Biological Diversity in Urban Environments

Positions, values and estimation methods

Mats Gyllin
Department of Landscape Planning
Alnarp

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Abstract

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The thesis approaches the concept of urban biodiversity from different angles in an attempt to explain its significance.

In a study from the constructed Toftanäs wetland park, methods of affecting local biodiversity are demonstrated as integrated with other functions, such as water quality and stormwater detention. Vegetation analyses are provided to show the rapid and sometimes unexpected change in species composition. Both spontaneous and introduced species were followed in a five-year project.

Theoretical aspects of urban biodiversity are studied in-depth and the different views on biodiversity in general and urban biodiversity in particular are scrutinised. It is concluded that a holistic view on urban biodiversity probably reflects the true conditions best.

In a method study, a few different kinds of biodiversity mapping were tested. It was concluded that the biotope-mapping model tested was easy and rapid, but incomplete. Patch mapping was more time-consuming, but possibly more informative. Patch shape was compared to species diversity, but there was no correlation. It was concluded that both kinds of mapping need to be calibrated with biological data, and that the human function of urban environments should be an integrated part of urban biodiversity studies.

A method of assessing the perception of biodiversity was tested using a semantic test on-site. An index for biodiversity experience was created and later tested also in a photo-based study. Both studies comprised laymen as well as experts. It was concluded that there were differences between photo-based and on-site ratings, but the biggest difference was detected with the on-site experts.

As a general conclusion of the thesis it can be stated that urban biodiversity is an integral part of the urban environment, and that it is impossible to regard the city without its biological component, as well as it is impossible to regard the biological component without its human connection.

Keywords: Urban ecology, perception studies, biodiversity measurement, biodiversity assessment

Author's address: Mats Gyllin, Department of Landscape Planning Alnarp, SLU, P.O. Box 58, S-230 53 Alnarp, Sweden

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Appendix

Papers I–V

The present thesis is based on the following papers, which will be referred to by their Roman numerals:

I. Stormwater as a resource – experiences from a multi-functional solution to onsite stormwater management in southern Sweden (Manuscript)
II. Understanding urban biodiversity – a matter of values, attitudes and professional positions (Manuscript)
III. Approaches to urban biodiversity mapping – methodological considerations (Manuscript)
IV. A semantic model for assessing the experience of urban biodiversity (Manuscript)
V. Visual, semantic assessments of biodiversity from photographs and on-site observations – a comparison (Manuscript)

Background

In 1997, the research programme Green structure and development of urban environment was launched at the Department of Landscape Planning Alnarp, Swedish University of Agricultural Sciences. Its main aims have been to expand the knowledge and initiate discussions regarding urban development and sustainability – socially as well as ecologically – by making three thematic studies concerning the 'green structure' of urban environments. In addition, a frame project with focus on investigating aspects of 'green knowledge' in municipality planning and management, and the relevance and communication of research efforts in that context, has been conducted by AgrD Gunilla Lindholm. She has also been project leader for the entire research programme since its second year.

Although the thematic studies have been conducted as separate projects regarding content, methods and results, there has been some co-operation concerning literature studies, focus group interviews, and study sites. There has also been a continuous discussion regarding concepts and other relevant theoretical and methodological issues. Of the thematic studies, children's perspectives on outdoors environments has been the focus of landscape architect Maria Kylin (cf. Kylin & Lieberg, 2001). Green space as a characterising element of townscape and urban design has formed the basis for the dissertation by landscape architect Karl Lövrie, which he defended in 2003 (Lövrie, 2003).

The third theme – biological diversity in urban environments – is reported through this thesis. It has been funded mainly by the Swedish Council for Building Research (project no. 95306-5), jointly with faculty funds of the Swedish University of Agricultural Sciences, Movium (frame programme for 1997–2000), the SLU project "Nya planeringsförutsättningar" (project leader: Erik Skärbäck), and the Department of Landscape Planning Alnarp. The study in paper I was financed by the Swedish Council for Building Research, although through a different project (no. 890790-1). Part of the study of paper III has been funded by the Swedish Council for Forestry and Agricultural Research (SJFR).

Introduction

Biological diversity (or biodiversity) has been mentioned in the scientific literature since the beginning of the 1980's. It was gradually shaped into its present form during the following decade through notable publications such as Wilson and Peter's "Biodiversity" (1988). The increased use of the concept depended largely on the active attempts to make it a means of political pressure, mainly in the hands of global nature conservation (Haila, 1999). It became popular to a wider audience with the conference in Rio de Janeiro, where the Convention on Biological Diversity (UNEP, 1992) was signed and ratified by a large number of nations. The convention was implemented in Sweden through national action plans, e.g. by the Swedish Environment Protection Agency (Terstad, 1995), and for the urban environments by the National Board of Housing, Building and Planning (Emanuelsson et al., 1996). Locally, the convention has been implemented through local Agenda 21 efforts (Ohlsson, 1997), although emphasis has often been on other sustainability issues than biodiversity.

It seems that urban biodiversity has played a rather insignificant role in most municipalities, with a few exceptions (e.g. Malmö stad, 2001). However, many municipal green plans have had "protection and conservation of nature values" as a theme since the introduction of green plans as an independent planning instrument (e.g. Natur- och kulturvårdsprogram för Göteborg, 1979; Stockholms friytor, 1982; Grahn, 1986, 1991). This theme seems to have continued during the following decades, somewhat strengthened by biodiversity as an additional argument. Since the biodiversity focus has been on conservation, most references from this later period to urban biodiversity from public authority sources concern remnants of wildlife within the bounds of the city (Bernes, 1994; Larsson & Wandén, 1995; Engström et al., 1996). Perhaps sources like Murphy (1988) from the expansive early phase of concern for global biodiversity have encouraged this attitude. A different view stems from urban planning and landscape architecture, where biodiversity is approached from another angle, exemplified by Lönngren and Persson (1995), where the visual experience of biodiversity is emphasised. The planning approach to biodiversity otherwise has a tendency to focus on generalised, large-scale elements, e.g. in the Swedish 'green plans' (e.g. Malmö stad, 1984; Lunds kommun, 1990; Ottoson, 1994; Svensson & Göransson, 1994; Umeå kommun, 1998). A conclusion could be that the typical biologist with an interest for nature conservation approaches biodiversity from a detail level, whereas the typical green planner approaches it from a large-scale level. That does not mean that biologists are rigid and simple-minded or that planners are shallow and indifferent, but there are certainly reasons to believe that there is a communications problem.

One reason for such communications problems may be that the purpose for addressing urban biodiversity is unclear, and therefore it is uncertain what aspects of biodiversity to emphasise. Of course, there is the general purpose of adhering to the biodiversity convention, and a list of reasons is provided there (UNEP, 1992), but they are very general and especially aimed at covering global biodiversity issues with special emphasis on sensitive areas. For urban environments in Sweden, they are perhaps too general. The correct question might be: What value does urban biodiversity have? Does it have a value in itself, or does it only have instrumental value, i.e. some sort of 'use' to people (Sagoff, 1992; Randall, 1994; Kellert, 1996; Bengtsson, Jones & Setälä, 1997; Oksanen, 1997). It is particularly important to be clear about this in cities with their dense human populations.

Another reason why biodiversity issues are easily misunderstood is that the interpretation of the concept differs. It may mean substantially different things to different groups of people, as has been demonstrated for example by van den Berg et al (1998). Sometimes it could be a simple matter of semantics, sometimes a more profound difference in opinions of what organisms biodiversity should comprise, and hence what effects directed measures might have. The various definitions of the concept (Delong, 1996) are not very helpful, since they are either too general or too specialised. The most 'official' definition (UNEP, 1992) states that biodiversity comprises the variability at three levels (ecosystem, species, and genetic level), while others add more levels and some say that it is the diversity 'at all levels' (De Leo & Levin, 1997). Common to all definitions is the opinion that biodiversity is more than just the number (or diversity) of species.

It is sometimes stated that biodiversity cannot be measured, at least not as a simple variable (Bernes, 1994; Catizzone & Larsson, 1997). It is a reasonable assumption, at least if the ambition is to measure all biodiversity at a certain place. Consider, for example, the enormous quantities of living creatures in a single soil sample (Brussaard et al., 1997; Bongers & Bongers, 1998; Couteaux & Darbyshire, 1998; Ekschmitt & Griffiths, 1998). A variety of methods have been suggested, all with a varying degree of limitations or extrapolations, such as the measurement of indicators, higher taxa, selected groups of organisms, landscape level features etc (Oliver & Beattie, 1993; Colwell & Coddington, 1994; Faith, 1994; Hammond, 1994; Harper & Hawksworth, 1994; Lovejoy, 1994; May, 1994; Pearson, 1994; Prance, 1994; Williams & Gaston, 1994; Witting & Loeschcke, 1995; Grandchamp, Niemelä & Kotze, 2000; Hermy & Cornelis, 2000; Löfvenhaft, Björn & Ihse, 2002; Sarkar & Margules, 2002). However, there is no general, standardised expert methodology adaptable to different needs and different scale levels, although biotope mapping as conducted primarily in Germany (Sukopp & Weiler, 1988; Duhme & Pauleit, 1992; Frey, 1999) could be considered a 'standard' for large-scale levels.

Some observers claim that the urban environment is primarily a place for people, and hence biodiversity assessments in urban environments should only reflect biodiversity as perceived by people. While the rationale behind such a statement is doubtful (it is argued elsewhere in this thesis that other species are not only abundant but also necessary and seamlessly integrated in the urban environments), it nevertheless adds another dimension to the motives for urban biodiversity planning.

The starting point for many of the ideas in the thesis emerged within the rather traditional, however innovative, Toftanäs project (presented in paper I). Much of the theory is rooted in the works of others. The notion that human well-being to a large extent depends on the proximity of other living creatures has its origin in the biophilia hypothesis (Wilson, 1984). However, the dependence on more recent findings in environmental psychology is perhaps more evident, particularly through the works of Patrik Grahn (Grahn, 1991; Berggren-Bärring & Grahn, 1995; Grahn et al., 2000; Stigsdotter & Grahn, 2002, 2003; Grahn & Stigsdotter, 2003). Regarding visual perception, the works of Gibson (1986) has provided some very useful insights. The view on nature expressed in the thesis owes a great deal to Kenneth Olwig (Olwig, 1983; Olwig, 1993a, b; Olwig, 1994), although this is not always explicitly expressed. The view on cities is based on the ideas of Amin and Thrift (2002), but Johan Rådberg (e.g. Rådberg, 1997) is also an important source for inspiration. A few central works in the ecological disciplines should also be mentioned; "The Ecology of Urban Habitats" by Gilbert (1991), "Biodiversity and Ecosystem Function" by Schulze and Mooney (1993), and "Principles and Methods in Landscape Ecology" by Farina (1998).

The approach by Lönngren and Persson (1995) comprised an assessment model for experienced biodiversity, based on a number of seemingly arbitrary factors, including expert judgements. In Jensen et al (2000) another model is used, although not well enough described, but also apparently based on expert judgements. Other ways of assessing biodiversity through judged ratings have been used, sometimes as part of more comprehensive investigations, comprising other assessments as well (Berggren-Bärring & Grahn, 1995; van den Berg, Vlek & Coeterier, 1998). There is, however, no method of measuring the experience of biodiversity comparable to a very reliable and rational method as the SBE (Scenic Beauty Estimation) method for preference studies in forest areas (Daniel & Boster, 1976; Daniel & Schroeder, 1979; Daniel, 2001).

Objectives of the thesis

The urban biodiversity issues discussed above could be summarised like this:

- Biodiversity is a very complex concept, particularly in an urban context. How should it be treated to avoid communications problems? What does it mean to different groups of people? Could it be made operative to science or urban planning?
- Biodiversity cannot be measured in full detail. Reliable, 'standard' estimation tools are mainly designed to function in large-scale studies or in rural environments for conservation purposes.
- The experience of urban biodiversity by non-experts is rather unknown territory, but in environments where people live, it may be a very important factor. Methods of measuring such experience need to be refined and formalised.

The general purpose of the thesis has been

- To formulate a conceptual framework for urban biodiversity, comprising definitions and evaluation of different approaches.
- To suggest measurement methods to be used by persons with some experience with ecology, particularly in an urban environment.
- To suggest and compare assessment methods concerning the experience of biodiversity.

Most of the theoretical considerations concerning urban biodiversity are treated in paper II, while measurement methods are discussed in paper III. Although the relevance for planning and management are not specifically investigated, some possibilities are discussed. The everyday experience, conscious or subconscious, of biological diversity, particularly in an urban context is investigated, and methods to measure such aspects are suggested in paper IV and V.

Methodology

The “Green structure and development of urban environment” project started with joint focus group interviews (Kitzinger, 1995; Wibeck, 2000) with participants representing different interests and competence. The purpose of those interviews was to capture the essence in the city green as perceived by those groups. These interviews provided very useful insights in the way that urban environments are perceived by residents, planners, teachers, and ecologists. Although this material has not been explicitly utilised in the thesis, it has nevertheless had profound influence on the direction of the work, particularly regarding papers II, IV and V.

In the Toftanäs project, standard ecological methods were used to register the succession of the vegetation. Species abundances were registered in permanent plots, and biomass was sampled according to a standard scheme. Other samples were also taken according to standard procedure (paper I). The overall purpose with the vegetation sampling was to register the success of introduced species and their influence on biodiversity development, and to check the speed and influence of the spontaneously invading species. The Toftanäs project is a case study from which important conclusions can be made regarding actions to affect biodiversity through establishment of wetlands in urban settings and the integration of biodiversity in multi-functional projects.

Paper II is a theoretical work, intended to conceptualise urban biodiversity. It comprises an extensive literature review, treated philosophically.

Paper III is based on two studies, both using GIS. The Lund study is based on large units, roughly equalling districts or blocks, while the Eslöv study is based on visually homogenous units (‘patches’), identified from an aerial photograph. The concept of functional groups, used to characterise the patches, is exemplified by groups of vascular plants registered on-site.

Paper IV and V are both based on semantic environmental assessments of environments made by groups of participants. In paper IV participants were recruited from students and ecology researchers who made assessments on-site, while in paper V participants were recruited via the Internet and made assessments from photographs, also via the Internet. Results from the studies were treated statistically and an index for biodiversity experience was created and evaluated.

For more details on methods, see below or in the respective papers.

Biodiversity as an integrated part of a multi-functional urban project (Paper I)

In paper I, the process and general results of a project aiming at a multifunctional stormwater detention facility, the Toftanäs Wetland Park, is described. The project was an attempt to join forces between vegetation science, limnology, landscape aesthetics, local planning and technical stormwater solutions. The aims of the project were summarised as a number of functions that the facility was supposed to provide in the long term. The four main functions were

- Hydrological function. This is the basic function of a stormwater detention facility, i.e. regulation of water flows. Regular measurements of water flow and water level were made.
- Water quality function. The site was designed to retain nutrients from agricultural drainage water, and heavy metals from stormwater. The water was slowed down and pollutants taken care of through sedimentation ponds and uptake in the vegetation. Sediments and vegetation were scheduled for removal according to a management plan. Since the basin floor was more or less regularly flooded, soil samples from the different zones were analysed for nutrients, organic content and heavy metals. Water samples were from the inlet and outlet were analysed for nitrogen and phosphorus.
- Habitat function. This summarises actions and observations aimed at biodiversity, i.e. the facility as habitat for spontaneous and introduced plants, and hence a potential habitat for wildlife animals – primarily birds, amphibians and invertebrates, but also mammals and fish. The dry and wet parts of the area (everything except open water) were sown with a very broad selection of seeds considered suitable for the local geological and climate conditions. The parts with open water were left for spontaneous development. The plant community was thoroughly monitored during a five-year period, and then analysed and evaluated. The animal community was also registered during the period, although less ambitiously. Apart from species diversity, biomass dry weight was measured in the different zones.
- Amenity function. Since the facility was placed within a residential area, it was supposed to function as a local park. However, this issue was never fully investigated and the residents were never asked for their opinions regarding the facility. Parts of the area were intentionally difficult to access to spare the wildlife. The more accessible parts of the area were occasionally used as an excursion site for school classes.

The Toftanäs project can be regarded as a test project for integrating biodiversity considerations in urban planning, although as an isolated project. As such, it was successful, since co-operation among the involved parties worked well and proved that making substantial contributions to local biodiversity could be made in combination with other functions. It also served as a starting point for more principal ideas regarding the position of biodiversity in the urban landscape.

Biological diversity – what is it and how can it be estimated (Papers II and III)?

Possibly, the expression ‘biological diversity’ was originally developed as an intuitive and visual concept, probably primarily within nature conservation, and later definitions have been more or less successful attempts to formalise this. In Paper

II, the various problems and aspects of biological diversity are discussed. The paper addresses moral/ethical approaches to biodiversity, its scalability, influences from different views of nature, and views of man's position vis-à-vis biodiversity, i.e. whether man should be considered a part of biodiversity or be kept out of it. The paper deals with the position of 'biodiversity' in the everyday language, and suggests common ways to treat it as a more holistic concept, since it is used in a number of rather different ways. The holistic approach is an attempt to respond to the need for reconciliation in an arena where 'biodiversity' needs to be addressed in an operational sense.

'Biological diversity' was given its current meaning within the American conservation movement in the beginning of the 1980's. Although the diversity of life had been discussed many times and in many ways before that, it was now presented as a seemingly quantitative measurement with the unified conservation movement to back it up.

Even though expressions like variation and diversity within species (from the UNEP definition) implies that this is a quantifiable, measurable entity, it is soon realised that it is impossible to measure all life forms, even in a very limited area. Thus, limitations are unavoidable, and depend on a number of factors such as the investigated area, the competence of the researchers, the economic and temporal limits of the project, etc. A relevant question is how well the conducted investigation represents the intended biodiversity. There are probably occasions when the results can be regarded as representative for biodiversity, but it is difficult to be certain, and more difficult the narrower the sample is.

For example, making statements about biodiversity based on bird fauna data alone would be less reliable than if bird and vegetation data were used together. However, it is less clear if it is better to choose birds instead of vegetation as 'biodiversity representatives' or vice versa, because that requires an estimation of how well the other group (and all other groups of organisms present in the current study area) is represented. In other words, how well do birds (or vascular plants etc.) as a group function as indicators of biodiversity? This could be narrowed down further, even to single species, in which case they are called 'indicator species', 'umbrella species', 'keystone species', 'flagship species', or 'focal species', depending on their function (Lambeck, 1997; Simberloff, 1998).

Such species are, in different ways, considered more important to biodiversity than others, or at least more informative. This can be generalised to comprise all species, i.e. all species are more or less unequal in a biodiversity context (Harper & Hawksworth, 1994) depending on factors such as:

- *Ecology*. Connections between species lead to dependencies, not always equal or even mutual. Species that many other species depend on could be considered 'weightier' than the dependant species, with keystone species as the 'weightiest'. A tree, for example, would be more 'important' than the parasites and epiphytes living in it.
- *Taxonomy*. It can be assumed that taxonomically isolated species have more unique genes than those with close relatives, e.g. 'living fossils'. These are extreme examples, since they are often the only surviving representatives of

high-level taxa, e.g. phyla, classes or orders. The same principle is, however, applicable at all taxonomic levels, where species with few relatives can be said to contribute more to biodiversity than those with many relatives.

- *Utility – affection*. This may be controversial, and could perhaps be considered a variant of ecological weighting. It comprises species that in one way or other induce human actions. Such actions can be to protect them (e.g. 'flagship species' – species that evoke particularly protective measures) or to favour them in other ways, e.g. through cultivation. Many cultivated species would not survive without protection. It could also be the other way around, with man acting to reduce species that are regarded as threatening, competitive, annoying, or simply misplaced. We may thus consider man as a particularly important 'keystone species'. A species that humans consider friend or foe will have a different effect on biodiversity than otherwise.

However, as has been mentioned before, the narrower the sample, the more reliable it has to be as predictor of biodiversity, i.e. the presence of a certain, single species should indicate the presence of a fair number of other, specific species, with some certainty. The American ecologist and researcher Daniel Simberloff has criticised the mechanical use of single species to represent entire communities (Simberloff, 1998). According to Simberloff, most single-species concepts are either too vague or inclined to measure the wrong thing. The only concept he finds to be of at least potential value is keystone species, i.e. species that affect the presence of a large number of other species in a very direct manner. Examples are predators of otherwise dominating species or species that alter the physical conditions of a certain place, e.g. conifers, coral reefs, or grazing sheep. According to Simberloff, there are still reasons to be cautious, since there may be systems that simply lack keystone species.

Groups of species characterised by some common functional feature could be considered a generalisation of keystone species (De Leo & Levin, 1997). Such groups are usually labelled 'functional groups' in the ecological literature and are generally considered an expression for some ecosystem function (Schulze & Mooney, 1993). The identification and use of functional groups, as suggested in paper III, should be a more robust and reliable indicator system than keystone species, since the concept as such implies that species are, in some sense, interchangeable. Thus, it does not rely solely on a single species, as is the case with the keystone species approach. An attempt to exemplify the use of functional groups attached to homogenous areas of urban environment is presented in paper III. A pilot project to that effect was carried out in parts of Eslöv, where homogenous areas were identified using aerial photos. These areas were then verified on-site and their biological content estimated by standard ecological techniques for further analysis to identify a few examples of functional groups. It is suggested that 'function' can be generalised to comprise other than just ecological functions, e.g. cultural, aesthetic or utility functions. Furthermore, it is also implied that the method should, when fully developed, concentrate on the functional groups directly, instead of as in the study, estimating the species level first.

Paper III also comprises a more general method to map urban biodiversity, based on earlier, primarily German, hierarchical biotope mapping methods (Sukopp & Weiler, 1988; Hartwig & Küchenhoff, 1998; Breuste, 1999; Frey, 1999). A pilot study from Lund is presented and discussed. The main advantages with this approach are its high reliability, the speed with which it can be done and its high 'codability' level, i.e. the nomenclature used is common ground to many people, at least those familiar with Swedish urban environments. Its disadvantages are that it needs to be calibrated regarding its biological content, because otherwise the 'biotopes' identified are only identified through their administrative properties, not their biological properties. It is finally suggested that an appropriate combination of 'biotope mapping', 'patch mapping' and inventories of 'functional groups' should provide a useful set of methods for urban biodiversity assessments with demands of reasonable speed and accuracy from an expert angle.

An important conclusion of paper III is that the purpose of the investigation ultimately decides how the methods should be approached. To use functional groups, the function has to be known in advance.

It should also be remembered that this kind of methodology does not provide guidelines regarding what kind of biodiversity should be preferred. This is a decision for planners and politicians to make. From an ecological point of view, there is no 'right' or 'wrong' biodiversity, just different kinds of biodiversity.

This is in analogy with the general conclusions of paper II, where a holistic attitude towards biodiversity is suggested as the most appropriate, when regarding the truly integrated nature of urban biodiversity.

The experience of urban biodiversity (Papers IV and V)

The concept of 'flagship species' was mentioned above, i.e. species that evoke positive reactions with the public (Simberloff, 1998). Hence, it is usually no big effort to motivate protection for them, unless some other, stronger interest gets in the way. There are, however, drawbacks with this kind of protective measure. The argument that a large number of other species are protected as a bonus effect may be true in some cases, but the benefits are unclear, perhaps trivial and probably unevenly distributed. Furthermore, if the flagship should become extinct, which is reasonably likely, since flagships are often large animals in small, sensitive populations, then the protection disappears for other species as well. There is also a risk that the protection of the flagship species becomes so expensive or prevailing that other protective measures are neglected or reduced. In that case, other kinds of protection might be more efficient.

This could be seen as an argument in favour of an expert view in matters concerning the protection of biological diversity. It is easy to join forces to save a charismatic flagship species, but views are likely to diverge when less familiar species are on the conservation agenda. The importance and sensitivity of many such species can often be assessed only by experts. On the other hand, there are reasons why the public should be given opportunity to express their views, not least since the biological diversity directly affecting the residential areas is treated in local planning documents with subsequent management of surrounding environments.

As stated in paper III, 'function' is not necessarily restricted to ecological function, but could be other kinds of function reflecting values that the public attach to plants and animals, e.g. aesthetics or health/utility aspects. Kaplan (1990) and Kaplan et al (1998) suggest that places rich in species are fascinating due to their content, which can strengthen the ability to concentrate. They may also have a reviving effect against fatigue and work-related stress. With this in mind, it becomes increasingly interesting to study the reaction to biodiversity by urban residents. An interesting question in that context is whether areas that are established with the purpose of having a high biodiversity level, also are perceived that way.

One way of capturing the experience of environmental phenomena is by letting people rate words in a semantic model. The difficulty lies in using words that are both relevant and interpretable to the participants. The works based on Wittgenstein's analysis of everyday language, particularly the reference of words, may be a suitable starting-point. Later researchers have identified hierarchic or taxonomic levels of unambiguous meanings of words, their codability (Hartnack, 1971; Strawson, 1975; Furberg, 1982), which indicates how clear and distinct a word's reference is. The logic of a language depends on how the words are used in a certain context. Examples of words with low codability are political terms like 'freedom' or religious like 'holy'. In the everyday language, when those words are surrounded by words with high codability, they do have meaning, though. However, the spoken language is more difficult to follow than the written language, since it contains cultural references that a foreigner may have problems with detecting (Ricoeur, 1984). When the same person writes down his statements, the references are generally more comprehensible. According to linguists like Ricoeur a word or phrase with low codability, e.g. 'biological diversity', can be comprehended through its use, or by its connection to words with high codability (Strawson, 1975; Sigurd, 1983; Ricoeur, 1984). The latter has been utilised by linguists using multivariate analyses of words with high codability to investigate the contents of conversations and the relations to words with lower codability, but at a higher philosophical, political, or religious level (Bierschenk & Bierschenk, 1985, 1986).

In 1957, C. E. Osgood presented the idea that loadings of words can be measured in a scale with a distinct mid-point, e.g. 1-5 or 1-7 (Osgood, Suci & Tannenbaum, 1957). Through such scales, anybody can state to what extent he or she thinks a word fits a certain phenomenon. Since the beginning of the 1960's, researchers in environmental psychology like Berlyne (1974) or Wohlwill (1983) have been using such knowledge to make preference studies. E. H. Zube developed a way of analysing photos with the aid of Osgood's scale and multivariate analyses (e.g. in Zube, Pitt & Anderson, 1974). In the 1970's, Rikard Küller conducted semantic studies using words of high codability, reliability and validity, which, after multivariate analyses, indicated how the participants perceived diffuse phenomena such as architectonic completeness, complexity and spatiality. Later, other researchers have used the same technique (Sorte, 1982; Axelsson Lindgren, 1990; Grahn, 1991; Berggren-Bärring & Grahn, 1995; Axelsson Lindgren, 1999; Axelsson Lindgren, Gyllin & Ode, 2002).

In paper IV, a tool to measure the experience of biodiversity (Biodiversity Experience Index - BEI) is suggested. It is based on visual impressions of environments and ratings of specific words connected to biodiversity. The method is based on the semantic environment description method outlined by Küller (1972; 1975). A number of words were selected from different semantic tests (Küller, 1975; Axelsson Lindgren, 1990; Berggren-Bärring & Grahn, 1995) concerning architecture, urban environments, parks and nature. The words were selected to catch the entire scope of biodiversity as well as possible, and through the earlier works were known to have high codability. The investigation sites were selected to represent different types of green urban areas, typical for South-Swedish municipalities. Results were then analysed by multivariate methods (factor analysis, cf. Morrison, 1990; Manly, 1994), and the BEI was then based on factor loadings of the words that were strongest correlated to 'biological diversity'. The words used in the final version of the BEI were plant richness, animal richness, wild, and varied, weighted by their factor loadings.

This instrument was used in the investigation that paper V is based on. To the data from paper IV, data from a photo-based investigation with digital pictures of the same sites were added. The purpose of this was partly to find out if photo-based ratings were comparable with on-site assessments. The results were not entirely conclusive. There were significant differences between on-site and photo-based assessments for five of the six sites. The general pattern was approximately the same, however, so it may be possible to reduce differences by choosing more photos, or more representative photos.

Part of the investigation was designed to address the difference between 'experts' and 'non-experts'. In the on-site study, six senior researchers in plant ecology participated, along with the 96 students representing 'non-experts', and in the Internet study, 36 of the participants had university degrees in biological subjects, whereas the rest were a mix of different professions and backgrounds.

There were no detectable differences in BEI between biologists and non-biologists in the Internet study. There were differences in individual words, but the pattern was difficult to interpret. There were, however, rather distinct differences for two of the areas in the on-site study. Those two areas were given significantly higher BEI scores by the ecologists than by the students.

How can this be interpreted? There are two main explanations:

1. *Experience*. It is reasonable to assume that the experts have acquired an eye for details that may go unnoticed by non-experts. Ecologists may observe more species, and the potential the site may have for even more species. Such details could be difficult to see in a photo. Perhaps more senses than just vision are involved.

2. *Values*. Ecologists may be biased by opinions that certain types of environments *should* contain more species. There is also a possible scale effect, since

the ecologist is aware of the uniqueness of a certain environment, and thus values it higher because of its contribution to biodiversity at a larger scale.

Thus, 1. is based on real, although possibly subconscious, knowledge, whereas 2. is based on experience-based values.

In the subsequent focus-group interview with the ecologists who had participated in the on-site study, an inventory of the vascular plants from the two sites they had judged most different was presented. At first, they were surprised to hear that the number of species was practically the same, but rather quickly made two assumptions: The first was that the species of the site they had given the highest biodiversity rating were more evenly dispersed throughout the area, and hence were easier to detect and make judgements about. Several species of the other site were represented by only a few individuals each. The second assumption was that the highest rated site had a more diverse insect fauna than the other site. This assumption was made from vegetation structure and the age structure of the trees.

In practice, they explained their ratings as a function of intuitive, experience-based judgements of things they did not have the time or means to actually investigate. Furthermore, it could be verified that the first assumption was true, since the inventory also comprised abundance data. Since there were no data concerning the insect fauna, the second assumption could not be verified. However, it seems reasonable that the ratings were largely based on knowledge of previous experiences with similar objects.

The study shows that on-site judgements of biodiversity are made differently by ecologists and non-ecologists, at least if the environments are in some way extreme.

Concluding remarks

It should be stressed that the links to urban planning implied in this thesis are merely conceptual. It is not the intention of this thesis to suggest concrete ideas or techniques for planning theory or planning practice, although planners have sometimes been consulted and even participated marginally in some preparatory focus groups and in the continuous discourse within the research programme. However, dealing with urban biodiversity inevitably leads to planning considerations, although in this case only as theoretical constructions. Sometimes techniques are suggested as suitable in a planning situation, but only in the most general terms. Further tests and studies are needed and should be made before the required planning tools have been created. The discussion below merely point out a few possible directions to take and a few pitfalls to avoid.

Biodiversity has sometimes been subjected to extensive publicity, which could seem like a good thing, but there are drawbacks with too much exposure. Like other ‘fashions’, it may simply become ‘unfashionable’ and disappear from the agenda as quickly as it appeared, particularly if there are forces reacting against the ‘fashion’ and even striving to oppose green initiatives. Urban planning in big cities may be particularly sensitive to urbanity ideals, compact cities and other trends that tend to reduce green open space, and thus biodiversity (cf. Rådberg, 1997).

Another possibly adverse effect of biodiversity as 'fashion' is uniformity, i.e. the tendency to adopt standard models for biodiversity, as discussed in paper II, e.g. exemplified by the use of standard seed mixes for meadow establishment etc. This could have the extreme effect of increasing species numbers locally, while decreasing them regionally. While this risk may seem far-fetched, there is definitely the risk that standard procedures to increase biodiversity sometimes are unnecessary or at least disproportionately expensive. There is a parallel in the costs for establishing movement corridors which, according to Simberloff et al (1992), sometimes are not justifiable in comparison with their benefits.

There is a tendency in recent Swedish urban planning to make isolated biodiversity projects, based on the governmental "Local investment programme" funds (Ministry of the Environment, 2000; IEH, 2003). This initiative seems like a good idea, but there are a few points that need addressing. At first, long-term management is usually not covered by the funds, which means that it has to be part of the regular municipal management, and the design of such objects should preferably be sufficiently robust to endure periods of low budget. In the Toftanäs case (paper I), which could be considered such a project, the area is managed according to a management plan. If this is not done, the intentions of the facility cannot be fulfilled. The second point is geographical integration. Again, the Toftanäs facility may serve as an example, since it is completely separated from the surrounding park areas regarding purpose, management, vegetation, and visual impression.

The two points illustrate integration in time and space of biodiversity considerations. With the awareness that humans are not the only organisms living in the cities (Healey, 1997, 164 ff.), and the conception of the city, not as an isolated entity, but as a constantly changing, dynamic mix of networks (Amin & Thrift, 2002), perhaps new views on urban planning will allow tighter integration of 'green' issues to match the notion that biodiversity is not isolated from the city, but is an integrated part of it.

Some places are suitable for actively favouring a certain type of biodiversity, but urban biodiversity is a dynamically fluctuating phenomenon at nearly all places in the city, not least those places that fall between the actively planned areas. The notion of urban biodiversity as the 'ambient green' of the city might be difficult to put on the planning agenda, but if it could be accomplished, along with a general understanding of the different aspects of biodiversity according to paper II, urban planning could become truly 'green'. The concrete evidence of well being connected to environments with green elements (Kaplan, 1983; Kaplan, Kaplan & Ryan, 1998; Ulrich, 1999; Grahn & Stigsdotter, 2003) and awareness that people want variation in their everyday environment (Berggren-Bärring & Grahn, 1995) may speed up the process.

As stated before, this thesis does not provide answers to the difficult issue of integrating biodiversity in urban planning, but merely suggests some directions to take. In paper I, a project is presented that demonstrates that it is possible to integrate biodiversity considerations with other urban issues, albeit as an isolated project, and presents ways of altering biodiversity through directed actions. In paper II, an attempt is made to conceptualise urban biodiversity and capture it's use and understanding. This could serve as a basis for urban biodiversity communication. In paper III a system for comprehensive, flexible measurement of urban biodiversity is presented as a tool for direct assessments of biodiversity. In paper IV and V, a way of measuring the perception of biodiversity is presented and tested. This is a way of making indirect measurements of biodiversity, based on semantic ratings. Together, the five papers try to provide a possible framework for treating urban biodiversity in planning and science.

Future research

It seems that a doctoral thesis evokes more questions than have been answered. At times, it is frustrating to be able to do so little about all the things that can be done. Perhaps the questions should be considered the most important results of a dissertation, since this, at least in some cases, is the starting point for further research.

There is a need for refinement of functional groups as a measurement tool. Although some ideas and a few examples are presented in this thesis, much work needs to be done before an operative methodology has been reached. The most important and central functions need to be properly identified and categorised, and the method needs to be tested in several urban areas in different geographical districts with varying ambition levels. Several functional aspects regarding aesthetics, preference and utility should be compared to the aspects of urban ecosystem functions.

Methods regarding biodiversity experience should also be developed and refined. Investigations should include environments of different complexity, and more groups of people should be involved, e.g. landscape architects, urban planners and nature conservationists.

References

Amin A., Thrift N., 2002. *Cities - Reimagining the urban*. Polity Press, Cambridge.

Axelsson Lindgren C., 1990. *Upplevda skillnader mellan skogsbestånd - rekreations- och planeringsaspekter* (Dissertation). Swedish University of Agricultural Sciences, Department of Landscape Planning, Movium, Stad & Land 87, Alnarp. (in Swedish with English summary)

Axelsson Lindgren C., 1999. *En semantisk modell för skogsupplevelse - arbetsrapport*. Institutionen för landskapsplanering Alnarp, Rapport 99:3, Alnarp. (in Swedish)

Axelsson Lindgren C., Gyllin M., Ode Å. 2002. *Skogsupplevelse: Fältförsök i Tranemåla*. Institutionen för landskapsplanering Alnarp, Alnarp. (in Swedish)

Bengtsson J., Jones H., Setälä H., 1997. The value of biodiversity. *Trends in Ecology & Evolution*, 12(9): 334-336.

van den Berg A., Vlek C. A. J., Coeterier J. F., 1998. Group differences in the aesthetic evaluation of nature development plans: A multilevel approach. *Journal of Environmental Psychology*, 18: 141-157.

Berggren-Bärring A.-M., Grahn P., 1995. *Grönstrukturens betydelse för användningen* (Licentiate dissertation for Berggren-Bärring). Institutionen för landskapsplanering, Rapport 95:3, Alnarp. (in Swedish, with English summary)

Berlyne D. E. (Editor) 1974. *Studies in the new experimental aesthetics: Steps toward an objective psychology of aesthetic appreciation*. Wiley, London.

Bernes C. (Editor) 1994. *Biologisk mångfald i Sverige - en landstudie*. Naturvårdsverket Förlag, Solna. (in Swedish)

Bierschenk B., Bierschenk I., 1985. *The Agent Function as the Basis for Perspective Control*. Institutionen för psykologi, Lunds Universitet, Kognitionsvetenskaplig forskning 1985:9, Lund.

Bierschenk B., Bierschenk I., 1986. *Concept Formulation. Analysis of Mentality*. Institutionen för psykologi, Lunds Universitet, Kognitionsvetenskaplig forskning 1986:12, Lund.

Bongers T., Bongers M., 1998. Functional diversity of nematodes. *Applied Soil Ecology*, 10(3): 239-251.

Breuste J., 1999. Biotopkartierung - deutsche Erfahrungen und Möglichkeiten zur Verbesserung einer erprobten Methode für meht Stadt-Naturschutz. In: J. W. F. Reumer and M. J. Epe (Editors), *Biotope Mapping in the Urban Environment*. Natuurmuseum Rotterdam, Rotterdam. pp. 57-66. (in German)

Brussaard L., Behan-Pelletier V. M., Bignell D. E., Brown V. K., Didden W., Folgarait P., Fragoso C., Wall Freckman D., Gupta V., Hattori T., Hawksworth D. L., Klopatek C., Lavelle P., Malloch D. W., Rusek J., Soderstrom B., Tiedje J. M., Virginia R. A., 1997. Biodiversity and ecosystem functioning in soil. *Ambio*, 26(8): 563-570.

Catizzone M., Larsson T.-B., 1997. *Understanding Biodiversity*. Stockholm, Brussels: EWGRB, Commission of the European Communities Directorate - General XII for Science, Research and Development. 122 pp.

Colwell R. K., Coddington J. A., 1994. Estimating terrestrial biodiversity through extrapolation. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, 345: 101-118.

Couteaux M. M., Darbyshire J. F., 1998. Functional diversity amongst soil protozoa. *Applied Soil Ecology*, 10(3): 229-237.

Daniel T. C., 2001. Whither scenic beauty? Visual landscape quality assessment in the 21st century. *Landscape and Urban Planning*, 54(1-4): 267-281.

Daniel T. C., Boster R. S., 1976. *Measuring Landscape Esthetics: The Scenic Beauty Estimation Method*. USDA Forest Research Paper RM-167, Rocky Mountain Forest And Range Experiment Station, Fort Collins, Colo.

Daniel T. C., Schroeder H., 1979. Scenic Beauty Estimation Model: Predicting Perceived Beauty of Forest Landscapes. In: G. H. Elsner and R. C. Smardon (Editors), *Proceedings of Our National Landscape - A Conference on Applied Techniques for Analysis and Mangement of the Visual Resource*. United States Department of Agriculture, Incline Village, Nevada. pp. 514-523.

De Leo G. A., Levin S., 1997. The multifaceted aspects of ecosystem integrity. *Conservation Ecology*, 1: 3.

Delong D. C., Jr., 1996. Defining biodiversity. *Wildlife Society Bulletin*, 24(4): 738-749.

Duhme F., Pauleit S., 1992. Naturschutzprogramm für München. Landschaftsökologisches Rahmenkonzept. *Geographische Rundschau*, 44(10): 554-561. (in German)

Ekschmitt K., Griffiths B. S., 1998. Soil biodiversity and its implications for ecosystem functioning in a heterogeneous and variable environment. *Applied Soil Ecology*, 10(3): 201-215.

Emanuelsson U., Johannesson R., Borgegård S., Benskjöld U. (Editors), 1996. *Aktionsplan för biologisk mångfald vid byggd miljö*. Boverket, Karlskrona. (in Swedish)

Engström C.-J., Oscarsson G., Göthe S., Husberger L., Emanuelsson U., Lundberg A. (Editors), 1996. *Sverige 2009 - förslag till vision*. Boverket, Karlskrona. (in Swedish)

Faith D. P., 1994. Phylogenetic pattern and the quantification of organismal biodiversity. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, 345: 45-58.

Farina A., 1998. *Principles and Methods in Landscape Ecology*. Chapman & Hall, London, Weinheim, New York, Tokyo, Melbourne, Madras.

Frey J., 1999. Practical aspects of biotope mapping in cities: methods, problems and solutions. An example of Mainz, Germany. In: J. W. F. Reumer and M. J. Epe (Editors), *Biotope Mapping in the Urban Environment*. Natuurmuseum Rotterdam, Rotterdam. pp. 41-56.

Furberg M., 1982. *Säga, förstå, tolka. Till yttrandets och textens problem*. Doxa, Lund. (in Swedish)

Gibson J. J., 1986. *The ecological approach to visual perception*. Lawrence Erlbaum Associates, Hillsdale, New Jersey.

Gilbert O. L., 1991. *The ecology of urban habitats*. Chapman and Hall, London.

Grahn P., 1986. *Grönplanering för människor*. Swedish University of Agricultural Sciences - Department of Landscape Planning - Movium - Stad & Land 44, Alnarp. (in Swedish with English summary)

Grahn P., 1991. *Om parkers betydelse* (Dissertation). Swedish University of Agricultural Sciences - Department of Landscape Planning, Movium - Stad & Land 93, Alnarp. (in Swedish, with English summary)

Grahn P., Stigsdotter U. A., 2003. Landscape planning and stress. *Urban Forestry & Urban Greening*, 2: 1-18.

Grahn P., Mårtensson F., Nilsson B., Ekman A., 2000. *Børns udeleg. Betingelser og betydning*. Forlaget Børn & Unge, København.

Grandchamp A.-C., Niemelä J., Kotze J., 2000. The effects of trampling on assemblages of ground beetles (Coleoptera, Carabidae) in urban forests in Helsinki, Finland. *Urban Ecosystems*, 4(4): 321-332.

Haila Y., 1999. Biodiversity and the divide between culture and nature. *Biodiversity and Conservation*, 8(1): 165-181.

Hammond P. M., 1994. Practical approaches to the estimation of the extent of biodiversity in speciose groups. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, 345: 119-136.

Harper J. L., Hawksworth D. L., 1994. Biodiversity - measurement and estimation - preface. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, 345: 5-12.

Hartnack J., 1971. *Mennesket og sproget*. Berlingske, København. (in Danish)

Hartwig C., Küchenhoff B., 1998. Extensive Biotope Mapping in Cologne as a Basis for the Protection of Nature through Landscape Planning. In: J. Breuste, H. Feldmann and O. Uhlmann (Editors), *Urban Ecology*. Springer-Verlag, Berlin, Heidelberg. pp. 702-705.

Healey P., 1997. *Collaborative Planning - Shaping Places in Fragmented Societies*. Palgrave, Basingstoke.

Hermy M., Cornelis J., 2000. Towards a monitoring method and a number of multifaceted and hierarchical biodiversity indicators for urban and suburban parks. *Landscape and Urban Planning*, 49(3-4): 149-162.

IEH, 2003. *Lokala investeringsprogram - Vägen till ett hållbart samhälle*. Naturvårdsverket, Stockholm. (in Swedish)

Jensen M. B., Persson B., Guldager S., Reeh U., Nilsson K., 2000. Green structure and sustainability - developing a tool for local planning. *Landscape and Urban Planning*, 52(2-3): 117-133.

Kaplan R., 1983. The Role of Nature in the Urban Context. In: I. Altman and J. F. Wohlwill (Editors), *Behavior and the Natural Environment*. Plenum Press, New York. pp. 127-161.

Kaplan R., Kaplan S., Ryan R. L., 1998. *With People in mind: design and management of everyday nature*. Island Press, Wahington, D.C.

Kaplan S., 1990. Parks for the future: A psychological perspective. In: G. Sorte (Editor), *Framtidens parker!* Movium/Institutionen för landskapsplanering, SLU, Stad & Land no. 91, Alnarp. pp. 5-16. (in Swedish)

Kellert S. R., 1996. *The Value of Life - Biological Diversity and Human Society*. Island Press/Shearwater Books, Washington D. C.
Kitzinger J., 1995. *Qualitative research - introducing focus groups*. British Medical Journal, 311: 299-302.
Kylin M., Lieberg M., 2001. Barnperspektiv på utemiljön. *Nordisk Arkitekturforskning*, 2001(1): 63-79. (in Swedish)
Küller R., 1972. *A semantic model for describing perceived environment* - Dissertation. National Swedish Building Research, Document 12, Stockholm.
Küller R., 1975. *Semantisk miljöbeskrivning (SMB),* Lund. (in Swedish)
Lambeck R. J., 1997. Focal species: A multi-species umbrella for nature conservation. *Conservation Biology*, 11(4): 849-856.
Larsson T.-B., Wandén S., 1995. *Mångfaldens mysterier*. Naturvårdsverket, Solna. (in Swedish)
Lovejoy T. E., 1994. The quantification of biodiversity: An esoteric quest or a vital component of sustainable development? *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, 345: 81-87.
Lunds kommun, 1990. *Grönplan för Lund*. Lunds kommun, parkförvaltningen, Lund.
Löfvenhaft K., Björn C., Ihse M., 2002. Biotope patterns in urban areas: a conceptual model integrating biodiversity issues in spatial planning. *Landscape and Urban Planning*, 58: 223-240.
Lönngren G., Persson B., 1995. *Stadens biologiska mångfald*. SLU, Alnarp. (in Swedish)
Lövrie K., 2003. *The green space as a characterising element of townscape and urban design - objects, concepts and structure* [Dissertation]. Alnarp: Swedish University of Agricultural Sciences. (in Swedish with English abstract)
Malmö stad, 1984. *Grönplan för Malmö*. Malmö stad. (in Swedish)
Malmö stad, 2001. *Grönplan för Malmö*. Malmö stad. (in Swedish)
Manly B. F. J., 1994. *Multivariate Statistical Methods - A primer*. Chapman & Hall, London.
May R. M., 1994. Conceptual aspects of the quantification of the extent of biological diversity. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, 345: 13-20.
Ministry of the Environment, 2000. *Local investment programmes - a Swedish initiative for sustainable development*. Ministry of the Environment (Brochure), Stockholm.
Morrison D. F., 1990. *Multivariate Statistical Methods*. McGraw-Hill Publishing Company, New York.
Murphy D. D., 1988. Challenges to Biological Diversity in Urban Areas. In: E. O. Wilson (Editor), *Biodiversity*. National Academy Press, Washington, D.C. pp. 71-76.
Natur- och kulturvårdsprogram för Göteborg, 1979. Fastighetskontoret, Göteborgs kommun, Göteborg. (in Swedish)
Ohlsson K., 1997. *Hållbara planer - Att integrera Agenda 21 i den fysiska planeringen*. Naturskyddsföreningen, Stockholm. (in Swedish)
Oksanen M., 1997. The moral value of biodiversity. *Ambio*, 26(8): 541-545.
Oliver I., Beattie A. J., 1993. A Possible Method for the Rapid Assessment of Biodiversity. *Conservation Biology*, 7(3): 562-568.
Olwig K. R., 1983. Miljö, utvecklingen och naturlandskapet - några litterära perspektiv. In: J. Allwood, T. Frängsmyr and U. Svedin (Editors), *Naturen som symbol*. Liber, Stockholm. pp. 50-67. (in Swedish)
Olwig K. R., 1993a. "Views" on Nature. In: L. J. Lundgren (Editor), *Views Of Nature*. FRN, SNV, Stockholm. pp. 90-103.
Olwig K. R., 1993b. The Archetypical City and the Concept of Nature before the Industrial Revolution. In: T. M. Kristensen, S. E. Larsen, P. G. Møller and S. E. Petersen (Editors), *City and Nature - Changing Relations in Time and Space*. Odense University Press, Odense. pp. 97-115.
Olwig K. R., 1994. *The "natural" landscape and agricultural values*. Humanities Research Center - Odense University, Odense.
Osgood C. E., Suci G. J., Tannenbaum P. H., 1957. *The Measurement of Meaning*. University of Illinois Press, Urbana, Illinois.

Ottoson U., 1994. *Förslag till grönplan för Burlövs och Staffanstorps kommuner*. Burlöv: Burlövs miljö- och räddningsförvaltning. 22 pp. (in Swedish)
Pearson D. L., 1994. Selecting indicator taxa for the quantitative assessment of biodiversity. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, 345: 75-79.
Prance G. T., 1994. A comparison of the efficacy of higher taxa and species numbers in the assessment of biodiversity in the neotropics. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, 345: 89-99.
Randall A., 1994. Thinking about the value of biodiversity. In: K. C. Kim and R. D. Weaver (Editors), *Biodiversity and landscapes - A paradox of humanity*. Cambridge University Press, Cambridge. pp. 271-286.
Ricoeur P., 1984. Tale og skrift. In: P. Kemp (Editor), *Sprog, tale og skrift*. Aros, Århus.
Rådberg J., 1997. *Drömmen om atlantångaren - Utopier & myter i 1900-talets stadsbyggande*. Atlantis, Stockholm. (in Swedish)
Sagoff M., 1992. Has Nature a Good of Its Own? In: R. Costanza, B. G. Norton and B. Haskell (Editors), *Ecosystem Health*. Island Press, Washington D.C. pp. 57-71.
Sarkar S., Margules C., 2002. Operationalizing biodiversity for conservation planning. *Journal of Biosciences Bangalore*, 27 (4 Supplement 2): 299-308.
Schulze E.-D., Mooney H. A. (Editors), 1993. *Biodiversity and Ecosystem Function*. Springer-Verlag, Berlin.
Sigurd B., 1983. *Möt språkforskningen*. Liber, Lund.
Simberloff D., 1998. Flagships, umbrellas, and keystones: Is single-species management passe in the landscape era? *Biological Conservation*, 83(3): 247-257.
Simberloff D., Farr J. A., Cox J., Mehlman D. W., 1992. Movement Corridors: Conservation Bargains or Poor Investments? *Conservation Biology*, 6(4): 493-504.
Sorte G., 1982. *Visuellt urskiljbara egenskaper hos föremål i den byggda miljön (Visually discernible qualities of components in the built environment)* [Dissertation]. Lund: Department of Architecture, Theoretical and Applied Aesthetics, Lund University. (in Swedish with English abstract)
Stigsdotter U., Grahn P., 2002. What makes a Garden a Healing Garden? *Journal of Therapeutic Horticulture*, 13: 60-69.
Stigsdotter, U., Grahn, P. 2003. Experiencing a Garden: A Healing Garden for People Suffering from Burnout Diseases. *Journal of Therapeutic Horticulture*, 14 (in press).
Stockholms friytor, 1982. Miljö- och hälsovårdsförvaltningen, Stockholms kommun, Stockholm. (in Swedish)
Strawson P. F., 1975. Semantics, Logic, and Ontology. *Neue Hefte für Philosophie, Heft 8: Semantic und Ontologie*.
Sukopp H., Weiler S., 1988. Biotope Mapping and Nature Conservation Strategies in Urban Areas of the Federal Republic of Germany. *Landscape and Urban Planning*, 15: 39-58.
Svensson E., Göransson C., 1994. *Tio grönplaner. En analys av tio grönplaner från svenska kommuner utförda 1987-1991*. Institutionen för landskapsplanering, SLU, Alnarp. (in Swedish)
Terstad J., 1995. *Aktionsplan för biologisk mångfald*. Naturvårdsverket, Solna. (in Swedish)
Ulrich R. S., 1999. Effects of Gardens on Health Outcomes: Theory and Research. In: C. Cooper Marcus and M. Barnes (Editors), *Healing Gardens: Therapeutic benefits and design recommendations*. John Wiley & Sons, New York. pp. 27-86.
Umeå kommun, 1998. *Umeå grönstruktur: förslag juni 1998*. Umeå kommun, Umeå. (in Swedish)
UNEP, 1992. *Convention on biological diversity*. UNEP.
Wibeck V., 2000. *Fokusgrupper - Om fokuserade gruppintervjuer som undersökningsmetod*. Studentlitteratur, Lund. (in Swedish)
Williams P. H., Gaston K. J., 1994. Measuring more of biodiversity: can higher-taxon richness predict wholesale species richness? *Biological Conservation*, 67: 211-217.
Wilson E. O., 1984. *Biophilia: The Human Bond with Other Species*. Harvard University Press, Cambridge.
Wilson E. O., Peter F. M. (Editors), 1988. *Biodiversity*. National Academy Press, Washington, D.C.

Witting L., Loeschcke V., 1995. The optimization of biodiversity conservation. *Biological Conservation*, 71: 205-207.

Wohlwill J. F., 1983. The Concept of Nature: A Psychologist's View. In: I. Altman and J. F. Wohlwill (Editors), *Behavior and the Natural Environment*. Plenum Press, New York. pp. 5-37.

Zube E. H., Pitt D. G., Anderson T. W., 1974. *Perception and measurement of scenic resources in the southern Connecticut River Valley*. Institute for Man and His Environment, University of Massachusetts, Amherst.

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