ECOLOGICAL PRINCIPLES AND GUIDELINES FOR SUSTAINABLE URBAN PLANNING

CASE: URBAN GARDENS: CAN THEY CONTRIBUTE TO LOCAL BIODIVERSITY WITHIN BLUE-GREEN URBAN NETWORKS?

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ABSTRACT

In this paper we describe some principles, in order to establish and to restore urban biodiversity, in which urban gardens can play an important role. We based this contribution on the following scientific basic principles and guidelines from ecology science:

- 1. Abiotic conditions are dominant over biotic conditions. Plants and animals need the right abiotic environment, but also human activities depend on appropriate abiotic conditions (Schroevers, 1982).
- 2. Some abiotic conditions are dominant, aggressive. Other abiotic environmental conditions are weak and vulnerable. Only when these different conditions are planned and designed in sustainable gentle gradients, a wide variety of organisms will survive and biodiversity will be huge (Van Leeuwen, 1966b).
- 3. Time is dominating over space, Process (time) is the cause; pattern (space) is the consequence. So ecologically sound management of the blue-green areas is important, as it generates biodiverse patterns (Relation theory, Van Leeuwen, 1966)
- 4. Design blue green infrastructure, connecting corridors and stepping stones as much as possible within (urban) landscapes and avoid creating borders, fences and obstructions (Island theory, Mc Arthur & Wilson, 1967).
- 5. Consider cities as ecosystems and approach them with the tools and insights from ecology science (Breuste et al., 2008). Designing a well-thought public-private gradient within a lobe city framework is a key success factor towards an increasing contribution of urban gardens to typical local biodiversity. That is because such a gradient contributes to increasing horizontal ecological relations and connectivity between isolated blue-green urban islands (Rombaut, 1987 & 2008).

Keywords: Blue-green networks – climate proof urban planning – ecological gardens – lobe city – urban biodiversity.

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1. THE ECODEVICE MODEL

Each ecological insight starts with the recognition that all human activities are depending on an intact biotic level: Humans need plants for food and to replenish oxygen in the atmosphere. But in turn, plants and animals need appropriate abiotic ecological conditions such as water, sunlight, soil fertility, etc. This means that the abiotic sphere dominates the biotic one. Both, the biotic and abiotic level are important for humanity (Figure 1).

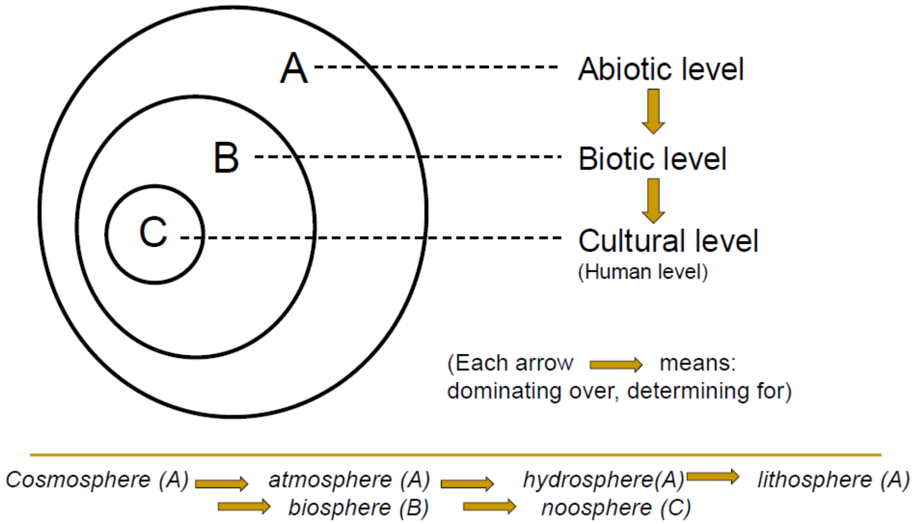


Figure 1: Human activities depend on intact biotic and abiotic levels (after Van Leeuwen, 1979 ; Schroevers, 1982).

There are two well-known approaches of nature and ecology.

The first discourse is the traditional approach in which city and nature are enemies; nature starts where the city ends. Nature is an object, a species or a nature reserve. Biologists do not care about the city; they are experts dealing with conservation biology and wild management in green rural areas. Humans and nature are kept separate from each other. Nature is an object which means *nature is something to have, to protect or to lose*.

Luckily a second discourse, in which nature is seen as a process, is emerging fast. Ecology science laws and mechanisms are working always and everywhere, thus also within cities. (Rain) water, soil, climate are abiotic conditions, influencing organisms. Organisms are influencing each other, also within cities. Urban city-planning and land-use planning are therefore working with nature and with the basic ecological processes. The aims of ecologically and socially sound urban planning and designing are to create ecological conditions which are attractive for plants, animals and for human activities. Humans are part of nature. So this second discourse is focussing on processes: n*ature and ecology as a process, as something to do* (Tjallingii, 2000).

Ecologically sound urban and rural planning is taking natural processes as the point of departure. Creating and restoring the appropriate conditions (patterns and processes) in order to restore biodiversity and social diversity in urban and rural areas, is the aim of this sustainable approach.

2. PATTERN PLANNING. ABIOTIC ECOLOGICAL CONDITIONS HAVE TO BE DESIGNED IN SUSTAINABLE GRADIENTS

Certain abiotic conditions are dominant and aggressive. Other abiotic environmental conditions are weak and vulnerable (Silence < noise ; clean < dirty ; quiet < dynamic ; fresh water < salt water). In habitats characterized by a lot of weak abiotic conditions, a lot of different species can grow: 80 % of the indigenous plant species (Waajen, 1985). Biodiversity is high. (Clean, silent, fresh water, very few minerals, etc.). In habitats (such as cities, coastal areas, etc.) with a lot of dominant, aggressive abiotic conditions, very few species can grow: 20 % (Waajen, 1985). Biodiversity is low. Those species can occur in very large populations with a great biomass: very few species can survive but very high densities and a lot of individuals can occur.

It becomes clear that aggressive abiotic conditions (Dirt, salt, dynamic, a lot of manure minerals, etc.) which are situated on dominant positions (topographically higher, upstream, etc.) or which are badly buffered, will affect vulnerable abiotic conditions situated downstream and situated on lower positions (Rombaut, 1987 ; Rombaut en Michielsen, 2005). So in each design the underlying ecological principle has to be, creating a stable gradient by allowing water to flow from clean to polluted, from nutrient-poor to nutrient-rich conditions, from low dynamic to high dynamic (Figure 2 &

Figure 3). It is the sustainable variation (gradient) of abiotic conditions that determines a sustainable variety of plants and animals.

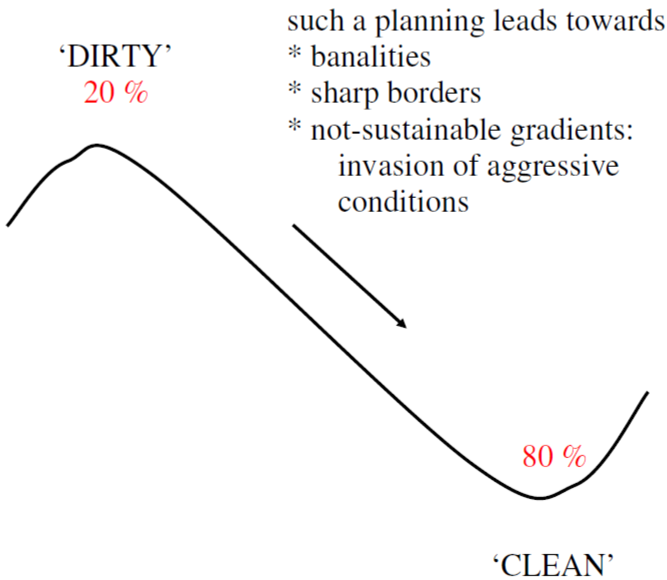


Figure 2: This situation of ecological conditions is to be avoided by design.

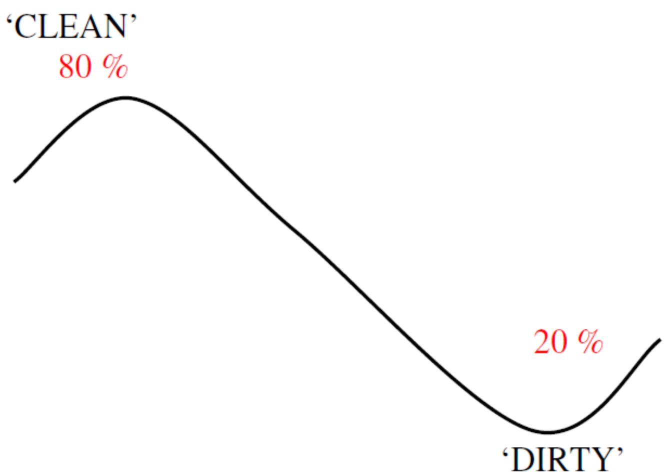


Figure 3: This situation is to be created, also while designing gardens and urban green areas. Such a planning leads towards blurred boundaries, sustainable gradients, increasing differentiation, high biodiversity.

Suitable guiding models for the interconnection between the urban water system with the rural water systems can be found in STOWA (2000), such as the connection model (already presented by Tjallingii, 1996, Figure

4). The connection model can be used to design a sustainable regional water system. In this connection model the underlying ecological principle is to create a stable gradient by allowing water to flow from clean to polluted, from nutrient-poor to nutrient-rich conditions. There are two possibilities: a series connection and a parallel connection. In both cases, the aim is to find the best mutual adjustment between the water systems and the land use of different areas. Indeed, nature and leisure areas need the best qualities of water. That is because of the linkage between clean ecological conditions and both a great biodiversity and an intact human health. In the connection model, residential areas are therefore located in the water system *upstream* from agricultural-industrial areas, but *downstream* from nature and leisure areas (Tjallingii, 2005). This entire means: taking into account important horizontal ecological relations (Rombaut, 1987).

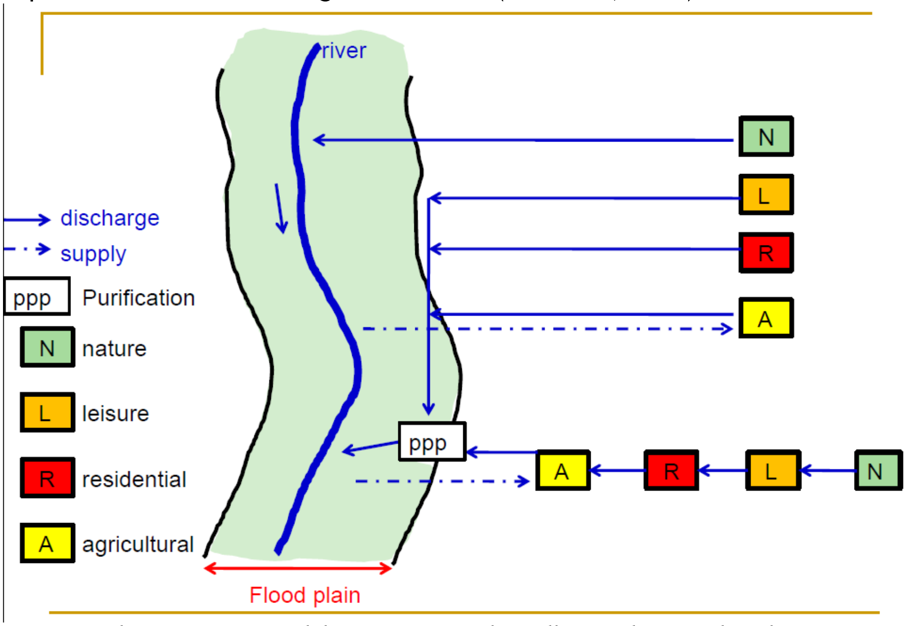


Figure 4. The connection model suggests an ecologically sound water-chain between rural and urban regions. (After Stowa, 2000)

Suitable guiding models for residential areas (sensu strictu) can also be found in STOWA (2000), in which the infiltration model and circulation model (already presented by Tjallingii, 1996) are applied. Key words are *retention* and *infiltration* of clean rainwater in urban areas, for which urban gardens are important The general principle ‘to keep and to retain clean (rain) water longer within the city’, leads to a cascade-like approach. Wadis are very useful to reach that aim (

Figure 5). A wadi is an Arabic word, which means a dry river valley in deserts. Those valleys contain water in the scarce rainy periods, most of the year they are dry. This is exactly the same situation with wadis, designed in urban areas, which are only filled with water in rainy periods. The word wadi has playfully given inspiration to a Dutch acronym "w.a.d.i." standing for: "**w**ater **a**fvoer **d**oor **i**nfiltratie" (evacuation of water by infiltration). Wadis can be very useful in urban regions to infiltrate water. A lot of experience is sampled in Germany (ecoquarters *Schüngelberg*' and *Kuppersbusch*, city of Gelsenkirchen, in German wadis are called 'Mulden-Rigolen-Systeme') and in the Netherlands (ecoquarters *Ruwenbos* and *Oikos*, city of Enschede). Wadis can be combined very well with green structures and they can support biodiversity within city quarters. Of course there are a lot of other infiltration techniques available, such as underground infiltration caissons. But those are of less importance for restoring biodiversity, though they are important to supply the groundwater level beneath the urban region.

Malmö (Sweden). Green roofs, permeable parking and wadis in the ecoquarter *Augustenborg*.

Culemborg (NL). Wadi in a garden of the eco quarter *EVALanxmeer*.

Helsinki (Fin.). Wadi in the ecoquarter *Eco-Viikki*.	Helsinki (Fin.). Rainwater playground for children in the eco-quarter *Eco-Viikki*.

Figure 5: Wadis and how they help to infiltrate clean rainwater in some European urban regions.

Perlman & Milder (2005: 208) put it like this: *'design storm water management systems that mimic natural ones, by treating and infiltrating water on-site (rather than piping it away), using natural vegetated systems for treatment and infiltration and integrating storm water management with landscape design'*.

One doesn't need to be an expert to understand that water (quality and quantity) as an abiotic ecological condition, is very relevant for maintaining and restoring biodiversity in urban green areas and gardens. But there is more to be told, because designing a good *pattern* alone seems not to be enough…

3. ABOUT PROCESSES AS THE CAUSE OF PATTERNS

Indeed, the Relation Theory (Van Leeuwen, 1966) explained clearly that *processes* (management) are at least as important. Process (time) is the cause; pattern (space) is the consequence. That means temporal aspects dominate spatial ones. So sustainable blurred gradients have not only to be designed gentle and correctly (Figure 3), they also need an ecologically sound management. So do choose management techniques, which will lead into biodiverse patterns, very carefully. The creation and maintenance of a great variety of different green structures and habitats is very important (in different stages of succession), also for fauna conservation and restoration. Haying, pruning and hewing (taking away biomass and thus mineral-impoverishing), extensive grazing with animals and keeping green areas wet, are measurements that often result in very different biotopes with a huge biodiversity. A lot of experience of nature management techniques is sampled in rural context. This kind of ecology-based management is of course also applicable in urban green areas and urban gardens.

In Flanders, due to guidelines for harmonic park and green management (HPG), developed by the Flemish government, more and more cities and municipalities incorporate sustainable green management into their urban planning. Gardens are also considered as an important category of urban green that deserve more attention from nature- and environmental policies (ANB, 2011). Although the ideas of Harmonic Park and Green management (HPG) are growing fast in a lot of cities, the urban biodiversity of plants and animals is often very low. A first important reason for that is the dominance of aggressive ecological conditions in urban areas, such as noise, stress, dirt, disturbance, etc.

But areas that could contain more kinds of species are not only badly equipped and designed for (**pattern**) but often also badly managed (**process**). The same aggressive species always benefit from cutting the lawn too often, using too many biocides, too much manure, etc. Large waste deposits, sewer systems, food storages, etc. are just optimal habitats for very few species. That's the reason why populations of these species (like nettles, rats and doves) can increase and become real pests within urban areas. Using pesticides against them is not advisable because that only focuses on the effects, not on the causes of the problems.

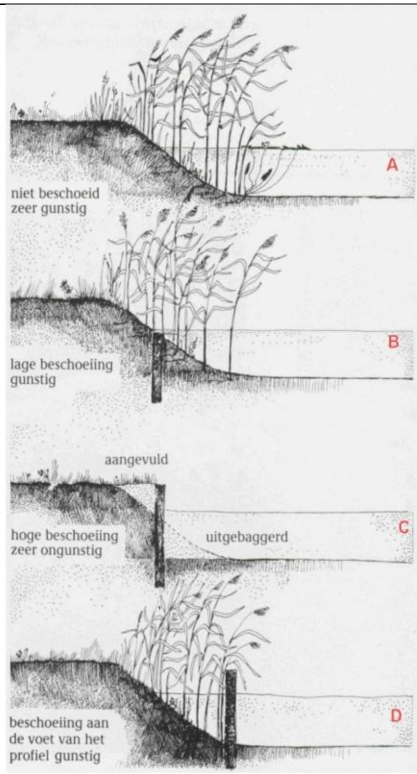
Designing and creating a various abiotic environment (pattern) followed by a well fitted nature-friendly way of management (process) is the best guarantee for a very rich, spontaneous flora and fauna, also within urban areas (Figure 9), and that for an attractive low cost. Indeed, the traditional intensive green management is more expensive than ecologically sound extensive green management techniques (Hermy, 2005). Ecologically sound green management needs less labour. So, the money savings can be used for the environmentally friendly maintenance of the stony city centre. On the contrary, the maintenance of e.g. cycling paths and footpaths, without using pesticides, needs more labour to be done. So on balance, employment is maintained with less management costs for the municipality (Vastenhout, 1994).

Hingene (B)

Figure 6: Too intensive management of gardens, road verges and green areas is problematic for a lot of indigenous plants and animals. Such a wrong management is expensive; it often leads to sharp boundaries, banality and monotony.

Stekene (B). The designing of a very gentle (blurred) water-land gradient ….

Culemborg (NL). …creates nice living areas for people and appropriate abiotic conditions for different plants and animals



Tenellaplas (Rockanje, NL). Gentle water-land gradients offer an appropriate situation for a variety of indigenous plants and animals in rural context. This is also applicable in urban areas.

Designing slopes in a gradual manner (A) instead of making them very steep (C) is better for waterfowl and marsh plants, also within urban areas. If it is needed to protect the riverbanks against damage (by passing ships) design solution B or D (permeable bank protection). Such a design creates breeding zones for all kinds of animals (fish, amphibians…) (Anonym, 1982).

Figure 7: Designing gentle, blurred gradients is interesting for indigenous fauna and flora in both rural and in urban situations.

4. BLUE GREEN NETWORKS ARE NEEDED, ALSO IN URBANIZED AREAS

In many countries, the insights from the Island theory (Mc Arthur & Wilson, 1967) lead into the designing of national rural networks of nature reserves (in Flanders the so-called Flemish ecological network) which are part of a European initiative: the Natura-2000 network. The aim is to give species better possibilities for unhindered migration through the countryside and to avoid nature reserves to become islands (with increasing danger for incest problems). There is growing evidence that such blue-green networks are also very important for the conservation and restoration of urban biodiversity (Van Zoest & Melchers, 2006).

As blue-green urban networks are important, use therefore existing blue-green structures that can be found in both the old city centre as in new city-extension. Connect them to the rural ecological network (Natura-2000). Create sustainable gradients (wet/dry ; high/low, etc.). Use water systems, ponds and rivers as carriers of the nature-network in the blue-green wedges through the lobe-city. Think of greening facades, native trees and shrubs along streets, nature friendly riverbanks (Figure 7) and green roofs etc. to link to this blue-green urban network, in which urban gardens of course play a major role.

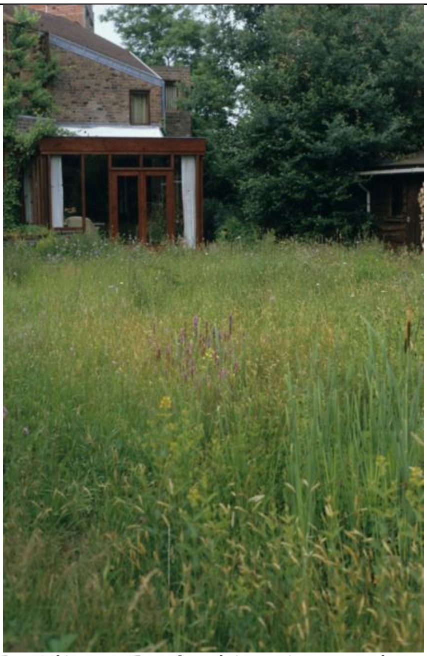
All this triggered the scientific research on urban biodiversity; there are different attempts to consider cities as ecosystems and to approach them with the tools and insights from ecology science (Breuste et al., 2008). That means that different concepts such as ecological infrastructure, stepping-stones and corridors, connectivity and abiotic diversity are used more and more in urban context and in scientific literature about the eco-city (Goddard, et al. 2009). Avoiding separation, obstruction and fence effects for plants and animals when designing infrastructure, is very important. This often means building the infrastructure (walking or cycling tracks) perpendicular to the abiotic gradient (slope). This means designing infrastructure perpendicular to the vegetation boundaries instead of parallel (Figure 8). As a consequence people walk or cycle through very different landscapes and vegetations in gardens and parks, which is also very attractive for recreational reasons.

Figure 8: Arnhem (The Netherlands). A huge biodiversity is created in the city park Presikhaaf, by designing sustainable gradients (pattern) in combination with a suitable ecologically sound management (process).

The ongoing climate change is adding more arguments. Because blue-green fingers have an interesting impact in urban climate, the concept of the lobe-city finds more and more followers and defenders (Rombaut, 2009). Blue-green fingers temper the urban heath-island effect and provide humidity (www.epa.gov/heatisland). The built-up areas have a higher temperature (concrete, bricks and paved tracks get warmer than water and green), thus a lower air pressure than blue-green areas have. Blue-green fingers remain colder. Air transport from the green wedges towards the city (convection) keeps lobe-cities cooler and brings more humidity in the built-up zones (Hermy, 2005).

This means that urban blue-green networks, with an important role for gardens, might play an important role in the search for a climate-proof city planning. Not only urban biodiversity is better off. Also all citizens have a strong interest in buffering and mitigating the ongoing climate change (Rombaut, 2008b).

City park Aalst



De Klinge (B). In this private urban garden ecologically sound management processes are applied, which lead to an increasing biodiversity.

Aalst (B). More and more lawns of the city park are maintained in an ecologically sound way: Haying once or twice a year diminishes the amount of minerals, from which rare orchids benefit (e.g. *Dactylorhiza fuchsii*).

Figure 9: More and more governments and individuals are switching to ecological green management, with good results.

5. A WELL-THOUGHT PUBLIC-PRIVATE GRADIENT OFFERS A LOT OF OPPORTUNITIES FOR SOCIAL AND ENVIRONMENTAL GAINS.

In a growing number of European ecoquarters, the creation of a semi-public green area from the start of the designing process seems a key for success (Figure 10). In a growing number of ecologically sound city-quarters and building blocks, the inhabitants buy and own an inner green area in common. In these ecoquarters with a common owned central green area, a lot of ecological problems can be solved, on the level of the quarter or the building block, such as infiltration of rainwater, common marsh plant purification, common composting initiatives, etc. (Rombaut, 2008). These common green areas create also social benefits. Residents may participate in the designing and the management of these common gardens, which is important for increasing the social cohesion. The advantages for the municipalities are clear: economising costs; local residents are actively involved in the garden management activities and there is an increasing social control in (semi)public green areas. In the municipality of Kolding (Denmark), local residents open their common-owned garden for the public during daytime, offering the citizens a nice green area. In exchange, the municipality decided to maintain the common-owned inner garden by the official park staff. A very nice consequence is the possibility for the creation of shorter and safer attractive urban cycling and walking tracks. Short-cuts like these, through the built-up areas can stimulate people to walk or to cycle in the inner city (Rombaut, 2009; Rombaut & Heuts 2010).

This interesting public-private-gradient-strategy is best framed within the lobe-city concept. In a lobe-city, the strategy of the two networks is applied (S2N) (Tjallingii, 2005). The water network carries the blue-green fingers; the traffic network carries the built-up city lobes.

Within the blue-green fingers (the slow lane), the *low-dynamic activities* are concentrated such as foot paths and cycle lanes, city farming, extensive recreational forms, nature, ponds for the infiltration of rain water, cemeteries, some sports infrastructure, etc. Sundseth & Raeymaekers (2006) showed that within lobe-cities, urban nature of great value can be conserved and restored: the number and the quality (even with red list species) of the urban Natura-2000 areas within the lobe-cities of Berlin and Copenhagen are very impressive.

Within the built-up city lobes (the fast lane), the *high-dynamic activities* are planned, such as industrial activities, (public) transport tracks, trade services, intensive mass recreation, etc. The residential areas are situated in-between. The two networks create a good position for residential land-use in the middle, with free access to both the slow lane and the fast lane. Notice that conventional agriculture is regarded as a highly dynamic activity, which is better linked to the industrial area rather than to the blue-green zone (Figure 4). Of course, organic urban agriculture and farming is to be integrated within the blue-green fingers. So in the lobe-city, it all boils down to the *design of contrasts,* close to each other and linked with the basic scientific ecological laws and principles. Just like the traffic network supports the fast lane of dynamic social and economic life, the water network supports the slow lane of leisure and nature.

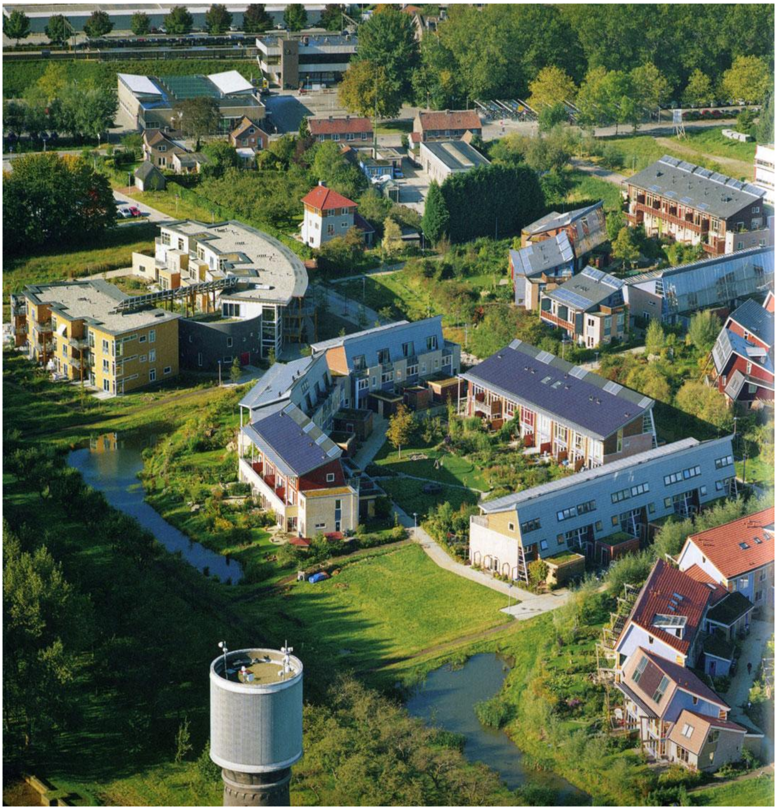
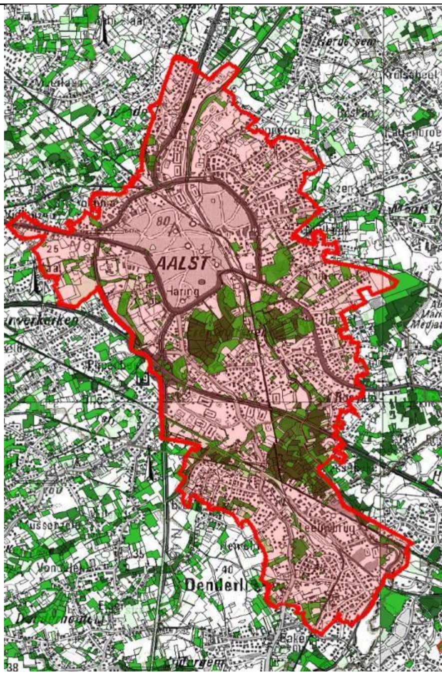
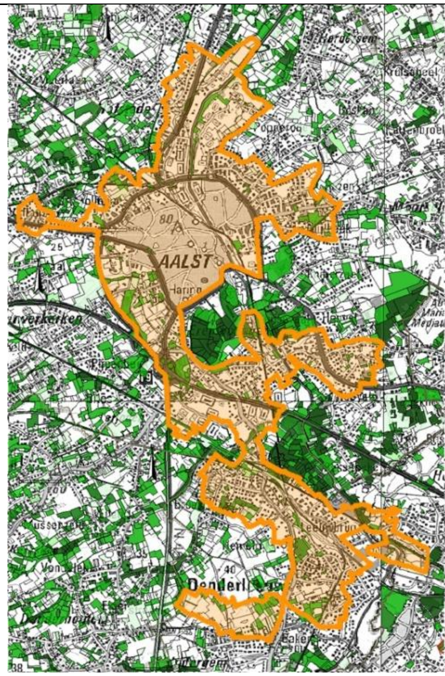


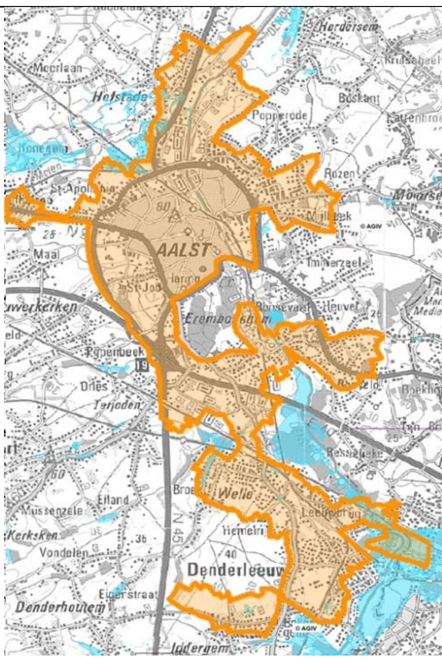
Figure 10: Private gardens, gently connected with semi-public green areas might play an important role in climate proof city planning. Those blue green fingers help cooling the urban areas down, provide surface for controlled flooding and provide water storage for dry periods. (Ecoquarter EVA Lanxmeer in Culemborg (NL). (Picture from bureau Eble (D.)

There is another important reason why lobe cities often show a huge biodiversity. A lobe-city has a long urban fringe between the built-up lobes and the blue-green fingers. That is opposite to a so-called compact (concentric growing) city which has a shorter circumference.

As an example we consider the official plans of the planning authority for the city extension of the Belgian city of Aalst, in which the principle of the concentric expanding compact city was used. Recently we presented a study in which we applied the lobe-city concept on this city, as an alternative for the proposed concentric grow (Rombaut et al. 2008). In Table 1 both models are compared.







The official proposal to expand the city of Aalst in a concentric way (above left) is threatening a lot of areas with a high biological value (green zones). The city expansion following the lobe-city guidelines (above right) excludes those green areas from city expansion, integrating them into the blue-green fingers.

The official proposal to expand Aalst in a concentric way (above left) is also occupying a lot of recently flooded areas (blue zones). The city expansion following the lobe-city guidelines excludes those wet areas along the river 'Dender' from city expansion, integrating them into the blue-green fingers (under left). From Rombaut (2009).

Figure 11. Comparison of the concentric city-expansion plans of Aalst with the lobe-city proposals.

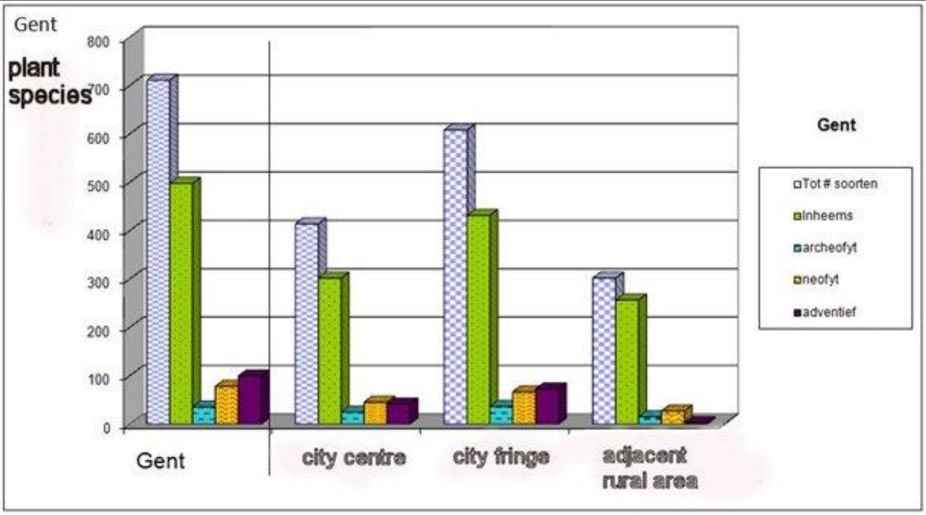
Aalst	Concentric model	Lobe-city model
City circumference (fringe)	+/- 44 km	+/- 60 km
City surface	+/- 3658 ha	+/- 2412 ha

Table 1. An expansion of the city of Aalst applying the lobe-city model results in a longer urban fringe and needs less city surface (Rombaut, 2009).

The longer the urban fringe, the better an ecopolis can be achieved. Citizens are rewarded with an attractive neighbourhood: rural and urban features both are very close to their dwellings. This strategy leads to the maximum of citizens living in attractive residential areas. (Tjallingii, 2000). But there is another advantage: it is well-known that the biodiversity of the city fringe is often much higher than in the stony and sealed city centre. (

Figure 12: Gent, Hermy, 2005). But also in the adjacent rural areas which are often occupied by intensive agricultural land, there is less biodiversity left, than in the outskirts of the cities (Honnay et al. 2003). For a lot of wild plants and animals the intensive use of both the centre of the cities and of the surrounding agricultural areas is a problem. City fringes are often used less intensive and show a huge spatial variety, the so called ‘patchiness’, which is related with species diversity (Van Zoest & Melchers, 2006). Because of the lower densities of dwellings and the presence of green (especially urban gardens and green corridors) urban fringes show a good connectivity (as in the lobe-city of Stockholm, e.g. Mörtberg & Wallentinus, 2000). However, edge effects from the (high dynamic) city lobes often can be too strong for the conservation of (low dynamic) high-quality nature in the blue-green fingers. Therefore, it still remains important to conserve big natural rural entities. The lobe-city can then play an important role in the connection of these bigger rural high quality natural entities with the city and the citizens, through the blue-green fingers.

Designers of rural areas and urban designers have to meet each other in this urban fringe and have to search together to a mutual adjustment of the plans. Unfortunately the urban fringe is under urban pressure, so it is time scientific attention is given to the design and management of the contact zones between urban and rural areas (Rombaut, 2001). This discourse is developing: e.g. the international congress in Gent (B) which was devoted to the problems of the urban fringe.



Stad Gent (B)

Figure 12: City fringes often have a very high biodiversity, not only in comparison with the centres, but also with the adjacent rural agricultural areas. The example of the city of Ghent (B, Hermy, 2005)

6. CONCLUSION.

Urban gardens, parks and green areas indeed can contribute to local biodiversity in urban areas if…

- If the basic laws and guidelines from ecology science – some of which we mentioned in this paper – are respected and applied within blue-green urban areas and networks.
- If they are interconnected with each other through a well thought public-private gradient, if possible within the frame of a lobe-city and linked to the rural blue-green networks (Natura-2000).
- If ecologically sound green management is used as a process in order to restore interesting biodiverse patterns.

Given the fact that more than 8 % of Flanders' surface is part of this garden complex and thus is to be considered as part of the urban green area, the potential for improving local biodiversity is huge. To achieve these goals, it is very important to import rural experiences and knowledge in managing and maintaining nature reserves, into the urban areas. That is important, not only for the reason that ecologically sound management of gardens often is cheaper, but also because it has been proven that this approach can lead to the conservation of an urban biodiversity that meets a very high standard. Even endangered red list species can be protected within urban areas, as e.g. the cities of Berlin and Copenhagen have been proving (Sundseth & Raeymaekers (2006). To conclude, the Flemish garden complex might play a major role in restoring urban biodiversity.

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