J. Nat. Hist. Mus. Inst., Chiba, Vol.2 No.1 : 53-62. March 1992.

Urban Ecosystems

Herbert Sukopp

Technische Universität Berlin
Institut für Ökologie
Ökosystemforschung und Vegetationskunde
Schmidt-Ott-Straße 1, D-1000 Berlin 41

Urban ecology is the study of urban ecosystems with ecological methods. These scientific studies are valuable in urban and landscape planning. However, comprehensive biotope mapping methods (e.g. investigation of all biotopes), and evaluation are also required. In order to achieve a theory of urban systems studies of human populations are necessary too. Nearly 100 projects have been carried out in the UNESCO Programme on Man and the Biosphere (MAB) 11 on urban systems in different regions of the world. Other international and national programmes are mentioned.

1. Approaches to urban ecology

When ecology was established as a scientific discipline last century attention was focussed on where and how plants and animals live in order to interpret the features of the organisms as adaptations of their environment. Today it is the obviously inadequate adaptation of human societies to their environment which places ecology at the center of the environmental discussion. Ecological statements about the relationship between our society and its environment, based on the knowledge of the natural living conditions are becoming more urgent. This is especially true of urban ecology, since the various forms of town and city as they have developed through history represent not only important forms of human existence, but also of relationships between Man and environment. The investigative minds of the ecologists were late addressing themselves to the towns. Attention was paid to biotopes close to nature, but not to human settlements. Town and nature are still the ultimate contradiction for many people today.

Initial interest was directed, traditionally, towards the flora and fauna. A common feature of the early investigations is the surprise that even in man-made sites characteristic combinations of organisms could be found under similar conditions. More exact analysis has shown a considerable variety of sites, organisms and communities. The Man and the Biosphere project 11 of UNESCO has given rise to the first attempts at integral studies: Hong Kong (Boyden et al., 1981), Tokyo (Numata, 1981) etc. These studies adapt a human ecological approach and deal with questions of health, human welfare and the connection between culture and nature.

In the first part of this lecture selected basic investigations are presented, in the second their application in town planning, nature protection and environmental education.

Urban ecology* investigates ecosystems in towns and cities using ecological methods, in just the same way as other branches of ecology investigate farm-land, forests or the sea. The town or city (Fig. 1) can be characterized ecologically in three ways (Sukopp, 1990a), historically (1.1), structurally (1.2) and functionally (1.3).

1.1 Historical perspective (A-D)

A. The urban proportion of the world population has been steadily increasing since 1700. Historically, urban settlements are classified as pre-industrial (with walls and gates; traders and crafts), industrial (extensive in rings and secotrs, cf. B and E) or post-industrial (with employment concentration in the tertiary and quaternary sectors).

B. The urban open spaces, even though they often represent completely new forms, are modifications of older ones. Careful historical analysis shows the links between present-day biotic communities and the former site conditions in the

* The term "settlement ecology" can be used to include villages and other settlements.

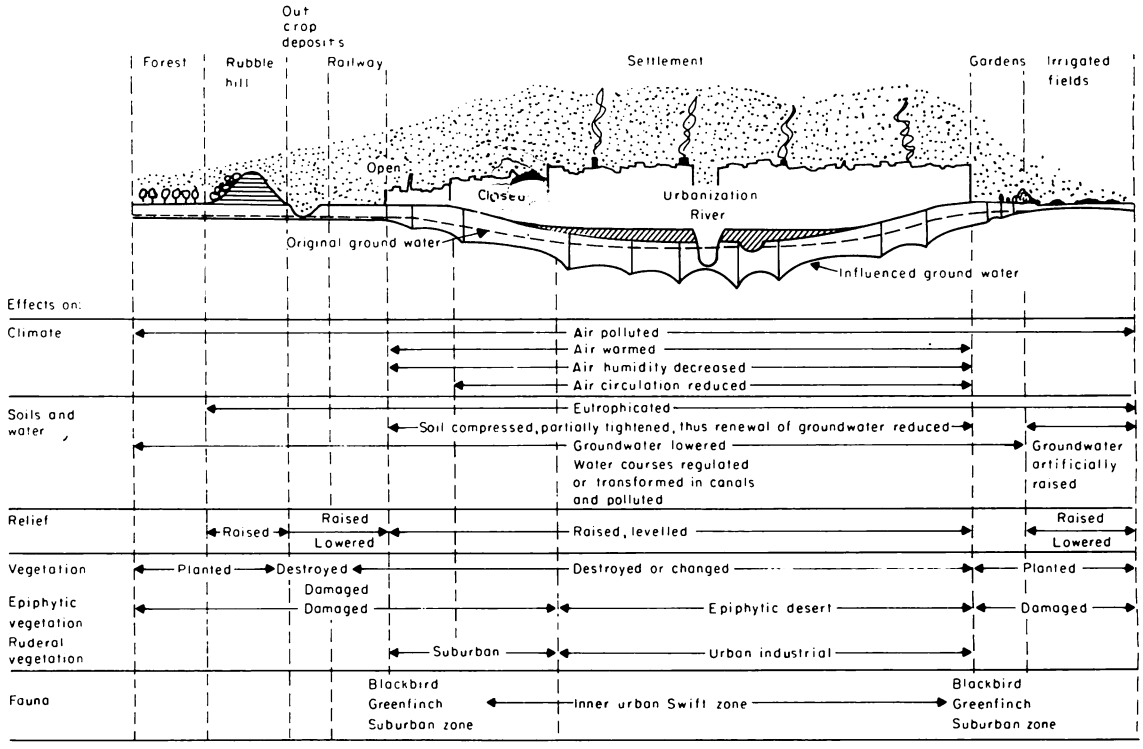

Fig. 1. Ecological characterization of the Town or city.

agrarian landscape.

The similarity between present-day and former siteconditions decrease from the periphery to the centre. Corresponding observations are available for numerous climatic factors, phenological data, frost damage, air pollution, species populations etc. A simplified model of a city and the alteration of its biosphere can be found in Sukopp (1968).

C. Native and long-established alien flora and fauna show a particularly marked decline in cities and industrial areas, particularly stenoecious species.

D. On the other hand the towns and cities represent distribution centres and concentration points for neophytes (species which have reached the area since 1500 with direct or indirect human assistance). The size of the settlement affects the proportion of neophytes in two ways; firstly the more trade and traffic the more possibility of species immigration, and secondly site conditions change with increasing settlement size.

1.2 Structural Perspective (E-G)

E. The heterogeneous urban ecosystems (a large number of different biotopes, usually sharply separated), and a dominance of imports of species over losses lead to large numbers of vascular plants, some groups of invertebrates, birds and mammals (excepting large carnivores) in comparison to similarly large surrounding areas (figures e.g. by Mulsow (1980) for birds in Hamburg, Sukopp et al. (1981) for ferns and flowering plants in Berlin (West)). Building and industry have led to concentric structures, at least in many European towns, with zones of continuous and disparate construction, with an inner and outer border region (e.g. Sukopp et al., 1980; Klotz, 1984). Many species can thus be found either at the centre or the periphery (together with indifferent species). Distribution charts as examples of such patterns are provided by Kunick (1980, 1984) and Wittig et al. (1985; with a classification of species as urbanophile, urbanoeutral and urbanophobic), for fungi Lawrynowcz (1982) and Erkkilä & Niemelä (1986). The border regions are particularly rich in species.

F. In the centres of towns and cities about half the vascular plants are aliens (having reached the site with either direct or indirect human assistance) and in northern countries often of southern

origin (Saarisalo-Taubert, 1963, Kunick 1974). This is also often true for the animals and fungi which prefer urban habitats (Pisarski & Trojan, 1976; Erkkilä & Niemelä, 1986, Klausnitzer, 1987).

G. Similar urban location conditions and also the effects of transport of organisms (the latter at least in the cases of plants and birds) lead to relatively uniform stocks of species in the centres of various cities, at least in the central European plains. Despite considerable differences in climate one can speak of a common stock of aliens in western and central European cities. Despite climatic and geological variations planted and well growing tree populations in central European cities are also very similar.

1.3 Functional Perspective (H-M):

H. Green plants no longer form the energy basis of the ecosystems in towns and cities (cf. I); decomposers play only a minor role.

J. The introduced energy can reach the same order of magnitude as the natural radiation energy from the sun absorbed at the soil surface (which besides is hardly used, c.f. Flohn, 1970). The effects of specifically urban climatic factors on the organisms is very great (see H.), whereas the organisms have little effect on the urban climatic conditions. For degree of effects of vegetation on climate see Stulpnagel et al. (1990). Specific stress factors are e.g. air pollution, winter salt, and leaks of natural gas. Communities of plants and animals in towns and cities have virtually no ability to regulate their own ecology. Biocoenotic connections are scarcely developed due to the mosaic of land uses (Klausnitzer, 1980) and to the high degree of temporal variability.

K. In spite of rapid alterations in the flora and fauna we find site-related combinations of organisms from various biogeographic "realms".

L. The new conditions in the towns and cities lead to alterations in the ecological amplitudes of populations (corresponding to the physiological amplitude or the preadaptations) and to an 'urbanization' of behaviour.

M. Altered conditions of selection and human influence can lead to new species forming faster than they would on uninfluenced sites. (Examples for Central Europe in Sukopp, 1972).

1.4 The role of the social sciences

If the social sciences are involved in urban ecology at the present state of the art then it remains an interdisciplinary discussion without a common definition of the subject and without hope of reconciling differences of method. The current discussion on the linkage of natural and social sciences in urban research has been summarised by Whyte (1982, 1985) and Spooner (1982, 1986). In multidisciplinary work the integration must be carried out professionally, and not by the individual sciences. The last point ("structured interaction") with three independent study-groups guides the MAB 11 Rome Project (Giacomni, 1981). Attempts have been made to merge the approaches of natural science and of the social sciences, but attempts to apply the same methods have been unsuccessful. Comprehensive studies (Boyden et al., 1981), such as the Hong Kong investigation, attempt to overcome the limits of the disciplines with the following approaches:

A. Human history is the history of the use of energy.

B. A central position is occupied by human welfare (cf. the WHO campaign "Healthy Cities").

Attempts to bridge the gap generally use a systems theoretical approach. This is true of the MAB 11 contributions in Frankfurt/Main, Rome, Gotland, Bangkok. Among other things this approach assumes a high degree of inter-dependence of the elements, i.e. it assumes that causal relationships exist between the various sub-systems or strata, or that these are known. However, due to the fact that in towns links between the elements are more often absent than present, the results are unsatisfactory.

Geography, which has failed as an union of natural and "Cultural" sciences, demonstrates that it is not enough to stitch areas together with definitions (for urban ecology: Bartkowski, 1985; Richter, 1984). A good example for the linking of the spatial order of vegetation with classical social-ecological urban models is given by Hard (1985).

2. Example Berlin (West)

The research in Berlin has been more concerned than most research elsewhere with the types, extent and consequences of human inter-

vention on the flora, fauna and vegetation, climate, soils and waters. It developed from general considerations of the influence of humans on vegetation and soil (Sukopp, 1969; Blume & Sukopp, 1976, Kowarik, 1988) to the drawing up and evaluation of red lists of endangered species (Sukopp & Elvers, 1982; Klawitter & Schaepe, 1985) and to biotope mapping for the landscape programme Berlin (Arbeitsgruppe Artenschutzprogramm Berlin, 1984).

The development of ecochore maps in the project "Ecological Maps of Berlin" saw the start of earnest interdisciplinary ecological research. The methodology is presented in Böcker & Sukopp (1985). The species and biotope protection programme for Berlin demanded different methods due to the cooperation of biologists and landscape planners (Henke & Sukopp, 1986). Summaries of urban ecology in Berlin can be found in Sukopp et al., 1980, Blume, 1981, Sukopp, 1984, Alaily et al., 1986 and Sukopp, 1990. The turn of the century saw the begin of the trend towards the differentiation between biological and ecological subdisciplines on the one hand and the necessity for cooperation in view of the practical problems on the other, and this trend has continued and grown in strength. Today it is the questions of general environmental protection, landscape care and nature conservation which demand new forms of cooperation.

3. International Programmes

3.1 UNESCO Man and the Biosphere Programme

When the MAB programme began in 1971 Programme 11 (Ecological aspects of urban systems) was the smallest of 14 sections. Today it is one of the four largest. Spooner (1986) has provided an overview of 47 projects.

At the start investigations of energy flow and water supply played an important role. Great hopes were set on the use of models and the application of systems analysis; the study of information and people flows; the study of the interrelationships and flows between the urban system and its hinterlands; the study of environmental perception and awareness; the study of open green urban and peri-urban spaces. The MAB Project Area 11 began with a limited number of pioneering studies in such diverse sites as Hong Kong, Franfurt, Rome, Gotland (Sweden), Tokyo and few others.

Such pioneering studies provided the conceptual and methodological basis for a second generation of field studies more orientated towards problem-solving in practical aspects of planning and management (e.g. Lae, Papua New Guinea; Ciudad Guayana, Venezuela; Bangkok, Thailand; Mexico City, Mexico; Chipata, Zambia). At the same time, industrialized countries contributed new experiences (Dayton, Ohio, USA; Moscow, USSR; Sczecin, Poland, among others).

A third generation of ongoing field studies attempts to fulfil MAB objectives, such as effective interdisciplinarity and integration of different actors, planning the research to ensure that expected results will serve planning and management needs and will ensure public involvement and participation and, very especially, confer a practical orientation to the studies, and at the same time contribute to the evolution of more appropriate scientifically sound conceptual and methodological approaches. This third generation of projects has been established in a broad range of biogeographical, social, cultural and economic situations in both developing and industrialized countries, covering a wide diversity of problem areas responding to pressing diverse real-life situations in sites such as Paris and satellite new towns (France), Delft (Netherlands), Barcelona, Madrid and Valencia (Spain), Buenos Aires (Argentina), Sao Paulo and Porto Alegre (Brazil), Kuala Lumpur (Malaysia), Seoul (Republic of Korea), among others.

In future investigations in areas a) and b) the dynamics of global phenomena of urbanization are to be considered, in the areas c) and d) the optimal administration of growing urban systems, with the aim of maintaining the quality of life for the inhabitants while at the same time reducing negative environmental effects.

a) The development of a general model for the relationships between urbanization and alteration of the environment of the town or city compared with that of the outlying areas.

The recommendation is to carry out this research in conjunction with the Scientific Committee on Problems of the Environment (SCOPE) of ICSU and the Project Ecoville of the International Federation of Institutes for Advanced

Studies (IFIAS), and to use the network of existing and future MAB-field projects to test the models in a series of environmental and urban contexts. Special attention is to be paid to marginal urban systems e.g. in mountainous or arid regions. Attention will also be paid to the relationship between the size and structure of the settlement and the effect on the environment. The models will also consider the political alternatives at the various levels of development e.g. population density and public services (water, sewage, health etc.) compared with the criteria of the welfare of humans and environment.

b) Empirical investigation of demographic alterations related to urbanization, especially migration between country and town and its effects on the environment.

The concentration of people in greater and greater settlements leaves its marks on both the environment and the social structures of the urban and rural areas. Therefore it is recommended that the investigation of the causes and effects of migration should address itself (at least) both to the cities and their outlying areas. This implies linked studies in urban areas and rural zones (including "biosphere reservations") to measure population migration as well as its causes (e.g. perception studies) and its effects (e.g. concentration, environmental health in the cities, loss of traditional methods in rural areas).

c) Studies, including demonstration projects, on biological productivity and for the improvement and/or recycling of resources such as energy, with a corresponding reduction of the burden on the regions supplying these resources.

In this area it is recommended to expand the work of some of the MAB field projects which are already running successfully. This includes work on test and evaluation methods for increasing biological productivity in urban areas (urban forestry, urban farming which increase the degree of self-reliance). It also includes local projects to conserve energy and model projects for recycling in urban systems, including water. Evaluation studies are also envisaged in order to assess the increase in biological productivity, taking into consideration factors such as soil fertility and contamination, land-ownership, food requirements and the economic viability of production and distribution.

d) Studies on the management of urban green areas including an analysis of people's need for green areas, their use and the burden on the natural environment in such areas.

It is recommended that a limited number of integrated studies should be carried out in different urban situations, in order to establish the need for urban green spaces and their uses, and to evaluate the burdens which threaten the further existence of such areas. It is to be expected that such a comparative study will lead to practical guidelines for the scientific management of urban green areas.

Studies of developing countries will form one central point. 12 of the 16 largest cities in the world are in developing countries.

In Europe emphasis will be on the care and development of urban open spaces as a specialisation and application of previous investigations on "Nature in the Towns and Cities". In addition to the Suzdal Conference 1984 (International Experts Meeting, 1984) the Barcelona Meeting in April 1986 furthered this work. In the previous MAB 11 Projects urban open spaces played a prominent role in the studies in Mexico, Dayton (USA), Rome, Tokyo and Vienna. Investigations of environment perception were part of the MAB 11 projects in Rome, Tokyo, Asuncion (Paraguay), Paris, Moscow, Delft and Warsaw among others.

3.2 INTECOL

The "Urban Ecology" study group of INTECOL was founded at the First International Congress of Ecology in the Hague, 1974. For the first four years Dr. LaNier was convenor. The exchange of bibliographies and other information and the preparation of symposia during the INTECOL Congresses has been continued by Prof. Numata, Chiba University, Japan and myself, most recently at the 4th INTECOL Congress in Syracuse, USA, 1986 and at the 5th Congress in Yokohama this week.

3.3 International Union of Forestry Organisations (IUFRO): Urban Forestry Project

The project group was newly founded in Ljubljana on 11 September 1986.

The widespread investigation and development of "urban forests" (McBride & Jacobs, 1976, Grey

& Deneke, 1976, Rowntree, 1986) in anglo-american regions has not met with much echo from other European foresters. Their investigations and planning remains restricted to the human influence on forests *near* towns or cities. Inner-city areas are only included in Sweden and Holland. For Düsseldorf Kürsten (1983) has analysed roadside trees using forestry methods and has developed planning concepts.

3.4 Council of Europe

Since 1981 the Council of Europe has had a study group on "Nature conservation in towns and cities", with participation above all from the Federal Republic of Germany and Great Britain. Further members are Ireland, the Netherlands, Greece and Cyprus. The results of the work were incorporated in two projects: in the bibliography "Nature in cities" (Sukopp & Werner, 1982) and in the project "Development of flora and fauna in urban areas" (Sukopp & Werner, 1987).

4. Methods of Urban Biotope Mapping

The methods of basic ecological research are not different in towns from those used in other areas. It is only the investigation of urban land use which requires special historical investigations of individual plots and more detailed mapping (1 : 2.000 to 1 : 10.000).

Such basic investigations are not sufficient for planning purposes, but are an essential prerequisite. Planning requires an areal inventory, comparisons and evaluations. In order to develop and carry through systematic conservation and development measures, biotope mapping has been found an appropriate and necessary measure.

Biotope mapping in rural (and in some states urban) landscapes was directed initially at registering valuable biological-ecological areas, worthy of protection (Sukopp et al., 1979) This led to the widespread misconception that the only biotopes were those worthy of preservation. In fact a biotope used in the sense of Dahl (1908) is any area with boundaries in which animals and plants can live. The entire landscape, including areas put to extreme uses, consists of a series of biotopes of different types, all of which however, even those apparently unworthy of protection, fulfill a function. This is a point which is especially significant for built-up areas.

The Federal Law for Nature conservancy of the FRG covers 100% of the land surface; therefore it is necessary that biotope mapping of built-up areas is also carried out in all towns and villages. A biotope mapping finds uses in planning, programmes and other measures at various levels, according to the amount of detail it contains, such as: Via the landscape and urban planning as an ecological contribution in the development planning in expert planning of nature and landscape conservation (*e.g.* demarcation of protected areas, evaluating intervention), in communal programmes and measures (communal nature conservancy programmes, laying out and caring for biotopes, supporting private measures).

The aim of guidelines for mapping applicable for the whole of Germany (work group "Methods for biotope mapping in built-up areas") is to present a largely uniform methodological basis for an overall, relevant assessment of the situation and for an ecological evaluation of the urban and village ecosystems. Results will then be more comparable, can be expanded upon e.g. by institutes at state level, or by the regions and communes, and more emphasis can be placed on the aims of nature conservation in the settlement areas.

The application of such mapping guidelines should not serve purely scientific ends, but should also relate to measures to increase environmental conservation, protection, and development. This includes drawing up programmes to protect species and biotopes at the community level (Arbeitsgruppe Artenschutzprogramm Berlin, 1984) as well as providing a basis for the investigation of the environmental compatibility of land use plans and local plans.

The numerous methods used for biotope mapping in settlement areas can be placed in three categories (Sukopp and Weiler, 1986, 1988):

(1) *Selective mapping* covers only biotopes worthy of protection, in some cases also those potentially worthy of protection. This presupposes a framework of evaluation for biotopes worthy of protection and thus of mapping (e.g. the first mappings of Munich, Augsburg, Düsseldorf).

(2) *Representative mapping,* in which examples of all types of use are mapped and the results transferred to all areas with the same use struc-

ture. In this way biologically and ecologically characterised biotope types or biotope type complexes are obtained. The evaluation of the biotope is not directly coupled to the registration (examples: Berlin, Hannover).

(3) *Overall mapping* covers the biological and ecological features of all actual biotopes (i.e. the entire area). Registration is initially independent of evaluation (examples: Berlin-Kreuzberg, Schleswig, Kassel; as grid mapping: Saarlouis, Bochum).

A common feature of representative and overall mapping is the fact that the results relate to the entire area under investigation and that the evaluation of the biotopes is a separate step. There are no fixed boundaries between the mapping methods. For the basic investigations in a built-up area the working group recommends the use of the representative method.

Selective mapping has the important advantage of being relatively quick, with less demands on personnel and money. It can provide quick results for building and nature conservancy planning. However, there are various reasons why it is not adequate to use the selective method alone. It is usually only possible to judge whether a biotope is worthy of protection in the context of its surroundings. If areas worthy of protection are selected on the basis of selective mapping then it is possible that the importance of a biotope will not be recognised which plays a vital role as a link between other larger refuge biotopes.

The duties of the landscape planning at the state level (with the exception of North Rhine Westphalia) cover the whole settlement area. In these areas it is not only important to protect species of particular value, but also the widespread, typical biotopes, which fulfill other functions such as recreation, education, or which help to shape the town.

The restiction to rare types of biotope raises "the danger of loosing sight of the direct environment of most urban inhabitants" (Kunick et al., 1983). Parallel to the development of selective mapping methods these considerations led to the development of methods for the biological and ecological registration of the entire built-up area.

The aim of the basic programme is to ensure that future urban biotope mappings of West Germany as a whole will use uniform criteria. This does not imply that mapping carried out at state level in the past using selective methods will not be able to continue being used e.g. for town development. This is shown by the results of urban biotope mappings already carried out, which contain important elements of the basic programme recommended later. These include indicating the spatial use of biotopes, mapping plant species found and selected animal species. The working group "Methods for biotope mapping in built-up areas" (1986) recommends the following points for a basic programme:

(1) Overall mapping of types of land use. The land use is regarded as factor with decisive influence on virtually all other ecological factors in settlement areas. Therefore the overall mapping of types of use is essential.

(2) Mapping of areas which are potentially biologically rich or worthy of preservation.

(3) Mapping of biotope complexes.

(4) Mapping of flora and vegetation on selected sites.

(5) Mapping of animal groups on selected sites.

5. Project of an European Academy of the Urban Environment

Currently, at the end of the 20th Century nature conservation and environmental protection are becoming areas of central importance to most people in industrialized countries. The inadequate adaptation of human societies to their environment endangers the very existence of future generations. More and more politicians, scientists, managers and other citizens recognise the need to encourage nature conservation and environmental protection if our further existence is to be guaranteed in the long term. Irrespective of the state of economic development of a country, and of its current economic situation, ecology and environmental protection must become an integral part of economic and social activity.

To question whether ecology or economy should be given priority leads nowhere. Societies, whether with free-market or planned economies, will only prosper in the long term, and will only be able to exist peacefully with each other in social harmony if they do not abuse or exhaust their environment and the natural resources it contains. Conversely, it will not be possible to reform production and life-styles, making societies

resource-friendly, if unfavourable economic developments mean that no funds are available for long-term restructuring or for research and training. Internalization of the environmental costs of present-day production, distribution and consumption will stimulate the development of environmentally compatible forms of production and consumption.

The common strategy of waiting until such damage has been done to the environment that it is impossible to overlook, and then trying to repair matters, has proved to be an expensive and unpromising affair. As a strategy it is detrimental to the health and welfare of the population. The one-track 'optimization' of individual sectors of the economy has been found to lead to negative results which were neither desired nor foreseen, and which may even be catastrophic for the natural environment and the structure of the society.

Against this background the formation of a single European market by the member-states of the European Community in 1992 can have the widest implications for the environment in Europe. Trade restrictions will no longer be permissible, even where they serve to protect the environment. The different levels of economic and social development of the member-states will make it difficult to harmonise the various standards of nature conservancy and environmental protection at a high level. The Common Market will therefore place demands on environmental policies, requiring the development and implementation of effective, practicable, economically realistic strategies of nature conservancy and environmental protection in town and country. The 'European Academy of the Urban Environment, Urban Ecology and Urban Open Space Planning' is intended to make a significant contribution towards this end.

The idea of an European Academy for the Urban Environment has been pursued by the Berlin Senat since 1987, at first under the Conservative-Liberal coalition, and now under the Social-Democrat-Green coalition.

The task of the Academy will be to develop practical interdisciplinary approaches to urban environmental problems at the local level. The aim is to encourage the selfdetermination of the urban population and population groups. The welfare of people in towns and cities is the most important concern. New forms of local, national and international cooperationn shall be tested. The participants of the Colloquim 1989 recommended the establishment of a decentralised structure, which works as a network, and handles the exchange of information and dissemination of model solutions for problems of urban ecology. The aim is an open forum on the urban environment, open to all European countries - and later on to all countries -, to function as a bridge between experts, administrators, politicians and environmental groups.

The work of the Academy shall be aimed above all at local levels; the ecological reorientation of urban management and consumer behavior shall make the towns and cities better and healthier to live in, and more compatible with their environment.

One of the most important pre-conditions for the future Academy is that it shall be financially independent from both industry and government. Financial support from several European states, including the Federal Republic of Germany, as well as from national and international institutions could guarantee this.

The holistic, inter-disciplinary mode of operation should be reflected in a dynamic and flexible organisational structure. Only part of the staff should be employed long-term, the majority having contracts for the duration of a project or a programme (Auhagen, 1990).

References

Alaily, F., R. Grenzius, M. Renger, K. Stahr, B. Tietz & G. Wessolek. 1986. Soilscapes of Berlin (West). Mitt. Dtsch. Bodenkdl. Ges. 50: 1-204.

Arbeitsgruppe Artenschutzprogramm Berlin. Leitung: Sukopp, H., Red.: A. Auhagen, H. Frank, & L. Trepl. 1984. Grundlagen für das Arten-schutzprogramm Berlin in drei Bänden. Land-schaftsentw. u. Umweltforsch. 23, Berlin, 993 S.u. Karten.

Auhagen, A. 1990. Europäische Akademie für städtische Umwelt. Bericht zum European Colloquium ' 89. Im Auftrag der Senatsverwaltung für Stadtentwicklung und Umweltschutz. 165 S. Berlin. (Deutsch/Englisch).

Bartkowski, T. 1985. Geosystemy miast - Stadtgeosysteme. Bilaterale Wissenschaftliche Konferenz 7.-9.X. 1985. 246 pp. Poznan 1985.

Blume, H.-P. & H. Sukopp. 1976. Ökologische

Bedeutung anthropogener Bodenveränderungen. Schr. Reihe Vegetationskunde 10: 75-89.

Blume, H.-P. (Red.) 1981. Typische Böden Berlins. Exkursionsführer zur Jahrestagung der DBG und eines Internationalen Symposiums über bodenkundliche Probleme städtischer Verdichtungsräume. Mitt. Dtsch. Bodenkdl. Ges. 31: 1-352.

Böcker,R. & H. Sukopp. 1986. Vegetation 1:50.000. Umweltatlas Berlin. Bd. 2. Karte 05.02. Hrsg. Senator für Stadtentwicklung und Umweltschutz Berlin.

Boyden, S., S. Millar, K. Newcombe & B. O. Neill. 1981. The ecology of a city and its people: the case of Hong Kong. 437 pp. Australian National Univ. Press, Canberra 1981.

Dahl, F. 1908. Grundsätze und Grundbegriffe der biozönotischen Forschung. Zool. Anz. 33: 349-353.

Erkkilä, R. & T. Niemelä. 1986. Polypores in the parks and forests of the city of Helsinki. Karstenia 26: 1-40.

Flohn, H. 1970. Produzieren wir unser eigenes Klima? Met.Rundschau 23: 161-164.

Giacomini, V. 1981. Rome considered as an ecological system. Nature and Resources 17: 1, 13-19.

Grey, G.W. & F.O. Deneke. 1978. Urban Forestry. 279 pp. Verl. John Wiley and Sons, New York, Chichester, Brisbane, Toronto.

Hard, G. 1985. Vegetationsgeographie und Sozialökologie einer Stadt. Ein Vergleich zweier "Stadtpläne" am Beispiel von Osnabrück. Geographische Zeitschrift 73: 125-144.

Henke, H. & H. Sukopp. 1986. A Natural Approach in Cities. *In* Bradshaw, A.D., Goode, D.A. and E. Thorp (eds.), Ecology and Design in Landscape, pp. 307-324 24th Symp.British Ecol. Soc., Manchester 1983.

Klausnitzer, B. 1980. Begriffsbestimmung und Inhalt von Großstadtökologie. Wiss. Z. Karl-Marx-Univ. Leipzig, Math.-naturwiss. R. 29: 543-549.

Klausnitzer, B. 1987. Ökologie der Großstadtfauna. Stuttgart. 225 S. u. Anhang.

Klawitter, J. & A. Schäpe. 1985. Gefährdung und Rückgangsursachen der Moose in Berlin (West) - Eine Rote Liste Verh. Berl. Bot. Ver. 4: 101-120. Berlin.

Klotz, S. 1984. Die Ruderalgesellschaften eines Neubaugebietes - ihre Verbreitung und Kombination. Acta Bot. Slov. Acad. Sci. Slov., Ser.A. Suppl. 1: 111-125.

Kowarik, I. 1988. Zum menschlichen Einfluß auf Flora und Vegetation. Theoretische Konzepte und ein Quantifizierungsansatz am Beispiel von Berlin (West). Landschaftsentwicklung und Umweltforschung 56: 1-280.

Kürsten, E. 1983. Luftbild-Folge-Inventuren und Baumkataster als Grundlagen für eine nachhaltige Sicherung innerstädtischer Vegetationsbestände, dargestellt am Beispiel der Stadt Düsseldorf. 169 + 27 S. Göttingen, Diss.

Kunick, W. 1974. Veränderungen von Flora und Vegetation einer Großstadt, dargestellt am Beispiel von Berlin (West). Diss. Techn. Univers. Berlin.

Kunick, W. 1980. Pflanzen, die bei der Kartierung von Stadtgebieten besonders berücksichtigt werden sollten. Garten u. Landschaft 90: 577-580.

Kunick, W., M. Kuoni, and I. Maass. 1983. Pilotstudie Stadtbiotopkartierung Stuttgart. Beih. Veröff. Natursch. Landslhaftspfl. Bad.-Württ. 36: 1-134.

Kunick, W. 1984. Verbreitungskarten von Wildpflanzen als Bestandteil der Stadtbiotopkartierung, dargestellt am Beispiel Köln. Verh. Ges. f. Ökol. 12: 269-275.

Lawrynowicz, M. 1982. Macrofungal flora of Lodz. In Bornkamm, R., J. Lee & M. Seaward (eds.). Urban ecology. 2nd Eur.Ecol.Symp.Berlin 1980: 41-47. Oxford.

McBride, J. R. & D. F. Jacobs. 1976. Urban forest development: a case study of Menlo Park, California. Urban Ecol. 2: 1-14.

Mulsow, R. 1980. Untersuchungen zur Rolle der Vögel als Bioindikatoren am Beispiel ausge wählter Vogelgemeinschaften im Raum Hamb-urg. -Hamb. Avifaun. Beitr. 17: 270.

Numata, M. 1981. Integrated Ecological Studies in Bay-Coast Cities. II. 174 pp. Chiba.

Pisarski, B. & P. Trojan. 1976. Zoocenozy obsza-row zurbanizowanych (Animal associations in urbanized areas). - Wiad. Ecol. *22*, 338-344.

Richter, H. 1984. Structural problems of urban landscape ecology. *In* Brandt J. & P. Agger (eds.), Methodology in landscape ecological research and planning. Vol. V. Proceedings of the first international seminar of The International Association of Landscape Ecology (IALE), pp.29-41. Roskilde 1984.

Rowntree, R. A. 1986. Ecology of the urban forest - Introduction to Part II. Urban Ecology 9: 229-243.

Saarisalo-Taubert, A. 1963. Die Flora in ihrer Beziehung zur Siedlung und Siedlungsgeschichte in den südfinnischen Städten Porvoo, Loviisa und Hamina. Ann. Bot. Soc. Vanamo 35: 1-190.

Spooner, B. 1982. Ecology in perspective: the human context of ecological research. International Social Science Journal 34 (3): 395-410.

Spooner, B. 1986. MAB Urban and Human Ecology Digest. UNESCO, Paris 1986. 135 pp.

Stülpnagel, A. von, M. Horbert, & H. Sukopp. 1990. The Importance of Vegetation for the Urban Climate. *In* Sukopp, H. and S. Hejny (eds.): Urban Ecology, 175-194.

Sukopp, H. 1968. Der Einfluß des Menschen auf die Vegetation. Habilitationsvortrag. Als Mskr. vervielfältigt.

Sukopp, H. 1969. Der Einfluß des Menschen auf die Vegetation. Vegetatio 17: 360-371.

Sukopp, H. 1972. Wandel von Flora und Vegetation in Mitteleuropa unter dem Einfluß des Menschen. - Ber. Landwirtsch. 50: 113－139.

Sukopp, H. 1984. Ökologische Charakteristik von Großstädten. *In* Grundriß der Stadtplanung. Akademie für Raumforschung und Landesplanung, pp.51-82. Hannover.

Sukopp, H. (Hg.). 1990. Stadtökologie. Das Beispiel Berlin. 380 S Berlin.

Sukopp, H. 1990a. Urban Ecology and its Application in Europe. *In* H. Sukopp et al. (ed.), Urban Ecology. 1-22.

Sukopp, H., A. Auhagen, W. Bennert, R. Böcker, U. Hennig, W. Kunick, H. Kutschkau, C. Schneider, H. Scholz & F. Zimmermann. 1981. Liste der wildwachsenden Farn- und Blütenpflanzen von Berlin (West). - Landesbeauftr. f. Natursch., u. Landschaftspfl. Berlin.

Sukopp, H. & H. Elvers (Hg.). 1982. Rote Listen der gefährdeten Pflanzen und Tiere in Berlin (West). Landschaftsentwickl und Umweltforschung 11: 1-374.

Sukopp, H. *et al.* 1980. Beiträge zur Stadtökologie von Berlin (West). - Landschaftsentwickl. und Umweltforschung 3: 1-225. Techn. Univ. Berlin. Berlin.

Sukopp, H., S. Hejny & I. Kowarik (eds.). 1990. Urban Ecology. Plants and Plant Communities in Urban Environments. 282 pp. The Hague.

Sukopp, H., W. Trautmann, & J. Schaller. 1979. Biotopkatierung in der Bundesepublik Deutschland. Nat. u. Landsch. 54 (3): 63-65.

Sukopp, H. & S. Weiler. 1986. Biotopkartierung im besiedelten Bereich der Bundersrepublik Deutschland. Landschaft + Stadt 18 (1): 25-37.

Sukopp, H. & S. Weiler. 1988. Biotope Mapping in Nature Conservation Strategies in Urban Areas of the Federal Republic of Germany. Landscape and Urban Planning 15: 39-58.

Sukopp, H. & P. Werner. 1982. Nature in cities. A report and review of studies and experiments concerning ecology, wildlife and nature conservation in urban and suburban areas. Council of Europe Nature and Environment Series 28. 94 pp. Strasbourg 1982.

Sukopp, H. & P. Werner. 1987. Development of flora and fauna in urban areas. council of Europe Nature and Environment Series 36. 67 pp. Strasbourg 1987.

Sukopp, H., P. Werner, W. Schulte & R. Flueck. 1986. Untersuchungen für Naturschutz und Landschaftspflege im besiedelten Bereich. Dokumentation zu Umweltschutz und Landschaftspflege 26, N. F. Sonderh. 7, Bibliogr. (51): 127.

Sukopp, H., P. Werner, W. Schulte & R. Flueck. 1987. Untersuchungen zu Naturschutz und Landschaftspflege im besiedelten Bereich. Dokumentation für Umweltschutz und Landes-pflege, 27, N.F. Sonderh. 8, Bibliogr. (52): 48.

Sukopp, H., P. Werner, W. Schulte & R. Flueck. 1988. Untersuchungen zu Naturschutz und Landschaftspflege im besiedelten Bereich. Dokumentation für Umweltschutz und Landes-pflege 28, N.F. Sonderh. 10, Bibliogr. (54): 55.

Sukopp, H., P. Werner, W. Schulte & R. Flueck. 1990. Untersuchungen zu Naturschutz und Landschaftspflege im besiedelten Bereich. Dokumentation Natur und Landschaft 30, N. F. Sonderh. 14, Bibliogr. (59): 135.

Whyte, A. 1982. The integration of natural and social sciences in the MAB Programme. International Social Science Journal 34 (3): 411-426.

Whyte, A. 1985. Ecological approaches to urban systems. Nature and Resources 21: 1.

Wittig, R., D. Diesing & M. Godde. 1985. Urbanophil - urbanoneutral - urbanophob: Das Verhalten der Arten gegenuber dem Lebensraum Stadt. Flora 177: 265-282.