were weak: respectively 0.3 and 0.4 points increase on the 0-100 mental health and vitality scales were associated with an increase of ten hours spent on visiting green space in four weeks (i.e. two and a half hours a week). In line with previous research that used green space quantity measures as proxy for exposure (de Vries et al., 2003; Maas et al., 2006; Mitchell and Popham, 2008), the results showed stronger association with vitality for the lower educated subgroups, compared with the higher educated groups. However, for a low educated person the 1.3 points increase on the vitality scale associated with an increase of 10 hours a month seems more substantial, although the clinical relevance might be unclear. Concerning childhood nature experience, the results were contrary to what was expected. It was hypothesized that childhood nature experience would promote a nature-orientated attitude and preferences for nature-based activities in adulthood (Asah et al., 2012; Chawla, 2009). In contrast, the association with perceived mental health was weaker for people with ample childhood nature experience, suggesting that these people are less sensitive to the mental health benefits of purposeful visits to green space. An explanation could be that other ways of exposure to green space, for example by gardening or by spending the weekends in a holiday home in the countryside, could satisfy their need for relief from urban stressors and nature experience.
Association between time spent on visiting green space and mental health: mediation by time spent on visiting green space in the immediate residential environment

To answer the third research question, again a mediation analysis was conducted to test whether time spent visiting green space in the immediate residential environment is a mediator in the association between the level of residential greenness (measured as NDVI within a 300 m buffer) and perceived mental health (Chapter 5). Despite that no significant overall associations were found between the level of residential greenness and mental health, the mediation analysis showed that time spent visiting green space near home was a significant mediator in the pooled data and in the data for Doetinchem. For the other cities, no significant mediation was found, although mediation was close to significance in Barcelona. Only for Doetinchem and Barcelona, significant associations were found between the level of residen-
tial greenness and the tested mediator: respondents from Doetinchem and Barcelona who had higher levels of residential greenness spent more time on visiting green space in their immediate residential environment. There is no clear explanation why in Stoke-on-Trent and Kaunas residential greenness was not associated with time spent visiting green space, but clues might be found in social and cultural differences between the cities and in differences in determinants of the use of green space (e.g. personal, motivational factors). In conclusion, the study provides only weak support for the hypothesis that the level of residential greenness contributes indirectly to mental health through purposeful visits to green space. To understand the role of visits with regard to the green space - mental health relationship, future research should focus on specific types and perceived safety and quality of green spaces in the immediate living environment. Perceived safety and quality of green space and other personal factors, such as health status and having a dog, may moderate the association between residential greenness and time spent on visiting to green space (Lachowycz and Jones, 2013; Lee and Maheswaran, 2011; Schipperijn et al., 2010) and influence mediation.

**Exploring psychophysiological stress response mechanism**

The third aim of the thesis was to explore the underlying psychophysiological mechanism of mental health benefits of green spaces. The cross-over experimental laboratory study presented in this thesis explored stress recovery and buffering of brief visual exposure to photos of urban green and built spaces, before and after stress was induced (Chapter 6). The study used sophisticated cardiovascular measures of the parasympathetic and sympathetic parts of the Autonomic Nervous System (ANS), i.e. respiratory sinus arrhythmia (RSA) and the pre-ejection period (PEP) respectively. The study aimed more specifically at differentiating between both parts of ANS to clarify their roles, especially that of the parasympathetic part (or vagal tone), which functions as a “brake” in the sympathetic influence on the heart. The findings provide support for greater recovery, indicated by a stronger increase in RSA, in participants who viewed green scenes, as compared to participants who viewed built scenes. There were no indications for greater recovery after viewing green scenes in PEP. Neither were indications found of greater buffering effects of green space in either RSA or PEP data. The findings of this study are in line with some recent studies, which have provided evidence for a predominant role of the parasympathetic nervous system in recovery from stress after viewing green scenes (Brown et al., 2013; Gladwell et al., 2012). The present findings point to the role of short moments of visual access to green space in providing readily available restorative opportunities (Kaplan, 2001).
METHODOLOGICAL CONSIDERATIONS

Systematic review and evidence synthesis

An important limitation of the systematic review presented in this thesis is that a meta-analytical approach was not possible due to the heterogeneity in the methods to measure green space quantity or quality. The “best evidence synthesis” that was used to assess the level of evidence involved some specific methodological challenges on how to deal with this heterogeneity. Due to the use of different selection criteria and methods of combining studies, systematic reviews that synthesize the evidence for health benefits of green space may differ in their conclusions.

With regard to the issue of heterogeneity in methods to measure green space quantity, two types of objective measures were combined in the evidence synthesis: i) the percentage of green space within a circular buffer around the residence, and ii) the percentage of green space in a geographically defined area. For assessing both categories of measures, land-use data as well as Normalized Difference Vegetation Index (NDVI) data were used. As a consequence of using data on different spatial scales, different aspects of green space might have been assessed, which may operate through different exposure pathways and mechanisms, and, therefore, may affect the associations with health outcomes. For example, large and easily accessible green spaces may provide better opportunities for physical activity and meeting people than small patches of greenery that are not accessible. However, those small green spaces may enhance the overall aesthetics of the neighbourhood and the view from windows at home. Especially important could be the distinction between the NDVI, which measures overall residential greenness, and the level or percentage of green space around residences based on land use data. The latter does not cover small green spaces, private gardens or street greenery (Rhew et al., 2011). Van Dillen et al. (2011) found that the (objectively assessed) level of street greenery was stronger associated with health than the ditto assessed level of green space. However, Mitchell et al. (2011), who compared the influence of different measures of green space with regard to origin and type on associations with several health outcomes, found that larger green spaces are the most important for health benefits. Overall, when more studies on the green space – mental health link become available, the evidence should be synthesized separately for different green space/greenness measures to account for different spatial scales and type of green space.

The review in this thesis provided strong evidence for an association with mental health in adults. This finding is not in line with that of the recently published systematic review of Gascon et al. (2015). That review concluded that there is limited evidence for such an association. This difference between the two reviews seems mainly due to differences in the search and selection criteria and in the methods used to grade the evidence. An important difference was that Gascon et al. (2015) also included studies on specific mental health disorders, such
as anxiety and depression, while the review in this thesis only included studies on general health outcomes, for example assessed with the General Health Questionnaire (GHQ-12). This scale assesses general feelings of psychological distress (worry, stress, lack of concentration): complaints which might be more susceptible for the beneficial effect of exposure to residential greenness (Hartig et al., 2003). The different findings of both reviews underlines the need to develop a uniform set of search terms and formal selection criteria for grading the evidence, thereby differentiating between cross-sectional and longitudinal studies, and between different green space/greenness and health measures.

Causality

The most important limitation of the three epidemiological studies presented in this thesis is undoubtedly its reliance on cross-sectional data. In cross-sectional studies, inferences about causality cannot be made because both exposure variables and health outcomes are measured at a single point in time and, therefore, do not allow to identify whether the cause, e.g. time spent on visiting green space, precedes the effect on mental health. Furthermore, there is a possibility of self-selection. People who have better health may prefer a living environment conducive to an healthy and active lifestyle and, therefore, may choose a residential environment with good access to green space. Moreover, people with better health are generally wealthier and thus can afford to live in such an attractive, green environment. To rule out this type of self-selection, the models were statistically adjusted for potential confounders, such as level of education and other indicators of individual SES. However, self-selection cannot completely be ruled out in cross-sectional studies. Concerns about unmeasured, residual confounding and reverse causality remain by definition when applying a cross-sectional study design.

Selection bias

There are several sources of bias that may limit the validity and generalizability of the findings. A possible selection bias due to the overall low response rate of 20% is the most notable. Response rates are the ratio’s between the number of residents who participated and the total number of residents who were invited, and ranged from 8% in Doetinchem to 47% in Barcelona. The primary aim of PHENOTYPE was to collect data of participants from different European cities, using a similar sampling strategy. In practice, this turned out to be difficult, due to differences in privacy regulations. In three of the four cities, a two stage sampling strategy was conducted. In the first stage a selection of approximately 30 spatial units (defined as neighbourhoods) was performed in each city in such a way to ensure variation in access to green space and SES. This selection was, however, not random. It was based on ensuring a representative range of types of green space and sufficient numbers of households. In the
next stage of the sampling strategy (i.e., the random selection of addresses that should be approached) the strategies differed between the four cities. In Stoke-on-Trent and in Barcelona, a face-to-face approach was used, where all selected addresses were visited directly after sending a letter of introduction (up to five attempts, when not at home). In Doetinchem, a more impersonal way of approaching participants was used, with just one attempt at first contact by mail. Here, sending a reminder did not help to increase the response. In Kaunas, participants were randomly selected from the sample of participants of a previous survey. The selected people were invited by mail to fill out a questionnaire, while in the other cities face-to-face interviews were held. The response rate in Kaunas (21%) was not adjusted for the response rate of the original survey. Overall, the results of the analyses for the separate cities might not be representative of the adult population of the four cities, especially for Doetinchem. For example, non-response analyses showed that people with lower education were underrepresented in the Doetinchem sample. The possible consequences of this selection bias for the results of the studies in this thesis are not clear, although underestimations of associations are possible, since stronger associations were found for groups with lower level of education.

Another possible source of bias is the selection of the cities, which was not random, but based on practical considerations. The aim was to include cities with different cultures and climates, but the four cities also differed in number, size and population density of the neighbourhoods used for this selection stage. The study that explored associations between time spent visiting green space and mental health, showed robust associations that did not differ much between the four cities with regard to its strengths. In contrast, the association between the level of residential greenness and time spent on visiting green space in the immediate residential environment did vary between cities (in two cities no significant association was found). This suggests that, for example, socio-cultural differences between cities may influence whether and why people visit green space on purpose. Culture may influence spatial planning and urban design and, thereby, the accessibility and quality of green spaces. Moreover, personal motivation and attitudes towards (use of) green space and a passive or active outdoor lifestyle often depend on cultural context (Ozguner, 2011). This thesis was the first to explore cultural differences in the green-space and mental health link, by investigating cities in different regions of Europe. However, more research is needed to identify the precise nature of those differences.

**Measurement issues**

The reliance on self-reported data of frequency and duration of visiting green space and of mental health could have biased the results of the analyses in all three studies presented in this thesis that used questionnaire data. In general, this so-called same-source bias might have caused overestimation of the associations. In addition, cultural differences could have influenced the self-reported data due to different interpretations of the survey questions.
Furthermore, validity and reliability of the data on visit frequency and duration were not tested and the results could have been biased due to people’s inaccurate recalling of their visiting behaviour in the past four weeks. For example, people with poor mental health might systematically underestimate their visit behaviour. The use of objective measures of use of green space, for example by using GPS, could forestall this and, at the same time, mitigate the risk of recall/same-source bias when both measures of exposure and outcome are based on questionnaire data. Furthermore, the difference in size of the four cities could have led to exposure misclassification of the green space close to home, which was defined by a 15 minutes walking or cycling distance. For many respondents living in Doetinchem, the smallest of the four cities, green space outside the city was easily accessible within the defined walking and cycling range. This could have led to a higher frequency of visits reported by the respondents from Doetinchem compared to those from the other cities.

In the study presented in Chapter 5, which investigated mediation by time spent visiting green space, NDVI was used to assess the level of overall residential greenness (within a 300 m straight line buffer). The NDVI provides an objective and quantitative measure that can be applied across different spatial scales and all types of areas. NDVI is based on the level of visible red and near-infrared reflectance of photosynthetic processes in healthy green vegetation, compared with that of unhealthy or non-vegetated surfaces. NDVI values range between -1 and 1. Water-bodies have a NDVI value below zero. A value of zero means no vegetation at all, while a value of 1 means dense vegetation like a tropical forest. The NDVI was originally developed for agricultural areas and not for urban settings (Rhew et al., 2011). To test the validity of the NDVI, Rhew et al. (2011) compared the mean NDV values (at a 30 x 30 resolution) in a 100 meter straight line buffer surrounding residences with ratings of sets of photographs (from the street side, thus excluding backyards) around each of the residences by three experts independently. Based on the high association between the NDVI and the expert ratings, the authors concluded that the NDVI constitutes a valid measure of overall neighbourhood greenness that can be viewed from the ground, for low as well as for high residential density (Rhew et al., 2011). The NDVI includes all types of vegetation, irrespective whether accessible for recreational use, or merely visible, such as (roof) gardens and street greenery. In contrast, methods of measuring the level of green space based on land use data include all types of open spaces classified as physically accessible, e.g. urban parks with a reasonable size (> 0.5 ha), but excluding small green spaces, private gardens and street greenery. However, the NDVI (as a mean value) does not inform on how neighbourhood greenness is organized around the residence (e.g. in many small green spaces or a few large ones), neither does it inform on type and quality of greenness. To obtain more detailed quantity and quality measures of neighbourhood greenness, specific audit tools are necessary. These tools could also include small natural features, such as small gardens or a single tree in front of the house, which may play a role with regard to visual exposure to greenness.
Statistical issues

Finally, some statistical issues need attention. First, testing mediation in cross-sectional data is disputed. An important assumption for testing mediation is that the relations between the independent, mediator and outcome variables are causal. This means that the independent variable should in time precede the mediator, which in turn should precede the outcome. As already stated before, the assumption of causality cannot be adequately demonstrated with cross-sectional data. Several researchers have advocated that mediation analysis should only be conducted with data based on randomly controlled experimental studies (Stone-Romero and Rosopa, 2008). However, in the epidemiological research literature, there are many examples of cross-sectional studies that have conducted mediation analyses, despite the fact that making inferences about causality are not possible and, therefore, proof of mediation is impossible. A more practical approach is advocated by MacKinnon (2008) and Hayes (2013) who both argue that mediation analysis can be applied, even without causal inferences, as long as “we couch our causal claims with the required cautions and caveats, given the nature of the data available” (Hayes, 2013, pp. 89) and add information from previous research and theory to support the conclusion of a possible mediation pathway (MacKinnon, 2008). In line with this approach, the consistency of findings of a relation between green space and mental health across populations in different countries or cultures and the evidence from experimental research about the restorative potential of physical access and visual exposure to green space might add to the plausibility of a causal mediation model. Until studies with more advanced designs become available to test mediation more rigorously, the results of the mediation analyses presented in this thesis should be interpreted with caution.

Another statistical issue concerns the population size related to the statistical power. Despite power analysis calculations prior to data collection, the number of respondents needed (about 1000 per city) was not sufficient to find significant associations between residential greenness and mental health, neither in the pooled data, nor in the data of the separate cities (Chapter 5). An explanation is that opposing mechanisms may have suppressed such an association.

Another explanation is that the context of the cities was too heterogeneous for pooling the data. Although previous studies provided evidence for such associations, these were weak (i.e. small effect estimate with large confidence intervals) and only statistically significant in large samples, mainly from one city or (part of) one country. Therefore, the power analysis that calculated the sample sizes of the current study might not have accounted sufficiently for the heterogeneity between the populations in the four cities. Although the PHENOTYPE project aimed at exploring the green space – health relationship in cities with different cultures and climates, other city differences such as number, size and population density of the neighbourhoods used for this selection stage may have influenced the results. In Barcelona (1061 units; mean size 0.11 square kilometre), the population density is almost 20 times greater
than in Doetinchem (83 units; mean size 0.96 square kilometre). This is supported by the fact that a previous study in Barcelona, which used a sample of 4000 people from 10 districts in Barcelona, did find an association between mental health and level of residential greenness as measured by NDVI in three buffers (100m, 250 and 500m buffers) (Dadvand et al., 2016). Moreover, almost no studies with small population sizes (below 2000 respondents) did find any significant associations, while studies with population sizes ranging from 2000 to more than 300,000 respondents did. An exception is the study conducted by Van Dillen et al. (2012) who collected data of 1600 participants in four Dutch cities, which were comparable in population size and urbanity. Thus, a selection of comparable cities with respect to population size and density, together with a larger number of respondents within each city, accounting for higher clustering within neighbourhoods, could increase the statistical power to establish significant associations. A larger number of respondents per city may also facilitate stratified multilevel analyses for separate cities.

RECOMMENDATIONS FOR FUTURE RESEARCH

More advanced study designs

Based on the general limitations of the cross-sectional design of the epidemiological studies in this thesis, other study designs that could strengthen the evidence for causality are highly recommended. Such studies should apply well-controlled interventions or quasi-experimental designs (“natural experiments”). For instance, an intervention with before and after measurement in case of improvement of a neighbourhood’s green spaces could be set up and matched with comparable neighbourhoods without such improvements as control. The design of a well-controlled “natural experiment” may be difficult to realize in practice and several methodological challenges are to be faced. Craig et al. (2012), who provided guidelines to evaluate public health interventions by using natural experiment, advocate that “quantitative natural experimental studies should only be attempted when exposed and unexposed populations (or groups subject to varying levels of exposure) can be compared, using samples large enough to detect the expected effects, and when accurate data can be obtained on exposure, outcomes and potential confounders” (pp. 3). Especially when subtle changes in outcomes are expected, as is the case with mental health benefits of green space, variation in exposure and sufficient statistical power might be crucial. Other challenges are: the selection of adequate control populations and sufficient follow-up post intervention measurements to assess long-term effects on, preferably objectively assessed, mental health outcomes such as morbidity data derived from medical registrations.

To date, there are few quasi-experimental or intervention studies that have investigated the impact of improvements in the quantity and quality of green space on health and health
behaviour. Most of these focused on physical activity as outcome. A review of such intervention studies showed stronger evidence for interventions that combined quality improvements in urban green space (e.g. park renovation) with a programme to promote physical activity in urban green space than for urban green space improvements only (Hunter et al., 2015). With regard to mental health, there are some examples of recent longitudinal studies that have overcome some of the limitations of an observation design, especially with regard to the change in green space exposure. One example is the study conducted by Alcock et al. (2014), which focussed on selecting groups of people who move to new neighbourhoods with different green space levels. Despite the limitation of a small sample size, this study showed that moving to a greener environment was associated with a sustained increase in mental health during the three years after the move. However, the reverse was not found: moving to a less greener environment was not associated with reduced mental health. A time-series approach over longer periods of time is needed to explore adaption processes of people who move house, or after an intervention that changes green space exposure. Another recent example of a longitudinal study that explored the impact of greenery interventions on mental health is a study of a Dutch adolescent and adult population with a low level of education (Gubbels et al., 2016). This study found that in adults an increase in perceived neighbourhood greenery (availability and quality) was associated with a small decrease in depressive symptoms, while no associations were found for actual greenery interventions (e.g. more street trees and improvements in green space quality). Moreover, the significant associations were mediated by perceptions of improvements and use of green space, which suggests that both objective and subjective or perception measures should be included in studies on the relationship between green space and mental health. This is in line with previous studies and theoretical frameworks that suggest an important mediating role of people’s perceptions of availability and quality of green space (Dadvand et al., 2016; Lachowycz and Jones, 2013): not merely the availability of green space or greenery in the immediate environment might influence people’s mental health, but the way people perceive and use it.

Mechanisms

Further research should identify which exposure pathways and mechanisms are most important with respect to mental health benefits of exposure to green space/greenness. The physical activity and social contacts mechanisms seem important, but could explain the associations only to a limited extend (Chapter 4). Use of green space in the immediate residential environment measured as time spent on visiting green space mediated the association between residential greenness and mental health (Chapter 5), however, not consistently across different cities. This suggests that other exposure pathways and mechanisms are relevant for which purposefully visiting green space is not conditional. The experimental study in this thesis suggests a direct physiological stress response to short-term exposure to nature views, but it is not clear yet.
what the role of longer exposure times and more intense experiences of being in “real” nature is. The use of virtual reality techniques could provide more realistic nature experiences (Annerstedt et al., 2013).

Another interesting research question is whether it is actually the greenness as such or the contribution to the attractiveness of the neighbourhood from an aesthetics and environmental quality point of view. Previous research has shown that neighbourhood satisfaction mediates the association between perceptions of built and green characteristics of the neighbourhood and mental health (de Jong et al., 2012; Leslie and Cerin, 2008). This links to the question why is the perception of green space quantity/quality so important with respect to the health benefits of green space (Hartig et al., 2014). Green space might also lower exposure to noise, air pollution and high temperatures. These mechanisms might directly be related to physical health by physiological mechanisms, but might also indirectly affect mental health through people’s improved perceptions of the environmental quality of their neighbourhood.

People who report visits are not necessarily consciously engaged with nature. Green space with its natural features may just function as an available setting or background for their leisure activities, but may also provide opportunities for a more intense way of contact with nature that is needed for more sustained restorative effects (Hartig et al., 2014) or might even promote personal development (Health Council of the Netherlands and Dutch Advisory Council for Research on Spatial Planning, 2004) and spiritual well-being (Keniger et al., 2013).

A commonly proposed component of personal development and spiritual well-being is a sense of connectedness and of purpose. Mayer and Franz (2004) argue that people’s feeling of connectedness with nature might be an important predictor of life-satisfaction and well-being. Therefore, nature connectedness, i.e. the feeling of belonging to a community or something “greater than oneself” (Mayer et al., 2008) might influence (by mediating or moderating) the green space – mental health association. The concept of nature connectedness needs more attention in future research and could be explored by using the Connectedness to Nature Scale developed by Mayer and Franz (2004). Another, but closely related scale is the Nature Orientation Scale, which assesses the affective, cognitive and experiential relationships a person has with the natural world. Both multi-item scales are validated and may yield more relevant results than the scales used in the PHENOTYPE questionnaire to assess attitude towards leisure activities in green space and the one-item question on childhood nature experience, which were tested on effect modification (see Chapter 3). More in general, knowledge on nature (or wilderness) experiences affecting personal development is still in its infancy and deserves further research, especially in the context of the re-definition of health proposed by Huber et al. (2011) as “the ability to adapt and self-manage” that accounts for people’s ability to cope with social, physical and emotional challenges. Several researchers suggest that engaging with natural environments may not only be beneficial for the mental health of people who are stressed, but also for that of non-stressed, healthy people. Hartig (2007; pp. 164) distinguishes effects of restorative environments that involve “deepening or strengthening capabilities for
Meeting everyday demands” from effects that involve recovering from stress and mental fatigue by calling the former “instorative”, rather than restorative. Examples of such “instorative” effects are improved self-confidence, development of new skills (Hartig, 2007), ability to reflect on life problems (Mayer et al., 2008) and vitalizing effects (Ryan et al., 2010). Thus, engagement with natural environments may enhance psychological resilience and the ability to cope with everyday demands and life events.

Besides these general recommendations for future research concerning the type of studies and underlying mechanisms, more specific recommendations can be given:

- The studies in this thesis that used time spent visiting green space as a proxy for exposure revealed the need for more insight in the factors that might influence use of green space; personal motivational factors, such as having a dog, and the perception of quality and safety of green space/greenness should be explored as possible predictors of green space use;

- Future research should not limit to green space solely, but involve other (multiple) built environmental characteristics and the social-cultural contextual factors. This is especially important to gain more insight in the behavioural mechanisms (i.e. the physical activity and social contacts mechanisms) and how they fit into the more complex socio-ecological models of healthy behaviour;

- With respect to methods for measuring the quantity and quality of residential greenness, audit tools need to be developed that can identify different types and designs of green spaces and residential greenness and assess its quality characteristics. The results of experimental studies, such as those presented in this thesis, will become more relevant for urban planning and therapeutic practice if the design and quality characteristics of the green spaces are systematically being varied;

- Despite that the study presented in this thesis does not support a positive association between residential greenness near home and mental health in the general adult population, the question remains whether green space provides health benefits in other contexts or settings, for example in health care settings, especially those for people with mental health problems.

Overall, despite the few excellent longitudinal studies mentioned in this thesis, controlled pre-post intervention studies are needed to better account for self-selection and individual’s exposure to green space by including more advanced methods to assess use of green space and visual exposure. These types of studies, when conducted within different population groups and in different settings, may provide more insight for whom and in which socio-cultural settings exposure to green space might be most beneficial for mental health. As already mentioned in the introduction of the thesis (Chapter 1), controlled laboratory and field experiments have provided support for restorative effects of contact with nature (i.e. reducing stress and mental fatigue) and have inspired many of the large-scale epidemiological studies. At the same time, more experiments are necessary, such as the experiment presented in Chapter 6, which may
deeper the insight in underlying psycho-psychophysiological mechanisms of mental health benefits of green space. Both controlled experiments and population level studies are important to strengthen the evidence base, to increase the plausibility for causality on one hand and to better understand the meaning (i.e. clinical relevance) of the benefits of green spaces for public (mental) health on the other hand.

**IMPLICATIONS FOR FUTURE POLICY AND PRACTICE**

The systematic review in this thesis provides strong evidence of a positive association between the availability of residential green space and mental health. The studies in the review do neither provide information on the type and size of greenness nor on how green spaces should be designed to enhance mental health benefits. Despite the evidence from previous research, the studies in this thesis of the studies on four European cities could not add to this evidence. However, the findings do suggest that time spent on visiting green space contributes to mental health. While for the general adult population the benefits appear small, for certain population groups the mental health benefits may be more substantial, especially for those with low levels of education. Thus, not only providing more green spaces in residential environments is recommended, but also stimulation people to visit those green spaces, which may be achieved by informing them about the benefits to (mental) health and by developing special programmes to promote visiting green space for physical activity, social contacts or mental restoration or a combination of all these active and passive ways to use green space and engage with nature. There are several examples of programmes that have shown to be successful such as the Walking for Health program, which was an initiative of Natural England, the British Heart Foundation and the Department of Health. This programme supports people to take control over their own health and to be more active by taking part in guided health walks (see http://www.walkingforhealth.org.uk). Other examples are the Dutch Biowalks programme for patients with diabetes type 2 (Maas and Ekkel, 2011) and programme “Natuursprong” to stimulate children to play outdoors and being physically active in nature (see http://www.natuursprong.nl). Although this thesis does not provide detailed insight in which personal and contextual factors stimulate or impede actual use of the available green space, the analyses per city showed a possible influence of different social-cultural settings. Culture-dependent perceptions of quality and safety, and attitude (or orientation) towards nature may be relevant and should be taken into account when developing programmes to stimulate green space use.
REFERENCES


