Use of ecological information in urban planning

VESA YLI-PELKONEN

Department of Biological and Environmental Sciences
Faculty of Biosciences
University of Helsinki
Finland

Academic dissertation

To be presented, with permission of the Faculty of Biosciences of the University of Helsinki, for public criticism in the lecture hall 2 of Viikki Information Centre (Viikinkaari 11) on December 2nd 2006 at 12 o'clock noon.

Helsinki 2006

Author's address:
Department of Biological and Environmental Sciences
P.O. Box 65 (Viikinkaari 1)
FI-00014 University of Helsinki
Finland

E-mail: vesa.yli-pelkonen@helsinki.fi

Cover design: Espen Horne

ISBN 952-92-1103-1 (paperback)
ISBN 952-10-3443-2 (PDF)
http://ethesis.helsinki.fi

Yliopistopaino
Helsinki 2006

USE OF ECOLOGICAL INFORMATION IN URBAN PLANNING

VESA YLI-PELKONEN

This thesis is based on the following articles:

I Yli-Pelkonen, V. & Niemelä, J. (2005) Linking ecological and social systems in cities: urban planning in Finland as a case. Biodiversity and Conservation 14: 1947–1967. *Reprinted with kind permission of Springer Science and Business Media.*

II Yli-Pelkonen, V. & Niemelä, J. (2006) Use of ecological information in urban planning: Experiences from the Helsinki metropolitan area, Finland. Urban Ecosystems 9: 211–226. *Reprinted with kind permission of Springer Science and Business Media.*

III Yli-Pelkonen, V. & Kohl, J. (2005) The role of local ecological knowledge in sustainable urban planning: perspectives from Finland. Sustainability: Science, Practice, & Policy 1: 3–14.

IV Yli-Pelkonen, V. (2006) Importance of ecological information in the political decisionmaking of urban land use. Manuscript.

V Yli-Pelkonen, V., Pispa, K. & Helle, I. (2006) The role of stream ecosystems in urban planning: a case study from the stream Rekolanoja in Finland. Management of Environmental Quality: An International Journal 17: 673–688. *Reprinted with kind permission of Emerald Group Publishing Limited.*

These are referred to by their Roman numerals.

Contributions

	I	II	III	IV	V
Original idea	JN, VY-P	JN, VY-P	VY-P, JN	VY-P	VY-P
Methods	VY-P	VY-P, JN	VY-P, JK	VY-P	VY-P
Data collection	VY-P	VY-P	VY-P	VY-P	KP, VY-P
Data analyses	VY-P	VY-P	VY-P, JK	VY-P	VY-P, KP
Manuscript preparation	VY-P, JN	VY-P, JN	VY-P, JK	VY-P	VY-P, KP, IH

VY-P: Vesa Yli-Pelkonen, JN: Jari Niemelä, JK: Johanna Kohl, KP: Karoliina Pispa, IH: Inari Helle

Supervised by: Professor Jari Niemelä
University of Helsinki
Finland

Reviewed by: Associate Professor Marina Alberti
University of Washington
USA

Professor Markku Kuitunen
University of Jyväskylä
Finland

Examined by: Professor Thomas Elmqvist
Stockholm University
Sweden

Contents

Summary

VESA YLI-PELKONEN
Department of Biological and Environmental Sciences, P.O. Box 65, FI-00014 University of Helsinki, Finland

Introduction

1. Ecological consequences of urbanization and land-use change

About three-quarters of the human population in the industrialized countries lived in urban areas in 2003 and half of the world's human population will live in such areas by 2007 (United Nations 2004). Urban growth is mostly occurring in developing countries, where rural residents migrate to urban areas looking for better livelihood. In developed countries, for instance in Europe, different stages of urbanization (urbanization, suburbanization, disurbanization and re-urbanization) have been recognized, and are defined according to the combined growth and decline of the urban center and the urban fringe areas (Antrop 2004).

One of the environmental problems of urbanization is that when new residential areas are planned and built on former agricultural and green areas in the need of new housing and other infrastructure for the growing population, it usually leads to irreversible land-use change (Grimm *et al.* 2000). This has ecological consequences such as the loss and fragmentation of green areas, functional changes in terrestrial and aquatic ecosystems, and changes in habitat structure, species richness and species composition (Bowman and Marzluff 2001, Paul and Meyer 2001, Shochat *et al.* 2005). These consequences diminish essential ecosystem services (Box 1), which are regarded important for human populations living in urban areas (Bolund and Hunhammar 1999, Alberti and Marzluff 2004). All this results in a conflict situation; how to meet the needs of city growth, and at the same time consider the principles of sustainable development and especially conserve important green areas within and around built-up areas?

In this thesis, the focus is on Finnish urban development, especially on Helsinki Metropolitan Area, southern Finland. In Finland, urbanization is and will be most intense in southern Finland due to migration to growth centre cities, where also most of the economic growth occurs (Etelä-Suomen maakuntien liittouma 2005). The cities in the Helsinki Metropolitan Area are currently planning large new residential areas and supplementary development within existing residential areas to provide better living environment for the growing population and to maintain city economies growth (Helsingin kaupunkisuunnittelu 2005). Many of the new residential areas will be planned in green areas, although in the City of

Helsinki the majority of new housing will be built in old and soon to be disbanded industrial and port areas.

The concept of a dense city structure as a part of sustainable development (White 2001) urges supplementary development, which in part threatens urban ecosystems, such as green areas encapsulated within the residential areas and the ecological networks of cities. Thus, one of the main challenges in city planning appears to be which green areas in a city are the most valuable to conserve, and on what basis.

If the new development is to be planned in green areas, planners must carefully examine the boundaries for the new plan (Land Use and Building Act 1999), and determine those parts of the green areas that are conservationally so valuable that they cannot be threatened by new development. Species and biotope inventories and biodiversity impact assessments form part of the ecological information that is used in determining the conservation value of the area (Söderman 2003). Ecological information should in this way be transmitted to a plan proposal, but actions of the political decisionmakers of cities eventually determine the importance of ecological information in land-use decisions (Kansanen 2004).

Box 1. Glossary

Conservation values: Nature conservation values related to species, biotopes and ecosystems.
Ecological information: Information from species and biotope inventories, and biodiversity impact assessments.
Ecosystem services: Benefits human populations derive from ecosystems, *e.g.* air filtration, micro-climate regulation, noise reduction, rainwater drainage, sewage treatment, and recreational and cultural values.
Green area: An area including *e.g.* urban forest or park, with or without a recreational or conservational status.
Metropolitan area: Includes not only the urban area, but also satellite cities and intervening rural land that are socio-economically connected to the urban core city.
Resilience: The amount of change the system can undergo and still retain the same controls on function and structure.
Rural area: Sparsely populated residential and agricultural areas away from the influence of large urban areas.
Urban area: An area with an increased density of human-built structures, such as industrial, business and residential districts, in comparison to the areas surrounding it, frequently called a city or town. Different countries have varying definitions for urban areas in terms of human population density and surface cover. Depending on the studied issue, it has to be decided what exactly is considered as an urban area.
Urban planning: A discipline of land-use planning, which deals with the physical, social, and economic development of metropolitan regions, municipalities and neighborhoods.
Urbanization: An expansion of an existing population in urban area, can illustrate a level of urban population relative to total population of the area, or the rate at which the urban proportion is increasing.

2. Dynamics of urban ecological and social systems

The intense interaction between urban ecological and human-social systems has resulted in that researchers have started to understand the importance of considering human-social systems when studying urban ecosystems (Pickett *et al.* 1997, Grimm *et al.* 2000, Pickett *et al.* 2001, Alberti *et al.* 2003, Kaye *et al.* 2006, Niemelä *et al.* 2006). Recent studies on social-ecological systems as complex systems in the changing world (Berkes and Folke 1998, Berkes *et al.* 2003) have also provided new frameworks for studying and understanding interactions

between natural and social systems, and addressing possibilities to build capacity to adapt to change in an urbanizing world.

The concept of resilient social-ecological systems, which can buffer a great deal of change or disturbance (Berkes *et al.* 2003), has recently been applied to urban ecosystems (Alberti and Marzluff 2004, Pickett *et al.* 2004, Elmqvist *et al.* 2004). Alberti and Marzluff (2004) proposed that resilience in urban ecosystems is a function of the patterns of human actions and natural habitats, and Berkes *et al.* (2003) stated that a resilient social-ecological system is synonymous with ecological, economic, and social sustainability. The complex task of building a compact, sustainable city while simultaneously conserving high quality green areas within and around built environment, such as in the Helsinki Metropolitan Area, provides a challenge for urban planning.

In this thesis, I use a framework developed by Grimm *et al.* (2000) for studying and understanding the complex dynamics between ecological and social systems in the land-use change driven by the social patterns and processes and the environmental context, focusing especially on the role and use of ecological information in urban planning and decisionmaking process.

3. Ecological information

As meant in this study, ecological information consists mainly of inventories of species and biotopes, and biodiversity impact assessments. Such information should include detailed data about species richness, species composition and population sizes, occurrence of valuable biotopes, biodiversity, integration among urban habitat patches, function of ecological networks, and predicted impacts of planned construction on the natural environment (*e.g.* Niemelä 1999).

Moreover, ecological knowledge coming from local residents and nature enthusiasts can supplement scientific ecological research information for decisionmaking (Olsson and Folke 2001, Barthel *et al.* 2005). However, as Kansanen (2004) noted, a decisionmaker does not usually make a clear separation between the various types of ecological information, whether it is a study report based on inventory or monitoring data, or such scientific research data that fulfils strict scientific criteria.

Aims of the thesis

In my thesis, I study the use of ecological information in the urban land-use planning process and related political decisionmaking process in the Helsinki Metropolitan Area, southern Finland. More specifically, my thesis addresses the following interlinked questions (Roman numbers in parenthesis refer to the articles in the thesis, see list of articles on page 3):

- What kind of approaches can be used for linking ecological and human-social systems for sustainable urban development, and what kind of a theoretical and conceptual framework can be elaborated for studying such linkages in the urban land-use planning process, especially in the Finnish setting (**I**)?
- What factors determine the importance and effectiveness of incorporation of ecological information into the urban land-use planning process in the study area, and what kind of challenges are related to the use of ecological information by urban planners (**II**)?
- Is Local Ecological Knowledge considered important in urban land-use planning in the study area, and in what ways Local Ecological Knowledge is obtained and used by urban planners (**III**)?
- What factors determine the importance and consideration of urban green areas and related ecological information in political land-use decisionmaking (**IV**)?
- As a case study illustrating the above considerations, I examine what is the importance of urban stream ecosystems in the land-use planning from the perspective of urban ecology, human health and social well-being, and how do the dynamics between ecological and social systems reflect on land-use change around the urban stream

ecosystem in the Rekolanoja stream in Vantaa (**V**).

Material and methods

All the empirical studies in this thesis were done in the Helsinki Metropolitan Area in Finland (Figure 1), which consists of cities of Helsinki, Espoo, Vantaa and Kauniainen with a 765-km^2 and 985 600 inhabitants. This area (also called the Capital area) covers just 0.2 per cent of Finland's surface area, but about 18.5 per cent of the country's population lives in the area (Helsinki Metropolitan Area Council 2006a). Despite the intensity of land use by Finnish standards, the Capital area also has a great deal of recreational areas and green spaces. Helsinki is the capital of Finland, with a 186-km² land area and 560 000 inhabitants (Helsinki Metropolitan Area Council 2006a). The current Master Plan of 2002 has made provision for population of 600 000 inhabitants in Helsinki by the year 2020 (Kansanen 2004), and according to the Helsinki Metropolitan Area Vision 2025, there will be 1 170 000 inhabitants in the Capital area by 2025 (Helsinki Metropolitan Area Council 2006b). The important variables related to this study from the Metropolitan Area are presented in Table 1.

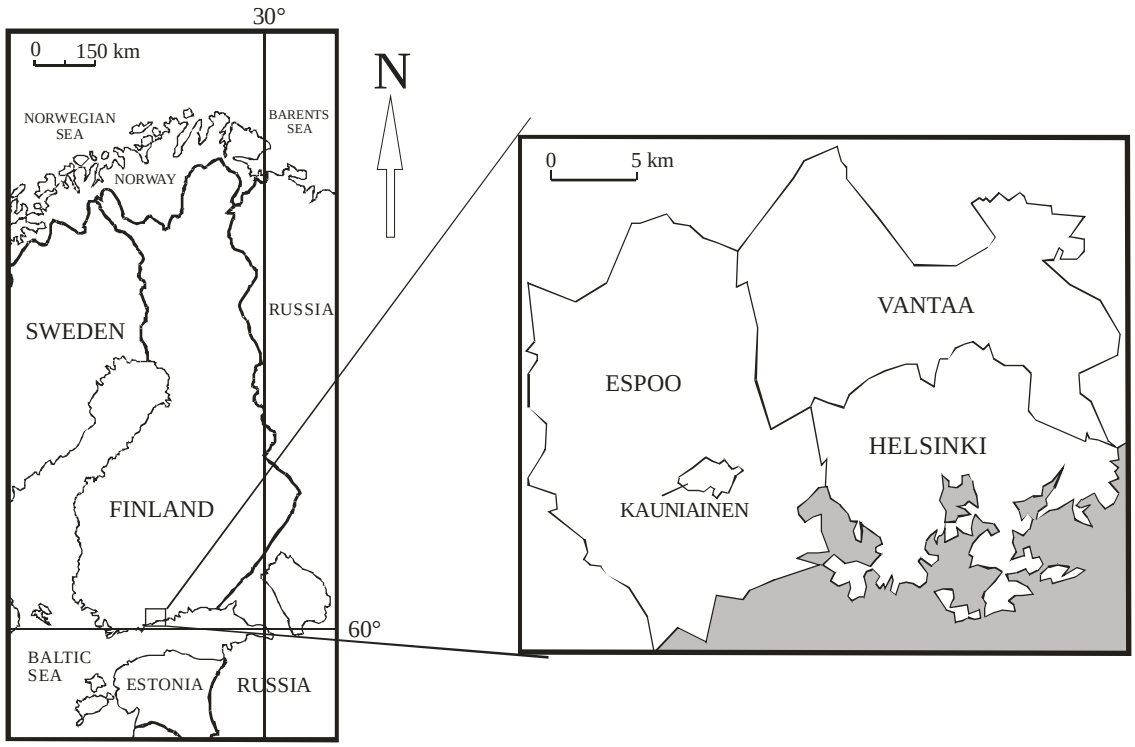

Figure 1. Helsinki Metropolitan Area in Finland (cities of Helsinki, Espoo, Vantaa and Kauniainen).

Table 1. Variables from the cities of the Helsinki Metropolitan Area (HMA) (Source: web pages of the cities).

	Helsinki	Espoo	Vantaa	Kauniainen	HMA
Population	560 000	231 700	185 400	8 500	985 600
Land area (km^2)	186	330	243	6	765
Population density / km^2	3 010	702	763	1 416	1 288
City Council members	85	67	67	35	
City Planning Board members	10	14	17	10	
City planning personnel	276	210	60	20	

The main methods in this thesis were qualitative research methods: reviewing existing literature (**I**) and ecological inventory reports (**V**), conducting semi-structured interviews (**II**, **III**, **IV**, **V**), a resident inquiry (**V**), and collecting written narratives (**V**).

Semistructured interviews were conducted because they may exhibit issues that are difficult to discover using other methods such as questionnaires (Flick 1998) and because the direct verbal and nonverbal interaction allowed the interviewer to target questions in the interview situation (Hirsjärvi and Hurme 2000). The interviewees were selected with the snowball sampling and saturation methods (Berg 2001) (**II**, **III**, **V**) or by determining a suitable group of interviewees based on the case study situation (**IV**).

The interviewees were given an outline of the questions prior to the interviews to prepare themselves. The interviews were usually carried out at each interviewee's workplace or home. The interviews were recorded and transcribed to text. The interview data were analyzed using qualitative content analysis (Flick 1998, Patton 2002). The data transcribed were classified to separate thematic files according to the research questions of each study and answers to the related interview questions. The most relevant sections of the thematic files were then condensed to text parts that were further analyzed to answer the research questions (Kvale 1996). The language used in all the interviews was Finnish, and the interview excerpts presented in the chapters are translations into English.

In addition to the interviews a resident inquiry and a writing contest to collect written narratives were used (**V**). A semi-structured questionnaire form was used as a resident inquiry to gather data from a local resident association, and a writing contest related to the Rekolanoja case was announced to gather knowledge, memories and expectations from the residents about the stream ecosystem. Both were analyzed using qualitative content analysis (Flick 1998).

The conclusions of the thesis are based on the results from the data collected. Although the results of these case studies may point to a general pattern of thought, the conclusions in the chapters should not be generalized (Berg 2001), but are meant to function as examples and suggestions concerning the state of affairs related to the subject matters of the thesis.

Main results and discussion

1. Ecological-social system linkages in urban land-use change

At first, the literature on ecological-social systems linkages, especially related to urban land-use planning, was reviewed. Based on the review, a theoretical and conceptual framework for the research on Finnish urban setting was adapted (**I**). The framework illustrates how the ecological and human social systems are linked in the land-use change of the study area of this thesis (Figure 2). The framework also helps to integrate the chapters in this thesis. Furthermore, the framework illustrates the factors affecting the use of ecological information in urban land-use planning and decisionmaking process.

According to my results, two variables, environmental context, and social patterns and processes, affect the planning and decisionmaking, and thus the land-use change (Figure 2). In the environmental context, the land-use decisions (building new housing areas and infrastructure) in the study area are constrained by biogeophysical settings and drivers (**I**), and especially the availability of vacant and suitable construction land. Furthermore, restrictions in building in green areas constrain land use (Nature Conservation Act 1996, Land Use and Building Act 1999).

Ecological information related to environmental context is used in the urban land-use planning (**II**) and related political decisionmaking (**IV**). Such information can include ecological research information (**II**) and Local Ecological Knowledge (**III**). In the context of social patterns and processes,

certain societal drivers, such as needs for new housing for remunerative families, affect the urban planning and decisionmaking process (**IV**).

Land-use planning process in the study area consists of master planning, which is done roughly once in every ten years in Helsinki, for instance, and is a general plan for the entire city (Helsingin kaupunki 2006). Detailed planning (also called zoning or town-planning) functions as a more elaborate planning for construction and development of a specific area within the master plan (**II**). Master and detailed plans are to be approved by the political decisionmakers in the City Planning Board, the City Board and the City Council (**IV**).

The actual implementation of the development plans, in this case, leads to land-use change (Figure 2). This in turn may lead to changes in various ecological patterns and processes, of which especially the ecosystem and landscape structure, species abundance, distribution and interactions, and disturbance were addressed on in this thesis (**V**).

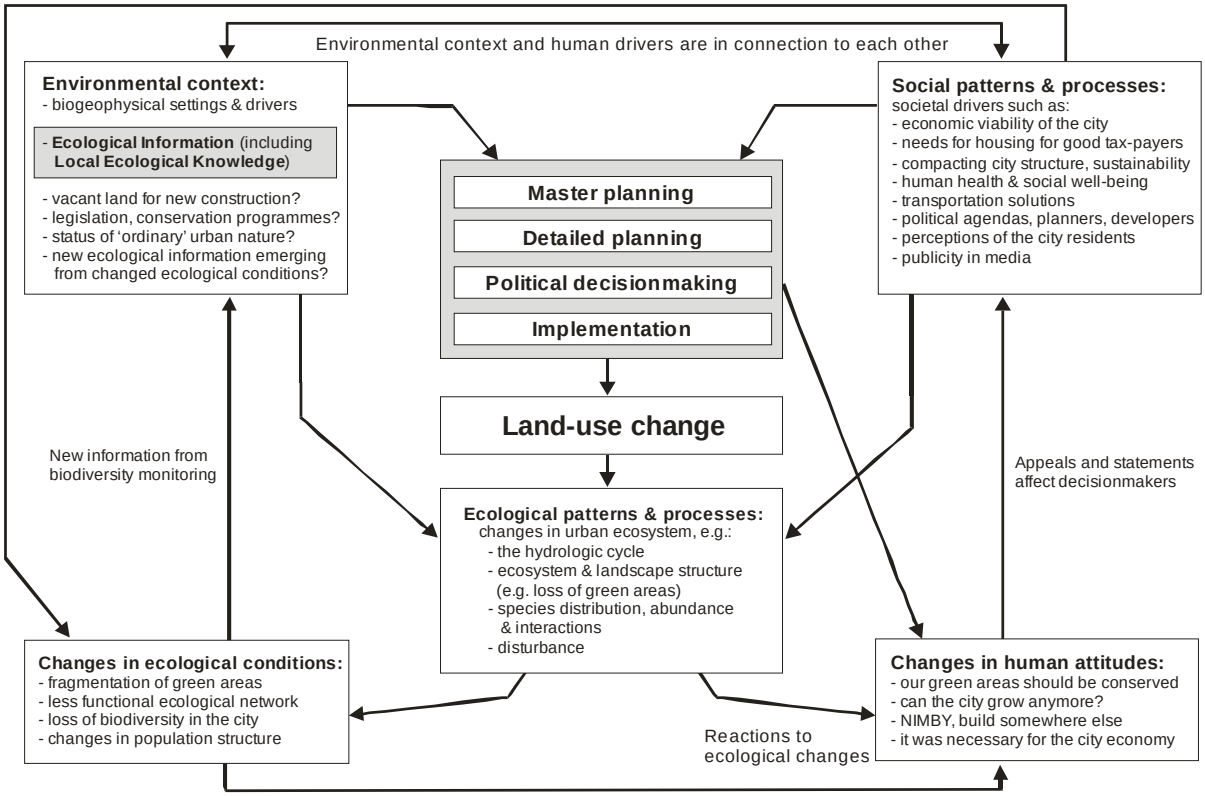

Figure 2. A conceptual framework adapted for illustrating the interactions between environmental, societal, planning and decisionmaking variables, drivers and feedbacks in the land-use change in the thesis' study area (adapted from Grimm *et al.* (2000) and Yli-Pelkonen and Niemelä (2005)).

The two final variables in Figure 2, changes in ecological conditions and changes in human attitudes, result from the preceding land-use change and changes in ecological patterns and processes (**IV**, **V**). As Grimm *et al.* (2000) suggested, changes in ecological conditions exhibit the next time step of ecological patterns and processes. Changes in human attitudes exhibit the experience-based human reactions to either the changes in ecological patterns and processes, subsequent changes in ecological conditions, or reactions to the planning and decisionmaking process

in the time step before the actual land-use change.

The interactions and feedbacks in Figure 2 reflect temporal dynamics between the variables. For instance, depending on how the land-use change is perceived, the feedback can result in altered land-use decisions in the next planning round. If the changes in ecological conditions are properly monitored and, thus, new ecological information is produced (Söderman 2003), this should feed back to the environmental context. Such monitoring of the ecological changes provides potential for adaptive learning (Berkes and Folke 1998) and maintenance of resilience of the ecological-social system (Alberti and Marzluff 2004). Moreover, the changed ecological conditions, or patterns and processes, may result in direct responses (*e.g.* restorative actions) from the society (Edwards *et al.* 1997). Lastly, the environmental context has an effect on ecological patterns and processes regardless of human-induced land-use changes (Figure 2).

2. Use of ecological information in urban planning and decisionmaking

Although the Finnish legislation determines the requirements of ecological information in land-use planning, the strategic importance of the plan area and personal attitudes of planners and decisionmakers often determine how much weight is eventually put on the use of ecological information and conservation values in the plan area (**II**, **IV**). The planners and ecologists interviewed considered ecological information important in urban planning for identifying and conserving valuable urban nature and biodiversity, mitigating negative environmental impacts of construction, and for enabling nature-related experiences and services for urban residents. The challenges for the use of the ecological information in urban planning include insufficiency, fragmented nature and lack of adequacy of information, and problems with the interpretation and presentation of information (**I**, **II**).

To provide more comprehensive ecological information from urbanizing areas in Finland there should be more coordinated efforts to produce research information that planners need (see Dale *et al.* 2000). Moreover, ecologists should be more active in the process in providing ecological insights for plans (also suggested by Broberg (2003)), a proper biodiversity valuation method should be developed (*e.g.* Mahon and Miller 2003), more research on the function of ecological corridors should be conducted (Niemelä 2001), and biodiversity monitoring (Niemelä 2000) of implemented planning projects should be developed.

Even if urban planners successfully incorporate the available ecological information into land-use plans, the final decision is still up to political decisionmakers of a city (**IV**, **V**). Ecological information on green areas becomes more important for political decisionmakers if there are protected elements connected to a plan area, if there are numerous contacts and appeals from plan participants, if the plan project gets lot of attention in media, or if a decisionmaker pays more attention on the issue due to his or her personal values, which was also noted by Willberg (1995) and Kansanen (2004).

The studied decisionmaking system resembles a mix of rational and incremental decisionmaking models (**V**), as presented by Weston (2000). This is because on the one hand the Finnish land-use plans and decisions are based on rational procedure of assessing information, including ecological, and on the other hand aims of land-use planning are largely political and the assessment of the importance ecological information in planning is nevertheless based on value judgements.

The decisionmakers interviewed were satisfied with how ecological information is presented. However, issues related to the validity of ecological information and lack of ecological monitoring information of implemented planning projects, were raised. This study showed that rare or endangered

species and biotopes, and related ecological information receive priority in the urban planning process and usually pass through the decisionmaking system, but those parts of green areas that are less important in conservational sense, are more easily ignored in the planning process. However, to urban dwellers the importance of green areas is not determined only by the specific conservation values, but the mere existence of ordinary forest or park, providing the essential ecosystem services, is important, as has been suggested also by *e.g.* Chiesura (2004). Balancing the weight of recreational and cultural values appears to be one of the most difficult tasks for decisionmakers to handle.

3. Potential of using Local Ecological Knowledge as a part of ecological information

In addition to ecological research information, Local Ecological Knowledge (LEK) can be a source of ecological information for planners (**III**). In the Helsinki Metropolitan Area, it was found that local nature enthusiasts and residents have Local Ecological Knowledge. Barthel (2006) noted that it has been suggested that LEK is generally low among urban residents, but active participation in land management and recreational use can increase the level of LEK, which the results of my thesis also indicate. According to my results, planners can obtain LEK in several ways, most notably through networks of knowledgeable key informants and local nature associations.

Based on the findings, the individuals who possess LEK can be presented as five different types – ranging from less knowledgeable local residents to ecological specialists (**III**). LEK from all these types can be useful to planners, although LEK from experienced nature enthusiasts and specialists was regarded as more precise and easier to interpret. All the types of individuals possess elements of LEK that can be sorted into species and biotope observations, single nature objects valuable to individuals, and opinions and aesthetic values.

Considering LEK in urban planning was found to be important because it can complement scientific ecological information and indicate places important to locals. Recent examples of using citizen science in urban bird studies (McCaffrey 2005, Lepczyk 2005) support the idea of harnessing LEK of nature enthusiasts for research purposes, and thus using LEK as part of ecological information for land-use planning and management. Some of the challenges of using LEK in urban planning include collecting it through participatory planning processes, distinguishing it from other information, valuing subjective knowledge, and empowering planning officials to use LEK. To enhance communication between stakeholders, social scientists should be integrated in the planning process, which has also been suggested by Huntington (2000) and Sairinen and Kohl (2004).

Furthermore, technical improvements, such as registers of key informants, more efficient use of nature associations' knowledge, and GIS-based public nature information websites would be useful in applying LEK in urban planning. In fact, the recently launched Finnish website Hatikka (Luonnontieteellinen keskusmuseo 2006), where nature enthusiasts can report their species observations, has rapidly become very popular, and could be one way to form a data bank for observations related to Local Ecological Knowledge.

4. Importance of small stream ecosystems in urban planning

In the last chapter of this thesis the importance of urban stream ecosystems from the perspective of urban ecology, human health and social well-being in the context of urban planning was studied (**V**). The focus was on the Rekolanoja stream in the City of Vantaa (Figure 1). Urban stream ecosystems have often been neglected in land-use planning, and the biological integrity of urban streams has decreased considerably

due to urbanization (Walton *et al.* 2006). Nevertheless, as Tjallingii (2005) suggested, small streams are increasingly relevant in the green structure of many European cities as many of the streams and stream valleys are transformed into greenways.

The results from the Rekolanoja case show that intense management of the streamside vegetation and the treatment of the stream channel in construction projects (see also **II**) throughout the land-use history have decreased species richness and diminished valuable streamside biotopes. However, the stream corridor can function as an important recreational and educational element within the local green space network and thereby become a symbol of local identity.

The Rekolanoja case indicates that planners and residents see the value of such an aquatic element as increasingly important for the local health and social values, such as recreation and stress relief. Furthermore, since it has been suggested that urban residents are becoming increasingly disconnected from nature (Miller 2005, but see also Mehtälä and Vuorisalo (2006)), urban stream ecosystems could give local urban residents chances for interactions with the natural world (McDaniel and Alley 2005, Meyer *et al.* 2005).

The study suggests that planners are increasingly valuing urban stream ecosystems in land-use plans (Vantaan kaupunki 2005), but it remains to be seen if the value of the stream ecosystems will increase in the thinking of local political decisionmakers. At least, in the Helsinki region, recent urban stream studies (Niemelä *et al.* 2004, Ruth 2004, Helle 2005, Tarvainen *et al.* 2005) and favorable media publicity (*e.g.* Mutanen 2005) indicate about an increasing level of positive interest in urban streams.

Conclusions

In this thesis I have demonstrated that ecological information is considered as an increasingly important part of the basic information used in urban land-use planning process and political decisionmaking in the Helsinki Metropolitan Area, in Finland. The basic determinants for this are the recent changes in environmental legislation, but also the increasing appreciation of green areas and their conservation values by planners, decisionmakers and citizens.

In the studied cities the ecological inventories and impact assessments are today done relatively thoroughly, but the lack of resources for such surveys in smaller municipalities may hamper the availability and effective use of ecological information, which in turn may result in losing important green areas for urban development. Political decisionmakers face a difficult task in trying to maintain the economic viability of cities by promoting new housing and infrastructure for better tax-payer residents, and simultaneously trying to follow the aims of sustainable development and contrasting wishes of different interest groups.

If political decisionmakers wish to build the city on the principles of sustainable development and maintain the ecological-social resilience of the city, a considerable amount of high quality green areas forming a functional ecological network within the city and surrounding areas should be conserved. This will also help in maintaining biodiversity in the city. Recent studies of urban green space corridors, greenways and green structures have demonstrated their great value for urban species and biodiversity conservation (Mörtberg and Wallentinus 2000, Werquin *et al.* 2005, Bryant 2006). Related work in Finland, which examined ecological networks and animal movements in Finnish cities, should provide reference material for urban land-use planning (Väre and Krisp 2005). The results of such studies should be incorporated into regional and municipal land-use planning processes in order to maintain functional biodiversity in urban areas. Moreover, urban stream ecosystems often form natural corridor systems, which should be taken better into account in green structures of cities.

Conservation and co-management of green areas may increase community spirit and networking amongst the urban residents (Barthel 2006), who may also provide local ecological knowledge in addition to ecological research information used in urban planning. Such development could increase the appreciation and knowledge on urban green areas (and potentially on nature in general) and help maintaining biologically diverse urban environment and the associated ecosystem services.

In other European countries outside the Nordic countries, the planning system and other land-use circumstances are often quite different from the Finnish settings and comparing the results and conclusion of this thesis should be made with caution. Nevertheless, same kind of challenges in relation to the conservation of green areas within and around built-up areas, use of ecological information and local ecological knowledge, and their evaluation in the decisionmaking process, determined both by environmental and social contexts, are found throughout the urbanizing world (*e.g.* Turner *et al.* 2004). This PhD thesis provides important and up-to-date perspectives on the subject matter from the Helsinki Metropolitan Area case. It includes potential implications for ecologists, planners, decisionmakers, urban residents, and other stakeholders in urban growth centers both in Finland and elsewhere, may guide the urban development into a more sustainable direction, and may thus help in building resilient urban social-ecological systems.

Acknowledgements

In October 2001, several months after my MSc graduation, I was living in London, trying to look for an interesting job from the field of biology or environmental sciences. Then I noticed an e-mail announcement from Professor Jari Niemelä, where he looked for a PhD student for a new interdisciplinary research project, funded by the recently established Helsinki University Environmental Research Centre. Although my initial plan was to work in the UK for a while, the ECOLINK project, where the idea was to study ecological and social systems linkages in sustainable urban planning, appeared very interesting and also a kind of research approach I had not encountered before. I decided to apply for the post, and while London was getting darker, colder and busier as ever, it sounded like a good idea to pack my things again and head back home in Helsinki, start my doctoral studies and work as a researcher. Things happened fast and I was chosen for the post, starting in mid-December 2001 in Helsinki.

This also started research collaboration with my supervisor Jari Niemelä, who had composed a basic set of ideas and a foundation for the PhD project, but who also from the very beginning gave me an opportunity to proceed with my own ideas in this research. I want to thank him for all the guidance. Despite of all the other work commitments he has always found the time for meetings with me and has advised and motivated me with my research project when ever needed. Jari has also hooked me up with several domestic and international research contacts which have been very useful in this project and I think also in the future.

I acknowledge the members of the ECOLINK steering group (Harry Schulman, Pekka Kansanen, Peter Clark and Johanna Kohl) for comments, discussions and guidance during the project, and especially Johanna Kohl as a co-author of Chapter **III** in my thesis. I also want to acknowledge Karoliina Pispa and Inari Helle, the co-authors of Chapter **V** in my thesis.

I thank Professor Markku Kuitunen and Associate Professor Marina Alberti for kindly finding the time to review my thesis. I thank Professor Thomas Elmqvist for accepting a proposal to arrive at Helsinki and act as an opponent at my public defence. I thank Professor Ilmo Massa for acting as Kustos.

The data for my thesis has been collected mainly by interviews in the Helsinki Metropolitan Area and I would like to thank all the interviewees who found the time from their busy schedules to meet me by the recorder. I thank the people at the Environmental Centre of the City of Vantaa, Vantaa City Planning Department (especially Laura Muukka for illustrations) and the Rekolanoja Work Group. I also want to thank Matti Eronen from the Helsinki City Planning Department for help.

Thanks to all the colleagues at the Department of Systems Ecology in Stockholm University, especially Stephan, Henrik, Sara, Erik and Beatrice for good discussions and constructive comments. Thanks to Mark McDonnell from the University of Melbourne for constructive comments on the frameworks. Also thanks to colleagues Maija Sipilä and Professor Liisa Tyrväinen in the GREENDECISION project for fruitful collaboration. Furthermore, I greatly acknowledge Espen Horne from Bergen for the cover design of this thesis book.

Thanks to our Urban Ecology Research Group for collaboration and lively discussions. Especially I want to thank my former and present roommates Inari, Stephen, Susanna, Katja M., Salla, Jarmo, Meeri, Anna, Katja B. and (almost roommate) Johan.

I want to thank Ilkka Teräs for help and patience, as well as all the 4th floor office staff for making the practical things happen. I would like to acknowledge Hannu Pietiäinen for guidance and supporting comments since the time of *pro gradu* phase, thanks! Furthemore, great many thanks to Heikki Hirvonen for stimulating research guidance and supporting words prior to my PhD work.

I also want to thank the whole department, the former and present PhD students, colleagues and friends in all the research groups for the excellent atmosphere to work at.

I want to thank all the friends from the fields of sports and music where I have spent most of my leisure time sweating, relaxing and recharging batteries for the research work. The warmest commendation to the whole Wahoo! crew for the mightiest times. A special thanks to Sampsa for being a friend since the late 1970's – there have been good times, scientific and non-scientific discussions, and laughs throughout the years, mate! Also special thanks to my cousin Tero for a long time friendship and shared enthusiasm in sports of all kinds since we were kids.

Suurkiitokset äiti ja isä kaikesta tuesta, kärsivällisyydestä ja rohkaisusta vuosien varrella – on todella ilo että minulla on noin mahtavat vanhemmat! Many thanks to my brother Jukka for friendship, support and practical arrangements of the party, as well to his wife Nanna and the kids Oskari, Olivia and Sylvia. Also many thanks to my sister Taina and to her husband Kimmo and their kids Iiris, Sonja, Jesse and Jimi for discussions and being there.

This research was funded by the Helsinki University Environmental Research Centre (HERC), Academy of Finland (Grant no. 110388 to J.Niemelä), Jenny and Antti Wihuri Fund, Ella and Georg Ehrnrooth Foundation, The City of Helsinki, and the Chancellor of the University of Helsinki.

References

Alberti, M., Marzluff, J.M., Shulenberger, E., Bradley, G., Ryan, C. and Zumbrunnen, C. (2003) Integrating humans into ecology: opportunities and challenges for studying urban ecosystems. BioScience **53**: 1169–1179.

Alberti, M. and Marzluff, J.M. (2004) Ecological resilience in urban ecosystems: linking urban patterns to human and ecological functions. Urban Ecosystems **7**: 241–265.

Antrop, M. (2004) Landscape change and the urbanization process in Europe. Landscape and Urban Planning **67**: 9–26.

Barthel, S., J. Colding, T. Elmqvist, and C. Folke (2005) History and local management of a biodiversity-rich, urban cultural landscape. Ecology and Society **10**(2):10. Read online September 2006. http://www.ecologyandsociety.org/vol10/iss2/art10/.

Barthel, S. (2006) Legacies and stewardship groups in ecosystem management. Licentiate Thesis 2006:3 in Natural resource management. Department of Systems Ecology, Stockholm University.

Berg, B.L. (2001) Qualitative Research Methods for the Social Sciences, fourth edition. Allyn and Bacon, Needham Heights.

Berkes F. and Folke C. (eds) (1998) Linking social and ecological systems: management practices and social mechanisms for building resilience. Cambridge University Press, Cambridge.

Berkes F., Colding J. and Folke C. (eds) (2003) Navigating social-ecological systems: Building resilience for complexity and change. Cambridge University Press, Cambridge.

Bolund, P. and Hunhammar, S. (1999) Ecosystem services in urban areas. Ecological Economics **29**: 293–301.

Bowman, R. and Marzluff, J.M. (2001) Integrating avian ecology into emerging paradigms in urban ecology. In: Marzluff, J.M., Bowman, R. and Donnelly, R. (eds), Avian Ecology and Conservation in and Urbanizing World. Kluwer Academic Publishers, Massachusetts, USA, pp. 569–578.

Broberg, L. (2003) Conserving ecosystems locally: a role for ecologists in land-use planning. BioScience **53**: 670–673.

Bryant, M.M. (2006) Urban landscape conservation and the role of ecological greenways at local and metropolitan scales. Landscape and Urban Planning **76**: 23–44.

Chiesura, A. (2004) The role of urban parks for the sustainable city. Landscape and Urban Planning **68**: 129–138.

Dale, V.H., Brown, S., Haeuber, R.A., Hobbs, N.T., Huntly, N., Naiman, R.J., Riebsame, W.E., Turner, M.G. and Valone, T.J. (2000) Ecological principles and guidelines for managing the use of land. Ecological Applications **10**: 639–670.

Edwards, P.J., Webb, N.R., Urbanska, K.M. and Bornkamm, R. (1997) Restoration ecology: science, technology and society. In: Urbanska, K.M., Webb, N.R. and Edwards, P.J. (eds), Restoration ecology and sustainable development. Cambridge University Press, pp. 381–390.

Elmqvist, T., Colding, J., Barthel, S., Borgström, S., Duit, A., Lundberg, J., Andersson, E., Ahrné, K., Ernstson, H., Folke, C. and Bengtsson, J. (2004) The dynamics of social-ecological systems in urban landscapes: Stockholm and the National Urban Park, Sweden. Annals of the New York Academy of Sciences **1023**: 308–322.

Etelä-Suomen maakuntien liittouma (2005) Regional structure 2030. http://www.etela-suomi.fi/english/aluerakenne_2030.htm. Read online September 2006.

Flick, U. (1998) An introduction to qualitative research. Sage, London.

Grimm, N.B., Grove, J.M., Pickett, S.T.A. and Redman, C.L. (2000) Integrated approaches to long-term studies of urban ecological systems. BioScience **50**: 571–584.

Helle, I. (2005) The benthic macro-invertebrate communities in the urbanized brooks in Helsinki. MSc thesis. Department of Biological and Environmental Sciences, University of Helsinki, Finland (in Finnish with an abstract in English). 63 pages.

Helsingin kaupunki (2006) Yleiskaava 2002. http://www.hel.fi/wps/portal/Kaupunkisuunnitteluvirasto/Artikkeli?WCM_GLOBAL_CONTEXT=/fi/Kaupunkisuunnitteluvirasto/Kaavoitus/Yleiskaavoitus/Yleiskava+2002. Read online May 2006 (in Finnish).

Helsingin kaupunkisuunnittelu (2005) Kaavoituskatsaus 2005 (Planning report 2005). Uusi Kivipaino Oy, Helsinki, Finland (in Finnish and Swedish).

Helsinki Metropolitan Area Council (2006a) Facts about the Metropolitan Area. http://www.ytv.fi/ENG/facts/regional_information/ytv_area/frontpage.htm. Read online September 2006.

Helsinki Metropolitan Area Council (2006b) Helsinki Metropolitan Area Vision 2025. http://www.ytv.fi/ENG/future/vision/frontpage.htm. Read online September 2006.

Hirsjärvi, S. and Hurme, H. (2000) Tutkimushaastattelu – Teemahaastattelun teoria ja käytäntö (Research interview – Theory and practice). Helsinki University Press, Helsinki, Finland (in Finnish).

Huntington, H.P. (2000) Using traditional ecological knowledge in science: Methods and applications. Ecological Applications **10**: 1270–1274.

Kansanen, P.H. (2004) The role of scientific environmental knowledge in decision-making in the City of Helsinki, Finland. Boreal Environment Research **9**: 543–549.

Kaye, J.P., Groffman, P.M., Grimm, N.B., Baker, L.A. and Pouyat, R.V. (2006) A distinct urban biogeochemistry? Trends in Ecology and Evolution **21**: 192–199.

Kvale, S. (1996) Interviews: an Introduction to Qualitative Research Interviewing. Sage, Thousand Oaks.

Land Use and Building Act (1999), (in Finnish). Read online September 2006. http://www.finlex.fi/linkit/smur/19990132.

Lepczyk, C.A. (2005) Integrating published data and citizen science to describe bird diversity across a landscape. Journal of Applied Ecology **42**: 672–677.

Luonnontieteellinen keskusmuseo (2006) Havaintopäiväkirja (Observation diary). http://www.hatikka.fi. Read online September 2006 (in Finnish).

Mahon, J.R. and Miller, R.W. (2003) Identifying high-value greenspace prior

to land development. Journal of Arboriculture **29**: 25–33.

McCaffrey, R.E. (2005) Using citizen science in urban bird studies. Urban Habitats **3**: 1–14.

McDaniel, J. and Alley, K.D. (2005) Connecting local environmental knowledge and land use practices: A human ecosystem approach to urbanization in West Georgia. Urban Ecosystems **8**: 23–38.

Mehtälä, J. and Vuorisalo, T. (2006) Changing values of urban biodiversity: a reply to Miller. Trends in Ecology and Evolution **21**: 116–117.

Meyer, J.L., Paul, M.J. and Taulbee, W.K. (2005) Stream ecosystem function in urbanizing landscapes. Journal of North American Benthological Society **24**: 602–612.

Miller, J.R. (2005) Biodiversity conservation and the extinction of experience. Trends in Ecology and Evolution **20**: 430–434.

Mutanen, A. (2005) Hyvät, pahat ja rumat ojat (Good, bad and ugly brooks). Helsingin Sanomat 7.6.2005, p. D1. Helsinki (in Finnish).

Mörtberg, U. and Wallentinus, H-G. (2000) Red-listed forest bird species in an urban environment – assessment of green space corridors. Landscape and Urban Planning **50**: 215–226.

Nature Conservation Act (1996), (in Finnish). Read online September 2006. http://www.finlex.fi/fi/laki/ajantasa/1996/19961096.

Niemelä, J. (1999) Ecology and urban planning. Biodiversity and Conservation **8**: 119–131.

Niemelä J. (2000) Biodiversity monitoring for decision-making. Annales Zoologici Fennici **37**: 307–317.

Niemelä, J. (2001) The utility of movement corridors in forested landscapes. Scandinavian Journal of Forest Research Supplementum **3**: 70–78.

Niemelä, J., Helle, I. and Jormola, J. (2004) Purovesistöjen merkitys kaupunkiluonnon monimuotoisuudelle (Significance of small surface waters for natural diversity in urban environments). Ministry of the Environment, Land Use Department, Sinari Ltd. Helsinki (in Finnish with an abstract in English).

Niemelä, J., Kotze, J.D. and Yli-Pelkonen, V. (2006) Comparative urban ecology: challenges and possibilities. In: McDonnell, M., Hahs, A. and Breuste, J. (eds), Comparative Ecology of Cities and Towns. Cambridge University Press, *in press*.

Olsson P. and Folke C. (2001) Local ecological knowledge and institutional dynamics for ecosystem management: a study of Lake Racken watershed, Sweden. Ecosystems **4**: 85–104.

Patton, M.Q. (2002) Qualitative Research & Evaluation Methods. Sage, Thousand Oaks.

Paul, M.J. and Meyer, J.L. (2001) Streams in an urban landscape. Annual Review of Ecology and Systematics **32**: 333–365.

Pickett S.T.A., Burch W.R. Jr, Dalton S., Foresman T., Grove J. and Rowntree R. (1997) A conceptual framework for the study of human ecosystems in urban areas. Urban Ecosystems **1**: 185–199.

Pickett S.T.A., Cadenasso M.L., Grove J.M., Nilon C.H., Pouyat R.V., Zipperer W.C. and Costanza R. (2001) Urban ecological systems: Linking terrestrial ecological, physical, and socioeconomic components of metropolitan areas. Annual Review of Ecology and Systematics **32**: 127–157.

Pickett, S.T.A., Cadenasso, M.L. and Grove, J.M. (2004) Resilient cities: Meaning, models, and metaphor for integrating the ecological, socio-economic, and planning realms. Landscape and Urban Planning **69**: 369–384.

Ruth, O. (2004) Kaupunkipurojen hydrogeografia kolmen esimerkkivaluma-alueen kuvastamana Helsingissä (Hydrogeography of urban streams: Three examples of catchments in Helsinki). Academic dissertation, University of Helsinki, Department of Geography, Helsinki (in Finnish with an abstract in English).

Sairinen, R. and Kohl, J. (eds) (2004) Ihminen ja ympäristön muutos – Sosiaalisten

vaikutusten arvioinnin teoriaa ja käytäntöjä (Man and environment change – Theory and practice of social impact assessment). YTK B 87, Helsinki University of Technology (in Finnish).

Shochat, E., Warren, P.S., Faeth, S.H., McIntyre, N.E. and Hope, D. (2006) From patterns to emerging processes in mechanistic urban ecology. Trends in Ecology and Evolution **21**: 186–191.

Söderman, T. (2003) Luontoselvitykset ja luontovaikutusten arviointi – kaavoituksessa, YVA-menettelyssä ja Natura-arvioinnissa (Biodiversity impact assessment – in regional planning, environmental impact assessment and Natura 2000 assessment). Ympäristöopas 109, Suomen ympäristökeskus, Edita, Helsinki, Finland (in Finnish with an abstract in English).

Tarvainen, V., Koho, E., Kouki, A-M. and Salo, A. (2005) Helsingin purot – Millaista vettä kaupungissamme virtaa? (Water quality of urban streams in Helsinki). Helsingin kaupungin ympäristökeskuksen julkaisuja 7/2005. Helsingin kaupunki (in Finnish).

Tjallingii, S. (2005) Green structure and water. In: Werquin, A.C., Duhem, B.D., Lindholm, G., Opperman, B., Pauleit, S. and Tjallingii, S. (eds), Green structure and urban planning. COST Actions C11 Final report. COST Office, Belgium, pp. 146–148.

Turner, W.R., Nakamura, T. and Dinetti, M. (2004) Global urbanization and the separation of humans from nature. BioScience **54**: 585–590.

United Nations (2004) World Urbanization Prospects: The 2003 Revision. New York, United Nations Department of Economic and Social Affairs, Population Division.

Vantaan kaupunki (2005) Rekolanoja – Eilen, tänään ja huomenna (Rekolanoja – Yesterday, today, and tomorrow). Vantaan kaupunkisuunnittelu, Vantaa (in Finnish).

Väre, S. and Krisp, J. (2005) Ekologinen verkosto ja maankäytön suunnittelu (Ecological network and land-use planning of urban areas). Suomen ympäristö 780. Edita Prima, Helsinki, Finland (in Finnish with an abstract in English).

Walton, B.M., Salling, M., Wyles, J. and Wolin, J. (2006) Biological integrity of urban streams: toward resolving multiple dimensions of urbanization. Landscape and Urban Planning, *in press*.

Werquin, A.C., Duhem, B.D., Lindholm, G., Opperman, B., Pauleit, S. and Tjallingii, S. (eds) (2005) Green structure and urban planning. COST Actions C11 Final report. COST Office, Belgium.

Weston, J. (2000) EIA, decision-making theory and screening and scoping in UK practice. Journal of Environmental Planning and Management **43**: 185–203.

White R.R. (2001) Sustainable development in urban areas: an overview. In: Devuyst, D., Hens, L. and De Lannoy, W. (eds), How green is the city? – Sustainability assessment and the management of urban environments. Columbia University Press, New York, pp. 47–62.

Willberg, H. (1995) Kunnan päättäjä ja biodiversiteetti (Communal decision-maker and biodiversity). In: Hiedanpää, J. and Haila, Y. (eds), Biodiversiteetin arvo päätöksenteon ongelmana (Value of biodiversity and environmental decision making). Satakunnan ympäristöntutkimuskeskus, Pori. SYKESARJA C, Kelan tutkimuskeskus, Turku, Finland, pp. 70–77 (in Finnish with an abstract in English).