A design strategy for a nature inclusive building

Ciske Buiter
Faculty of Architecture & the Built Environment, Delft University of Technology
Julianalaan 134, 2628BL Delft

Abstract

This paper is a qualitative thesis depicting the way a design strategy can be constructed for a nature inclusive building by giving an example case. By first doing a set of case studies of projects describing themselves as nature inclusive and looking into their design strategy, then applying this to a case location together with the help of literature and an urban ecologist to test if this is a reliable way of designing. The main findings of this paper are that to set up a design strategy that is actually nature inclusive, the location needs to be thoroughly studied with the help of experts in the field of ecology to translate natures requirements to design elements.

Keywords: *Symbiotic, Biodiversity, Biotope, Species, Ecosystem, Visual Green, Nature-inclusive, Haarlem, Schalkwijk*

1. Introduction

Human population keeps growing and with it our cities do too (figure 1. Giller & Stichting Bio-Wetenschappen en Maatschappij, 2016). Due to the increasing demand for housing, our cities are continuously being intensified and expanded. While our cities grow, the biodiversity in them keeps declining (figure 2. -Stiphout et al., 2020). The urban ecosystem becomes vulnerable due to the decline in animal and plant species, which has consequences for us, humans. The built environment has a part in this decline of species, it sees nature as an accessory to projects instead of an integral part of the product. This comes mostly from the mindset of building first and foremost for humans and adding nature as an afterthought or accessory. These are often in the form of single or wrong applications of animal housing or visual green that might increase a single organism in unintended proportions in the target areas, which could be counterintuitive to the intended goal of aiding nature, thus S. Andela urban ecologist Haarlem (2021). Another problem that the built environment creates for species, is the removal of spots which animals and plants have adapted to use. In the built environments mission to make everything sustainable it started to remove hide places. An example of this are the spaces underneath roofing tiles, these spaces are now being insulated which means species such as the swift do not have a place to go (Natuurmonumenten, 2021).

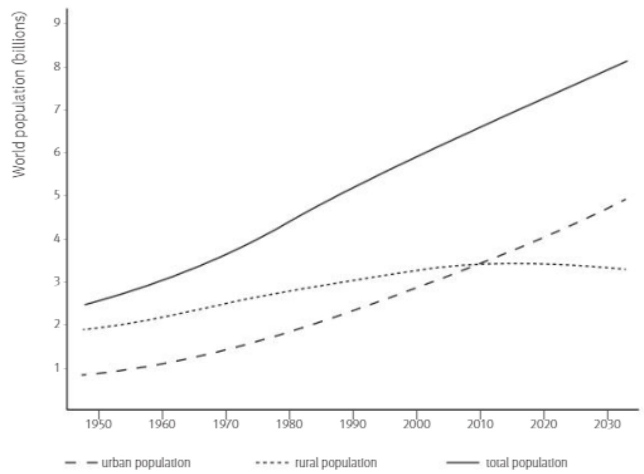

Figure 1: The Growth of the world population.

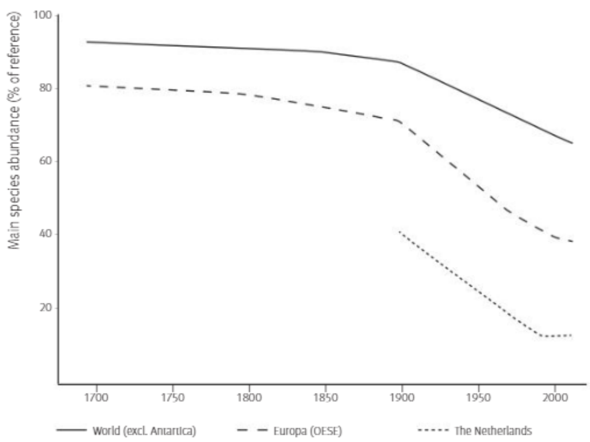

Figure 2: Main species abundance.

To approach these problems the mindset of the built environment has to be changed. Through this research and the attached project an example will be set for true nature inclusive designing. As for the example location, Haarlem Schalkwijk the Netherlands is chosen, this area was built around the 1970’s to solve the housing shortage at that time. The chosen area consists of mostly concrete flats and has a lot of low mowed grass throughout.

The following question will be answered in this paper:

‘’How can a design strategy be made to improve biodiversity through architecture in Haarlem Schalkwijk?’’

2. Method

This research will look towards setting up a program of requirements and design strategy for architecture in Haarlem Schalkwijk that will make nature an integral part of the design process. To create a suitable design strategy, case studies will be made of other buildings which are known for their nature inclusive design to see if there is any overlap in the way they were designed; examples being ACROS by Emilio Ambasz architects (1994), Bosco Verticale by stefano Boeri architects (2014), Vertical by NL architects, studio DVMB, Space Encounters, Chris Collaris architects, DS landscape architects and De Dakdokters (2020) and other projects. Using that information a location study will be made of the case location by looking at the current ecological situation, an analysis will be made documenting the best suited target group of organisms for the location and their needs by working together with ecologists such as Eline Hin, Haarlem's urban ecologist specialized in nature inclusive building. The selection of organisms will be based on the ability of these to live in symbiosis with each other, humans and if they fit in the native ecology.

All this information will be combined into a program of requirements, which will be used to create a design strategy which demonstrates the possibility of true nature inclusive design.

3. Results

3.1 Case Studies of nature inclusive designs

Acros - Fukuoka - Emilio Ambasz architects (1994):

Acros was designed to be an icon for sustainability in the 90s. By integrating parks on its stepped facade it compensated for the loss of park surface in an already densely built city. This new park terrace is a public space where 78 species of local flora were planted when it was constructed, this has by now increased to 120 species. The terrace park was designed by landscape architects Plamtago, where they first designed a biotope using a local hillside forest for their main inspiration before choosing the species of plants. When water is used or when it's raining, it slowly moves from terrace to terrace until it reaches the ground floor, often at this point all the water is used by the plants and in this way helps reduce strain on the sewer system of Fukuoka. This entire system has caused the local temperature on the slope to be on average 15 degrees lower than its surrounding (ACROS Fukuoka Prefectural International Hall, 2020).

Aarden hospice - Zwolle - Bart van der Salm [Theoretical Design] (2014):

The Aarden hospice was a graduation project of architect Bart van der Salm where as the main design topic, he wanted to create a space where people in their last stage of life would be in full connection with life. This was done by making enough space in the design for varied native flora, a new ditch as a water feature, a brown roof made from the dug up earth during construction and implementing niches, edges, recesses and nesting areas in a majority of the project's walls. In Bart van der Salm's project these implementations were made in cooperation with urban ecologists from Zwolle and a planting expert (Van der Salm, 2014).

Bosco Verticale - Milano - Stefano Boeri architects (2014):

One of the most famous designs related to nature inclusive design is Bosco Verticale. This residential tower is filled with flora, from flowers to trees. The design itself is dependent on the health of its vegetation, to such an extent that before construction a study was conducted by agronomist Laura Gatti to analyse the growth conditions of the tower (Belerri, 2013). Which resulted in a concrete choice of local flora that is resistant to the conditions of such heights. Following this study many facilities were designed to make sure the health of vegetation was sustained throughout the lifespan of the tower. Such as 8 kilometers of water pipelines and deep balcony containers.

Biodiverse Garden Shed - Delft - Atelier GroenBlauw & DS Landscape Architects (2020):

The Biodiverse Garden Shed placed in the Green Village in Delft is a design that was made for the contest ‘’Natuurinclusief Ontwerpen’’ (Nature Inclusive Designing) of The Hague. This design was made closely together with the bird protection organisation to ensure the correct use of nature inclusive elements. Integrated in this design are Insect bricks at the ground floor in the south wall, bird boxes in the east wall together with an artificial nest for the house martin on the east gutter, underneath the west gutter a hollow space was created for bats to spend the summer, on the ground floor hollow spaces were created in the wall for summer and winter shelters for hedgehogs and lastly a green-brown roof for insects and birds (The Green Village, 2021).

Groenmarkt - Amsterdam - Buro Harro (2021):

Groenmarkt is a design created to showcase the possibility of pulling a bit of nature into the city. The design includes bird, insect and bat boxes spread all over the facade, possibility for plants to climb all over the facade through its brick design and a dune landscape as roof. This dune landscape is filled with many native plants you would typically find in such an environment, such as black pines and dune grasses. Another feature that can be found on the roof is a natural swimming pool, this creates a water surface on a height level often used by swifts, martins and bats. The main idea of the design was that instead of taking away from nature by building, it is also possible to give something in return on a different level (Buroharro, 2021).

Vertical - Amsterdam - NL architects, studio DVMB, Space Encounters, Chris Collaris architects, DS landscape architects and De Dakdokters [Under Construction 2021]:

Vertical is the newest design (at the time of writing) that tries to be truly nature inclusive. This housing complex houses over 90 species of native plants and has 1 box for birds of prey in the east facade, 95 boxes for swifts; 60 east and 35 west, 38 boxes for bats; 24 east and 14 west and 72 boxes for small birds all located at the east facade. In the lower tower patterns of holes for nesting of insects, swists, bats and sparrows are implemented. The reason for the specific directional placement of all these elements is the result of an in depth study looking into the activity hours of the chosen species and placing them according to the sun's direction at different hours (Stiphout, V. M., Lehner, M., Architects, A. L. L. D. D. S., & Havik, G., 2020).

3.2 Current ecosystem of Schalkwijk

According to the division of ecology of Haarlem (2019), Haarlem can be divided into two groups of zones; the landscape zones and the built zones.

The landscape zones, as seen in figure 3, go from dunes (orange), beach plains (light green), beach ridge (dark green), peat meadow area (pink) to reclaimed land (blue). The urban ecosystem of Haarlem is different from the surrounding dunes on the west side and the polders on the east side of the city. Haarlem is largely stony, is warmer and more nutrient-rich. It is also much more dynamic due to renovations and civil works. Due to intensive use of humans, the landscape types are no longer always easily recognizable. Despite all that, the large green areas that enclose Haarlem are still relatively intact.

The built zones are less structured than the landscape zones. These zones are sorted based on the opportunity of ecological hotspots appearances. Going from most densely built to least;

Center and densified neighborhoods: Few and small green spaces with mostly non-native species of trees, shrubs and herbs, with very common types of animals in low densities and some species bound to rock and calcareous mortar.

Residential areas and business parks: Little nature, small-scale private gardens full of shrubs and rich flowering garden plants with garden birds, butterflies and other insects.

Parks and residential areas: Mostly native trees and groups of mature shrubs with undergrowth and flower borders with high herbs with more songbirds, more butterflies, hedgehogs, martens, bats, squirrels, weasels, mice and other animals.

Outside area: Peace and space for bushes, grasslands, water and swamps with even more variety of birds, butterflies and mammals, alternating dry and wet.

The Schalkwijk area completely falls under the peat meadow landscape (pink in figure 3) and includes zones from the residential areas and business parks & outside area, because of its border location within Haarlem. This means that even though most of Schalkwijk has little nature and is mostly densely built it has an ideal connection to the outside area.

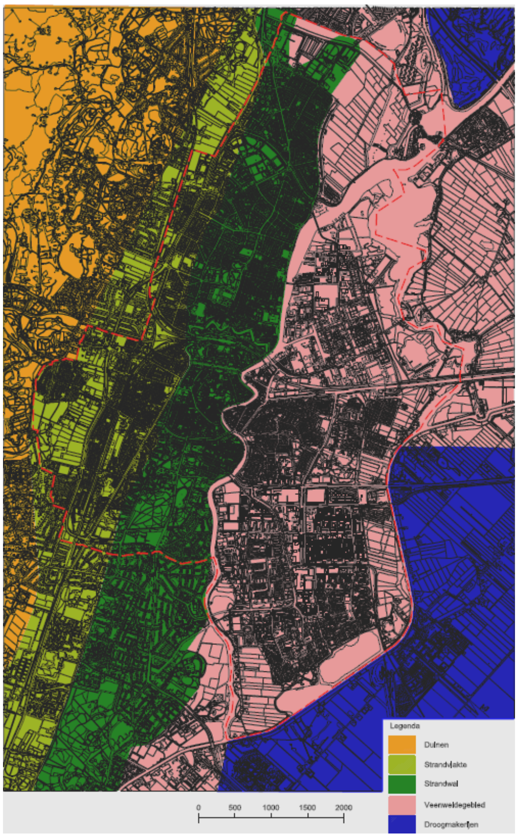

Figure 3: Landscape zones - Haarlem.

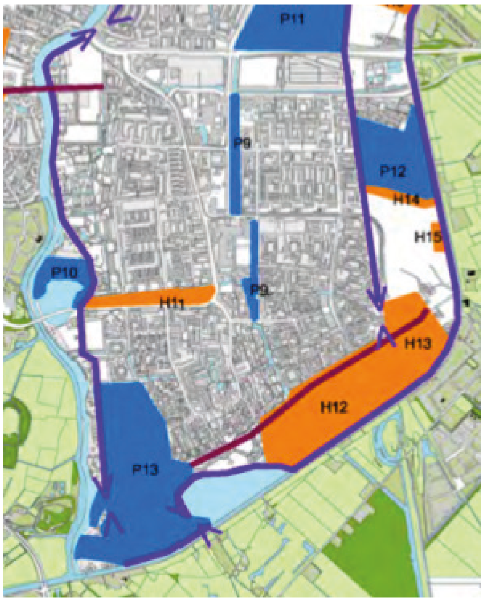

Figure 4: Ecological hotspots & potential areas.

In a report describing ecological hotspots from the municipality of Haarlem (2019), Schalkwijk has eight locations that could be considered ecological hotspots or potential hotspots Figure 4.

Five of these spots are confirmed hotspots (numbers with H on figure 4, described in Table 1.) and three are potential spots (numbers with P on figure 4, described in Table 2.) which could become hotspots within the future.

Table 1. Ecological hotspots.

Location	**Biotope**	**Species**	**Ecostructure**	**Vegetation**
H11: Romolenpark	Small-scale thickets with flowery grassland, young stinsebos and pools	Reed orchid, meadowsweet, common weed, creeping willow	City nature core area for butterflies, breeding birds and winter guests	Forest, scrub and rough grass
H12: Meerwijkplas, specifically the north-bank	Reed banks, flowery grassland and rainwater pools	Waterfowl, Cuckoo, Reproduction dragonfly species bluethroat, reed orchid, sea buckthorn	Eastern part north-south route	Rough grass on poor soil and bank vegetation
H13: Poelbroek	Nutrient-rich Swamp Area with artificial variation in soil type and height ground level and with reduced influence bosom water	Geese colony and many species of reed birds & other songbirds, including bluethroat and cuckoo, three kinds of orchids and various plants of open, wet bottoms, many types of aquatic animals	Eastern part north-south route	Reed Fields, Overgrowth, flowery grassland and small-scale bushes
H14: cross path through Poelpolder	Clean water biotope with embankment and flowery roadside	Possibly water rail, dragonfly species, hedgehog buttercup	-	-
H15: Swamp in Poelpolder on the Ringvaart	Outer dike peat moss reedland	Sphagnum moss, marsh marigold, angula deer hay, bald squire, reed orchid	Eastern part north-south route	-

Table 2. Potential ecological hotspots

Location	**Biotope**	**Species**	**Ecostructure**	**Vegetation**
P9: Amerikavaart and green belt	Urban water in broad nutrient-rich green belt	Reed orchid, candlestick, Species-rich insect life, hairy fireweed and present shrubs	Green corridor in district	Flowery roadside and rough high herbs
P12: Poelpolder	Peat meadow area with wet coppice forest	Natterjack toad, reed orchid, swamp and riparian plants with it dependent animal life, water rail	Green part eastern edge of Haarlem	Grassland
P13: United polders	Nutrient-rich agricultural grassland	Natterjack toad and others amphibians, remnant meadow birds, bitterling	Green part zoom of Schalkwijk	Grassland, mostly overfertilized

Next to these hotspots there is also the ecology of the urban area of Schalkwijk. As mentioned before this is mostly made up of residential areas and business parks, where nature is not as prominent as in the surrounding hotspots. In this area humans are an essential part of its ecosystem. Buildings create housing for birds and bats, humans are a source of food for animals in the urban area by placing bird feeders or planting nutritious vegetation. In a well balanced rural ecosystem there usually exists a large mammal managing the growth of plants by grazing (Veen et al., 2011). In urban areas where there is not a stable living situation for these kinds of large mammals, humans fill this spot by artificially removing plants by either mowing or weeding. Humans also unintentionally play the part of predators, by creating dangerous blockades for land dwelling animals where the chance of survival by crossing is low. Examples being roads (SPELLERBERG, 1998), fragmentation of habitats (Rogan & Lacher, 2018) and construction of buildings (Graham, 2002).

3.3 Biodiversity in Schalkwijk

Total biodiversity is very difficult to measure according to retired urban ecologist D. Vonk (Van Engelen, 2015). It is therefore not (yet) possible to determine how much biodiversity decreases or increases due to climate change, pollution or the application of sustainable techniques and ecological management. Simply because this is not measurable and comparable. There have been general indications on the other hand made by the PBL Netherlands Environmental Assessment Agency (Lucas et al., 2013) describing the decline in species abundance in the Netherlands.

Biodiversity is under pressure. Worldwide, but also in the Netherlands, many species are declining or have disappeared. As a result, communities are out of balance. This not only makes nature less fascinating, but all kinds of essential functions, such as water purification, agriculture and climate control, are also at risk (WU, 2008). Biodiversity is also important for Haarlem and the surrounding area. Biodiversity has an important economic value. Landscapes and cities with a high biodiversity are an attractive, healthy living environment where people like to live and companies want to establish themselves. High biodiversity provides a buffering effect for, for example, water, pollution and air quality (Smith et al., 2012). And can therefore better cope with extreme (weather) conditions and pests.

Nature in the city, especially variation in vegetation, can form a buffer against pests (Henri et al., 2015). Insect-eating birds, predatory insects such as parasitic wasps, native ladybugs and spiders will form a buffer against too large an increase in less desirable insects. Due to more variation in the city, pests of new species can be better absorbed. Swifts and bats, for example, eat many small insects, especially many flies and (new species) mosquitoes. In addition, there are a number of species that, at the request of urban ecologists such as Eline Hin, Haarlems urban ecologist (2021), can have a positive impact on biodiversity if they are supported. Such as;

Bats: Pipistrelle, Serotine bats, Shaggy pipistrelle, Rufous bats & Water bats

Birds: Swifts & House sparrows

Insects: Sand bees, Mason bees, Longhorn beetles & Dragonflies

Mammals: Hedgehogs, Shrew, Marten, Ermine & Weasel

Amphibians: Natterjack toads, Common toads & Small newts

Plants:

Retainers of particulate matter - Coarse pine, Norway spruce, Bergden, Black pine, Yew, Water cypress, Ivy (Hedera helix), Ordinary bird cherry, Downy birch, Tree hazel & Common maple

Absorbers of ozone - California cypress, Uniform hawthorn, European larch, Silver birch, Black pine, Black alder & Different types of maple

Absorbers of nitrogen oxides - White acacia, Honey tree, Magnolia, Curly willow, Japanese zelkova, Black poplar

Valuable plants for insects - Butterfly bush, Blackberry, Royal weed, Wild marjoram, Lungwort, Rosemary, Lavender, (Shrub) ivy, Licorice plant, High autumn aster, Verbena bonariensis (vervain) & Large centaury and other types of Knapweed

There are also species that pose a threat to human interests, for example: Oak processionary caterpillars, tiger mosquitoes, Asian longhorn beetle, corn beetle and Egyptian geese. A number of new (tree) diseases threaten many native species such as the elm and ash. Japanese knotweed, giant hogweed and American bird cherry have been a threat to native flora for years because of their extreme proliferation (Gemeente Haarlem, 2019). In such a case we speak of invasive exotics. By supporting the aforementioned positive contributing species, the invasive exotic species can be reduced.

3.4 Biotope requirements

Together with Haarlems urban ecologist Eline Hin (2021), a list of species was constructed as a suitable target biotope for Schalkwijk. These species are, according to E. Hin, either in decline or can have a positive influence on the biodiversity of Haarlem. Species chosen are native to the Schalkwijk area and fall within the researched ecology. The requirements of the species have then been translated to architectural elements which can be used in designing for the Schalkwijk area (Table 3.). The list that describes the requirements for each species to be attracted to an area can be found in the appendix I.

Table 3. Translated design elements

Height in meters	Species	Orientation	Design elements
0-20>	Dragonflies	/	Undeep permanent water, green-brown roofing
0-20>	Small newts	/	Undeep permanent water, green-brown roofing
15-20	/	/	/
5-15	Swift	East	Nest stones, rough facade, no reflective surfaces, nooks and crannies
5-10	Serotonin bat	West	Cavities in facade
1-10	House sparrow	East	Holes and cracks in facade
1-5	Mason bees	South	Small holes in facade, preferably brick or wood
<1	Longhorn beetles	South	Small holes in wood on facade
<1	Shrew mouse	/	Small cavities in facade, reachable through climbing or walking
<1	Natterjack toad	/	Openings in stone facade
<1	Ermine	/	Cavities in facade resembling rabbit holes
<1	Martens	/	warm and dry cavities in facade
0	Sand bees	South	Sand paths
0	Hedgehogs	/	Hiding cavities on ground level

0	Common toad	/	Access to water

4. Conclusion

To conclude, by looking at the six case studies done in this paper a common theme can be found in the design of nature inclusive design. This theme is summarised as follows; clear connection to surrounding ecology. By doing extensive research together with local professionals, such as urban ecologists, these projects have strived to fit better into the native flora and fauna. By creating an urban biotope a clear requirement plan can be created to connect flora and fauna to a man made location. When all of this was projected onto Haarlem and more specifically Schalkwijk a local ecological profile was created. This ecological profile showcased that Schalkwijk is a mostly urban area on peat meadow with some small separated hotspots in the centre and larger connected hotspots around the edge. These hotspots exist mostly with reeds, swamp like plants and flowery grassland with some pools within, habiting small amphibians, insects, small birds and varied small mammals. With this information an attempt was made to analyse the current biodiversity of Schalkwijk. This is impossible, the sheer amount of species existing within the Schalkwijk area is near impossible to count. Many different variations of flora and fauna are found within the area, so to reduce the strain help was asked from urban ecologist Eline Hin. Together a list of species was constructed which had the appropriate possibility to be used in urban planning. The next step was reducing the list of species to a usable range for a biotope creation, this was done with advice from Eline Hin as well. This list was then analysed based on the chosen species requirements for a suitable living habitat, this included; living environment, nesting height, food and water. Lastly, these species requirements were translated into elements that can be used into design for this biotope in this context.

In the end to answer the main research question ‘’How can a design strategy be made to improve biodiversity through architecture in Haarlem Schalkwijk?’’ It is all based on local information. Create in depth analysis of the local environment using experts, design a concrete biotope to narrow down requirements and in the end create a requirements list which translates to design elements.

This way of designing is relatively easily achieved. Experts often have readily available information they are willing to share and are often more than happy to be included into the design process. Translating flora and fauna requirements is not that difficult either, many animals have pre-existing artificially made nesting places which can easily be included into design or have concrete requirements to which these nesting places can be designed.

During this research the main methods for research where; observation, interview, case studies and literature. The observation method was mostly ineffective, as I am an architect and not a biologist I could not create any accurate or usefull results from observing the target location. The interviews with urban ecologist Eline Hin were, on the other hand, extremely helpful. As an expert in the field, she could bring information to this research I would not have found on my own. The only limit with this was the fact that I could only contact Eline Hin, which limits the scope of reliability as most of my information comes from a single source. The case studies were insightful into the design applications of nature inclusive elements, although all of the information gathered were claims from the designers themselves. In the information used I have no reason to doubt the claims made by the designers of the projects as they were mostly quantitative data. Lastly the literature, most of my information is thanks to the books *First Guide to Nature Inclusive Design (1ste ed.)* (Stiphout, V. M., Lehner, M., Architects, A. L. L. D. D. S., & Havik, G. (2020) and *Samen [E-book].* Van Stiphout, M., Van Stiphout, M., Van Veen, R., See, A., & Academie van Bouwkunst (Amsterdam). (2014). Macmillan Publishers. In both these books Van Stiphout, M. was the main writer, this too would narrow the scope of reliability, although there are not many other sources available that have written about nature inclusive design. Lastly much of the data on Haarlem has been gathered from policy plans made by the municipality of Haarlem.

Even though this paper almost exclusively talks about the case location of Haarlem Schalkwijk, the paper's results are applicable in all situations. The direct results showcase the research needed for nature inclusive design to be implemented properly within architecture. This paper can be used as a template for further design projects to take the correct steps needed for nature inclusive implementation.

The results of this paper seem to align with the conclusions made by Van Stiphout, M. (2020) in the book *First Guide to Nature Inclusive Design (1ste ed.)*. Although Van Stiphout, M. (2020) concludes that urban design should be treated as mountainous biotope, I disagree with this statement. The biotope of urban design should always follow the native location. For example in the Netherlands, almost no species are adapted for mountainous areas. A better way of stating this would be to start calling the urban setting as a biotope.

This paper can be followed up with research into different situations in different locations. By looking into similar research in a different country with totally different ecology the results might differ.

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Appendix

Appendix I : Biotope requirement list

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Species	Habitat info	Nesting height meters	Feeding	Water	Comments
Swift	Nests often build under gutters, behind a downspout, dormer window, roof tile, or in a hole in the wall and also in nest stones. Often swifts tend to nest in colonies.	+/- 10	Flying insects such as mosquitoes, flies, hoverflies and butterflies.	For hydration they skip over water surfaces while flying.	No reflective surfaces & no smooth surfaces around their nesting height.
House sparrow	Nests are often made under roof tiles, in holes and cracks in buildings and in sparrow boxes. Often nest in colonies.	1-10	Seeds, grains, insects, flower buds, bread, berries, peanuts and fat balls. In the breeding season mainly insects.	Puddles that form after rain or undeep permanent water.	Picky birds that only come to areas where there are bushes, sand paths and grass.
Dragonflies	Often found near water sources, preferably stationary water. Also like high and warm spaces.	-	Flying insects such as mosquitoes, flies, hoverflies and butterflies.	*See habitat.*	Like all insects, they are dependent on the sun for warmth.
Longhorn beetles	Often found in (dead) wood.	<1	Tree sap, nectar and pollen.	not needed.	Ability to create housing for other insects by digging holes in wood.
Sand bees	Nests are dug underground on sand surfaces.	0	Pollen and nectar from Butterfly bushes.	not needed.	Sand paths needed.
Mason bees	Nests are created in small holes in wood, reed or stone.	<5	Pollen and nectar.	not needed.	Make use of artificially created holes.
Hedgehogs	Nests are well hidden made of leaves, moss or other material that is often located under (blackberry) bushes or fagots.	0	Beetles, caterpillars, earthworms, earwigs and snails.	Puddles that form after rain or undeep permanent water.	Hedgehogs are nocturnal.

Shrew Mouse	Sheltered places such as piles of branches or nests of dry grass and leaves. In gardens, they also often use compost heaps or man-made material.	0	Hunts insects, spiders, larvae, woodlice, snails, worms, moths, mosquitoes and cockroaches, as well as lizards, young mice and carrion.	Puddles that form after rain or undeep permanent water.	Vulnerable to hard sounds. Mainly nocturnal but also active during the day.
Natterjack toad	Puddles that form after rain or undeep permanent water and sand paths. Other possibilities are openings in rocklike surfaces.	<1	Flies, ants, beetles and spiders.	*See habitat.*	Natterjack toads are mainly nocturnal. Hibernation in piles of leaves.
Common toad	Small scale varied landscape with access to deep water.	0	Ants, beetles and larvae.	*See habitat.*	
Small Newt	Undeep water sources, preferably stationary water with nearby vegetation or cairns.	-	Water fleas, small snails, worms and varied insects.	*See habitat.*	
Ermine	A burrow, usually an old mole den or rabbit hole and usually moves along linear elements that provide cover such as hedges, walls, bank lines, etc.	<1	Small mammals, birds and bird eggs	Puddles that form after rain or undeep permanent water.	
Martens	Warm and dry spaces with soft materials.	<1	Small mammals, birds, fruit, insects and fish.	Puddles that form after rain or undeep permanent water.	
Serotine bat	Dependent on buildings for nests; cavity walls, behind the paneling, under roof moldings and roof tiles or under the lead around the chimney.	5-10	Big night butterflies, beetles and mosquitoes.	For hydration they skip over water surfaces while flying.	Notorious for not using bat boxes. During mating season colonies are between 10-150 individuals.