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## The role of connectivity in the urban landscape: some results of research

**Abstract.** The role of ecological isolation is recognised by most ecologists. In cities, where many artificial elements are introduced into the environment, the effects of isolation are of special importance. It is necessary to learn how connectivity may be ensured in planning if we want to improve natural conditions in the urban environment. Thus, the character of ecological corridors and barriers as well as their functions have to be learnt. Studies conducted by the staff of the Department of Natural Bases for Physical Planning (IPPME) deal with small mammal movements in corridors; vegetation and microclimate within corridors; and the role and identification of barriers for insects. The important conclusion is that some enclosed areas (e. g. those associated with single-family homes) may be more valuable from the ecological point of view than some spaces traditionally classified as "green areas". It means that ecological surveys are indispensable in planning practice and until now planners have been happy to include green belts and corridors in their plans with poor knowledge of the biological functions of such areas.

### INTRODUCTION

The effects of isolation on so-called habitat islands has been shown by many authors, both in theoretical models and in field experiments (McCLINTOCK et al. 1977, GOTTFRIED 1982, FAHRIG, MERRIAM 1985, SZACKI 1987). Populations of plants and animals can live in a landscape as long as there is a constant flow of individuals between separate patches in the landscape (RISSER et al. 1984). Small and isolated populations may become extinct very easily as a result of stochastic processes or local catastrophe (HANSKI 1989). At the same time, recolonisation is unlikely in the case of isolated patches. Such isolated patches are common in urban areas and isolation there is reinforced as a result of introducing many artificial, anthropogenic elements. These are population questions but individual species are parts of complex ecological systems and their presence determines species diversity. The problem is not only the presence of some particular species of insects or rodents. We should aim at preserving the richness of nature in cities as only complex systems may be stable and resilient in the urban environment where there are so many factors inimical for nature.

If the urban natural system is to work properly, that is be a real system and not a collection of patches, then individual habitats have to be linked and also connected to ecosystems outside the city. The connectivity may be maintained by ecological corridors and it is disturbed by ecological barriers. So, if we want to diagnose the state of a system of natural areas in cities and to plan its structure we have to know what can and what cannot act as a corridor and what constitutes a barrier. Therefore the aim of studies conducted in our Institute is to learn the nature and role of urban corridors and barriers.

## THE STUDIES

Corridors have been investigated in two ways. The first is the study of small mammal movements along two river valleys in Warsaw: one in AN urban area (Służewiecki Stream) and another in suburbia where human impact is lower (Wilanówka River). In both valleys snap traps were set in several localities differing in their habitat configuration. Coloured bait consisting of flour, margarine and woollen fibres was placed in different biotopes within the study area. Different colours were used in individual biotopes. It enables us to observe movements between biotopes and we could learn how movements along corridors were influenced by the urbanisation gradient and what the role of habitat configuration (proportions of individual types of habitats) was.

Results obtained so far indicate that frequency of movements is significantly higher in the river valley outside the city centre than that inside the city (38% of animals with coloured bait vs. 14%, $N_1 = 84$, $N_2 = 88$, $p < .05$). Also, the range of movements is greater in Wilanówka River valley (20% of animals moved more than 300 m vs. 4%, $N_1 = 84$, $N_2 = 88$, $p < .05$). The analysis of distribution of catches along trap-lines running across corridors suggests the significant role of habitat configuration. A corridor is especially effective for these species when it consists of dense and woody or bushy vegetation (Fig. 1).

Table 1. Character of vegetation vertical structure (number of layers) in different habitats

| Habitat | Number of layers |
|---|---|
| Detached housing in forested plots | 5–6 |
| Detached housing in large non-forested plots | 5–6 |
| Detached housing in small plots | 2–3 |
| Allotments | 2–3 |
| Orchards | 2 |
| Orchards intensively cultivated | 1 |
| Deciduous forests | 5–8 |
| Agricultural areas | 1–2 |

Another study of corridors concentrates on vegetation and climatic relations within corridors. The previously described studies focus on the function and role of existing corridors whereas this one is designed to find those elements of a landscape which could play the role of a corridor. The hypothesis is that some built-up areas, namely low density single family homes may play the role of corridors, being elements of an ecological system in a city.

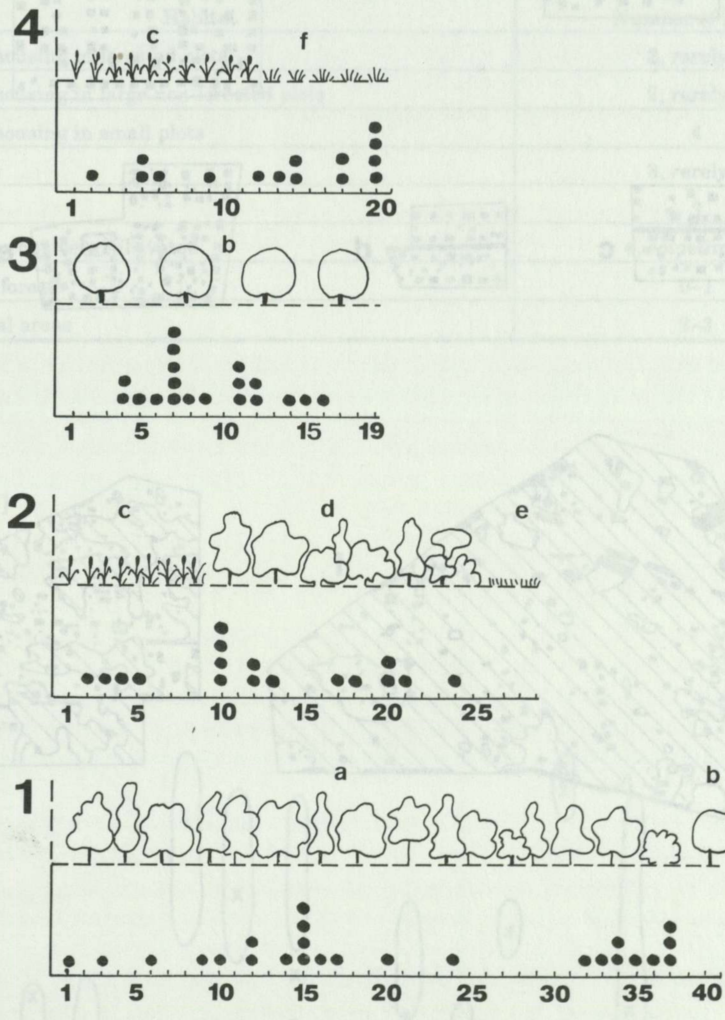


Fig. 1. Distribution of small mammal catches along trap-lines crossing ecological corridors. Black dots represent number of catches per trap station. a – alder wood; b – orchard; c – riparian vegetation; d – mid-field afforestation; e – field; f – meadow.

During the studies seven types of landscape-vegetation complexes (MATUSZKIEWICZ 1990a) were studied in the field and with the use of air-photographs. The character of active surface, that is, the surface reached by solar radiation (Fig. 2), vertical structure of vegetation (number of layers, Tab. 1) and the degree of geometrisation (Tab. 2) in detached housing were compared to those in urban areas traditionally classified as open ones. The above analysis shows that some built-up

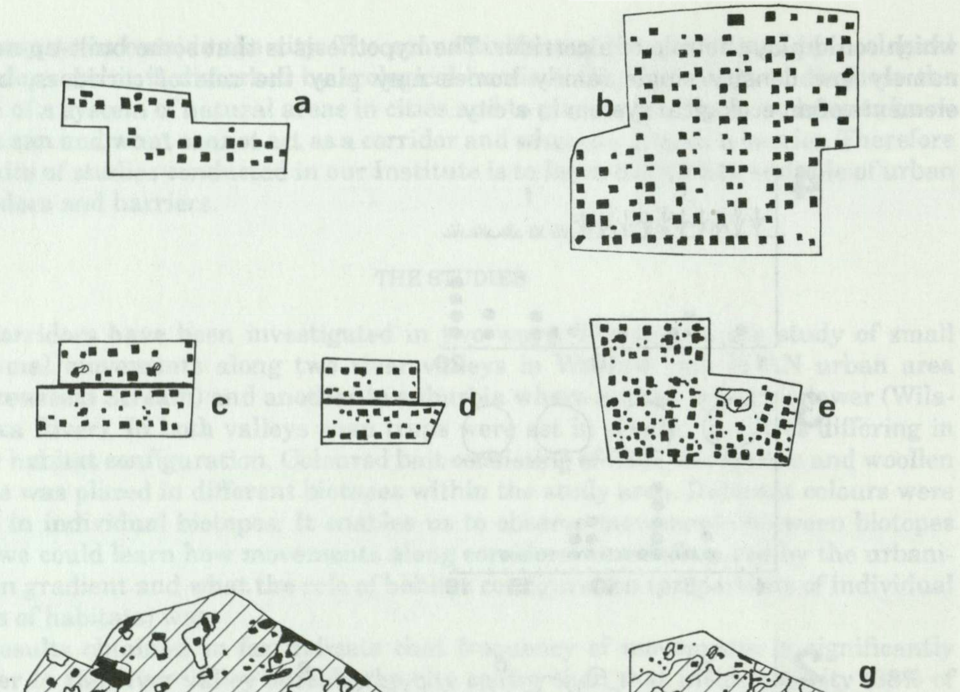


Fig. 2. The character of active surface in different types of landscape-vegetation complexes. a – allotments, scale 1:5000; b – recreation grounds, 1:5000; c-e – detached housing in small plots; f – buildings in forested plots; g – detached housing in large plots (c-g in 1:10000 scale). Black areas represent artificial surface (buildings, roads etc, hatched areas represent tree canopies, unfilled areas represent other surfaces (low vegetation, roads).

areas are more similar to natural habitats than many areas recognised in physical plans as "green" ones. This is also confirmed by studies of phenology (KOSIŃSKI, STULGIS 1990) and microclimate (FORTINI-MORAWSKA, unpublished).

Table 2. Degree of plot geometrization, determined on the base of proportion of lines in a landscape. Scale: 1–6 (MATUSZKIEWICZ 1990a)

| Habitat | Number of layers |
|---|---|
| Detached housing in forested plots | 2, rarely 3 |
| Detached housing in large non-forested plots | 2, rarely 3 |
| Detached housing in small plots | 4 |
| Allotments | 3, rarely 4 |
| Orchards | 2 |
| Orchards intensively cultivated | 4, sometimes 5 |
| Deciduous forests | 0–1 |
| Agricultural areas | 2–3 |

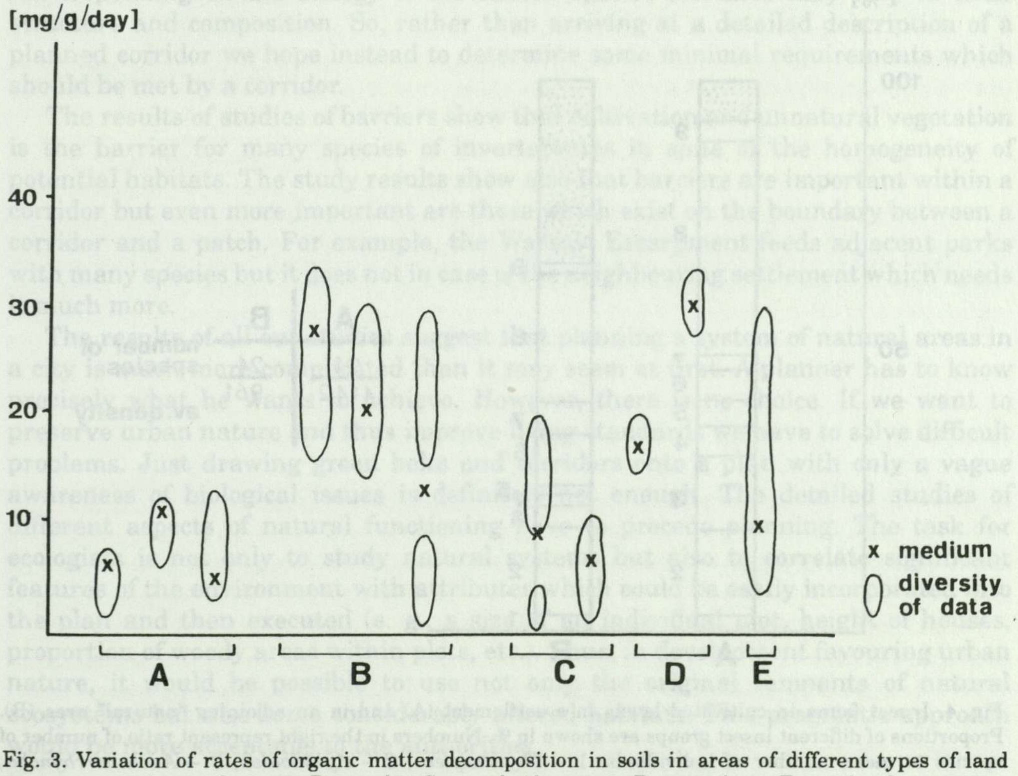


Fig. 3. Variation of rates of organic matter decomposition in soils in areas of different types of land management. A – settlements; B – parks; C – road-side verges; D – meadows; E – ruderal vegetation; x – mean value; ovals represent dispersion of data.

Yet another study aims to identify those elements of the environment which constitute ecological barriers. Some types of enclosure considerably change natural conditions and thus they either become a barrier to animal movements or they eliminate most species. The aim of the study is to find those factors which determine the nature of a barrier.

Cultivation of green areas in housing estates is an example of disturbance significantly changing natural communities. It involves a whole complex of factors working permanently, although occurring in cycles. Development of vegetation structure: planting trees and bushes, creating lawns, etc., is in favour of particular animal species which are resistant to urbanisation stress and eliminate many others. Human activity also reduces the amount of organic matter in soil thus changing the quantity and quality of animal soil communities. Rates of decomposition of organic matter found in the study indicate that human activity reduces differences between biocenoses occurring in different habitats (Fig. 3). It results in poor species composition and dominance of special species of invertebrates, mainly herbivores (Fig. 4), e. g. it was found that the number of insect taxa in relation to the number of individuals was lower, and the proportion of *Diptera* was higher in built-up areas than in nearby semi-natural habitats.

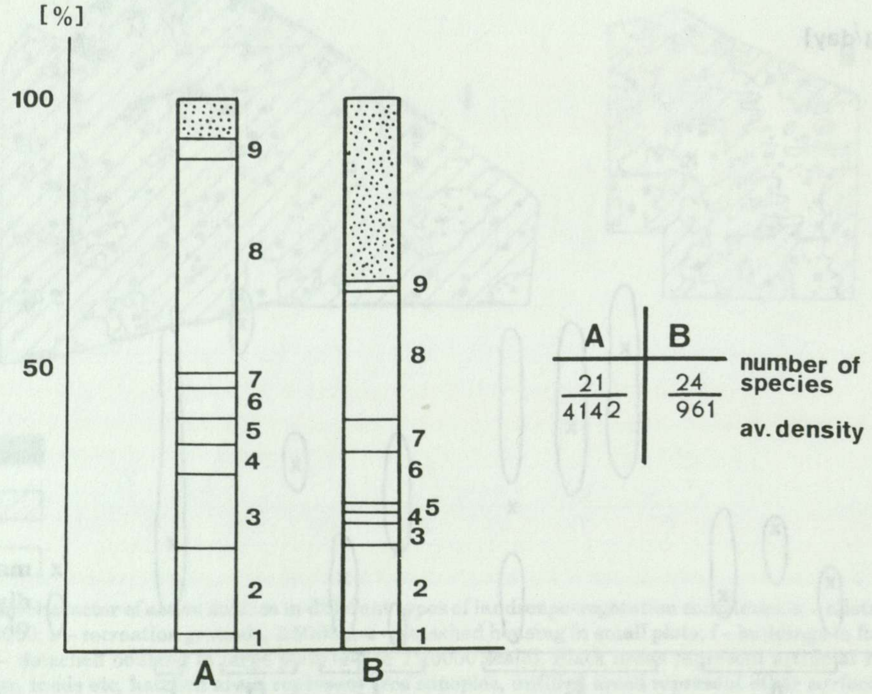


Fig. 4. Insect fauna in cultivated lawns in a settlement (A) and in an adjoining "natural" area (B). Proportions of different insect groups are shown in %. Numbers in the right represent ratio of number of species to mean number of individuals. 1 – *Thysanoptera*; 2 – *Aphidoidea*; 3 – *Auchenorrhyncha*; 4 – *Heteroptera*; 5 – *Chrysomelidae*; 6 – *Hymenoptera parasitica*; 7 – *Nematocera*; 8 – *Acalyptratae*; 9 – *Calyptratae*. The remaining part of bars represents other species.

## CONCLUSIONS

Usually, two categories of urban areas are distinguished in planning practice: open and built-up ones. It seems that such a classification is useless from the ecological point of view. The results of studies of vegetation and microclimate indicate that some types of built-up areas may be valuable elements of natural systems in cities and they do not disturb the continuity of those systems. Built-up areas with detached houses, especially those with forest vegetation as well as those with a rich park-garden type of vegetation may act as ecological corridors for many species. In urban areas they may even be donor habitats. The ecological values of built-up areas depend to a large extent on the size of individual plots and type of management. As these two properties may be determined in local plans it is possible to develop built-up areas and also serve the interests of nature.

Providing that small mammals can be seen as model animals (that is that some generalities about them may be applicable to other species) studies of small mammals in corridors may yield information about how corridors should look. That does not mean, however, that we can derive hard and fast rules, e.g. the exact width of a corridor. That depends on the particular purpose we have in mind when designing corridors – for instance which species deserve special attention and should be catered for. Depending on the biology of the chosen species corridors may vary in their structure and composition. So, rather than arriving at a detailed description of a planned corridor we hope instead to determine some minimal requirements which should be met by a corridor.

The results of studies of barriers show that cultivation and unnatural vegetation is the barrier for many species of invertebrates in spite of the homogeneity of potential habitats. The study results show also that barriers are important within a corridor but even more important are those which exist on the boundary between a corridor and a patch. For example, the Warsaw Escarpment feeds adjacent parks with many species but it does not in case of the neighbouring settlement which needs it much more.

The results of all our studies suggest that planning a system of natural areas in a city is much more complicated than it may seem at first. A planner has to know precisely what he wants to achieve. However, there is no choice. If we want to preserve urban nature and thus improve living standards we have to solve difficult problems. Just drawing green belts and corridors onto a plan with only a vague awareness of biological issues is definitely not enough. The detailed studies of different aspects of natural functioning have to precede planning. The task for ecologists is not only to study natural systems but also to correlate significant features of the environment with attributes which could be easily incorporated into the plan and then executed (e. g., a size of an individual plot, height of houses, proportion of woody areas within plots, etc.). Thus, in development favouring urban nature, it would be possible to use not only the original remnants of natural ecosystems but also some considerably altered habitats. This pragmatic approach would be more acceptable to the authorities.

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