

Laboratory for New Urban Biotopes

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Abstract: The significance of urban green space in the metropolis gains weight if ecological value is linked to daily use in the urban living environment in a proper manner. A different layout of the urban domain is needed for a contribution to climate adaptation and biodiversity increase, and it is relevant to examine how plants can develop more according to the principles of succession of natural vegetation. Creating a 1:1 laboratory in Merwede, the Netherlands, provides a test case for introducing the urban biotope at various locations. Greenery in the city may be different than a natural ecosystem, but it can meet qualities that contribute to biodiversity, improvement of the urban air quality, reduce heat stress, seasonal effects and food production in the city.

Key words: Agriculture, agroforest, biodiversity, foodscapes, landscape, permaculture, planting, urbanism.

1. Biodiversity in the Metropolis

The vulnerability of the urban landscape is painfully apparent when there are floods or periods of severe drought. The urban landscape is suffering from heat stress. In this light, it is striking that biodiversity is higher in the urban region at this time than in the landscape outside the city. That appears to be a major achievement, but says more, unfortunately, about the intensification of land use and the growth in scale of agriculture outside the city. For a better urban climate and good environment, it is desirable to create more green space and aim at biodiversity, and to introduce a variety of species in the area.

Increasing the variety of plants is not only desirable from a biodiversity perspective, but also to prevent illnesses. In past years, there has been mass mortality due to, in successive order, Dutch elm disease caused by the fungus *Ophiostoma ulmi*, sweet chestnut blight caused by *Phytophthora* infections and ash dieback caused by the fungus *Hymenoscyphus fraxineus*. The picture is changing dramatically in urban regions where these trees are planted en masse. Planting specific species to the exclusion of others makes the tree stock in the city vulnerable. The sorry picture of a

single tree in the street is far removed from a more natural kind of experience of green space in the public space.

Various places in the city can be greened. In the first instance, it is desirable to create larger green areas, but for the city as a whole it is desirable to actually make an impact in the public space of streets, boulevards and squares, where the city is paved the most and used the most intensively. The majority of these spaces' surface is paved. Changing that is the basis for greener and more liveable cities.

1.1 Thinking about an "Urban Biotope"

The significance of urban green space gains weight if ecological value is linked to daily use in the urban living environment in a proper manner. A different layout of the urban domain is needed for a contribution to climate adaptation and biodiversity increase, and it is relevant to examine how plants can develop more according to the principles of succession of natural vegetation. It becomes interesting to think in an "urban biotope", in which interplay of plants can also develop in the public space. The principles of permaculture are relevant to that. The strength of the natural ecological communities is that species reinforce each other and that the symbiosis leads to a succession occurring, in which the biotope gains in value.

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In order to arrive at a meaningful urban biome, it is useful to evaluate a number of new types of urban spaces that are aimed at nature in the city and increasing biodiversity, stemming from permaculture. In the recent past, the urban forest and the “tiny forest” have been introduced and the “food forest” has emerged. On the basis of the principles of permaculture, principles can be derived from the restoration of natural vegetation as used in the tiny forest and from the food forest (“agroforest”). In addition, the development over time is crucial to the idea of the urban biome. In contrast to formal planting, such as an avenue, the image of dynamic planting will be subject to changes. It requires a new conceptual framework that can be related to interventions in the planting. The points of reference for the urban biome will be applied in a living lab for the urban biome: Merwede, the Netherlands.

2. Learning from Permaculture

2.1 Mother Tree

In the case of planting in the city, one must ensure that the plants, just as in nature, reinforce one another. Trees exhibit interaction, depending on the species

and environmental circumstances [1]. Research has revealed that trees communicate with other plants in the forest via an invisible underground fungal network. A crucial role in this regard is played by the “mother trees”—the largest, oldest trees in the forest—where nutrients, water and defence signals are passed on to other trees [2]. Of course, the urban environments differ greatly from the natural forests surrounding the city, but there are interesting principles to translate to the urban environment (Fig. 1).

In the application of principle from nature, it is relevant to realise that there is a leap in scale, a higher intensity of use and difficult conditions for plants. The size of the urban space is many times smaller than outside the city. The green space is not only nature, but is also used for meetings, sport and play. Plants are faced with fall winds, higher temperatures in the city and lots of paved surfaces in the surroundings.

In general, permaculture refers to landscapes where advantage is taken of natural ecological processes by integrating various plants, animals and pests in one system. There are also trees with their own habitat in the urban environment, but supporting plants are almost always missing in the surroundings.



Fig. 1 The crucial role played by the ‘mother trees’ passing on nutrients, water and defence signals onto other trees (photo: Roeland Meek, OKRA).

In the urban area, it is translated to a simpler principle, where each element of the landscape must support at least two other elements and must be supported by at least two others. It requires a design that caters for the fundamental microclimatological parameters, sun and shadow, such as short and long wave radiation, wind effects, soil and nutrients.

A second principle can be derived from the notion of the mother tree. In the case of new urban developments, the monumental tree is often spared, but it would be even more interesting to give this a role in the planting by incorporating this into a more spacious green area and also to consider the soil quality as basis for the new plants. The selection can be tailored to the existing tree or numerous existing trees [3].

2.2 Food Forest

The principle of permaculture is also used on a small scale in the cultivation, in the food forest. In the search for varied plants in contrast to monoculture plants in the urban region, the food forest is interesting due to the analogy of the crop diversity in contrast to the monoculture of cultivation of annual crops. It derives from the principles of the ancient forests in which people collected food.

One of the examples that are currently demonstrating long-term results is the food forest of Robert Hart, who planted a prototype on his farm in Shropshire (UK) in the 1960s [4]. Food forests are being created in a wide range of initiatives in Europe varying in scale from garden to agricultural area. Outside the city, the food forest is an alternative form of agriculture, where use is made of the “third dimension” (rising plants instead of crops close to the ground). In contrast to regular agriculture with ground-level production, the food forest rises with its trees [5].

In the city, the accent is shifting from the “agroforest” to “forest garden”. The forest garden is, in fact, carefully designed greenery in accordance

with the structure of a young natural forest, with trees, shrubs, annuals, root crops and climbers that are of direct or indirect value to humans. The structure of the plants is supported by canopy species, not necessarily large trees, and sometimes just three metres high [6]. The translation into the urban area also means that the accent shifts from only production to experience, engagement and education. An experiment with “edible public realm” in Leeds (UK) not only involves local residents in food production, but also lays the foundation for “ethical foodscapes”. It means handling public space in a different manner, accepting a different aesthetic image, more responsibility from the local residents [7] (Fig. 2).

2.3 Tiny Forest

The manner in which restoration of natural vegetation takes place provides input for the development of planting in the city. In the 1980s, the Japanese botanist Akira Miyawaki developed a method for restoring natural, native forests. Referring to “potential natural vegetation” (PNV), he developed a method of “ecological engineering” making use of seeds in deforested areas with extremely degraded soils without a humus layer. Of the more than 1,700 forests that he planted, a very large number of them developed a resilient ecosystem within 10 years. Although the method was chiefly applied in the Far East and Latin America, it also offers opportunities in Europe [8].

The concept of the “tiny forest” is a translation of the “Miyawaki method” to the urban environment by the Indian engineer Shubhendu Sharma. In order to bring nature to the city, a tiny forest is made at various places, a small, fast-growing forest with native trees close together on a small piece of land, about as large as a tennis court. The tropical tiny forest was further developed to include temperate climates and introduced to the Netherlands by the Instituut voor Natuureducatie en Duurzaamheid (Institute for Nature Education and Sustainability, IVN).



Fig. 2 The quality of the edible garden, Kirchberg-Grünwald (photo: Pierre-Alexandre Marchevet, OKRA).

Intensive soil cultivation is required, of course, and the tiny forest consists of a collection of plants with homogeneous ages. Ensuring there is a good habitat for almost each location is necessary for the green space in the urban region. Initial evaluations of the tiny forest in the city show that the plants have ecological value in spite of the homogeneous structure. Wageningen Environmental Research examined the biodiversity of two tiny forests in Zaandam (NL) and it turned out that both the number of groups of species and their numbers had grown substantially compared with the start [9].

The actual drawback to application of tiny forests in the city lies in the usage. The significance of the urban forest as public space is different to that of the forest outside the city. The perception of the visitor is that he/she expects a different forest, closer to the image of the park. Interviews of users revealed that the forest should be larger, between one and five hectares, and should lend itself to social activities, an intensive nature experience, a brief nature experience, cycling, jogging and sport [10]. A small forest will also be planted in Paris at Tour Montparnasse, taking a

minimum of one hectare as a starting point [11].

3. Development over Time

The time dependency in the development process of the planting is a crucial factor in the landscape architecture. Human-designed succession plays an important role in French landscape architecture. The idea of Gilles Clément, the “garden in motion”, was inspired by the neglected land (*friche*): a parcel of land left behind to the unhindered development of those plants that settle there. In the case of succession planting, the gardener must choose which balance between shadow and light is relevant, which adjustment between the species present, with the aim being to preserve and increase the biological diversity, a source of amazement, a guarantee for the future. The preservation and improvement of the biological quality of the substrate, water, soil and air is required for this. The intervention takes place with the fewest possible resources and limited input from water and machines [12].

Process-related design has become more important. Recently, “curation ecologies” and “managed

succession” have been explored. The relationship between man and nature is given a contemporary dimension, succession on the man-made subsoil, or succession via human control. For the design of a contaminated site for the Museum Park Louvre-Lens, Catherine Mosbach opts to work with a conceptual framework of “condensation”, “contamination” (of forms and uses), “initiation” and “consolidation” due to the contaminated site and the anthropogenic ecology. A different type of nature arises, which is anthropogenically driven, but develops further via natural processes [13].

That form of intermediary nature can also be found in the work of Michel Desvigne. He gives a prominent place to agricultural practices, geomorphology and cartography, and chooses a position therein as landscape choreographer. The unfinished aspect dominates and his point of departure is that the landscape is an instrument (rainwater collection, improvement of the air and water quality, safeguarding the biodiversity) rather than an environment [14].

4. A New Concept for Urban Green Space: the Urban Biotope

The urban landscape demands an approach that brings green space closer to people, but simultaneously makes the ecological value of green space palpable. The scale on which answers need to be sought is larger than that of the “tiny forest”, the “urban forest” and the “agroforest”, but at the same time the capillaries of the system are thinner so it is accessible to people. The plants can develop over time, but are and remain greenery in an urban setting; it is not an imitation of nature.

In order to bring nature closer to residents in the urban public domain, there is a greater focus on experience.

It is about making sure that the challenge of climate change and heat stress mitigation is not only addressed pragmatically.

It is not simple to effectuate a different experience of the greenery in the city, because the use of the public space is intensive and must provide space for different functions: for movement, play and meeting. The new concept for the green space is the “urban biotope” [15]. It extends on the scale of a residential district and more than a single small forest: it is a network, linked up with larger green connections and places.

The accent, therefore, is no longer on a tiny forest or agroforest, which are larger in size and aimed at either nature or food production in nature, but it functions more like an “edible district”. Within the urban biotope, people play an important role; it is a district where people come into direct contact with green space. However, the green space is not only aimed at that which is edible, but chiefly on symbiosis; the species help each other. Not everything produces. There are also plants that do not yield something, but are required for the symbiotic system (Fig. 3).

4.1 Permaculture in the Urban Biotope

The process of generating a new healthy urban biotope is inspired by the principles of permaculture, with which an urban ecosystem is created on the scale of urban districts. The use of basic concepts for permaculture in the design of the public space can increase biodiversity considerably and enhance the ecological value of the public domain. Because it is based on principles of permaculture, the plants contribute to heat stress mitigation, greater biodiversity and carbon reduction, but above all they are part of the public domain and integrated into the urban use of the public space.

In the case of the urban biotope, attention is paid to the combination of plants. The green space is not monofunctional, but is always stratified. It consists of all layers of plants: trees, shrubs, understory, ground cover plants and stinzen plants/bulbs; it is subject to seasonal effects and has edible elements for animals and humans. The tree stock will consist of large trees



Fig. 3 The quality of the forest in urban environments, Parc Matisse Lille (photo: Jean-François Gauthier, OKRA).

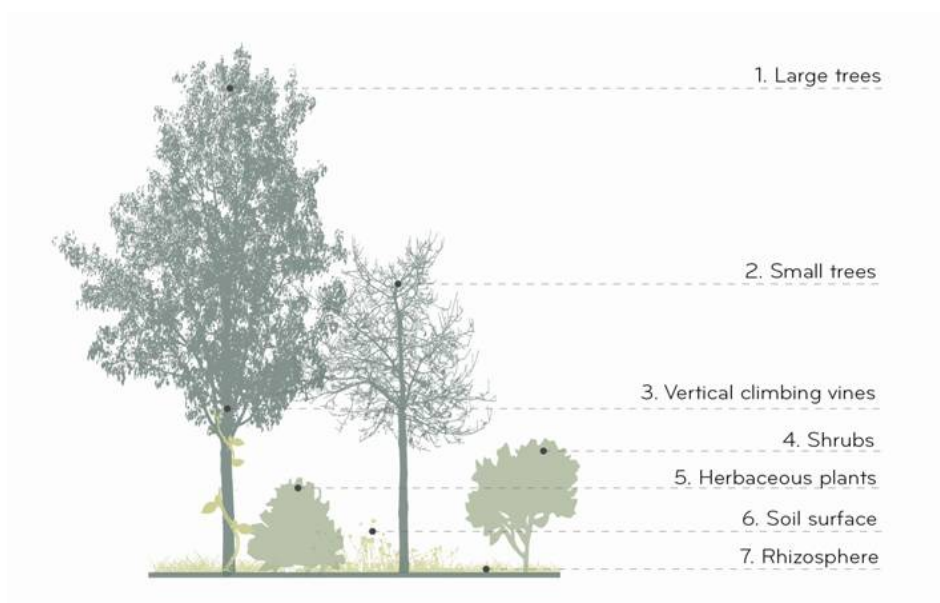


Fig. 4 Merwedebiotop, layers of planting (marco.broekman, 2019).

that form a crown, supplemented with lower trees (from the second and third order) (Fig. 4). The tree selection is such that the trees are of the first and second magnitude, but do not have overly dense foliage. They provide shade if necessary, but also ensure that the trees do not already result in dark streets in the spring and that filtered light from the sun

comes through the foliage in the green street. They form the canopy for a layer of bushes and shrubs, perennials, annuals and ground cover plants. Soil improvement ensures there is a suitable soil stratum.

The basis of the tree stock consists of the existing tree, and based on the existing trees and the urban conditions (light and shade, wind, size of the habitat),

a range of plants is determined, which mark the start of the growth process, a dynamic development of plants. The plants under the canopy are context-bound, and therefore actually different than the “prairie planting” that is currently used a lot in the city as universal undergrowth.

4.2 Succession in the Urban Biotope

A next step is to be made and a conceptual framework to be developed for the design of a dynamic planting scheme in the existing area, analogous to the steps of succession. It can be converted into a strategy of different steps (Fig. 4).

4.2.1 Consolidation

The existing trees that can remain in the area are therefore valuable. They will remain wherever possible and they will be included in the urban plan, and if possible trees that are healthy, but which can not remain in their habitat, will be replanted in the area.

4.2.2 Initiation

New zones will be made, which are the start of a development. The species of young plants selected has to do with the urban climate and the existing species richness. A couple of zones will be designated with trunks planted close together, which will be thinned out later, like in a growing forest, where a few trees from the young shoots remain. The group of trees consists of fast-growing trees (fillers) and permanent trees (stayers) and will therefore undergo an evolution over time. The stayers give structure to the space.

4.2.3 Development

The plants must be able to develop gradually in order to reach maturity. In order to ensure that trees of the first magnitude can be used on the squares and in the residential streets, a tailored approach must be sought: where can space be made? where can exceptions be made? It may also be possible to achieve results by opting for smart combinations in the trunk distance-crown distance. The development of the understory can be monitored: evaluate annually

how the growth conditions develop and adjust the selection on the basis thereof.

4.2.4 Metamorphosis

Change to a situation where plants develop and where species are not only added, but species also disappear. The tree planting changes towards a picture in which the stayers dominate. There will only be more shade when the trees have a fully-grown crown; the undergrowth will change too and pioneer plants will gradually come and go out of the picture.

The total process is the development towards an atmosphere that changes and is not fixed in a specific moment in time. It adapts to the scale of the area and to the difference in management of the various zones.

5. The 1:1 Design Laboratory in Merwede

The demonstration area for the urban biotope is located at a former industrial estate along the Merwede Canal (Merwedekanaal) in Utrecht. The urban planning approach for the new residential and working area that has been created in the Merwede Canal Zone creates the conditions for a fundamentally different public space from that is customary. The area is based on public transport and slow traffic. Car use will be limited to approach roads at the western main access, leading to car parks and mobility hubs (Fig. 5).

The zone is a high-density district. By having a multidisciplinary team [16] makes an integral design with a new mobility concept and energy concept, conditions will be created through which the public space of the district can become green. The underground infrastructure in the district will also be organised in such a way that it does not restrict the generous planting of trees (Fig. 6).

The context in the centrally-located area requires smart combinations: there is a high usage pressure, climate conditions are more difficult, the temperature in the city is higher, and there are downdraught effects from the buildings. OKRA will ensure that in the public space of the Merwede Canal Zone, the greenery will be designed as an urban biotope, the Merwede

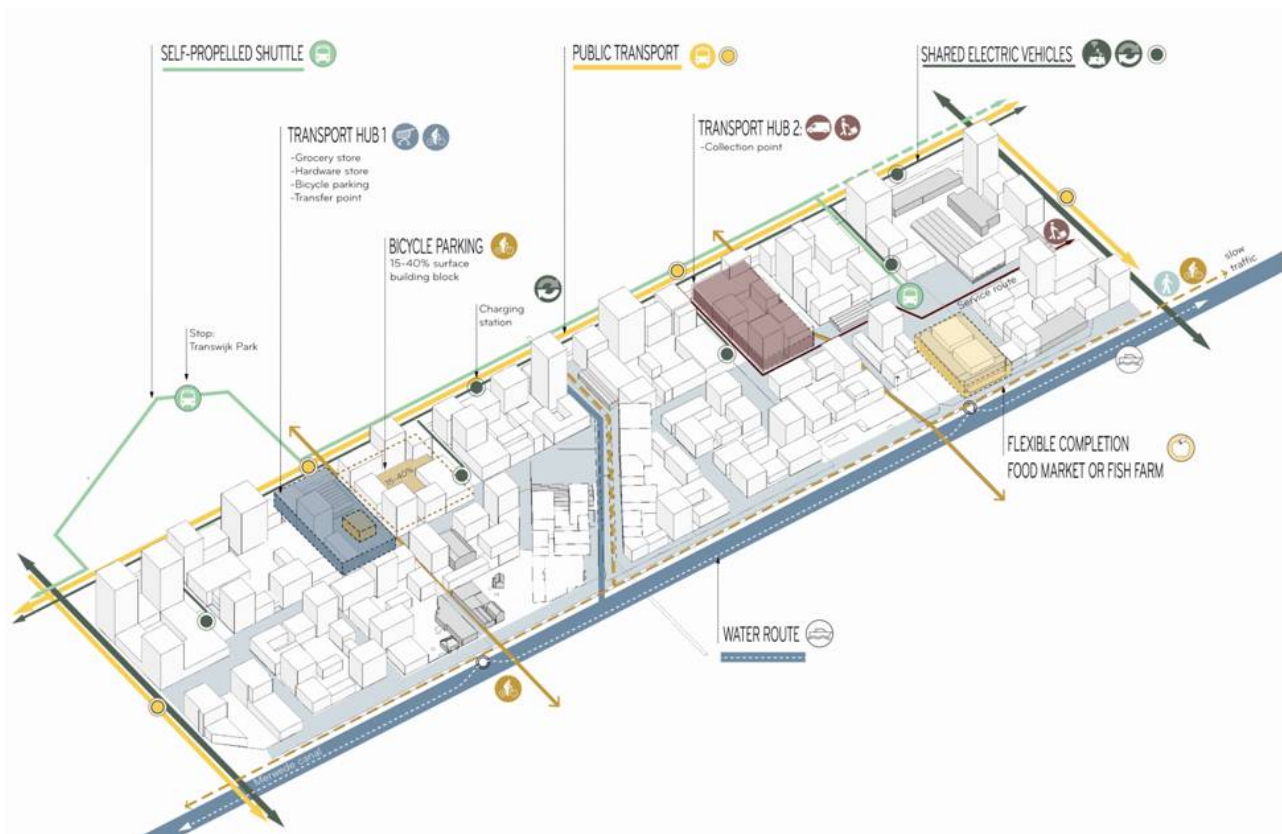


Fig. 5 Rethinking urban mobility setting the scene for a pedestrian-friendly environment (Knuijt, 2019).



Fig. 6 Integrated system on green and blue infrastructure for Merwede (Knuijt, 2019).



Fig. 7 Green loops connecting the green infrastructure to different neighbourhoods (OKRA, 2019).

biotope. On the east side, the public space will link up with the Rondje Stadseiland, a linear park with a recreational circuit of 11 kilometres [17] (Fig. 7).

5.1 Urban Ecosystem on the Scale of Merwede

The holistic design of biodiversity with principles of permaculture requires zoning in terms of intensity

of planting and use. The combination of species is such that the different atmospheres of the Merwede Canal Zone are expressed in the planting. The foundation lies in the presence of existing trees and in the nature of the area. Although there will be high-density construction, existing trees will be spared as much as possible or replanted within the area. On

the basis of a health assessment, a tree map has been made with an indication of how the individual trees will be handled.

A connection will be made to larger green structures in the surroundings. Various atmospheres will be created within the area, related to the typology of spaces and consisting of varied plants. The Merwede Canal Park consists of a mix of species that are in keeping with a canal, the poplars and the white poplars, but also alder, cypress and ash. There is a different mix of plants in the centre of the district with species appropriate to the sections situated slightly higher. The stepping stones to the green park streets form a transition between park and residential streets. The east-west streets have a shaded environment, especially on the west side. Tree crowns form a new ceiling between the tall buildings. Shade-loving understory forms the fern blankets. On the east side, the space opens up and this atmosphere changes to more flowering plants.

The plants are also adapted to wind. In order to limit the negative effects of wind, trees will be planted at places likely not to be wind-sensitive. Careful consideration will be given with the species selection by choosing tree species at these spots that are not very prone to branch breaking.

5.2 The Combination of the Different Plant Layers

It is important that there is the herbaceous layer under the canopy layer of trees of the first, second and

third magnitude, and some shrubs and bushes that flower in the different seasons. That produces a beautiful seasonal appearance and is attractive to urban microfauna. Climbing plants complete the picture along the facades or at other spots.

The introduction of productive planting, as an integral part of the principles of permaculture, contributes to a large extent to the enrichment of the biotope, as a result of which new relationships arise between the various components of the system. An edible urban landscape not only has ecological value, but also stimulates the interaction between the public domain and the people, as a result of which bonds are created and the sense of community is strengthened. In the urban biotope, food is part of the green space in the district. The cultivation, harvesting and sale of food in the city on the scale of Merwede contribute to the food requirements of the city in a modest manner. More important still is that it interacts with the urban (eco)system and forms part of the way of life of the contemporary urban resident. In order to further strengthen the relationship and contribute to education about greenery and food in the city, attention is paid within the palette to planting with edible nuts and seeds, fruits and aromatic herbs (Fig. 8).

Furthermore, green roofs in the centrally located area provide an extra opportunity to increase the biodiversity by creating habitats at previously unused places. On the higher roofs in particular, there are opportunities to make natural roofs, which provide a

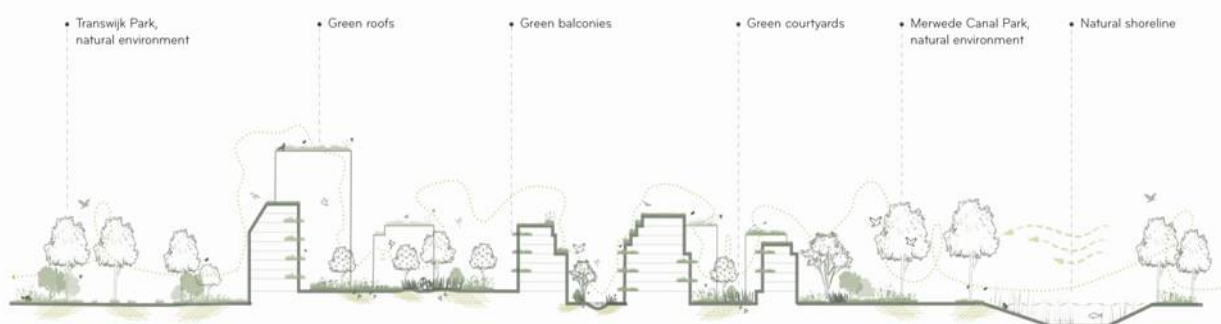


Fig. 8 The Merwede biotope expanding onto the entire development, public space, innercourts, and roof gardens (marco.broekman, 2019).

living environment for insects, butterflies and birds. Small facilities, such as a bird bath or nesting site, contribute to the habitat.

The development of the greenery in the urban residential district demands good habitats for trees in the details and good subsoils for green space in a city undergoing densification. Extra attention is paid to the habitat, as a good soil is vital to the health of the tree. For example, the soil must have a suitable acidity and also retain enough water. If the soil is sufficiently open, the soil life can develop optimally and lack of oxygen for the tree is prevented.

5.3 Seeds for New Development

It is important to make the development of the greenery work for the urban residents. A development has been set in motion in Merwede, but not geared towards a clear-cut final objective. In fact, the foundation is being laid for an artificial succession. It is also in keeping with planting, which is unpredictable to a certain extent. And it is in keeping with adaptation to the residents and users of the district; they can also intervene in the planting appearance via targeted management. Wherever possible, use is literally made—for example on the roofs and inner courtyards—of seeds and annuals, which germinate and give an extra dimension to the planting.

6. Conclusion

Making a successful urban biotope imposes conditions on the urban developments and on the planting conditions. The ambitions for creating an urban biotope are in keeping with the context of the creation of a circular economy within new, dense urban development plus climate-adaptive design. New concepts with regard to mobility of energy, combined with the integral design of subsoil and topsoil create different conditions for plants in streets and on squares. The playing field is changed and provides opportunities for the introduction of the “urban

biotope” on the basis of principles from permaculture, translated to the urban conditions.

Creating a 1:1 laboratory in Merwede provides a test case for introducing the urban biotope at various locations. Greenery in the city may be different than a natural ecosystem, but it can meet qualities that contribute to biodiversity, improvement of the urban air quality, reduce heat stress, seasonal effects and food production in the city.

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