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Ecological models and urban wildlife

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Abstract

The promotion of urban ecological values is currently receiving a certain degree of political attention in the Netherlands, although not nearly as much as housing and jobs. In recent years, wildlife in and around cities has been studied as part of a long-term project called The Ecological City.

One of the questions being studied is how cities could be provided with a sustainable network of green areas (including water bodies), i.e., areas that could house viable plant and animal populations. The present paper reviews two questions. It first discusses how the viability of animal populations can be assessed, using a specially developed spatial expert model called LARCH-city. The second question that ensues is whether such a sustainable urban ecological network can actually be developed and maintained? The first question will be answered by illustrating the functions of the LARCH expert model, and specifically its application to urban areas. Answering the second question requires linking ecological expertise with expertise in the area of planning and people's wishes with regard to the use of and perception of urban green space. This is currently the focal point of our research.

1 Sustainability of urban green networks: the LARCH expert model

Alterra Green World Research has in recent years been developing an expert model called LARCH (Landscape ecological Analyses and Rules for the Configuration of Habitat), designed to assess the sustainability of ecological and spatial networks in rural areas.

LARCH is based on the concept of *meta-populations*. Many species have seen their habitats become highly fragmented and spread out over numerous larger and smaller landscape elements. The individual specimens form small (local) populations, which are often not viable on their own. Nevertheless, each patch has its own biodiversity and may house many different plant and animal species. The presence of these species is the result of links between the various (local) populations, which provide mutual support. They constitute a network of interlinked populations, a so-called meta-population (Opdam, 1987; Bergers & Opdam, 1996). Because of its larger size and spatial distribution, such a population network is more viable than individual small populations. This reduces the risk of a species disappearing from a particular patch. If a local population is about to die out, the patch can be recolonised from other, nearby patches, which are still inhabited by the meta-population.

How does the LARCH expert model predict the long-term chances of survival of a particular indicator species in a particular landscape? For this purpose, the model calculates the sustainability of each species in a number of steps (Pouwels, 2000, Opdam et al., 2001; Verboom et al., 2000; Vos et al., 2001) (see also Figure 1):

1. A vegetation map of the area is used to locate the potential habitat of each species. Some vegetation types constitute an ideal habitat and hence have a high carrying capacity, while others are marginal and have much lower carrying capacities. This analysis provides the change from vegetation map into habitat map (Fig. 1A). Data on the carrying capacity of particular vegetation types for a particular species are obtained from so-called species experts or from nationwide or even international studies. The LARCH model currently incorporates data on a few dozen indicator species for rural areas. The model input has been tested against many actual field situations, as described by Verboom *et al.* (2000) and Vos *et al.* (2001).
2. The spatial configuration of habitat patches, linking zones and barriers is then used to indicate the locations of the local and meta-populations of a species. Patches that are too far removed from each other, or are separated from each other by barriers (such as motorways or canals), are not regarded as belonging to the same local population. Habitat patches located close together and allowing daily exchange of individuals are regarded as belonging to the same local habitat network (Fig. 1B). Some individuals may be able to travel long distances in search of a new habitat at a particular stage in their lifecycle, a phenomenon known as dispersion (Bergers & Opdam, 1996). Local populations situated within dispersal distance from each other are regarded as belonging to the same meta-population. If the exchange of individuals is completely impossible, the groups are regarded as belonging to different meta-populations (Fig. 1D).
3. In the next step, the model can evaluate the sustainability of the habitat networks of meta-populations (Fig. 1E). The sustainability of a habitat network that houses a meta-population depends on the total number of individuals and the presence of key populations. Such key populations include a relatively large number of individuals and can therefore function as reservoirs for the colonisation of neighbouring habitat patches (Fig. 1C).

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Standard values for a number of species have been determined on the basis of guidelines from population dynamics.

4. In addition to the sustainability assessment, LARCH also provides information about the value (in terms of carrying capacity) of the various habitat patches for the network as a whole, and about the locations of corridors and local and meta-populations. This allows problems in the ecological structure to be identified and proposals to be made to solve these problems.

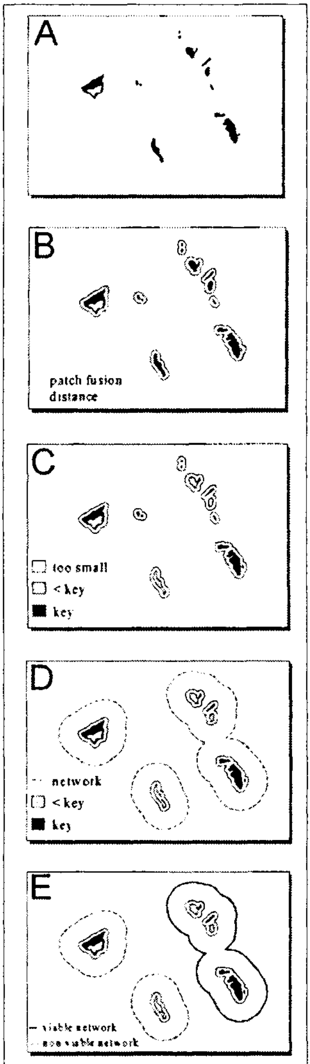

Figure 1: Measuring viability of animal populations in fragmented landscapes by the expertmodel LARCH.

2 The LARCH-city expert model

The LARCH model is currently being adapted for application to a number of urban areas in the Netherlands. The model has been used, for instance, in the Port of Rotterdam and in the city of Arnhem, to assess the sustainability of the ecological network for a number of animal species. These studies have revealed a number of specific problems (Snep *et al.*, 2000). To begin with, many animal species behave differently in urban than in rural areas. In addition, the dynamics of urban networks differs greatly from that of rural networks, as a result of a combination of factors. For instance, public gardens, parks and ponds in cities are managed and maintained far more intensively, and the level of direct interference by humans and domestic animals is more extreme. The urban system also has a number of specific characteristics: it is warmer than the surrounding countryside and has a highly regulated water system, which nevertheless shows high levels of qualitative and quantitative dynamics. The working mechanism of the urban system has been described only in anecdotal reports: research has often been limited to individual cities or groups of species. The frame of reference has usually been either environmental or biological (Roemer, 2000).

Research for the construction of the LARCH-city model is currently concentrating on two tracks. In the first track, the basic parameters of the model, a vegetation typology and profiles for indicator species are being adapted to the specific urban situation. The other track involves research in urban pilot areas, where the outcomes of calculations can be compared with data on the local distribution of animal species. By way of illustration, the next sections briefly discuss two projects carried out as part of the development of the LARCH-city model.

3 Learning by doing, the Arnhem case study

The city of Arnhem is situated on the edge of the Veluwe, a large area of more or less uninterrupted forests and nature reserves. Because of its large areas of urban green space and the proximity of large conservation areas like the Veluwe and the Rhine floodplains, Arnhem has considerable ecological potential. A LARCH analysis (Snep *et al.* 2000) was used to assess the opportunities and problems presented by the spatial structure of the urban green space, in particular the tree- and shrub-dominated biotopes, for two bird species, the Nuthatch (*Sitta europea*) and the Blackcap (*Sylvia atricapilla*). Figure 2 shows part of the Arnhem green space, viz. the Sonsbeek park and its surrounding area, indicating which patches are valuable to a species like the Blackcap. In a sense, the park was evaluated for its habitat potential through the eyes of this particular species. This occasionally results in an unexpected picture of its true ecological value. Certain parts of the park prove to be relatively uninteresting, while some housing and industrial areas actually turn out to be very valuable, especially as regards their potential habitat quality. Surveys made in the city have confirmed this picture.

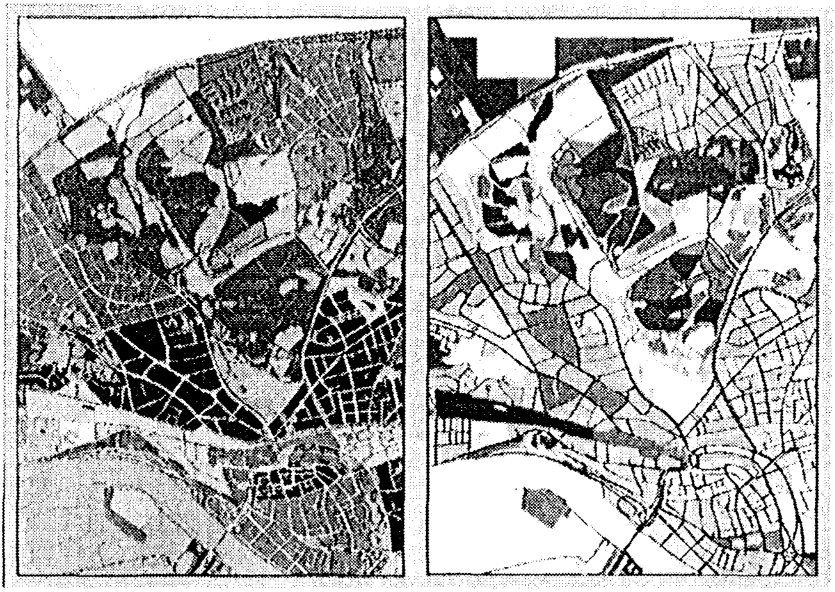

Figure 2: The urban park Sonsbeek in the city Arnhem. Left: the vegetation map, including urban green (light grey) and built-up area (dark grey). Right: the habitat map of the Black Cap. Areas with a high carrying capacity (optimal habitat) are dark grey, minimal or non-habitat is light-grey.

Results for the Nuthatch also indicate close parallels between the potential values calculated by LARCH and the animals actually observed in the areas. Nevertheless, there are some clear differences between the outcome of the model and the results of the field surveys. Nuthatches have actually been found in far more places than the LARCH-city model had predicted. A further analysis of the results leads to the following conclusions. In the older parts of the city the species occurs regularly in areas that the model predicted to have low carrying capacity. This can be explained from the presence of many large trees in wooded streets.

There is also another area that houses a large population, even though the model predicted a low carrying capacity. In addition, there is a considerable difference between two of the districts in this part of the city. Although both are relatively young districts (built after WWII), they differ in one crucial characteristic. In the western district, the existing ecological infrastructure was incorporated into the newly built estate, unlike what happened in the eastern district.

The conclusion from this study was that the city of Arnhem offers good long-term opportunities for maintaining and even enlarging its Nuthatch population. A useful tool for this is wooded streets integrated with the existing ecological infrastructure. For the development of the expert model, the findings mean that its carrying capacity estimates for certain vegetation types will need to be refined, and that a new type of vegetation, wooded streets, will have to be added.

4 Learning by doing, the Port of Rotterdam case study

The model was used in Rotterdam to calculate the sustainability of the existing ecological infrastructure in the port area for a number of indicator species (Snep *et al.*, 2001). The Port of Rotterdam is a unique landscape in terms of scale, dynamics and location, which not only accommodates various industrial activities but also offers space for wildlife.

An important ecological network is formed by the strips of land covering pipelines, which at surface level shows as large areas similiar to road verges, with high wildlife potential. Three management scenarios for these pipeline verges were compared for the indicator species Brown Argus (*Aricia agestis*): the present situation, a situation in which some pipelines would be constructed aboveground (which might be necessary in view of the predicted shortage of capacity) and a situation in which shrubs would be allowed to develop along the edges of the strips (as wildlife habitats). The first scenario is the present situation, in which pipeline verges are recognisable as wider (>30 m) or narrower strips of land with grassy vegetation, often running parallel to the roads infrastructure. In the second scenario, parts of the pipeline verges would be paved over, reducing their width by 25%. The third scenario would allow rows of shrubs to develop, including mainly species characteristic of dune shrubwood (because of the nearness of the coast).

Values of all relevant population dynamics parameters were included in a so-called species profile, from which LARCH calculated the effects of the three scenarios. The results of this analysis show that in the present situation, the pipeline verges contribute little to the total size of the population, in terms of the surface area and quality of the habitat. At the same time, however, their spatial structure offers a crucial network, which greatly contributes to the viability of the existing meta-populations of the Brown Argus in the Port of Rotterdam (see Figure 3).

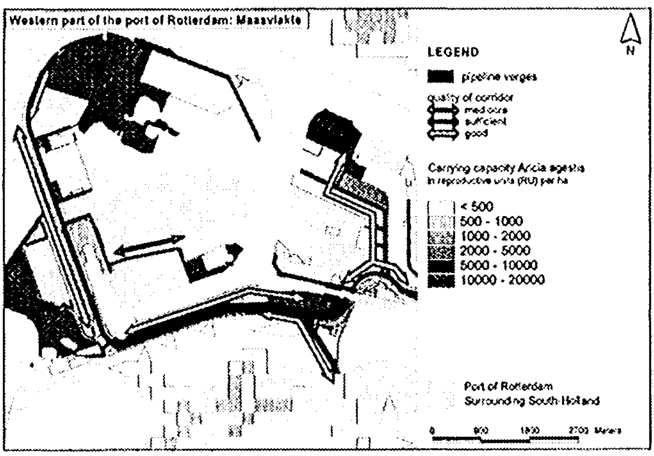

Figure 3: Connectivity function of pipeline verges (indicated with arrows) for the Brown Argus in the western part of the Port of Rotterdam.

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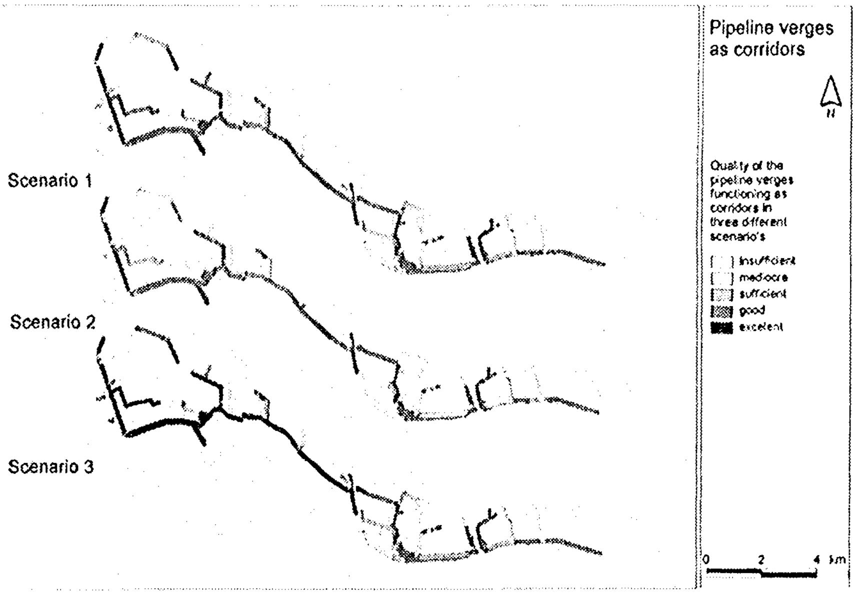

Figure 4: Connectivity function of pipeline verges for the Brown Argus in three scenario's. Scenario 2 will decrease the connectivity in the eastern part, while in scenario 3 the connectivity will increase in the western part of the Port of Rotterdam.

If parts of the pipeline verges are made unsuitable as a habitat (Scenario 2), this will have little effect on population sizes in the short term, but in the long term, unfavourable effects are predicted (Fig. 4). Scenario 3, in which shrubs are allowed to develop along the verges, will not only means a substantial increase (10%) in the total population size, but will also strengthen the linking function of the verges (Snep *et al.*, 2001).

5 Sustainable green networks and the city

The two examples discussed above illustrate different applications of the expert model. In Arnhem, the results constituted a potential ecological agenda for measures of urban planning and the design and management of urban parks and public gardens. In other words, the model can produce ecological input for a planning process. In the Rotterdam situation, the model was used to assess the consequences of various design and management scenarios, that is, to evaluate the output of the planning process. The model's empirical basis allows it to be used for both purposes, making it a powerful tool for predicting the sustainability of urban population networks. In itself, however, this is not enough to actually implement such networks, as that would require greater influence on the actual design processes and more attention for the support for particular plans among the residents. Hence, the second question was: how can a sustainable urban ecological network actually be developed and/or maintained? Answering this question means

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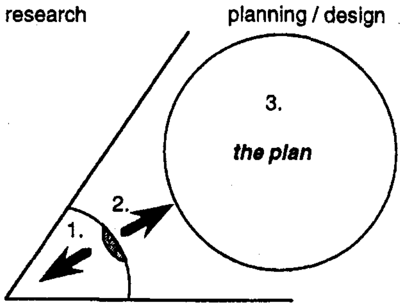

disciplines	1. empirical sciences	2. problem-oriented sciences	3. design-oriented sciences
aim	*the true* explanatory (general)	*the good* effective, efficient (categorical)	*the good* appropriate, legitimate (specific)
product	hypothesis prognosis	solution, standard	plan, policy

Figure 5 Relation between ecological research and planning proces (Tjallingii, 1996)

considering the process of development of local urban planning and the link between ecology and people's wishes regarding the use and perception of urban green space.

6 Discussion: physical planning and the various disciplines involved

Tjallingii (1996) discusses the relation between ecology as a science and the planning process. He distinguishes between empirical disciplines, problem-driven disciplines and design-oriented disciplines (Fig. 5). LARCH is based on a combination of expert judgement and empirical data, and uses this combination to assess design plans. LARCH assesses whether a particular ecological network could sustainably accommodate a particular population. This is the application that was used in Rotterdam.

Problem-driven disciplines produce 'good' solutions from one particular line of approach, and this is what was attempted in Arnhem: an ecological approach was used to formulate a programme of requirements to assist urban planning in this particular city.

In reality, cities face other problems besides the question how sustainable networks for animal populations can be achieved. These other problems, which include housing, employment, transport and social coherence, are usually far more important than the ecological problem, and may indeed be incompatible with it. While LARCH can be used as a basis for planning in those areas whose main

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function is wildlife, areas with various competing functions require a different, more design-driven approach.

Design-driven disciplines look for the most appropriate solution in situations where it is not just one specific problem that needs to be solved through planning, but a whole range of different problems. This requires creativity, communication, coalitions and co-ordination. How can wildlife be introduced at an industrial estate? How can a city house forms of wildlife that satisfy people's wishes? How can wildlife be developed within an economically viable scheme? How can wildlife be combined with water storage? What is needed is not so much an expert system, but a creative expert who is aware of the interfaces between ecology on the one hand and housing and employment on the other, and who is able to switch rapidly from one approach to another, as a team member. At least, this will be the case until LARCH-city has been developed to the stage where it is a straightforward calculator, requiring only that the designer enters a few parameter values to test various design solutions. Although this is indeed the long-term goal, LARCH is at present mainly suitable for testing the final outcomes of intangible design processes for the benefit of politicians and interest groups.

Does this mean there is currently no design-driven ecological approach to integrated planning? In fact, there is. Tjallingii (1996) formulated six guiding principles for ecologically sound urban planning, which have already been applied in a number of urban planning projects in the Netherlands (cf. Timmermans, 2000). These principles are:

1. Flexibility. Cities should develop in flexible patterns, based on supportive networks of roads and waterways. Large, unwieldy spatial claims should be avoided, since they make it hard to adapt to changes in societal preferences.
2. Flows. Water flows from clean to polluted reservoirs; motorised traffic flows from tranquil to crowded areas. This creates contrasts in water quality and tranquillity within cities.
3. Urban networks. Cities should accommodate networks of parks and water bodies, as well as reservoirs of species, such as historic estates or railway lines. Clean and tranquil areas should preferably be situated within the urban ecological network.
4. Ecological links. The urban ecological network should be adequately linked with comparable networks in the surrounding rural areas.
5. Change. There should always be room for new experiments and to learn from experience.
6. Shape. The ecological city does not imply a choice for a particular design.

Tjallingii uses these principles to try and create ecological conditions for wildlife and humans in cities, regarding the entire city as one ecosystem. Within Tjallingii's approach, LARCH-city can already be used to set an agenda for the introduction of urban wildlife and to evaluate whether the existing ecological infrastructure is actually able to accommodate particular species.

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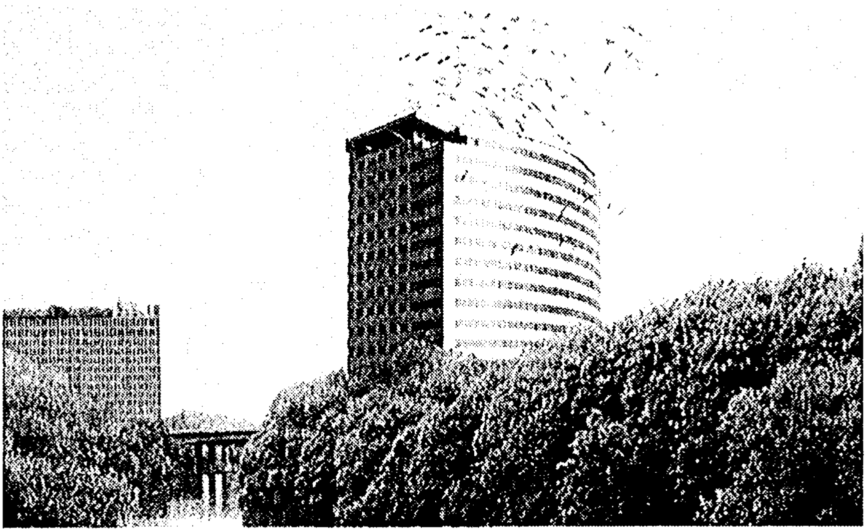

Figure 6: Technological image of wildlife as a setting for buildings. A colony of Common Tern (Sterna hirunda) on the roof of a high building.

7 Discussion: urban wildlife and public support

If designs introducing wildlife into cities are to enjoy a sufficient level of popular support, they should not only be based upon a balanced planning process, but also offer consumer value and perception value, since cities are meant for people.

Most cities give precedence to the consumer value of parks and public gardens, and do not include areas exclusively allocated to wildlife. Hence, the question how urban wildlife relates to the social and psychological, physical and economic functions of parks, public gardens and water bodies has been the subject of research for some time now (Butera, et al. 1998). Urban wildlife and social contacts, sports or recreation are not mutually exclusive entities, but do not automatically reinforce each other either. The same is true of urban wildlife and physical functions, such as attenuating traffic noise or buffering peaks in precipitation. And the economic value of parks and public gardens, which is reflected in the increased property prices near parks or water bodies, can also be fulfilled without increased ecological value (Timmermans & De Molenaar, 1999).

Finally, it is not only parks and gardens which can contribute to urban wildlife, but also 'non-green' objects like walls and roofs. For the time being, LARCH-city concentrates on the sustainable qualities of park and garden structures for plant and animal populations. Over the next few years, however, new research will also address the themes of urban wildlife and multiple use of space.

People have different ideas of what wildlife should look like. Buijs (2000) distinguishes five images of nature in rural areas. For instance, farmers tend to have a functional image of nature, while ecologists tend to base their image of nature on historical references, like wilderness or Arcadian landscapes. Finally, Buijs distinguishes a technological and an interactive image, which he assumes

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also have their proponents or will find them in the future. Research is now being done to find out whether these five images, which have been proposed on the basis of research in rural areas, are also applicable to urban settings.

A number of design studies for housing projects (Timmermans, 2000) have produced some expertise on this subject. Participatory studies of planning processes have shown that some architects prefer a more technological image of wildlife as a setting for their buildings, rather than, for instance, an Arcadian image (Fig. 6).

8 Conclusion

The LARCH-city expert model provides new opportunities to assess the sustainability of particular urban parks and garden structures as habitats for specific plant and animal species. The model can be used for agenda-setting as well as for the assessment of existing structures. It cannot as yet be used to participate directly in the actual urban design processes, but is expected to allow this application in the future. It could then be used within a broader view of the city as an ecosystem (Tjallingii, 1996). Since cities are primarily intended for people, further research will have to show how support among residents can be optimised, giving priority to consumer and perception values.

This means that the research effort will have to integrate contributions by cultural, scientific and social disciplines. If research intends to achieve the actual implementation of urban wildlife projects, then urban ecology should no longer be the exclusive domain of ecologists, but should also involve teams of sociologists, psychologists, planners and landscape architects.

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