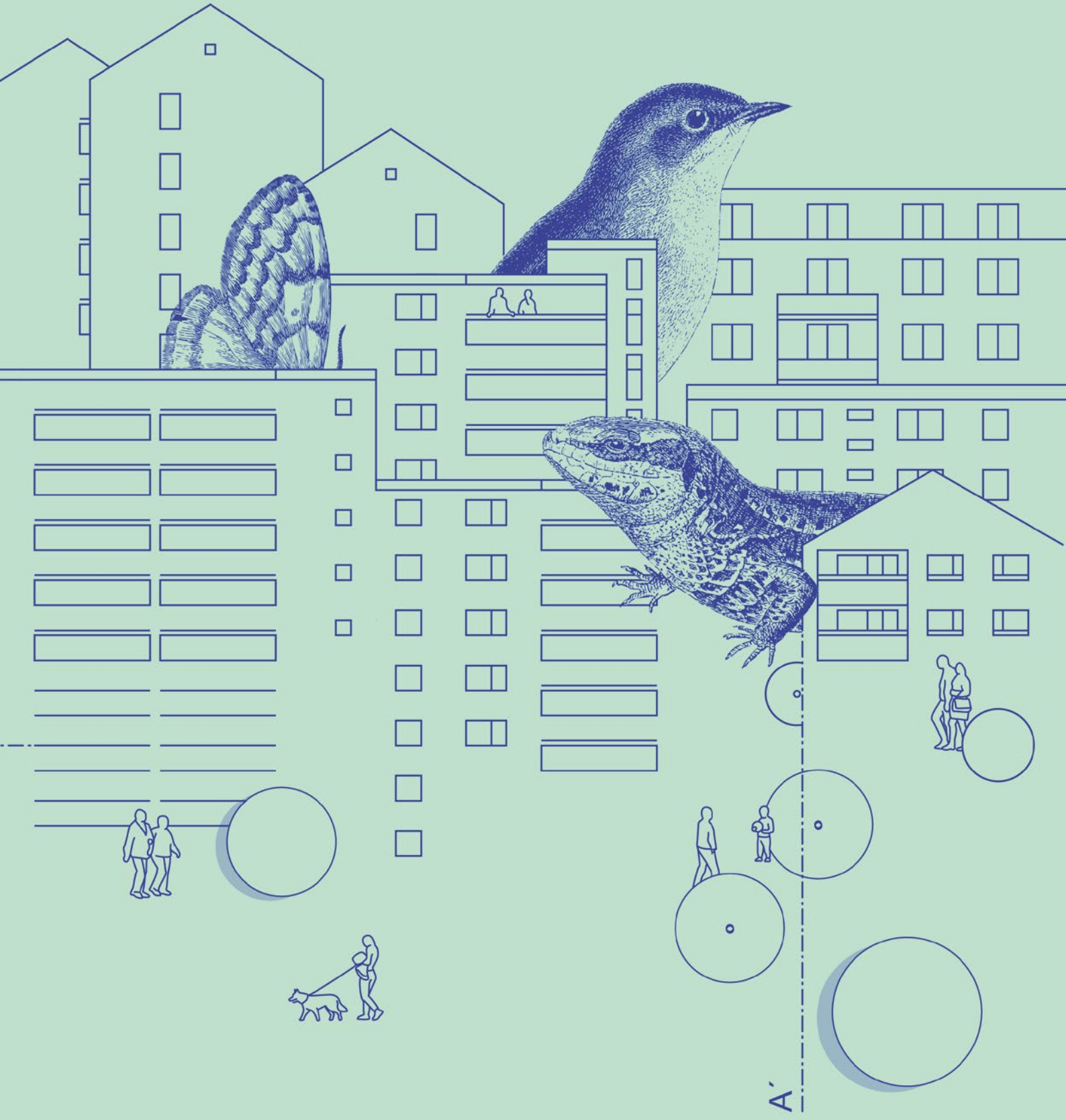
ANIMAL-AIDED DESIGN IN THE LIVING ENVIRONMENT

Integrating the needs of animal species into the planning and design of urban open spaces



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FOREWORD *Prof. Dr. Beate Jessel, President of the German Federal Agency for Nature Conservation*

Biodiversity is associated with numerous positive effects on our quality of life, how we experience nature, and the ways in which urban areas can be adapted to climate change. So there are good reasons, and indeed numerous opportunities, to integrate aspects of nature conservation into urban development, not only at a higher level but also in terms of planning and designing living environments and buildings. While botanical diversity has already been successfully integrated into open space design, there are only a few practical examples of planning for a diverse fauna in urban areas. However, existing potentials could — often with very little effort — be much better exploited. Animal-Aided Design is intended to fill this gap.

The concept of Animal-Aided Design uses an interdisciplinary approach encompassing ecology, zoology, architecture, landscape architecture, and planning to show how specific initiatives to protect and develop urban biodiversity in the living environment can succeed in a way that is both ecologically meaningful and aesthetically pleasing. And at the same time, new working relationships develop, not only between stakeholders from landscape architecture and green space planning but also from the housing and architecture sectors. In this way, important new target groups with large spheres of influence and responsibility in residential areas can be reached.

German federal strategies supporting this concept include the National Biodiversity Strategy, one of the goals of which is to expand the habitats of those plant and animal species that are typically found in residential areas. In addition, the federal government intends to use the Urban Nature Master Plan as a means of preserving and increasing biodiversity in our cities. This includes implementing the “Green in the City” white paper. Since 2015, the annual administrative agreements between federal and state governments on urban development funding have recognized that the green and open spaces created with urban development funding should provide for biodiversity.

The Animal-Aided Design approach developed by the Technical University of Munich and the

University of Kassel does not just consider how the open spaces of residential neighborhoods could meet the needs of birds, insects, and small mammals. Roosts and nesting aids for birds and bats can also be created on the buildings themselves, for example by integrating nesting aids for common swifts into the facades. In addition, areas of flowering and nectar-rich plants for butterflies and protective trees and shrubs for sparrows and other bird species can be established. Because to provide animals with good living conditions, both suitable places to live and sufficient food supplies are required. Only then can animals establish themselves in a residential area on a permanent basis.

This brochure contains numerous examples of newly constructed and renovated housing complexes. The draft designs were created in close consultation with housing organizations during the preliminary phase of the development and testing project “Animal-Aided Design in the Living Environment.” They clearly demonstrate how green spaces can be designed to be functional and attractive for people while at the same time promoting biodiversity. It is the residents who ultimately benefit from this kind of living environment as it gives them the opportunity for everyday interactions with nature, be it on the doorstep or just by looking out of the window.

I would like to take this opportunity to thank the housing organizations involved for their cooperation. I would also like to thank the research team from the University of Munich and the University of Kassel, as well as all those who were involved in the project in an advisory capacity.

We would like to use this brochure to disseminate the idea of Animal-Aided Design more widely. It is intended for housing construction companies and cooperatives, but also for the municipal departments responsible for building and for environmental, landscape, and green and open space planning. We would like to support you in your efforts to sustainably plan, develop, and secure species-rich habitats in cities and communities – for people and nature.

INTRODUCTION

In our cities, the green and open spaces in which people relax and socialize are becoming increasingly scarce due to increasing building densification. Urban nature, that is, plants and animals, plays an important role in the quality of these spaces and places. Many cities are looking for strategies to combat the loss of urban nature and secure and develop urban green infrastructure. Animal-Aided Design facilitates an integrated approach to housing construction and nature conservation, bringing together what are often regarded as opposing interests.

URBAN BIODIVERSITY

Many wild animals live, forage, and reproduce in urban areas. In Berlin, for example, more than 17,000 species of insect, 180 types of breeding birds, and 59 mammal species can be found.[1] There are manifold reasons for this abundance of wildlife. On the one hand, the abundant food supply, warmer climate, and diverse green areas make cities suitable habitats, causing wild animals to migrate in from the surrounding areas. On the other, this migration is also a sign of the continuing loss of biotopes in rural areas; the city then becomes a substitute habitat.

Urban nature plays an important role in city dwellers' everyday experience of the natural world. In a study by the German Federal Agency for Nature Conservation on the attitude of the German population toward urban nature, 44% of the respondents viewed urban open spaces as areas in which to experience nature and 68% saw them as important habitats for animals and plants.[2] Another study found that residents' acceptance of near-natural areas in their living environment increases once they are aware of the animal species that live in them.[3] According to a survey, the most popular city-dwelling animal species are small birds, squirrels, butterflies, hedgehogs, ducks, geese, and dogs.[4] Another study asked which animals would be particularly welcome in public parks. Ladybugs were chosen most frequently, followed by great tits, peacock butterflies, goldfish, ducks, and robins.[5] Urban nature offers city dwellers the opportunity to experience nature in the urban environment.[6] This is of central importance to nature conservation as childhood interactions with the natural world help the development of environmental awareness.[7] Furthermore, current studies indicate that the presence of birds or a greater diversity of organisms can have a positive effect on general human well-being.[8] In contrast, the increasing urbanization of our world poses two dangers for the relationship between humans and animals: firstly, urbanization is also accompanied by a loss of biodiversity,[9] and secondly, we humans are becoming increasingly out of touch with nature[10]. As people migrate into cities, building density

1. Naturbarometer Berlin 2015: S. 14, https://www.berlin.de/senuvk/natur_gruen/biologische_vielfalt/download/naturbarometer_berlin.pdf
2. BMUB, BfN 2016.
3. Gloor et al. 2010.
4. Bjerke, Østdahl 2004.
5. Shwartz et al. 2012.
6. Turner et al. 2004.
7. Soga et al. 2016.
8. Ratcliffe et al. 2013; Dallimer et al. 2012.
9. Aronson et al. 2014.
10. Soga et al. 2016; Turner et al. 2004.

is increasing and conurbations are expanding. Unless nature conservation is actively integrated into urban planning processes, space for animals in the city will become scarce. Access to nature for all is a form of environmental justice; however, this will be lost if city dwellers only rarely come into contact with the natural world outside cities and urban nature disappears.

Cities can be distinguished from rural areas by the difference in their environmental conditions. Cities are heat islands and have high levels of pollution from light, noise, and exhaust emissions.[11] Urban nature can appear in various forms, for example in the isolated remnants of the natural landscape or in urban wastelands. However, the majority of urban nature is shaped by human activity, for example in the traditionally cultivated landscape of suburbia, gardens in residential areas, landscaped green spaces, and parks. The animals and plants that are to be found in a city will be influenced by various factors. The biogeographical location of the city affects the pool of species able to migrate into it, but the specifically manmade configuration of the city determines which animals and plants are actually present. Not every species is able to live in a city, but the number of species that have characteristics enabling them to do so under the right man-made conditions is greater than most people would think.[12]

REURBANIZATION AND INNER URBAN DEVELOPMENT

Our cities are facing substantial challenges. Demographic change and the influx into cities, in particular into large cities, require the adaptation of both the existing housing stock and the infrastructure, in order to cope with the increasing number and heterogeneity of city dwellers. In many cities in Germany, the increased demand for living space is leading to both the promotion of more cost-effective housing construction via municipal housing companies and cooperatives, and more private-sector construction. In addition to this need for new living space, many of today's rental apartments dating from the 1950s to 1970s are now in need of complete renovation, while many existing apartments also require renovation in terms of energy efficiency. Generally higher levels of prosperity have also led to higher requirements on the part of residents when it comes to their built environment, for example leading to more living space per person.[13] This development and the influx into cities will lead to further consolidation, in accordance with the principle of "inner development before outer development."[14] The objective is to integrate new residential property into the existing built infrastructure of a city in order to curb its outward growth. In growing cities, inner urban development and the demand for building land thus put a great deal of pressure on green and open spaces. At the same time, the diverse functions of urban green spaces are becoming increasingly important against the background of current challenges such as adapting to climate change, environmental justice, and the protection of biodiversity. This tension between building densification and the significance of existing green and open spaces has been addressed in Germany through the concept of "dual inner urban development."[15] This involves the use of precautionary planning processes to safeguard, improve, and expand the green and blue urban networks of green spaces and bodies of water while densification takes place, i.e., they are to be improved functionally, aesthetically, and in their value for the urban population.

Dual inner urban development is a significant challenge. Animals are not currently taken into account during the design of urban open spaces, even though many people regard them as an integral part of an intact urban natural environment and of high-quality open spaces. For larger and complex construction projects, the legal requirements of Impact Mitigation and species protection (EU Habitats Directive) come into play. The EU Habitats Directive focuses on the protection of a number of selected species; however, these must already be present at a site for it to be protected. Only a small proportion of species, for example all bats, most birds, some lizards, frogs and toads, but less than 1% of all insects, enjoy this special protection. Within the Impact Mitigation Regulation, species-specific requirements are rarely considered. While the integration of plants into open space design is now quite successful, for example through the use of native species, there are hardly any practical examples of planning and design for the presence of animals in urban areas. Animal-Aided Design (AAD) is intended to close this gap, bringing tangible and active planning methods into the existing processes for urban construction and open space planning.

11. Summarized in: Kowarik 2011.

12. Aronson et al. 2016.

13. According to the German Federal Statistical Office, Germany's per-capita living space was 46.5 m² in 2017. In 2005, it was 41.2 m². See: German Federal Statistical Office 2018.

14. This principle has its legal basis in the "Gesetz zur Stärkung der Innenentwicklung in den Städten und Gemeinden und weiteren Fortentwicklung des Städtebaurechts" [Act to Strengthen Inner Urban Development in Cities and Municipalities and the Further Development of Urban Planning Legislation] of June 2013.

15. See German Council for Land Stewardship 2006.

FROM TARGET SPECIES SELECTION TO DESIGN *The Animal-Aided Design method*

In view of strong urban growth, it is necessary to actively integrate biodiversity-promoting initiatives into urban planning processes. However, in current urban development it often seems difficult to combine human interests with the requirements of urban animal species. This is where Animal-Aided Design (AAD) comes in[16], with its aim of integrating animal needs into urban and open space planning. AAD is a planning and design method intended to serve as an interface between the very different disciplines of urban planning — encompassing architecture, traffic planning, general urban planning, nature conservation and landscape architecture. The goal of the AAD cooperative planning process is to explicitly plan for the presence of animals in urban open spaces and to incorporate them into the design.

When using AAD in the planning process, the first question that comes up is: "Which animals should be present at a particular site?" The selection of the animal species that are going to inhabit a site should be made as early as possible and, like other programmatic planning decisions, should take place at the beginning of the analysis and draft phase of a project planning cycle. It is not primarily a matter of protecting any rare species that are already present in a planning area; AAD rather encourages a transparent selection process of target species. The selection process makes it possible to bring in the different on-site stakeholders and enable their participation in decision-making[17]. AAD makes use of the fact that landscape-architectural and urban design planning take place at spatial scales that allow the implementation of measures suitable to meet the habitat needs of the target species in question.

16. Hauck, Weisser 2014.

17. Apfelbeck et al. 2019.

18. Cf. Wolfgang Borchardt, Pflanzenverwendung – Das Gestaltungsbuch, Stuttgart 2013.

A SPECIES-SPECIFIC APPROACH

AAD focuses on the needs of individual species and aims to integrate these needs into landscape-architectural and urban design planning in order to enable new ways of viewing and experiencing urban nature. In contrast to "unstructured" nature, such as the "urban wilderness" concept, AAD – as with all landscaping and landscape architecture – creates a new image of nature or reconstructs an already existing one, offering it as an aesthetic experience to the viewer or user. AAD views wild animals as elements within this design context, similar to the way plants have long been regarded in landscaping and landscape architecture.[18] AAD offers the knowledge and tools required to "design with animals." The target species approach allows for a great deal of creative freedom and opens up the option of involving stakeholders in both species selection and the design of habitat structures for the selected species. It also offers the opportunity to respond in a flexible manner to the potentials and drawbacks, both spatial and functional, of urban open spaces. Importantly, AAD involves more than fulfilling individual species requirements. Isolated activities such as hanging up nest boxes can only meet some of a target species' needs. They do not take into account other essential needs in an animal's life cycle, the fulfillment of which is then left to chance. This is why it is so important that the measures developed with the help of AAD are integrated into an overall design through a collaborative design process. As the various designs already developed using AAD show, it is worth translating the animals' specific requirements into critical needs (e.g. characteristics of

the nesting site or food) and taking them as the starting point for design considerations – they can inspire a design.

A comparison of some successful international projects[19] revealed three important factors that, if taken into account, can lead to the creation of urban spaces that are equally livable for humans and wildlife:

1 – **Involving species experts early on**, that is, in the analysis and draft phase of the planning process, ideally as part of a continuous collaboration within interdisciplinary planning groups.
2 – Setting up the **planning process in a participatory manner** by bringing together stakeholders such as property developers, tenants, and approving authorities. This makes it possible to determine, compare, and balance the needs of humans and animals.
3 – **Actively monitoring and evaluating the results** after completion. This creates opportunities for feedback and adjustments, so that "best practice" approaches can be developed and disseminated.

THE ANIMAL-AIDED DESIGN PLANNING STEPS

In every AAD planning step, both the needs of the animals and the requests of the human stakeholders must be taken into account Fig. I. In the **analysis and draft phase (A)**, target species are chosen. Potential target species are not just the animals already present at the site but also species from surrounding areas that could realistically reach the project site. Both the project site's habitat potential and its limitations are analyzed to narrow down the choice of target species. At the same time, the values, requirements, and concerns of the human stakeholders are identified. Based on these analyses, the target species are selected and a spatial concept that meets the habitat requirements of these species is developed. In the **detailed planning and design phase (B)**, the animals' habitat-related needs are directly incorporated into the site design with the help of the species' critical needs. The aim is to create spaces in which the human residents can experience the natural world. In the **realization and construction phase (C)**, it is especially important that all provisions are correctly implemented. This can be achieved, for example, through a targeted training program for the construction company's

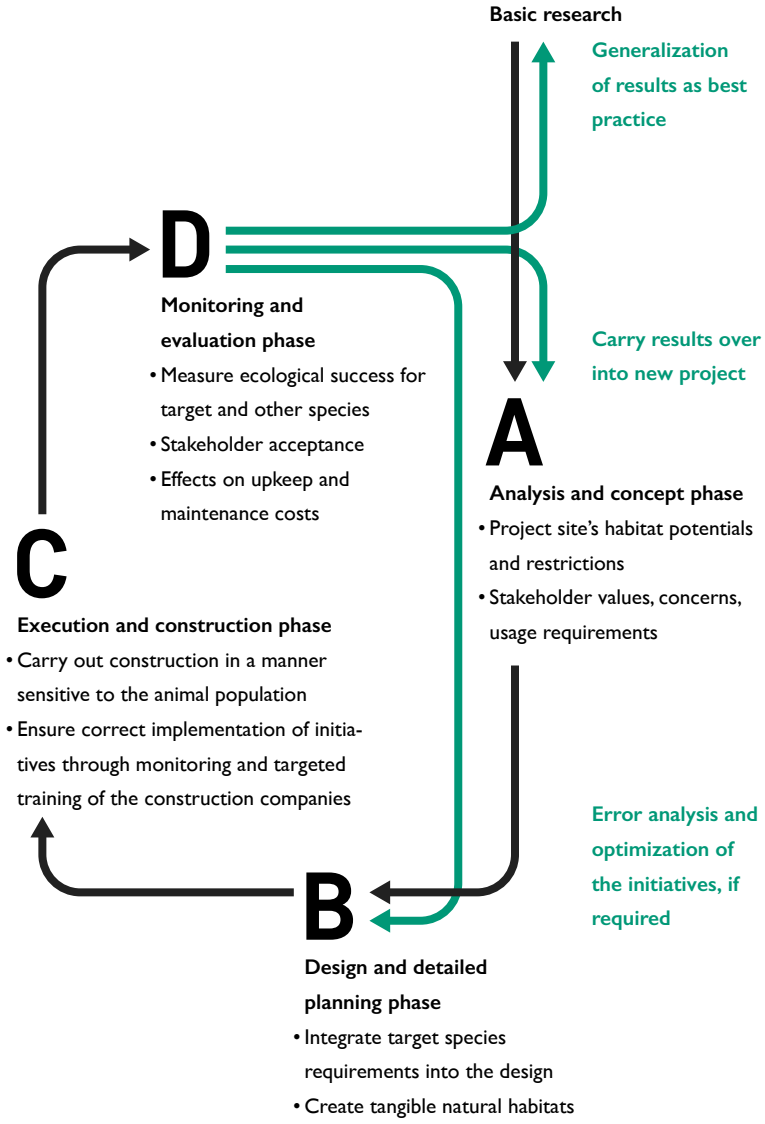


Fig. I
Graphic showing AAD planning cycle

19. Apfelbeck et al. 2019.

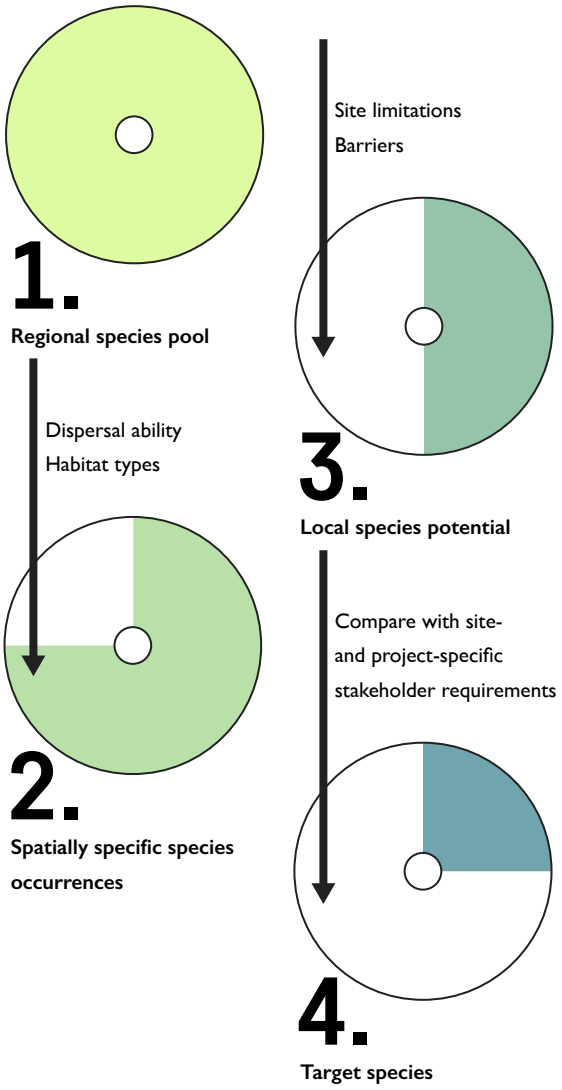


Fig. 2
Selecting the target species

employees. Throughout the execution and construction phase, it is important to be considerate of existing animal populations; construction must be carried out as sensitively as possible, and at a time when the animals are least likely to be disturbed. If Animal-Aided Design is to succeed, it is particularly important that the project is followed by **post-occupancy monitoring (D)**. Monitoring and evaluating the ecological, social, and economic aspects of the project means that these can, if necessary, be adjusted and serves as a measure of success. Did the target species embrace the provisions that were put in place? How do the residents feel about the initiatives? Have the initiatives caused additional maintenance costs, or did they actually save money? If at all possible, the results should be discussed with the stakeholders. They can also be used to further improve the structural elements of the site or to optimize the next planning process. The goals and approaches for each of the planning steps are detailed below:

A. Analysis and draft phase — selecting target species and involving stakeholders

In the context of AAD, a target species is a species selected for specific reasons (e.g., because of its aesthetic qualities or its cultural or conservation value) that is to be actively supported through the fulfillment of its specific habitat-related requirements. The use of the term "target species" in AAD is compatible with the current definition of the term in nature conservation because the goal in each case is to make it possible for a selected species to live in a specific location. In AAD, target species are not selected purely because they are rare, endangered, or enjoy legal protection; their importance to humans must also be factored in, thus supplementing the already legally regulated area of (special) species protection. Our understanding of the factors that influence the presence of species in cities has grown significantly over the past few decades.[20] It is now time to put this knowledge into practice and incorporate it into the planning of urban districts. Animal habitat requirements should be included in the design process in the same way that other requirements for open space (e.g., space for sports or bicycle parking) are taken into account. This requires targeted species selection, adapted to the location in question, of animals whose habitat requirements can be included in the design. Above all, cities serve as living space for us humans and so differ significantly from both other man-made structures and natural landscape environments.

20. Beninde et al. 2015; Turrini and Knop 2015.

Therefore, when selecting target species for AAD, both biological and socio-cultural factors must be considered and balanced against each other to ensure that people do not later reject them. The following aspects should therefore be taken into account when selecting species:

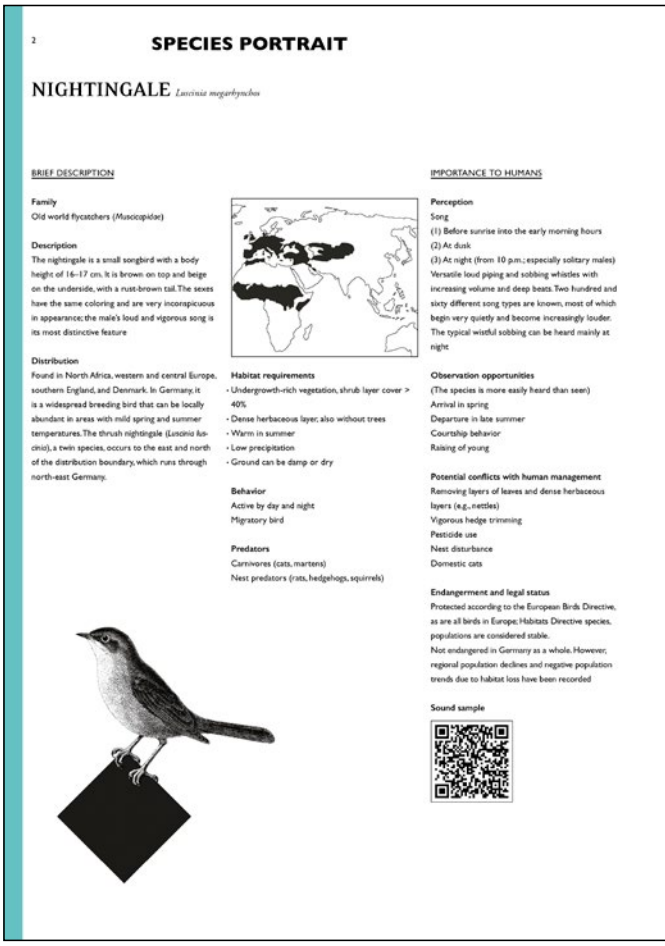
- The **Ecological characteristics of the species** that provide information on the critical needs that must be fulfilled for it to be able to live at the project site.
- **Socio-cultural considerations** that reflect preferences or aversions for / to certain species or groups of species.
- **Species occurrences in the city** as well as potential barriers for dispersal.

When selecting species Fig. 2, potential species for the project site are first identified based on publicly available data on species occurrences, resulting in the regional species pool. The regional species pool is trimmed by assessing both the project site's potential (and limitations) as well as dispersal barriers preventing potential target species colonizing the project site. This local species potential is then assessed, taking into account socio-cultural considerations. The final target species selection is then made in consultation with the stakeholders. AAD measures will then be planned and implemented for these species. It is advisable to check the population levels of the target and other species in the project area and the surrounding area by carrying out species surveys before construction begins.

B. Detailed planning and design phase — designing for the life cycle

The planners' knowledge of a species' life cycle and of its critical needs in all phases of its life are key to a successful design. In order to have a good chance of providing all necessary means for supporting a population of the desired target species, the designers must have a good knowledge of the specific needs of the animal in all phases of its life. This knowledge has to be incorporated into the design Fig. 3.

To communicate the requirements of a species in all the different phases of its life, AAD uses purpose-made species profiles. These take the form of a life-cycle diagram that includes all critical needs for each phase of the species' life. These include the specific conditions necessary for the continued existence of the species population, such as cavities in which to raise their young or the presence of certain plant species for food. The



2

SPECIES PORTRAIT

NIGHTINGALE *Luscinia megarhynchos*

BRIEF DESCRIPTION

Family
Old world flycatchers (*Muscicapidae*)

Description
The nightingale is a small songbird with a body height of 16–17 cm. It is brown on top and beige on the underside, with a rust-brown tail. The sexes have the same coloring and are very inconspicuous in appearance; the male's loud and vigorous song is its most distinctive feature

Distribution
Found in North Africa, western and central Europe, southern England, and Denmark. In Germany, it is a widespread breeding bird that can be locally abundant in areas with mild spring and summer temperatures. The thrush nightingale (*Luscinia luscinia*), a twin species, occurs to the east and north of the distribution boundary, which runs through north-east Germany.

Habitat requirements
- Undergrowth-rich vegetation, shrub layer cover > 40%
- Dense herbaceous layer; also without trees
- Warm in summer
- Low precipitation
- Ground can be damp or dry

Behavior
Active by day and night
Migratory bird

Predators
Carnivores (cats, martens)
Nest predators (rats, hedgehogs, squirrels)

IMPORTANCE TO HUMANS

Perception
Song
(1) Before sunrise into the early morning hours
(2) At dusk
(3) At night (from 10 p.m.; especially solitary males)
Versatile loud piping and sobbing whistles with increasing volume and deep beats. Two hundred and sixty different song types are known, most of which begin very quietly and become increasingly louder. The typical wistful sobbing can be heard mainly at night

Observation opportunities
(The species is more easily heard than seen)
Arrival in spring
Departure in late summer
Courtship behavior
Raising of young

Potential conflicts with human management
Removing layers of leaves and dense herbaceous layers (e.g., nettles)
Vigorous hedge trimming
Pesticide use
Nest disturbance
Domestic cats

Endangerment and legal status
Protected according to the European Birds Directive, as are all birds in Europe; Habitats Directive species, populations are considered stable.
Not endangered in Germany as a whole. However, regional population declines and negative population trends due to habitat loss have been recorded

Sound sample

4

SPECIES PORTRAIT – NIGHTINGALE

LIST OF PLANTS

I. Plants for building nests

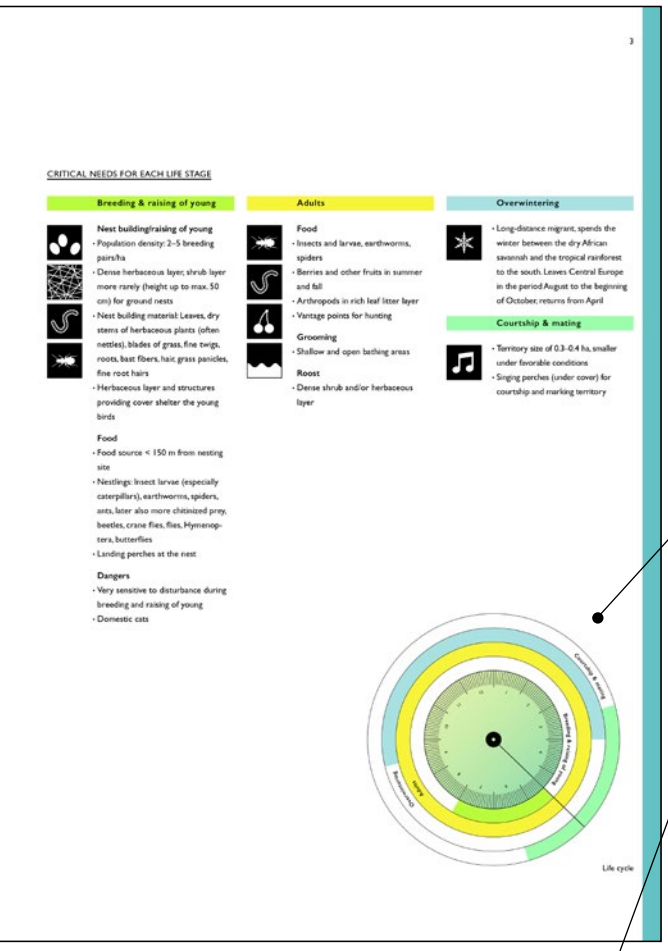
Common name	Scientific name
Common nettle	*Urtica dioica*
Small nettle	*Urtica urens*
Hops	*Humulus lupulus*
Blackberry	*Rubus* section *Rubus*
Raspberry	*Rubus idaeus*
Common ivy	*Hedera helix*
Reeds	*Phragmites communis*
and other grasses	

Ii. Plants for foraging

Common name	Scientific name
Elder	*Sambucus nigra*
Red elderberry	*Sambucus racemosa*
Currants	*Ribes rubrum, Ribes nigrum*
Alder buckthorn	*Frangula alnus*
White dogwood	*Cornus alba*
Shadbush	*Amelanchier lamarckii*

PROFILE

Breeding and raising of young
Nest Available nesting materials should include dry leaves, dry stems of herbaceous plants (often nettles), blades of grass, fine twigs, roots, bast fibers, hair, grass panicles, the fibers of old nettle stems, and fine root hairs. Moss and fine reed leaves are used less frequently. The hollow of the nest is padded with skeletonized leaves, hair, grass panicles, the fibers of old nettle stems, and fine root hairs. Working alone, the female builds a deep, loose bowl in 3–5 days. The nest is usually very well hidden in partial shade, either in a thick herbaceous layer directly on the ground or in the vegetation up to a maximum height of 50 cm (usually no more than 30 cm), and is always near twigs of bushes or young trees that can be used as landing perches. Nests are often to be found near streams and rivers, in the herbaceous and shrub layer of mixed forests, in the hedges and bushes of cultivated land, or in the herbaceous and shrub layer of overgrown gardens and parks.
Breeding From May, as soon as the nest is ready, the female lays one egg per day until she has a clutch of 4–6 olive-gray or olive-brown eggs. The female incubates the eggs for around two weeks and keeps the chicks warm while the male brings her food. The female passes some of the food on to the chicks. After the first few days, both parents will feed the chicks, which stay in the nest for around eleven days; if they are disturbed, they will leave sooner. One brood per year is the norm.
Food Newly hatched young birds tend to be fed softer prey, and then increasingly more chitinized prey as they get older; this mainly consists of beetles, crane flies, and flies. They are also fed Hymenoptera, butterflies, and small earthworms. Numerous other small invertebrates will also be eaten if they are available. Food for the raising of young is usually sought within 150 m of the nest.
Disturbances Nightingales are very susceptible to disturbances. In the early days of incubation, the female will covertly leave the nest for a short time if she is disturbed. From around the nineth day of incubation, it becomes very difficult to drive the female away from the clutch. The males sing loudly when disturbed; during the nestling period, couples will try to drive away interlopers that come within several meters of the nest by whistling loudly, sometimes together with birds from neighboring territories. They only return to the nest once everything is completely quiet again. The adult birds often walk the last few meters back to the nest under cover of the herbaceous layer.



3

CRITICAL NEEDS FOR EACH LIFE STAGE

Breeding & raising of young

Nest building/raising of young
- Population density: 2–5 breeding pairs/ha
- Dense herbaceous layer, shrub layer more rarely (height up to max. 50 cm) for ground nests
- Nest building material: Leaves, dry stems of herbaceous plants (often nettles), blades of grass, fine twigs, roots, bast fibers, hair, grass panicles, fine root hairs
- Herbaceous layer and structures providing cover shelter the young birds

Food
- Food source < 150 m from nesting site
- Nestlings: Insect larvae (especially caterpillars), earthworms, spiders, ants, later also more chitinized prey, beetles, crane flies, flies, Hymenoptera, butterflies
- Landing perches at the nest

Dangers
- Very sensitive to disturbance during breeding and raising of young
- Domestic cats

Adults

Food
- Insects and larvae, earthworms, spiders
- Berries and other fruits in summer and fall
- Arthropods in rich leaf litter layer
- Vantage points for hunting

Grooming
- Shallow and open bathing areas

Roost
- Dense shrub and/or herbaceous layer

Overwintering
- Long-distance migrant, spends the winter between the dry African savannah and the tropical rainforest to the south. Leaves Central Europe in the period August to the beginning of October, returns from April

Courtship & mating
- Territory size of 0.3–0.4 ha, smaller under favorable conditions
- Singing perches (under cover) for courtship and marking territory

Life cycle

5

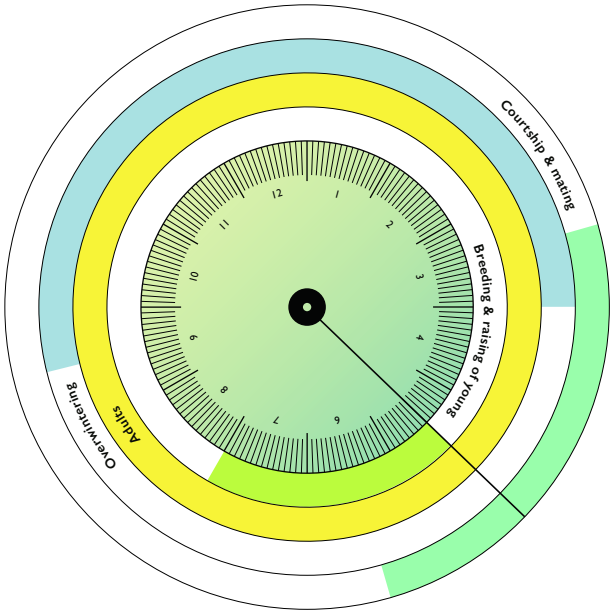
Juveniles
The chicks cannot fly until they are 16 days old; freshly fledged chicks conceal themselves in the herbaceous layer under protective structures such as roots; in this manner, they can roam as far as 100 m from the nest. The parents coax them out with "errrp" calls. Hungry young birds call out to reveal their location. After a few days, the parents will lead the chicks up to 150 m away from the nest; around two weeks after leaving the nest, the young birds are independent. They eat the same food as nestlings.

Adults
Food Nightingales are mostly busy looking for food during the day, especially at the beginning of the breeding season and before they migrate in the fall. The search for food is mostly carried out while hopping along the ground, with prey being taken from the ground or vegetation. Occasionally, the search for prey also starts from a perch or takes place while leaping or in flight. The birds like to feed on insects and their larvae (especially caterpillars), earthworms, spiders, and, depending on what is available in the area, ants. In summer and fall, they also feed on berries and fruits.
Resting places and roosts The nightingale's roosts and refuges are hidden in thick bushes or shrubs. The birds like to groom themselves by bathing in water. Bathing areas should be shallow, wide, easily accessible, and not too close to cover for predators to hide in, but close enough for the birds to quickly find cover themselves. They generally do not completely submerge themselves but rather wet their plumage with water and then clean and tidy their feathers with their beak. There should be perches near the bathing area for drying out and sunbathing, and these can also be used for grooming.

Overwintering
Nightingales are long-distance migrants; they spend the winter between the dry African savannah and the tropical rainforest to the south. They leave between mid-August and early October, returning to their breeding areas in Germany from the beginning of April. Nightingales migrate at night and also sing during the migration.

Territory occupation
Nightingales' territories are between 0.3 and 0.4 ha in size, although smaller distances between nests have been measured under very favorable conditions. The actual size of the territory depends on its composition (supply of food, cover, and nesting options). Here, the proportion of the territory covered by an herbaceous or shrub layer seems to be the decisive factor for foraging: The greater the proportion of the territory covered by an herbaceous or shrub layer, the smaller it can be in total. The male nightingales that reach the breeding area first initially occupy what are known as preliminary territories, which are reduced in size as further males arrive and occupy territories of their own. Whistling tones and "karr" and "tak" sounds warn birds from neighboring territories when they are approaching the boundaries. After frequent warnings, they will be chased away. Territory sizes and which territory a bird occupies can often change up to the point when a nest is built. From then on, the birds will only relocate if the nest or clutch is lost. Territory boundaries often seem to follow existing structures such as open spaces/clearings, wide paths, etc. The territories shrink after the breeding season, as the young birds start defending their own feeding grounds.

Courtship and mating
Nightingales reach sexual maturity once they are one year old, and around half of the nightingales that hatched the previous year then start breeding. If a female appears in his territory, the male will begin courtship. He will stay close to his potential mate, singing softly and occasionally flying to branches above, where he will exhibit display behavior made up of slow movements. This is characterized by raising the wings and lowering the head, as well as alternately fanning, folding, raising, and lowering the tail. On the ground, the male circles the female and jumps toward her in an arc. If she flies away, she will be pursued by the male. Aggression between the partners gradually reduces as the courtship continues, with the courtship song being replaced by soft contact calls. Mating is usually initiated via short pursuit flights that end on the ground. The courtship continues until a few days after the female has begun incubating the eggs, when the male returns to performing a more territorial song. After pair formation, the female chooses a nest location, which the male shows her by nestling down on the ground and flapping his wings. Nest building usually starts immediately. Nightingales form monogamous pairs for the duration of the breeding season; it is rare for one male to have several mates.



The circular chart shows the life cycle of an animal species over the course of a year (this may be different for animal species with longer or shorter life cycles)

Breeding and raising of young The innermost circle shows the period within the life cycle in which animals of the respective species are born or eggs are laid and in which, if applicable, the young are raised. The hand of the "clock" marks the approximate beginning of this first phase in the species' life cycle.

Adults The second circle shows the period in which the species goes through its adult life cycle. For species that go through several life cycles, this circle is closed.

Overwintering The third circle shows the period within a life cycle in which the species changes its behavior in order to survive the winter. This can, for example, be through hibernation or dormancy, or migration to warmer regions.

Courtship and mating The outermost circle shows the time period in which the species finds a partner and mates.

CRITICAL NEEDS FOR EACH LIFE STAGE

Breeding & raising of young

Nest building / raising of young

- Population density: 2–5 breeding pairs / ha
- Dense herbaceous layer, shrub layer more rarely (height up to max. 50 cm) for ground nests
- Nest building material: Leaves, dry stems of herbaceous plants (often nettles), blades of grass, fine twigs, roots, bast fibers, hair, grass panicles, fine root hairs
- Herbaceous layer and structures providing cover shelter the young birds

Food

- Food source < 150 m from nesting site
- Nestlings: Insect larvae (especially caterpillars), earthworms, spiders, ants, later also more chitinized prey, beetles, crane flies, flies, Hymenoptera, butterflies
- Landing perches at the nest

Dangers

- Very sensitive to disturbance during breeding and raising of young
- Domestic cats

Adults

Food

- Insects and larvae, earthworms, spiders
- Berries and other fruits in summer and fall
- Arthropods in rich leaf litter layer
- Vantage points for hunting

Grooming

- Shallow and open bathing areas

Roost

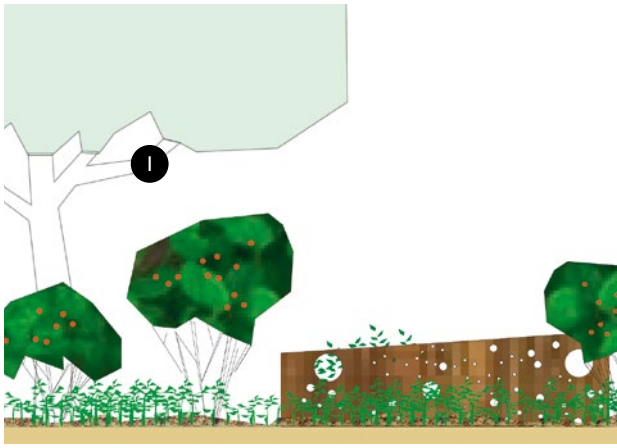
- Dense shrub and / or herbaceous layer

Overwintering

- Long-distance migrant, spends the winter between the dry African savannah and the tropical rainforest to the south. Leaves Central Europe in the period August to the beginning of October, returns from April

Courtship & mating

- Territory size of 0.3 – 0.4 ha, smaller under favorable conditions
- Singing perches (under cover) for courtship and marking territory



Design cutout

Fig. 3
Designing with the life cycle: Illustration of how the information from the species profile is incorporated into a design, using the nightingale as an example
- The general characteristics of the species, the importance of the species to humans, the life cycle of the species from the species profile, and the life-phase-related critical needs are used as planning tools
- Further planning aids: Lists of plants and a more detailed description of the life cycle
- Excerpt from species profile: Life cycle of the species as a circular chart
- Excerpt from life-phase-related critical needs used as a planning tool
- Example of locating the location factors within the design

Illustration taken from the Animal-Aided Design brochure (Hauck, Weisser 2015) financed by the Bavarian State Ministry for the Environment and Consumer Protection.

critical needs are either given as values, with a minimum and maximum, for example the nest cavity dimensions required by cavity nesters, or they are defined on a qualitative basis, for example the presence of a certain plant that the animal needs to survive. These detailed descriptions of the critical needs indicate how wildlife-inclusive planning can be achieved. Based on them, concrete species-specific measures can be developed for the planning area in question. The critical needs should also address anything that represents a danger to the target species; the Animal-Aided Design strategy must ensure these dangers are avoided. Two sources of danger that are rarely considered in building projects, and that kill numerous birds and insects, are glass and light. Birds can crash into panes of glass, as the transparency of and reflections in the glass can cause them to believe they are heading toward, for example, trees, bushes, or the open sky. Light can attract large numbers of insects; they then circle the light sources, which can cause them to starve. This impacts their population levels, meaning that they can no longer serve as long-term food sources, for example for birds and bats. Effective solutions are available to mitigate both of these factors, and they must be implemented in order to avoid endangering animals unnecessarily.[21]

The species profile lists all critical needs of a species that a designer needs to consider. The creative challenge is to find appealing and innovative design solutions for all the critical needs that can work within the overall design. The critical needs are symbolized by icons in the species profile that can be integrated into the design proposal. The measures necessary to fulfill the critical needs for each phase of the target species' life and their placement in the planning area can thus be identified in the draft design. In this way, the entire life cycle of the target species is visually represented on the plan. Critical needs that can only be met outside of the planning area should also be represented and their accessibility for the target species demonstrated.

C. Realization and construction phase — ensuring ecologically sound construction

In order to ensure that AAD is taken into account during the construction phase, and that the AAD elements are correctly constructed, ecological advice is necessary. The ecological monitoring of the construction process needs to include a critical review of all plans made by the architects and other planners in order to help find the optimal technical solutions and to avoid planning errors. The regular participation of an ecologist in on-site meetings is necessary in order to ensure that the construction work is being carried out in an animal-friendly manner (e.g., avoiding disturbances and on-site hazards), and to support the planners during construction site supervision. When AAD is put into practice, it is likely the case that the technical details will need to be redeveloped and tested. This makes it essential to develop the detailed planning in close cooperation with the construction site management and to monitor its implementation. Construction supervision also involves taking part in the viewing of samples as part of the selection of standard components, e.g., for facade-based nesting aids, bird-safe glass, and insect-friendly light sources. The ecologist should also be involved in the quality control for custom-made products, and in the inspection and approval of completed work.

D. Post-occupancy monitoring — recording and learning from the results

Whether the target species already occur in the project area and its surroundings will already have been determined during the target species selection process. During construction work, monitoring of the population levels of the target species and other species should be continued. This will make it possible to observe any changes in species occurrence caused by the construction process. In this way, the success of initiatives such as providing substitute nesting cavities when renovating a facade can be assessed. After a project has been completed, target species' population levels should then be mapped over a longer period in order to check whether the implemented measures are successful. This data, that also include observations of the behavior of the target species in the project area, can be used to learn for future AAD projects. Which measures work and which do not? How long does it take for the target species to appear on-site, e.g., for them to start using the nesting cavities? As part of the monitoring, it makes sense to focus not only on the animal species but also on the human inhabitants of the project area and their relationship to the development. Has vandalism taken place? Have the initiatives been recognized and accepted? It is particularly important to involve residents if they took part in the AAD target species selection process. Has it been possible to successfully support the jointly selected target species? Is there anyone who is particularly

21. Schmid et al. 2012..

interested in the target species and could look after the provisions that have been put in place, for example by cleaning the nesting cavities?

EMBEDDING ANIMAL-AIDED DESIGN INTO ESTABLISHED PLANNING PROCESSES[22]

Due to legal regulations, aspects of animal ecology play an important role in most planning and approval procedures. The basis for this is the German Federal Nature Conservation Act (Bundesnaturschutzgesetz), which regulates various aspects of the protection of nature and the landscape.

Promoting animal species through spatial planning
In addition to instruments for safeguarding populations and avoiding adverse effects on them, there are various planning instruments into which aspects of promoting and developing animal species occurrence can be integrated. Landscape planning offers a central point of contact for the integration of AAD into planning processes, especially when it comes to creating biotope networking strategies. Other informal strategies, such as municipalities' internal development concepts, water authorities' water development plans, or rural development concepts, can also be used for the promotion of animal species in planning areas. However, it should be noted that the content of these environmental development concepts is often not firmly embedded into urban land-use planning (e.g., in the zoning plan or the development plan). The following strategies can be used to better establish and implement the promotion of animal species in spatial planning through the use of AAD. They are motivated by the legal regulations in Germany, but many of these considerations also can be applied to other countries.

Urban land-use planning stipulations
When drawing up new urban land-use plans, municipalities can formulate specific goals and stipulations for the integration of AAD both across an entire district, via the zoning plan, and for specific areas, via the development plan. At a zoning-plan level, they can set specifications for development planning, in particular for biotope networking both outside and inside built-up areas. Landscape planning, a local biotope networking strategy, or an urban biodiversity strategy could form the basis for these specifications. An overarching concept for an entire district could serve to increase the effectiveness of individual initiatives in different areas. Such a concept could form the functional basis of both urban land-use planning and the granting of construction permits for projects in extant buildings, being used in conjunction with the biotope networking instrument and the climate change adaptations required by the German Federal Building Code. This would allow targeted initiatives for the promotion of animal species to be justified in a larger context. Small-scale measures (e.g., nesting aids on buildings) can only be regulated via the development plan in a somewhat generalized manner and possibly not in the depth required for AAD. However, in the course of the construction permit process it is possible to impose conditions relating to the promotion of animal species that go beyond the stipulations of the development plan.

Urban development contracts
Urban development contracts with private investors can, in accordance with Section 11 BauGB [German Federal Building Code], refer to the implementation of AAD, and it may be possible to dispense with development plan stipulations.[23] Prior to an urban development contract, the investor can submit a declaration of interests in the form of a "Letter of Intent." This is particularly important in the allocation of land by the municipality. Here, too, a municipal biodiversity strategy or a biotope networking strategy can be an advantageous technical justification.

Promoting private initiatives
In already built-up areas, stipulations for retroactively integrating AAD can only be made to a limited extent. In such areas, it is generally necessary to create targeted programs that promote improvements to the living conditions of wildlife in urban areas by creating financial incentives for building owners (funding programs, housing improvement districts). Such programs can be initiated by the municipalities or by owners and investors. The aim here should be to encourage as many stakeholders in an area as possible to participate. In the context of project planning and implementation, AAD can be supported by municipalities through funding programs from the EU, the federal government, and the federal states,[24] as well as through their own financial funding programs. City-specific concepts can serve as a basis for funding, as these can highlight a spectrum of possible initiatives and provide specific advice on the planning and implementation of appropriate initiatives.

22. See for this section: Koch et al. 2019 (in German only).

23. Roden 2017, S. 292.

24. Böhm et al. 2016.

ATTITUDES TOWARDS WILDLIFE IN THE RESIDENTIAL ENVIRONMENT

The results of a survey of German housing companies

Most urban open spaces, such as parks, cemeteries, or roadside planting, are maintained by municipal bodies. A further significant share of a city's green areas is made up of the open spaces in residential areas, a large part of which are owned by residential housing companies. These areas are very important for the improvement of inner-city open spaces and thus for the implementation of the dual inner urban development model.[25] Although housing companies play an important role as owners and managers of urban open spaces, there are hardly any studies on their attitudes toward urban nature and the presence of wildlife in the residential environment. This gap has been closed by a nationwide survey of German housing companies on their attitudes toward wildlife.[26] One hundred and fifty-five completed questionnaires were included in the evaluation. The participating companies come from 14 German federal states. In addition to planning and construction, most of the companies (72%) were also responsible for the care and maintenance of their housing complexes. Eighty-one percent of the companies were responsible for rental apartments only.

THE EVALUATION OF OPEN SPACES AND WILDLIFE IN THE RESIDENTIAL ENVIRONMENT

Most of the participating housing companies agreed with the statement that open spaces in urban residential areas play an important role in increasing quality of life. They also agreed with the statements that open spaces are important to improve the appearance of the urban landscape, protect the climate, and provide play areas for children. The statement that open spaces are important because they provide habitats for animals and plants received less support, while the statements that open spaces are important for increasing the market value of properties or providing parking spaces met with the least approval. When asked about the objectives they have when planning and maintaining open spaces in their housing complexes, the housing companies attached great importance to ensuring that the open spaces they plan are safe, clean, and contribute to healthy living conditions. Facilitating a closeness to nature or the opportunity to experience nature at first hand, climate-friendly design, and the biodiversity of flora and fauna were classified as less important at present. Most of the participating companies expressed a clear stance on the presence of certain species in urban areas Fig. 4. Songbirds and butterflies, followed by hedgehogs and squirrels, were rated as very desirable by the participants. However, some typical species that already thrive in cities such as, for example, pigeons, foxes, raccoons, magpies / crows, and rabbits, which are known to come into conflict with human residents, were considered to be undesirable. This is largely consistent with other results obtained when surveying the urban population on attitudes to wildlife.[27] The response of the housing companies to statements on bats and wild bees, for which there was no clear agreement as to their desirability, are also interesting. On the one hand, this could be due to a degree of "social desirability bias" in the participants' response behavior, since the animal species concerned are protected or worthy of protection. On the other, the presence of bats, for example, could lead to complications for the housing companies if renovations are required.

25. Böhm et al. 2016.et al. 2004.

26. Jakoby et al. 2019.

27. Shwartz et al. 2012; Bjerke, Østdahl 2004.

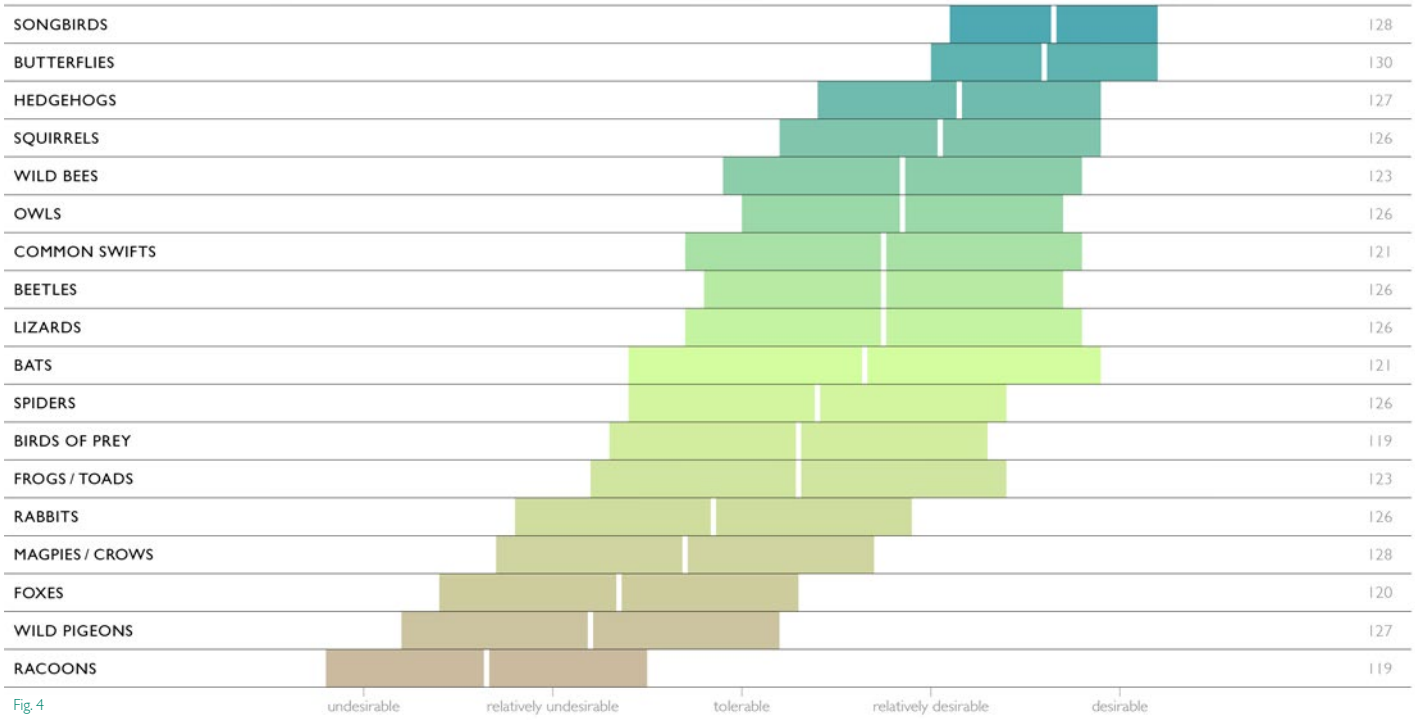


Fig. 4

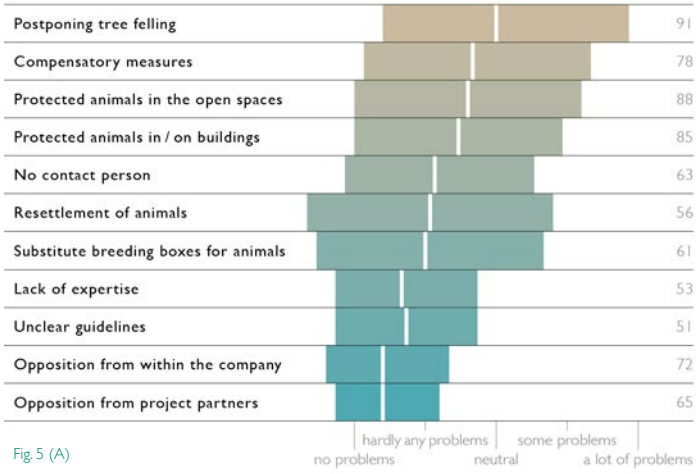
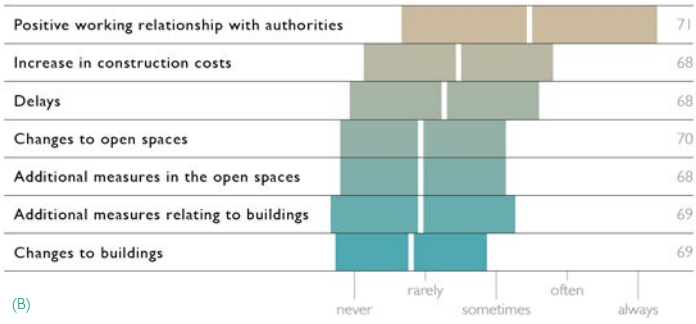


Fig. 5 (A)



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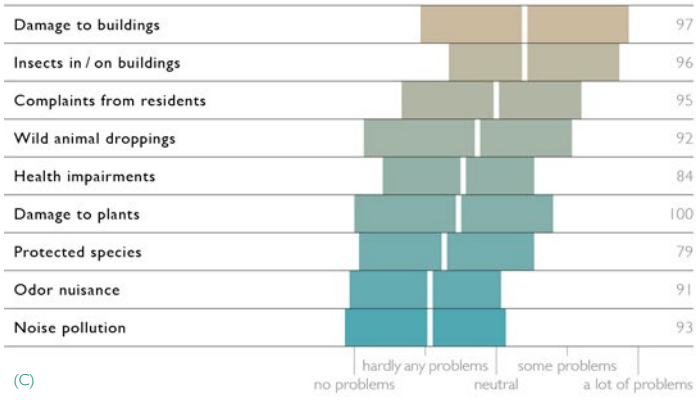
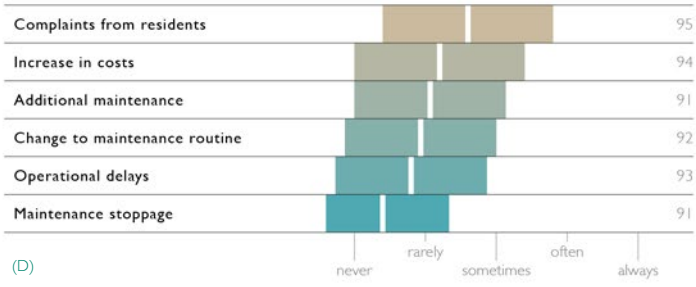


(C)



(D)

Fig. 4
Evaluation of various animals in urban residential areas by the participating housing companies (white: means, colored bar: standard deviations; total number of responses on a Likert scale (1 undesirable – 5 desirable) for each animal group are given on the right-hand edge of the graphic).

Fig. 5
(A) Scale of problems with animals during the planning / construction phase.
(B) Frequency of situations caused by the presence of animals during the planning / construction phase.
(C) Scale of animal-related problems affecting upkeep / maintenance.
(D) Frequency of situations caused by the presence of animals during upkeep / maintenance (white: means, colored bar: standard deviations; total number of responses on the Likert scale (1–5) for each option can be found on the right-hand edge of each graphic).

PROBLEMS PRESENTED BY WILDLIFE IN THE RESIDENTIAL ENVIRONMENT

Very few companies stated that they had experienced problems with wildlife during a planning or construction phase in the last few years Figs. 5 A, B, and it was only in rare cases that postponements to the housing construction process were necessary. Having to postpone tree felling, carrying out compensatory measures, and the presence of protected animal species in open spaces or in / on buildings caused the most cited problems. It should be emphasized that a few species were named in response to an open question as being a frequent cause of problems during the planning and construction phase. Common swifts and bats seem to cause the most such problems. Since they are subject to special species protection in Germany, it is likely that conflicts of interest will arise during the renovation of buildings, or a larger amount of planning work may be necessary if there is a legal requirement to provide them with alternative breeding sites when existing cavities in the buildings are closed in the course of refurbishment.

In contrast, there were hardly any problems involving wildlife that impacted the care and maintenance of housing complexes Figs. 5 C, D. "Damage to buildings and facades" and "Insects in buildings" (especially wasps) were rated as being the most problematic. Woodpeckers and pigeons were mentioned most frequently, followed by common swifts, bats, and other (nesting) birds. Overall, there was no general opposition to the presence of animals in the residential environment on the part of housing companies, and the housing companies had hardly had any negative experiences with animals, except with a few particular species.

PREVIOUS INITIATIVES PROMOTING WILDLIFE

By their own admission, the housing companies had in the past done very little to encourage wildlife, having only taken relatively simple steps such as avoiding paving over areas or maintaining and planting native trees and shrubs Fig. 6. Less often, roosts for birds and bats were created, or roofs and building façades were greened. Wetland biotopes or wildflower meadows were seldom created, and avoiding frequent mowing or refraining from the removal of dead wood and fallen leaves were also rare. Insect-friendly lighting and bird-friendly glass were mentioned very occasionally. Around half of the initiatives we asked about had only very rarely been implemented by the companies.

When asked what would motivate the voluntary implementation of such initiatives, creating a positive corporate image was frequently mentioned Fig. 7, followed by being able to act in accordance with their corporate philosophy or contribute to corporate social responsibility. Environmental reasons, such as contributing to green infrastructure or the conservation of species, were also mentioned, albeit much less often. Factors such as being able to (better) participate in invitations to tender, the receipt of subsidies, or efforts to network biotopes played a minimal role. None of the reasons we suggested stood out as obstacles that may thus far have prevented the respondents taking action to promote wildlife in the residential environment.

Concerns about the associated increase in costs were mentioned, but not very often. Other concerns that were stated in a few questionnaires were a lack of internal expertise, possible resistance from residents, concerns about future conservation requirements, concerns about hygiene problems and problems with wildlife, and a lack of outside expertise.

Overall, the results show that the housing companies have so far not given a great deal of attention to the promotion of wildlife in the residential environment. Raising awareness of the value of animals and of supporting them in the residential environment could therefore increase the demand for initiatives promoting the presence of wildlife among both housing companies and residents. Mowing grass less frequently or allowing dead wood to remain in situ presupposes, for example, a certain acceptance of "disorder"; targeted environmental education could focus on the value of such initiatives for the promotion of biodiversity.[28]

MOTIVATIONS FOR AN INCREASED PROMOTION OF WILDLIFE

Residential housing companies would primarily be motivated to implement wildlife-promoting initiatives if this would increase the residents'

28. Gloor et al. 2010.

quality of life. Alignment with the corporate philosophy, having lower maintenance costs due to non-intensive maintenance procedures, and the knowledge that they were contributing to species protection or climate protection were also frequently mentioned in the questionnaires. In terms of the reasons why so few wildlife-promoting initiatives have up to now been implemented, only a few obstacles were mentioned, including concerns about increased costs, extra work, and being required to adhere to more legal stipulations.

These results show that wildlife-promoting initiatives are most likely to be implemented by residential housing companies if they are desired by residents, are compatible with their corporate philosophy, and do not lead to any legal consequences or additional costs. Future research projects should therefore examine the motivations of residents and quantify the monetary costs and benefits of measures supporting wildlife.

CONCLUSIONS FROM THE SURVEY

Residential housing companies are key players in urban development and the design of open spaces in the residential environment. They have a great deal of experience in the planning, construction, care, and maintenance of housing complexes and are well acquainted with their tenants' preferences. It is encouraging for programs promoting wildlife in urban areas that problems with wildlife during planning / construction and care / maintenance were reported as being relatively rare and / or minor. The fact that any reservations about wildlife-promoting initiatives seem to be slight is also positive. Previous initiatives were mostly carried out voluntarily by the companies and not because of any requirements imposed by the authorities. Although the housing companies surveyed were very much human-focused, environmental issues are increasingly becoming part of their corporate philosophies and are particularly popular when they can make a contribution to quality of life.

In summary, it can be stated that there is a great deal of potential for the implementation of wildlife-promoting initiatives among key players in German housing construction.

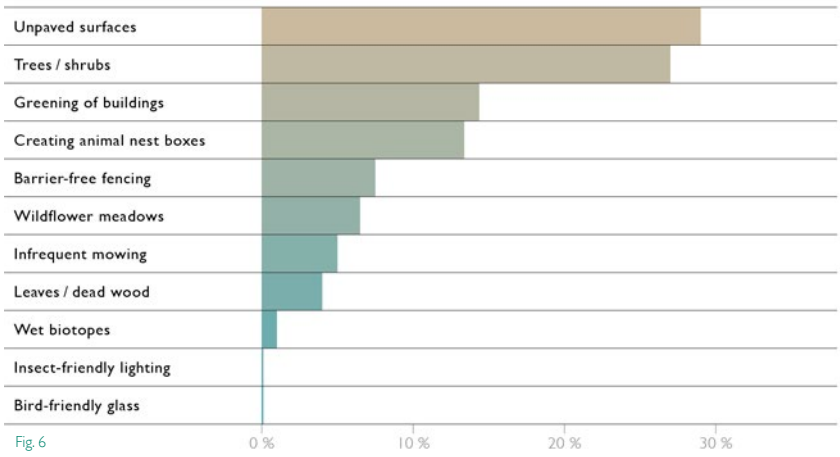


Fig. 6

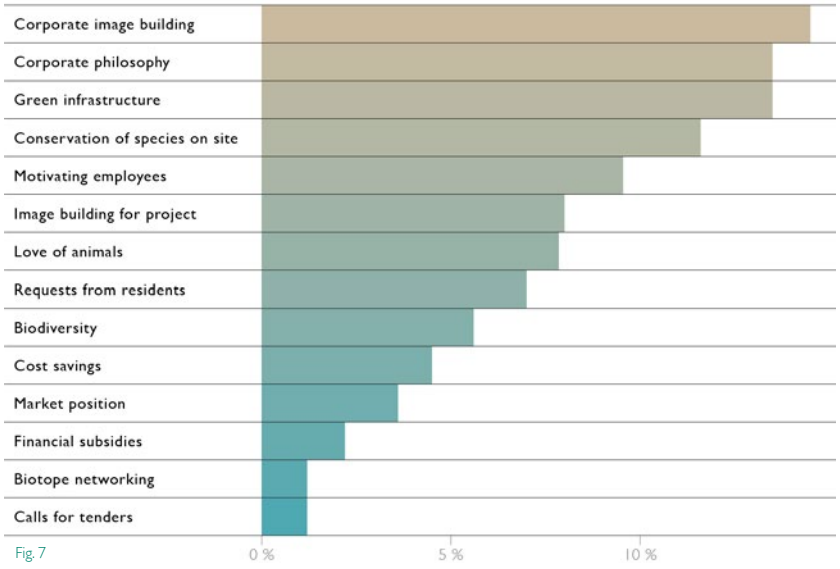


Fig. 7

Fig. 6
Frequency of measures implemented by companies. Multiple responses per company were permitted. A total of 276 measures (100%) were reported by 113 companies.

Fig. 7
Motivation for implementing voluntary initiatives. Proportion of companies that cited a particular reason. Multiple responses per companies were permitted (a total of 401 reasons (100%) were given by 107 companies).

DESIGNING THE RESIDENTIAL ENVIRONMENT WITH ANIMAL-AIDED DESIGN *Ten case studies*

SELECTION OF THE CASE STUDIES

In our preliminary study, the application of AAD was played out for specific real-world case studies in order to gain insights into the challenges of implementing AAD initiatives. To find cooperation partners, we offered the chance to become a cooperation partner for a case study at the end of our questionnaire. From the proposed projects, ten were ultimately selected as case studies.

When selecting the case studies, a distinction was made between new residential construction, the renovation of existing residential housing, and planned changes to the maintenance of open spaces, as well as between different forms of urbanization Fig. 8. In making the selection, we also took into account different types of construction and the construction phase that the project in question had reached, i.e., whether the project was just starting and was still in the initial analysis and draft phase, was in the detailed planning and design phase, or was already under construction.

Working with a total of nine project partners, the case studies were then used to investigate whether AAD can be implemented in different project development phases and for different project types – restructuring maintenance processes, renovation projects, and new buildings Fig. 9. There was also an analysis of where synergies arose, i.e., where planning for animals could easily be integrated into planning for humans, and which challenges would need to be overcome. The most common challenges, along with the project-specific solutions, are presented in the chapter: "The Synergies and Challenges of Applying AAD in the Residential Environment".

TARGET SPECIES SELECTION

In order to ensure the comparability of the planning processes, the same target species were selected for all ten case studies:

Passer domesticus **– house sparrow**, a bird typically found in residential areas

Erinaceus europaeus **– European hedgehog**, one of the most popular wild mammals

Vanessa atalanta **– red admiral**, a colorful butterfly whose caterpillars live on nettles

All three are species typically found in residential areas in Germany, although their populations are declining in cities. They were in principle suitable for all the case study locations due to their geographic distribution and critical needs. There are significant differences between the species' biological characteristics, such as the way they move (fly vs. walk), the food they need, their life cycles, and their habitat requirements. The three species also have socio-cultural and biological characteristics that are relevant for the preliminary study: They are easily observable by humans and are positively evaluated by many people for various reasons (beauty, usefulness). Nevertheless, there is also potential for conflict due to, for example, bird droppings, noise, or parasites. All three species have requirements that would not automatically be fulfilled by the living environment in the planning areas but would need to be planned for. Hedgehogs and house sparrows need easily accessible water sources that are safe from predators and that will contain water even when weather conditions are dry. House sparrows require areas with sandy, fine-grained, and open soil in which they can take dust baths; this allows them to combat parasites in their plumage. House sparrows also need nesting cavities; when these are provided as nesting aids, they must be arranged in groups as the species breeds in a colony. In the vicinity of the nesting aids, hedges or other protective trees and shrubs are required for young birds who have recently left the nest, as are sufficient food sources for birds of all ages. Hedgehogs need barrier-free, less fragmented open spaces, as well as protected sites within dense vegetation, under bushes or in piles of leaves in order to rest during the day, raise their young undisturbed or hibernate through the winter. To ensure they are adequately provided with their food sources of insects and vertebrates, hedgehogs rely on the presence of areas containing diverse vegetation and dead wood. Red admirals are dependent on the presence of nettles, the host plant which their caterpillars feed on, while

Location	in municipal area / centrally located	in municipal area / suburb	on outskirts of municipal area
Construction type			
Project type: Change to maintenance procedures			
Group of multi-story buildings with central outdoor area	Hamburg - Saarlandstraße		
Linear blocks / Zeilenbau		Salzgitter - Rabenwinkel	
Single-family houses and / or apartment blocks			Kirchheim unter Teck
Project type: Renovation			
Linear blocks / Zeilenbau	Kaiserslautern - Kappellenweg	Hamburg - Lüttmelland / Sasel	Schwarzheide - Ruhlander Straße
Group of multi-story buildings with central outdoor area			Frankfurt / Main - Leuchte
Project type: New building			
Linear blocks / Zeilenbau			Hannover - Herzkamp
(High-rise) point block buildings	Kaiserslautern - Friedenstraße	Ingolstadt - Stargarder Straße	
Single-family houses and / or apartment blocks			Hannover - Herzkamp

Fig. 8

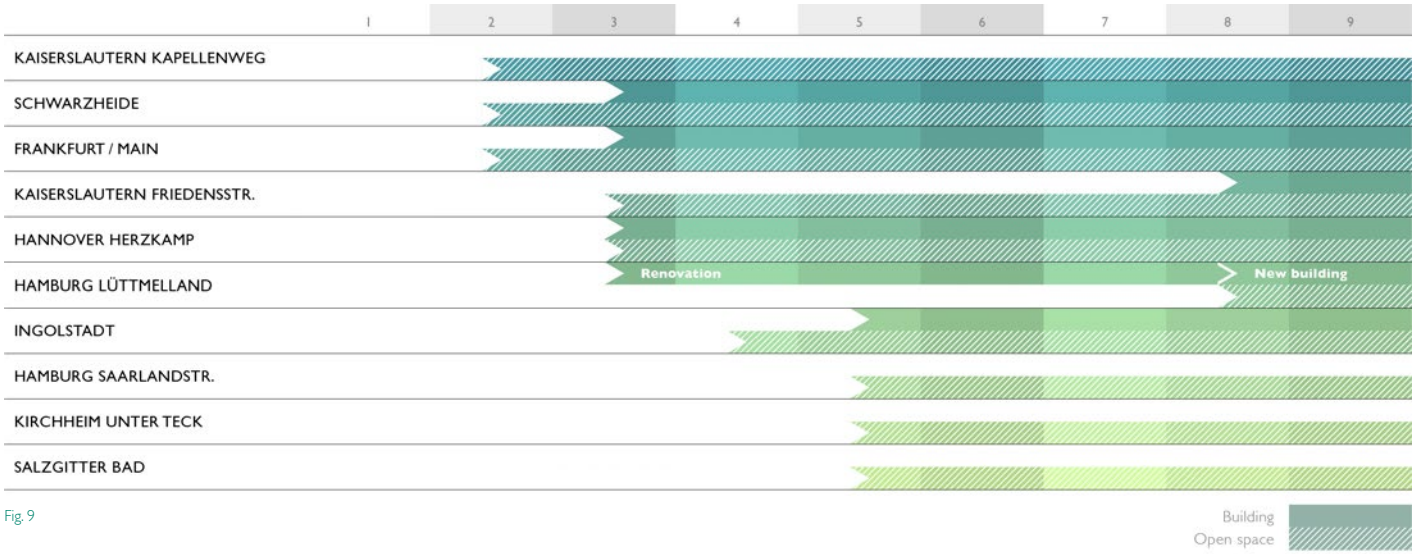


Fig. 9

the adult butterflies need flowering plants for food, as well as fallen fruit in the fall (see the red admiral species profile in this brochure).

DESCRIPTION OF THE CASE STUDIES AND PLANNING WITH AAD

AAD measures were developed for the case studies based on the planning documentation made available by the project partners. A site visit, on-site discussions, and telephone calls served to explore the options and work out solutions. The design proposals were discussed with the project partners in joint planning meetings. The designs presented below are therefore example solutions developed together with the project partners to illustrate the potential for AAD under real-world conditions; however, they have not actually been constructed.

Fig. 8
Matrix for the selection of the ten case studies

Fig. 9
Project planning phases
1: Basic evaluation
2: Preliminary planning
3: Design documentation
4: Approval planning
5: Execution planning
6: Preparation for award of contract
7: Award of contract
8: Construction supervision
9: Property management

INGOLSTADT, STARGARDER STRASSE *Case study 1*

Fig. 10
Ingolstadt AAD plan; based on draft design by Adler Olesch Landschaftsarchitekten. Building: Diezinger Architekten

Housing company: Gemeinnützige Wohnungsbaugesellschaft Ingolstadt (GWG)
Project type: New building (densification)
Location: In municipal area / suburb (size of project area: 10,527 m²)
Construction type: (High-rise) point block buildings with central open space (161 apartments)

Motivation: Corporate philosophy; the project is a showcase location for the GWG, who are supporters of the "Ingolstadt summt!" [Ingolstadt is buzzing!] action group.

Project: Five new residential buildings (including two high-rise point block buildings) are to be constructed in an inner city location; they will be arranged around a central open area above an underground car park and surrounded by further open spaces. The site is bordered by a tree-covered embankment along the road that separates the site from the banks of the Danube and is directly adjacent to an existing residential area and the remains of an alluvial forest. The central area, which features internal entrances to the residential buildings and a day-care center, serves as both an entry point and a place in which to spend time. Numerous trees and other planted areas enliven the open space.

Planning status and integration of AAD: When the collaboration began, the project was already in the approval planning phase for a project-related development plan (known as a Vorhaben- und Erschließungsplan or VEP); shortly afterwards, it progressed to the construction planning phase. Despite the advanced stage of planning, the GWG saw great scope for AAD initiatives on buildings and in the design of the open spaces. Planning of how the open spaces were to be planted had the greatest potential; reducing the extent of the paved-over areas was discussed, but it was not possible to incorporate any substantial reduction of sealing. For house sparrows, the project managers saw few problems with the integration of nesting aids into façades or the selection of suitable materials for the open spaces, e.g., for dust baths. They were also very willing to install a permanent water source for hedgehogs and house sparrows, which, being in the form of a drinking fountain with a spill tray, should also be of use to the human residents. It was easy to make provision for the red admiral with low-maintenance wildflower strips and the greening of peripheral areas with common ivy. The planning for a nettle planting along borders to support the red admiral was not completed during our consultations. Overall, it was important that all of the provisions made had multiple benefits, for example also improving human usability or assisting with climate change adaptation.

Synergies and challenges: Synergies arose in terms of drainage planning, as it proved possible to combine this with the creation of a water source. The GWG's goal of adapting to climate change (by implementing cooling mechanisms) could be furthered by the greening of roofs and facades (e.g., at the underground parking garage exit). It was not possible to implement additional planted areas or green roofs on the connecting structures due to fire safety and fire department access requirements. The planned day-care center still offers an opportunity to establish winter feeding for birds. To accommodate sparrows, tried-and-tested standard solutions involving façade nest boxes were favored over a design idea involving offset clinker bricks containing cavities.

Species-specific design elements for the European hedgehog

1 
Lawn allowing foraging for earthworms and serving as an open space for hedgehog mating rituals, which involving much circling, during early summer

2 
Border of perennials and grasses along the existing embankment with a biannually mown meadow area in front. Areas with long and short grass to provide food in the form of beetles, earthworms, and other invertebrates

3 
Undergrowth consisting of dense ground vegetation, ivy, and native shrubs in undisturbed wooded succession areas for daytime refuges and hibernation

4 
An enclosed area of dead wood, with logs/branches arranged in layers and with an access point, located under a balcony to provide a nesting area suitable for the raising of young. Another fenced-in pile of branches and leaves at the edge of the wooded area

5 
Alternating areas of short and long grass and shrub-rich peripheral vegetation offer refuge and protection in the transitional area between dense and open vegetation

6 
Retention basin: Water is retained by an impermeable layer, thus creating a water trough. Surrounded by seasonally flooded vegetation

7 The fence bordering the busy road is installed close to ground level to prevent access points forming

Site plan detail

HANOVER, HERZKAMP BOTHFELD *Case study 2*

Housing company: Gundlach GmbH & Co. KG
Project type: New building (urban district)
Location: In municipal area / suburb (size of project area: 9.2 ha)
Construction type: Row (terraced) houses and linear blocks known as Zeilenbau (315 apartments)

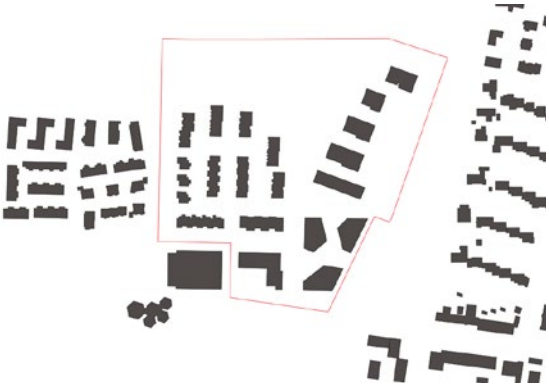


Fig. 11
Hanover Herzkamp AAD plan; overall design based on draft design by nsp christoph schonhoff landschaftsarchitekten stadtplaner. Building: blauraum architekten

Motivation: The company's focus on climate-adaptive and ecological building as part of its corporate philosophy; flagship project for the project "climate-adaptive sustainable neighborhood housing and living."

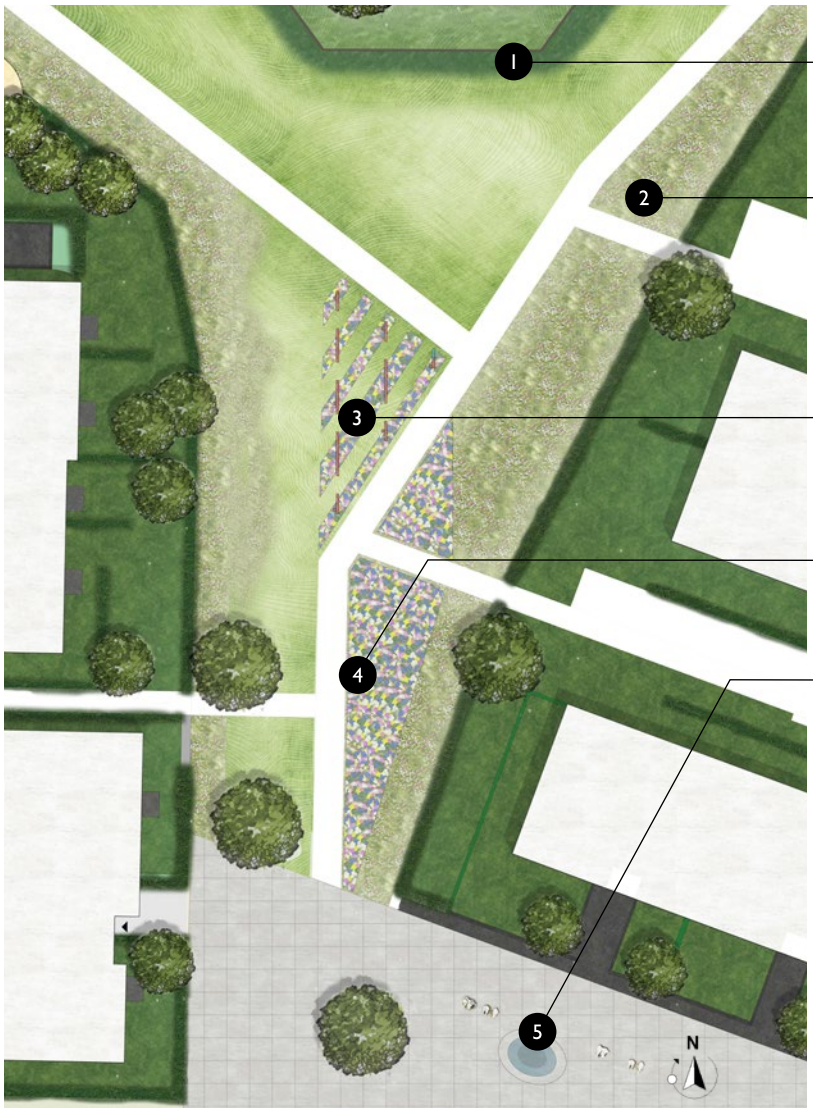
Project: This new urban district in the north of Hanover is characterized by its mixture of different building and apartment types and an overall open space planning concept. It will come into being over the course of several construction phases. The overall objective is to implement the city of Hanover's climate change adaptation strategy in an exemplary manner. The wooded border area, which had already been put in place as a compensatory measure for impact mitigation, provides a habitat for birds and other wildlife; when planning the district, both cold air corridors and bat flight routes were taken into account.

Planning status and integration of AAD: The different areas of the construction site were in different project phases. For some sub-areas, the approval planning phase had already been completed (construction area for owner-occupied apartments); others were still in the detailed planning and design phase (e.g., construction area J). Networking of green areas proved possible on a large scale within the district. The open spaces around the buildings in construction area J had great potential for the integration of AAD measures, and their landscape architecture was still in the design planning phase. For the owner-occupied apartments, there was less room for maneuver in the design of the open spaces; if the project had been limited to this area, the needs of the target species could only partially have been met. In addition, façade nesting aids on the owner-occupied apartments would have had to be integrated into the façade before the sales launch. However, special "nesting bricks" could theoretically be included as standard components, as could "hedgehog holes" in the planned bar mat fences. The roadside drainage areas planned within the project area, which will not be maintained by the city of Hanover, were well-suited for development as wildflower strips for the red admiral. The areas bordering the woods were suitable for nettle borders (for the red admiral) and for accommodating hedgehogs. Changing the material of footpaths to a water-bound surface in order to facilitate dust baths (for the house sparrow) met with approval. A permanent water source for hedgehogs and house sparrows was provided by the planned small pond in the neighborhood square. The planting plans for the rental apartment buildings' green roofs were enriched with food plants of the house sparrow. Façade greening of the buildings through the use of trellises was already planned. It proved possible to convince the company of the added benefits that façade greening and green roofs can provide for insects and house sparrows. These measures effectively complemented the development of a sustainable, climate-adaptive district.

Synergies and challenges: The AAD measures showed synergies with initiatives designed to implement the climate change adaptation strategy, for example in terms of improving the microclimate. Dust baths or water sources on the roofs will need to be compatible with the space requirements of solar thermal energy and PV modules. For aesthetic reasons, nesting aids should not be attached to the outside of buildings, but they do not pose a problem if they can be integrated into the facades.

Species-specific design elements for the red admiral

This design element is made up of a combination of wildflower strips and retaining walls needed to restrain soil to the slopes in the open spaces. Cavities included in the walls offer the red admiral a potential winter refuge, while the wildflower strips provide various nectar plants for the butterfly.



A nettle border along the wildlife fence forms the basis of the caterpillars' diet

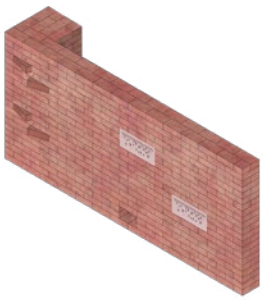
Areas of perennials, green roofs, fruit trees, and low-maintenance wildflower meadows in the district serve as food sources for the adult butterfly

Cavities in the retaining walls offer a winter refuge

The linear form of the retaining walls provides the males with opportunities to establish territories in which to find a mate

Water source in the neighborhood square

Site plan detail showing design elements for the red admiral



Detail of design element – retaining wall

View of the central axis of design elements for the red admiral

KAISERSLAUTERN, FRIEDENSTRASSE *Case study 3*

Fig. 12
Kaiserslautern Friedenstrasse AAD plan; based on draft design by L.A.U.B. Building: Gemeinnützige Baugesellschaft AG

Housing company: Gemeinnützige Baugesellschaft Kaiserslautern AG
Project type: New building (densification)
Location: In municipal area / centrally located (size of project area: 4,950 m²)
Construction type: Point block buildings (56 apartments)

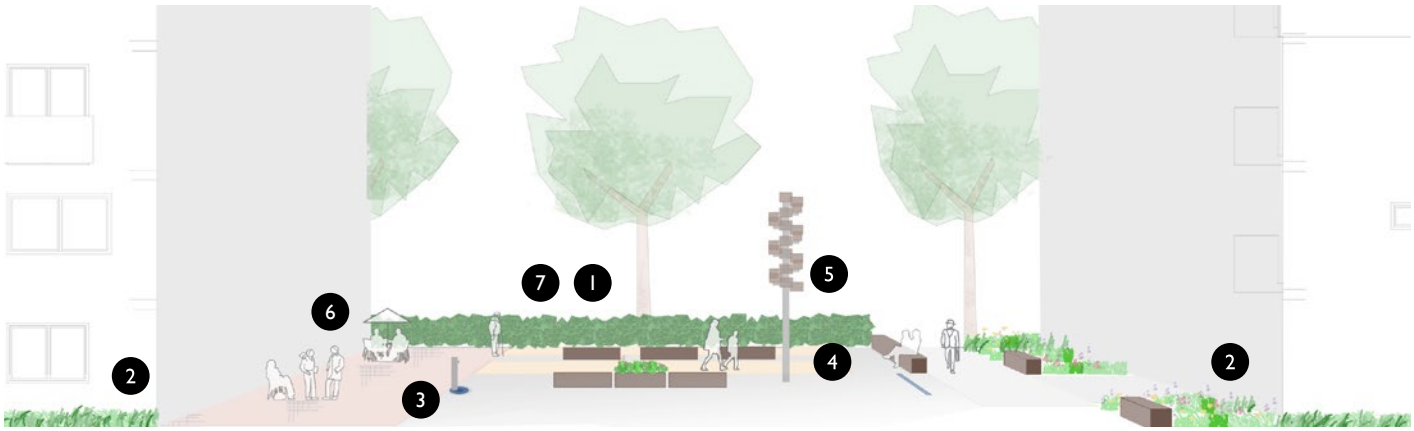
Motivation: The opportunity to offer tenants something extra with the motto "City life with added flora and fauna"; Bau AG would like to support the concept of bringing nature back into the city.

Project: Three new residential buildings are being built in the Kalkofen district of the Kaiserslautern metropolitan area; this district is considered to be socially disadvantaged. Following the Bielefeld model ("NILS – neighborly, inclusive, livable, and self-determined living in the local neighborhood"), the buildings will offer barrier-free, socially mixed accommodation for multiple generations and for people with and without disabilities. The open spaces will also be redesigned. The project site is bordered by two roads, and the planned open spaces combine several functions in a small space.

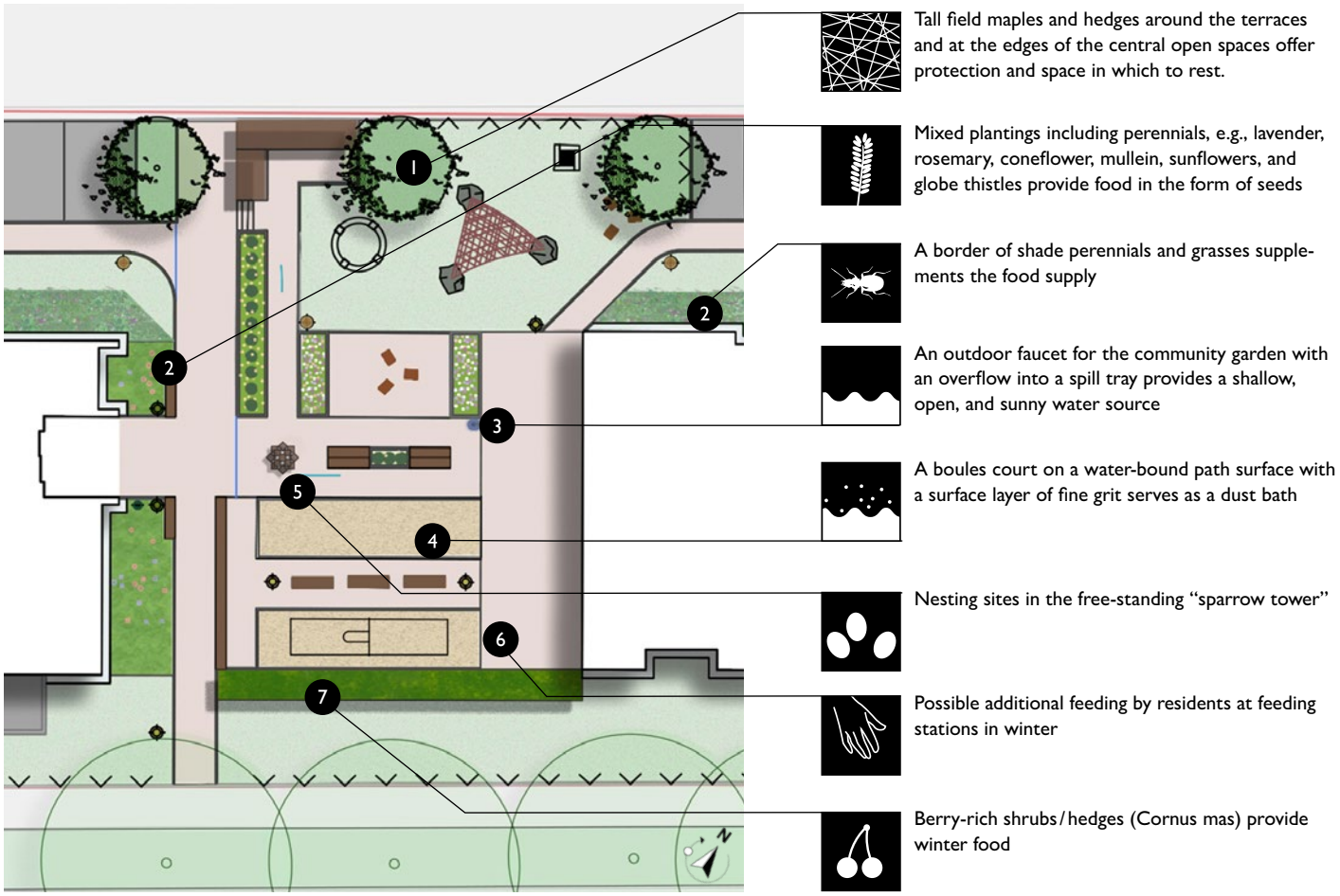
Planning status and integration of AAD: The buildings were already under construction when the planning of the AAD measures began. It proved possible to revise an existing early-stage preliminary design for the open spaces. The commissioned landscape architects were also in the process of drawing up a draft design. It was not possible for the AAD team to be directly involved in the design process, but they worked independently on solutions for the target species. However, due to the very limited space available, concordant ideas and concepts emerged. It proved possible to find solutions for all the critical needs of all three target species. Overall, there was little space for low-maintenance wildflower strips for the red admiral or for protected areas containing vegetation for hedgehogs to nest in. However, it did prove possible to use a small area of free space near the parking lots and garages for this purpose. At a planning meeting with the management, the project manager, other employees (from the technical customer service, green / open spaces, and gardening / cleaning departments), and the commissioned landscape architect, potentials and challenges were discussed, including the use of what had been designated as a "wild" corner in the landscape architect's design for targeted AAD measures for the target species. The landscape architect emphasized that major changes at this point would come with additional costs. With respect to nesting cavities in the façade, this suggestion was rejected by the Bau AG as, in the opinion of the management and the architects, it would not be in harmony with the architecture. A free-standing solution to accommodate sparrows was therefore considered preferable. The creation of a partially planted rain overflow basin, which can also serve as a water source, was welcomed as a supplementary measure.

Synergies and challenges: Urban nature on the doorstep should be made tangible. There are important synergies here, e.g., through flower-rich plantings that are attractive for both humans and the target species. Nesting aids on the outside of the buildings were rejected on the grounds that they would aesthetically impair the facades; a free-standing solution (e.g., a sparrow tower) was considered preferable. The implementation of some AAD measures could be financially supported as part of the city of Kaiserslautern's ecology program, which aims to integrate the long-term unemployed back into the labor market by, among other things, imparting specialist knowledge from the field of nature and environmental protection

Species-specific design elements for the house sparrow



View of central area showing design elements for the house sparrow



Site plan detail showing design elements for the house sparrow

Sectional view showing design elements for the red admiral and European hedgehog

FRANKFURT AM MAIN, LEUCHTE *Case study 4*

Fig. 13
FFM Leuchte AAD plan; based on open space plan by die Werkplaner Architekten

Housing company: Wohnungsbaugenossenschaft der Justizangehörigen FFM e.G. (JuBa)
Project type: Renovation (buildings and open spaces)
Location: On outskirts of municipal area (size of project area: 12,493 m²)
Construction type: Group of multi-story buildings with central open space (87 apartments)

Motivation: The ecological enhancement of open spaces helps to define the company's identity; innovative approaches such as AAD are welcomed as a means to improve their image.

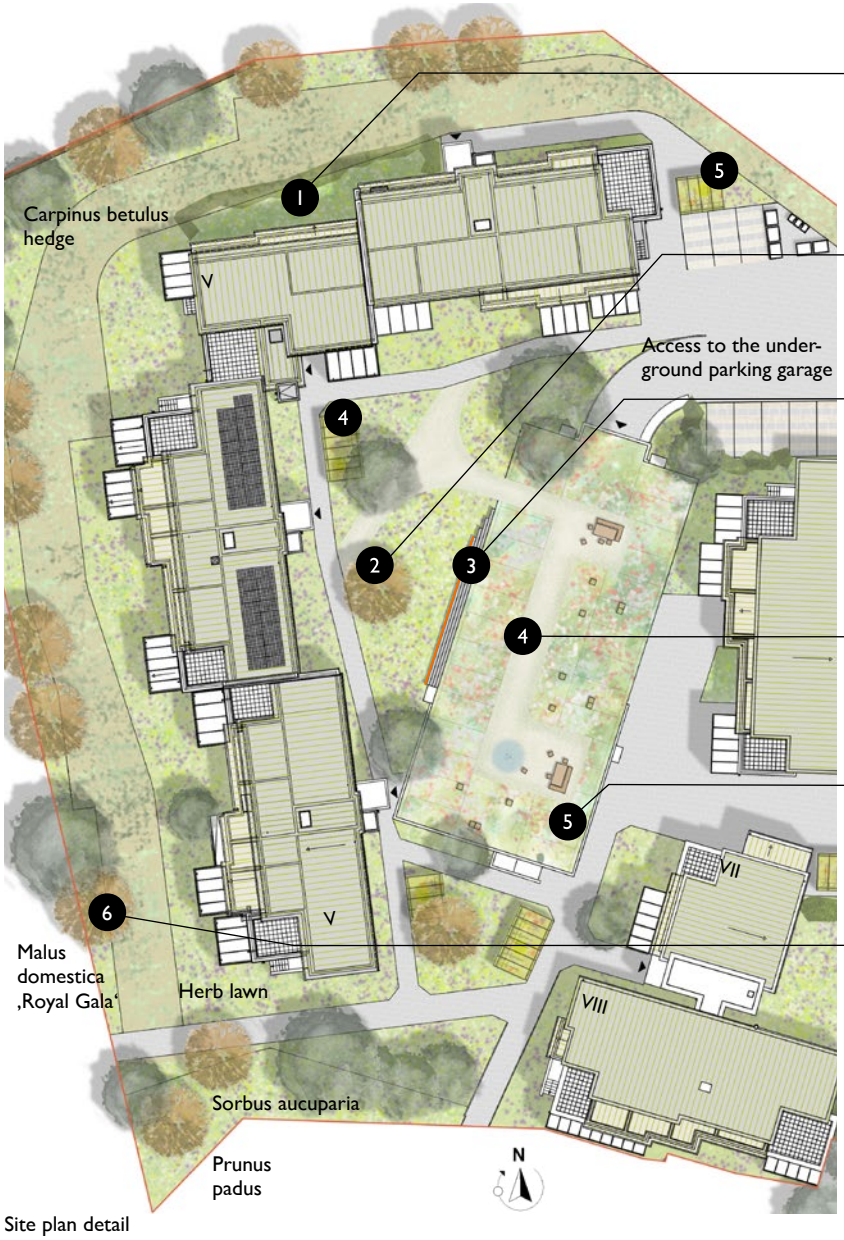
Project: The 1980s housing complex is located at the edge of a residential area in the Bergen-Enkheim district. It borders the Enkheim forest and is in the immediate vicinity of the "Enkheimer Ried" nature reserve. The project involves six multi-story apartment buildings arranged around a central open space that is partially situated over an underground parking garage. The buildings are being modernized and having additional stories added, with the open spaces also being upgraded. The housing development is not fenced in, and the surrounding road has relatively little traffic. Along the northern edge, there is a low earth wall covered with grass and spontaneous vegetation that follows the property boundary, and there is a population of mature trees throughout the project area.

Planning status and integration of AAD: The renovation and procedures to add additional stories to the buildings were already in the approval planning phase at the beginning of the collaboration and, when the later planning meeting took place, already under construction. In contrast, the open spaces had not yet been planned out, apart from designating the locations of bicycle racks, parking spaces, and garbage bins. This meant that active planning with AAD could take place, and solutions were found for all target species. It would be possible to accommodate sparrows in structures attached to the façades. Wildflower strips and some areas containing nettles could be created at the edges of the green spaces, while existing shrubs and hedges would provide space to accommodate hedgehogs. At the JuBa, the residents are members of the cooperative and thus often vote on and have a major say in proposed modernizations, i.e., they are involved in planning projects and take part in decision-making on the design of their living environment. The AAD measures would therefore have to be presented to the members. During a tour of the property, potential AAD measures were also discussed with the caretaker responsible for the site, who is a trained gardener and was able to give good advice based on his ecological knowledge. In the upcoming planning of the open spaces, the proposed AAD initiatives are expected to largely be adopted.

Synergies and challenges: Switching to less intensive pruning methods, e.g., for shrubs, would not be easy to implement due to the maintenance pruning that has already taken place over the years. In future, the long-term development potential should be taken into account when planning new plantings.

It became clear that, above all, green spaces should be safe and manageable. As an integral part of the redesign of the open spaces, the AAD measures should primarily add value for the residents. It also became clear, however, that planning with AAD can contribute to the broader objective of defining the identity of the housing complex. Here, the JuBa is conscious of the potential to carry this over to other housing complexes.

Species-specific design elements for the red admiral



Site plan detail

A "nettle garden" enclosed by a hedge allows females to lay their eggs on their host plants (common nettle, small nettle). The eggs will hatch after one week and the caterpillar will feed on nettle until pupation

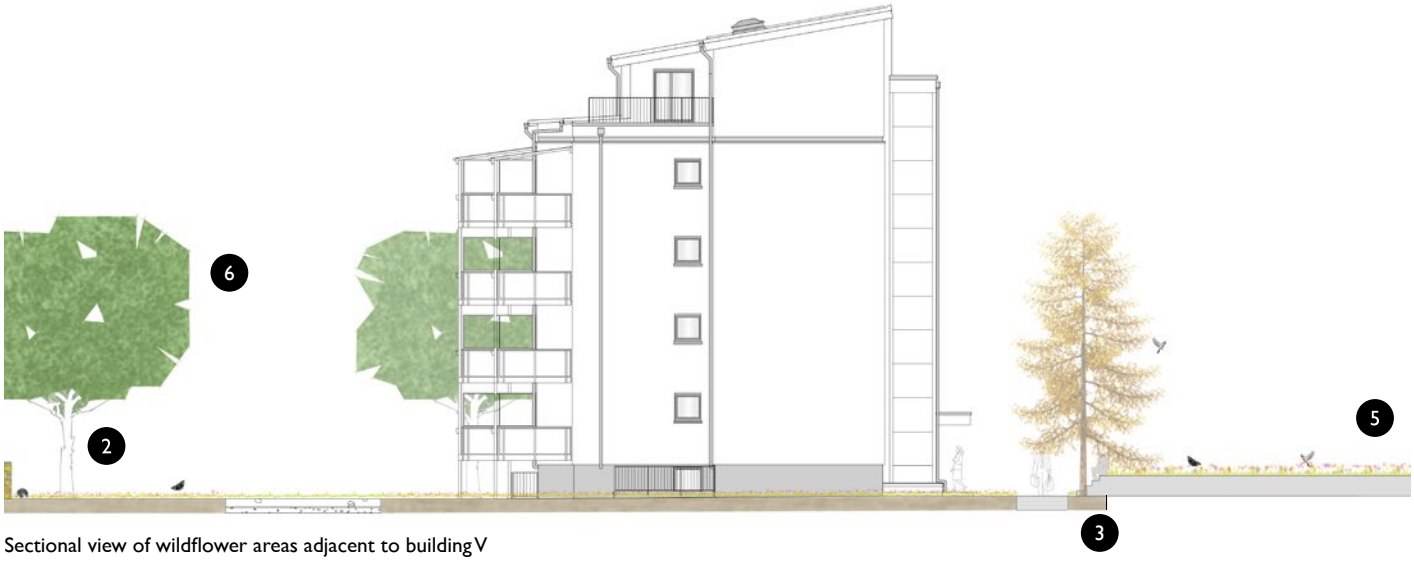
Tall trees and vegetation-free ground areas serve as resting places

In addition to their function as seating elements for humans, concrete block steps on the slope of the underground parking garage offer cavities in which the red admiral can spend the winter. At the same time, the roughened surface of the steps provides an area where the males can rest and wait during their search for a mate

Sun-exposed, linear structures 50–200 meters in length containing flowering plants allow males to establish territories

Nectar-rich flowering plants (e.g., wild marjoram or asters) in sun-exposed areas and on greened bicycle shelters provide the butterflies with a source of food from May to October

Fallen fruit supplements the food supply in the fall

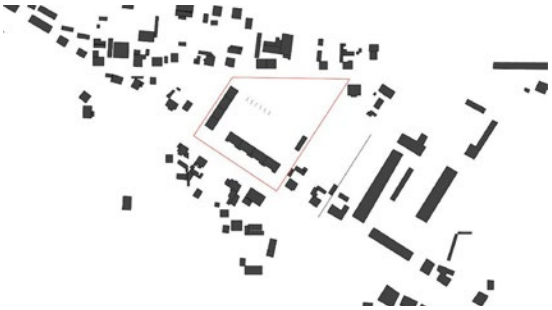


Sectional view of wildflower areas adjacent to building V

SCHWARZHEIDE, RUHLANDER STRASSE *Case study 5*

Fig. 14
Schwarzheide AAD plan

Housing company: Wohnungsbaugenossenschaft Schwarzheide eG
Project type: Renovation (buildings and open spaces)
Location: On outskirts of municipal area (size of project area: 12,919 m²)
Construction type: Zeilenbau or linear blocks (85 apartments)



Motivation: Implementation of an ecological showpiece; high level of commitment from the management.

Project: The project area is located in the immediate vicinity of two wooded areas and several lakes on the outskirts of Schwarzheide West. Elevators will be added to the outside of two 1980s apartment buildings. While this takes place, the parking spaces are to be rearranged and extended, and the open spaces will be upgraded using AAD. The natural landscapes in the immediate vicinity give this location great ecological potential, as well as creative freedom in terms of the development of the action plan. The project is situated in a very open location with generous green areas and few fences. There are fruit trees in neighboring community gardens.

Planning status and integration of AAD: The building renovation was still in the planning stage when the collaboration began, but construction had started by the time the next site visit took place. No preliminary design for the open spaces had yet been decided on, but fencing to the north, new bicycle racks, and a leveling of the site to enable barrier-free access to the buildings were planned. Greening the new elevators and the windowless end walls of the buildings was an option. Areas of shrubs in front of the buildings already provided a refuge for hedgehogs and house sparrows. In addition, new plantings were agreed on, e.g., a fence will be replaced by a new hedge in order to avoid limiting accessibility for animals such as the hedgehog. The creation of a near-natural pond as a water source for hedgehogs and house sparrows was also planned. Suggestions for nettle plots and wildflower meadows, as well as the installation of facade nesting aids, were positively received. AAD initiatives for all three target species could thus easily be incorporated into the overall concept for the redesign of the open spaces. If AAD were actually to be implemented, and this was combined with a free choice of target species, it would be desirable to involve the tenants in this selection process and in the development of the measures. If the proposed measures are implemented, changes in the maintenance procedures would also be an option, such as mowing the meadows less frequently.

Synergies and challenges: The project is intended to serve as a showcase promoting opportunities to experience nature and supporting nature education (e.g., for school classes) in the community, and AAD is seen as a way of achieving these objectives. The housing cooperative could thus act as an ambassador in the region. The greening of the elevators is seen as an aesthetic upgrade. The head of maintenance is open to changes that would facilitate the sustainable development of the open spaces. Financing the initiatives is the greatest challenge, but there are plans to monitor the implementation over a longer period of time.

Species-specific design elements for the European hedgehog

Site plan detail

1 Lawn allowing foraging for earthworms and serving as an open space for mating rituals during the mating season

2 Areas containing perennials and grasses alongside the parking lot, with a biannually mown meadow area stretching to the edge of the property and a meadow including a tall forb community, as well as areas with long and short grass, all supplying food in the form of beetles, earthworms, and other invertebrates

3 Dense ground vegetation, ivy, and native shrubs make up the undergrowth in undisturbed areas, serving as daytime refuges and for hibernation

4 Fenced-in dead wood arranged in layers with a 10 x 10 cm access point serves as a nursery habitat. An additional pile of twigs and leaves offers a daytime refuge

5 Shrub-rich peripheral vegetation and new hedges made up of native plants offer refuge and protection in the transitional area between dense and open vegetation

6 A new pond bordered with stones and with a water inlet supplied by rainwater retention forms a water trough; it has an exit aid and is surrounded by seasonally flooded vegetation

KAISERSLAUTERN, KAPELLENWEG *Case study 6*

Fig. 15
Kaiserslautern Kapellenweg AAD plan, southern area: Based on draft design by L.A.U.B. Further planning: Planungsbüro Stefan Laport

Housing company: Gemeinnützige Baugesellschaft Kaiserslautern AG
Project type: Renovation (open spaces)
Location: In municipal area / centrally located (size of project area: 13,874 m²)
Construction type: Zeilenbau or linear blocks (138 apartments)

Motivation: Redesign and reorganization of tenants' private gardens; enabling access to and active use of the open spaces for all tenants.

Project: This 1950s housing complex in the municipality of Kaiserslautern includes open spaces bordering a railroad line behind the buildings. A few years ago, some of the tenants' gardens in the southern part of the site were converted into garages and parking spaces, as well as into a large green space with seating areas. However, the residents are not actively using the green spaces. A redesign of the northern area into a more communal open space is to take place over several years. The objective is to increase usability for all tenants and relieve those who can no longer afford to care for their gardens. AAD measures to support the target species should go along with making the garden wildlife more tangible for the tenants. Several animal species typical of dry habitats and residential areas are already present at the project site.

Planning status and integration of AAD: The existing garden plots already offered a high level of structural richness fulfilling many functions for the target species. The railroad line provided a possible access corridor for the hedgehog that connected the site with the surrounding area. The required measures for all of the target species turned out to be feasible on the site. The existing garage roofs could be greened by sowing grasses and herbs, which would provide food for the house sparrow. Protective trees and shrubs for the house sparrow were for the most part already present. The gaps between the individual garages could potentially serve as nesting areas for hedgehogs. An existing wildflower strip could be extended over a larger area for the red admiral, and the middle shrub layer could be developed into a protected area for the hedgehog. Individual areas at the edge of the site alongside the railroad embankment could provide space for the development of a nettle border (the host plant of red admiral caterpillars). A sparrow colony with hanging nest boxes could be installed on the end walls of the buildings or, alternatively, a free-standing sparrow tower could be erected in the outdoor space. The options for AAD measures were discussed with the project manager from the technical customer service department responsible for green spaces, employees responsible for gardening / cleaning, and the commissioned landscape architect. Options such as, for example, an ecological garden plot were also considered. Planning with AAD turned out to offer a good opportunity to make tenants aware of the value of their open spaces, and the regularly published tenant newspaper could serve as an effective means of conveying such information.

Synergies and challenges: The housing cooperative's main concern was the ability of the human residents to use and experience the site's open spaces. It was important to the cooperative to achieve largely stable vegetation structures requiring little maintenance. Integrating the planning of measures for animals with that of measures for humans made it possible to include the additional costs of AAD measures in the general renovation costs. With regard to the city of Kaiserslautern's intended strategy for climate change adaptation, AAD could help to achieve exemplary ecological planning and implementation. Critical questions were raised regarding the design and technical execution of the integration of sparrow nest boxes into the façade and the annual maintenance costs. The housing cooperative was very interested in trying out biodiversity-promoting initiatives on a prototype basis and then possibly carrying the design approaches and maintenance routines over to other locations.

Species-specific design elements for the red admiral

Site plan detail

Sectional view of planting areas near the buildings

Resting places on tree trunks and in sunny open spaces on the site

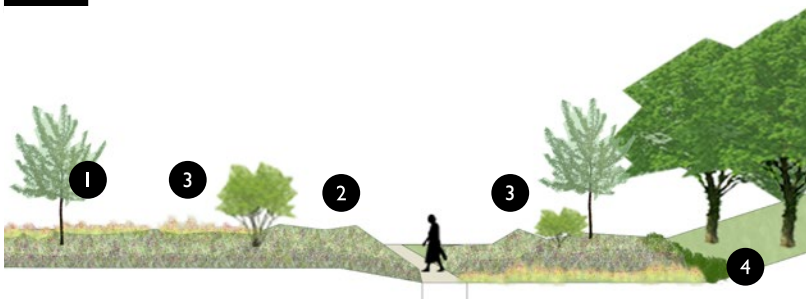
Nectar-rich flowering plants in the wildflower strips and areas of perennials alongside the residential buildings provide food for adults, as do extensive green roofs on the garages

Linear, sun-exposed hedge borders provide space for males to set up territories in which to find a mate

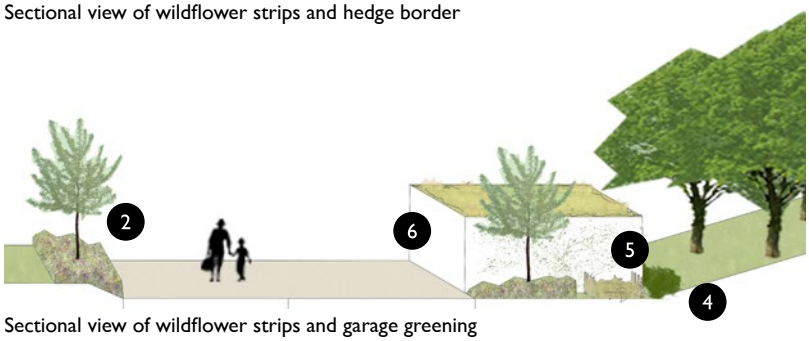
Permitting and encouraging a nettle border along the boundary with the railroad line creates an area for egg laying and larval development

Greening of garage walls and smaller walls, for example with ivy, which serves a source of food, especially in the fall

Protected winter refuges in cavities and buildings, for example in the garage ventilation shafts or basement entrances



Sectional view of wildflower strips and hedge border



Sectional view of wildflower strips and garage greening

HAMBURG, LÜTTMELLAND *Case study 7*

Housing company: Baugenossenschaft Hamburger Wohnen eG
Project type: Change to maintenance procedures (renovation, new building, and densification)
Location: In municipal area / suburb (size of project area: 57,142 m²)
Construction type: Zeilenbau or linear blocks (364 apartments)

Fig. 16
Lüttmelland AAD plan; based on draft design by Outside! Landschaftsarchitektur Building: henningerarchitekt

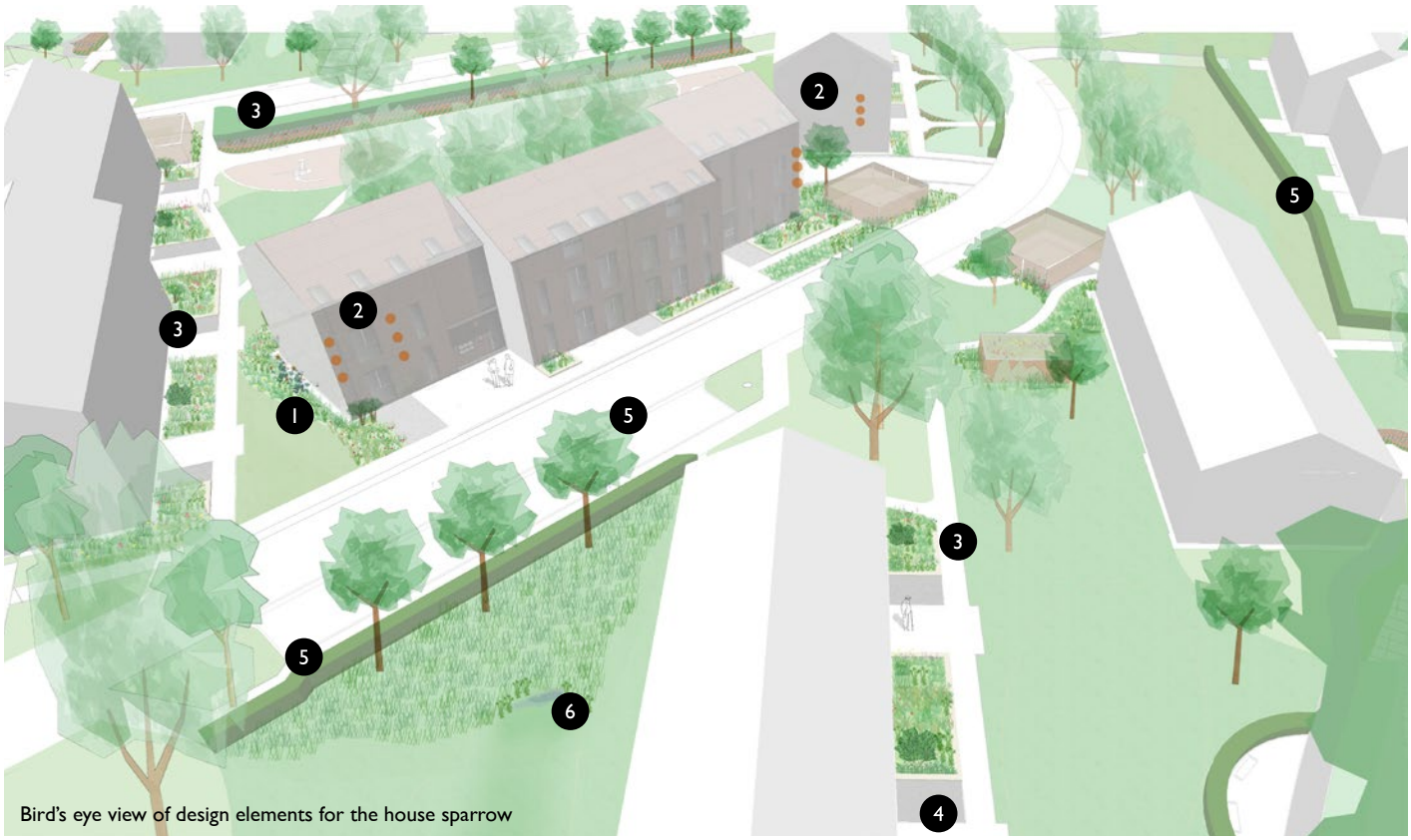
Motivation: AAD is seen as an innovative approach that allows the company to emphasize its ecological and sustainable credentials.

Project: Densification by erecting new buildings and renovating existing ones in a self-contained residential area on the northern outskirts of Hamburg. The location is characterized by apartment blocks loosely arranged in rows, with large existing trees as well as shrubs and hedges in peripheral areas. Due to a stipulation laid down by the city, plans had already been made to accommodate sparrows on the new buildings. However, the further requirements of the house sparrow had not been taken into account. The existing residential buildings were being modernized, with the open spaces being redesigned.

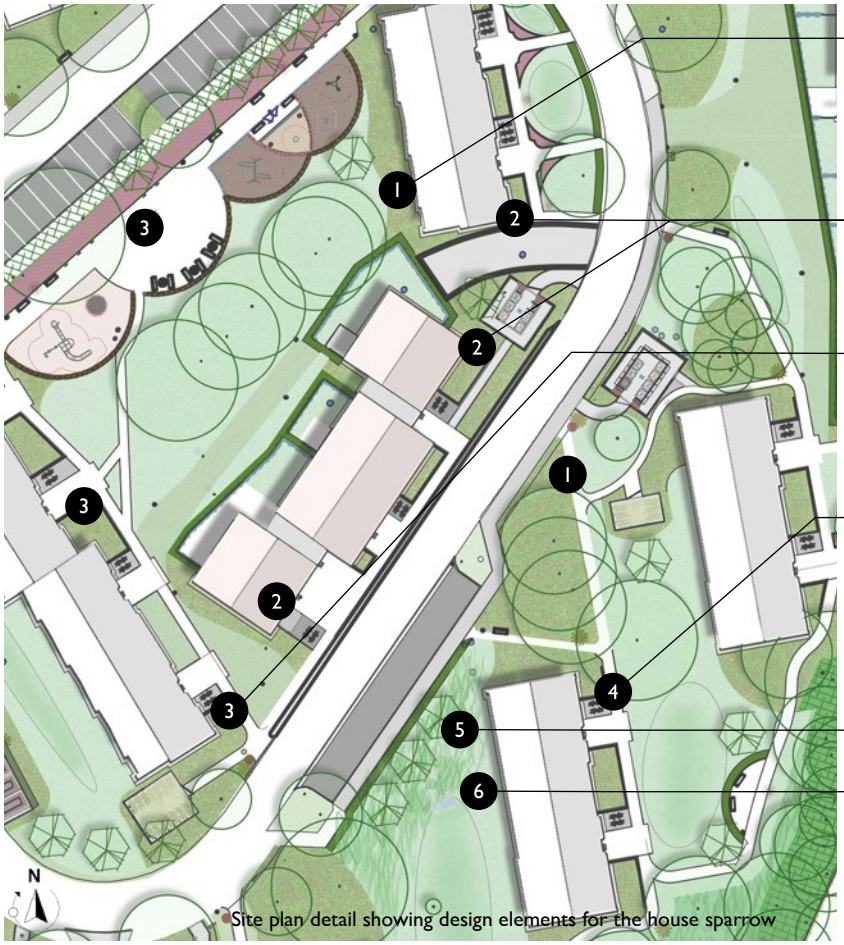
Planning status and integration of AAD: Some of the site, including the associated open spaces, had already been renovated. All the work to be done in the open spaces had already been put out to tender, and the contract was awarded to a horticultural company in order to guarantee its "seamless" implementation. The final new building was already in the approval planning phase. The decision was taken to evaluate this location as a maintenance restructuring project. Protective trees and shrubs for hedgehogs and house sparrows were already in place in the peripheral areas. Numerous wildflower areas including perennials and grasses had already been planned and would provide food for house sparrows and red admirals. For the hedgehog, it would be possible to create further low-maintenance meadows at the edges of the areas planted with shrubs or over the drainage basins in the lawns. There was also sufficient potential for hedgehog refuges, individual nettle borders for the red admiral, and dust baths for the house sparrow. However, it was no longer possible to make suggestions for adjustments to the open spaces, e.g., to the planned planting, but this already contained a wide variety of planting areas with different species compositions. With some additional expenditure, it would be possible to test a less intensive maintenance concept at the site.

Synergies and challenges: The creation of water sources was not considered to be possible, on both technical and safety grounds (danger to small children). The assumed preference of the long-term tenants for the open space to have a neat appearance was argued to be an important challenge for the design of AAD measures. The housing company considered nettles to be particularly problematic in this regard. In general, there had already been substantial resident participation on the topics of the recently constructed buildings and the open spaces. For example, at the beginning of the construction project, before the AAD research project entered the scene, a planning workshop for the open spaces was held with the tenants. According to the cooperative, a change to maintenance procedures would only succeed with the renewed involvement of the members. It was not possible to carry out a discussion with the tenants as part of the research project, so the measures were only discussed with the housing cooperative. A workshop with the landscape architects covering the topics of species selection and the selection of potential AAD measures would have been an option in this project, but did not take place. Thus, the plan presented below is one that the cooperative only partially agreed to. For future projects, the housing cooperative would be in agreement with the early application of AAD, from the very beginning of the planning process.

Species-specific design elements for the house sparrow



Bird's eye view of design elements for the house sparrow



Site plan detail showing design elements for the house sparrow

Low-maintenance perennial plantings alongside the buildings and in the open spaces. Seeds mainly serve as food in winter. Wildflower strips, berry shrubs, and the grass and herbs sown on the extensive green roof of the carports and bicycle shelters supplement the food supply

Nesting aids on the south and east facades; 5–10 nesting aids on each facade at heights of 3–10m; integrated into the clinker brick facade

Wildflower strips in the central communal area and diverse plantings alongside the buildings and open spaces encourage insects and other invertebrates, which then serve as food while chicks are being reared

Dust bath on the water-bound surface of the bicycle parking spaces

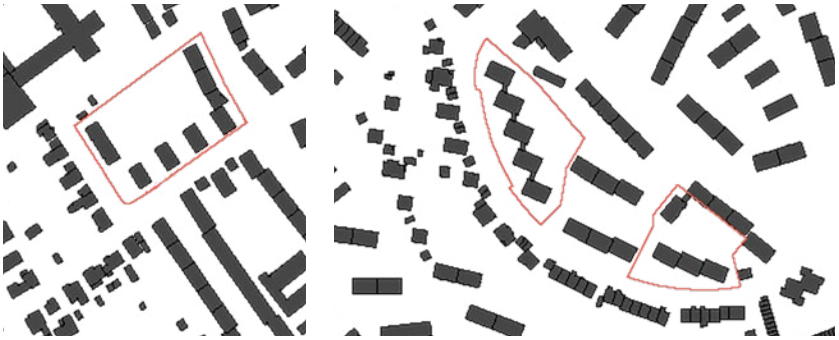
Protective woody plants and resting places around the central communal area and alongside the paths and tenants' gardens consisting of small trees and hedges

Water bath in a damp hollow in the dip of the lawn. Puddle-like formation of a seasonally flooded bathing area

Fig. 17
Salzgitter-Bad AAD plan

SALZGITTER-BAD, RABENWINKEL / FRIEDRICH- EBERT-STRASSE / HEINRICH-VON-STEPHAN-STRASSE *Case study 8*

Housing company: WBV Wohnbau Betreuungs & Verwaltungs GmbH Salzgitter
Project type: Change to maintenance procedures
Location: In municipal area / suburb (size of project area: 40,117 m^2)
Construction type: Zeilenbau or linear blocks (ca. 420 apartments)



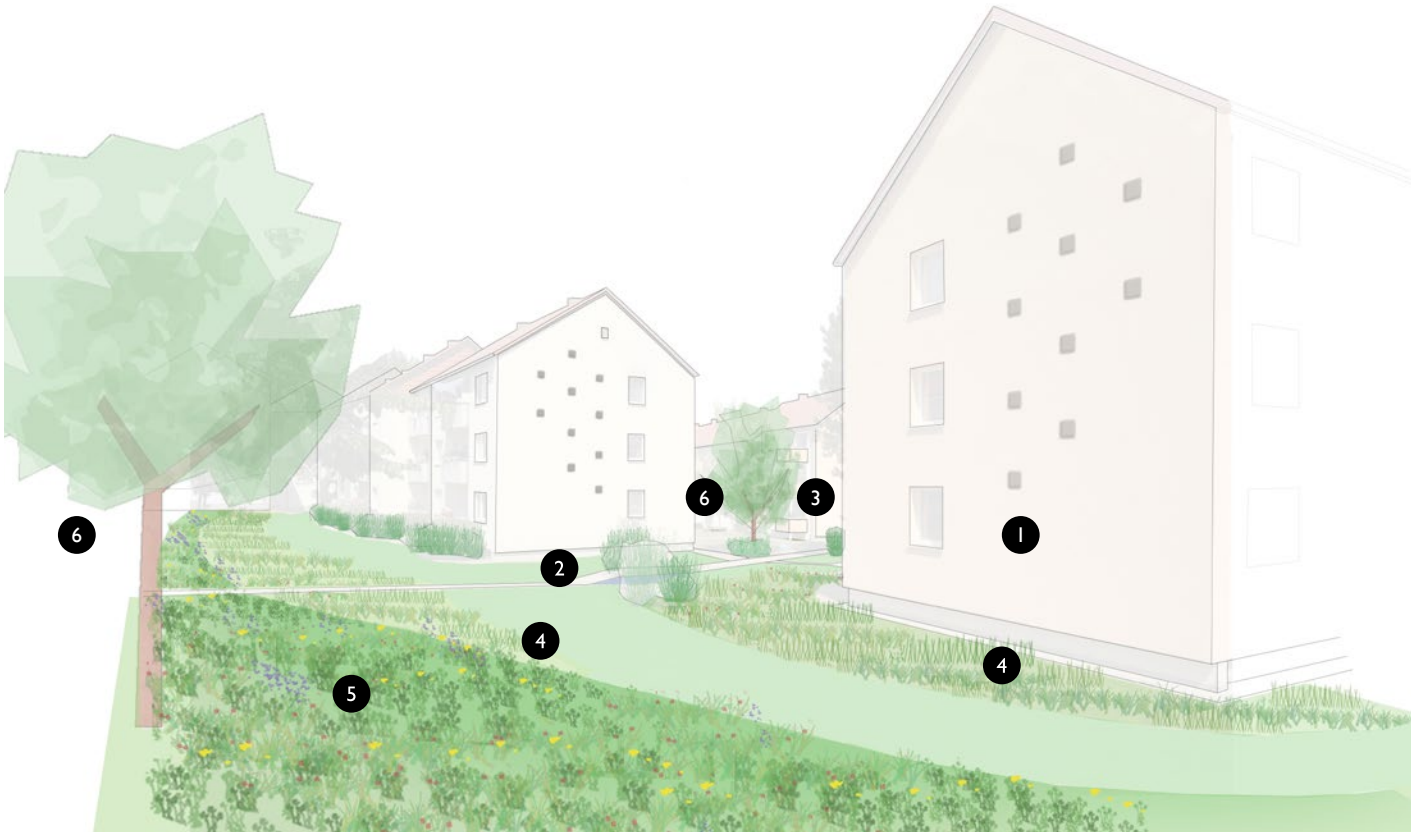
Motivation: The main focus is on reducing the amount of maintenance carried out in the regularly mown lawn areas in order to encourage, among other things, the presence of bees and butterflies; the tenants should be informed in advance of the AAD initiatives, which should also be presented to the public.

Project: The WBV's apartment buildings in Salzgitter-Bad are linear blocks surrounded by large lawn areas, individual trees, and shrubs. One of the project areas is in an inner part of the residential area and contains two central tenant garden plots and newly terraced areas. The other location is on a slope and includes a central lawn, a playground, and some individual trees. The majority of the green areas are mown regularly and are largely featureless. Some of the existing trees are very old. The regularly mown lawns imply that the maintenance requirements are currently very high. A maintenance concept for the open spaces has not yet been developed.

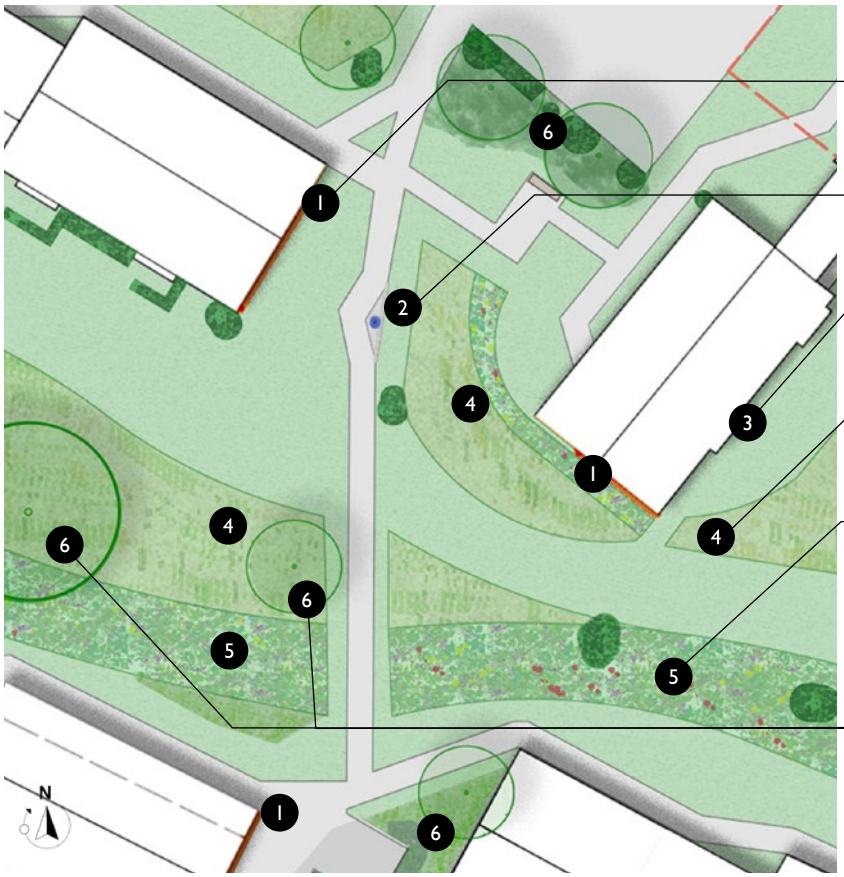
Integration of AAD: The planting of low-maintenance wildflower strips had been planned for the existing lawns, and these would have a positive effect on the development of the future food supply for the three target species. More protective trees, shrubs, and hedges for the house sparrow would, however, also be required. The installation of sparrow boxes on selected facades as well as the establishment of water sources for the target species could be achieved in various ways, for example by diverting downpipes on buildings, or by collecting drainage water from the garages via water-retaining retention basins and subsequent infiltration, especially in shady locations. Areas that are to remain constantly wet could be created in low-maintenance meadows; these would then need to receive additional watering in the event of prolonged drought. Another option would be to embed water bowls into the ground in protected areas, but these may have to be fenced in. Watering was conceivable, as it already took place in the open space when required for new or particularly decorative plantings. The introduction of dead wood was also planned, which could be additionally greened with ivy. New maintenance procedures would need to be developed for the AAD measures, with a focus on low maintenance costs. Over the next few years, renovations to the existing buildings are planned; AAD could be integrated into this process. The company considered it conceivable that AAD recommendations could be incorporated into possible future projects and other open spaces.

Synergies and challenges: The measures developed for the target species were seen as a good opportunity to introduce less intensive and more nature-oriented maintenance procedures. It was pointed out that piles of leaves, dead wood, unmown meadow areas, spontaneous vegetation on paths, and other consequences of the AAD design will need to be accepted and valued by tenants if they are to be preserved over the long term. This could only be achieved by keeping them well informed and doing the required public relations work. Wohnbau Salzgitter was already involved in smaller environmental education projects, for example at the Wiesenschule, a local elementary school in Salzgitter-Bad. The AAD initiatives could also be used for such environmental education work. With the help of various funding opportunities and possibly also the participation of interested tenants, many smaller and larger initiatives could be implemented over the medium term.

Species-specific design elements for the house sparrow



View of low-maintenance meadow with wildflower strips



Nesting aids on the south and east façades; approximately ten on each facade, at heights of 3–10 meters; could be individually attached onto the facade

Water bath: Creation of a retention area in which rainwater would accumulate. Could be combined with water drainage from downpipes

Dust bath in open areas, e.g., under the balconies

Low-maintenance (biannually mown) long grass meadows with possible sowing of herbs for seeds. Planting of fruit-bearing perennials and shrubs alongside the balcony areas

Wildflower strips along the edge of the site to encourage insects and other invertebrates

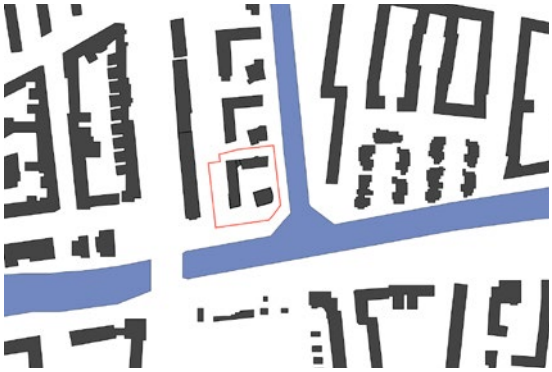
Resting places and protective trees and shrubs alongside the tenants' gardens / balcony areas near / on the buildings and the seating area between the buildings; consisting of small trees, shrubs, and hedges

Site plan detail showing Heinrich-von-Stephan-Strasse. Design elements for the house sparrow

HAMBURG, SAARLANDSTRASSE *Case study 9*

Fig. 18
Saarlandstrasse AAD plan; plan based on draft design by Mareile Ehlers, landscape architect

Housing company: Wohnwarft Genossenschaft für autofreies Wohnen e.G.
Project type: Change to maintenance procedures
Location: In municipal area / centrally located (size of project area: 4,602 m^2)
Construction type: Group of multi-story buildings with central outdoor area (49 apartments)



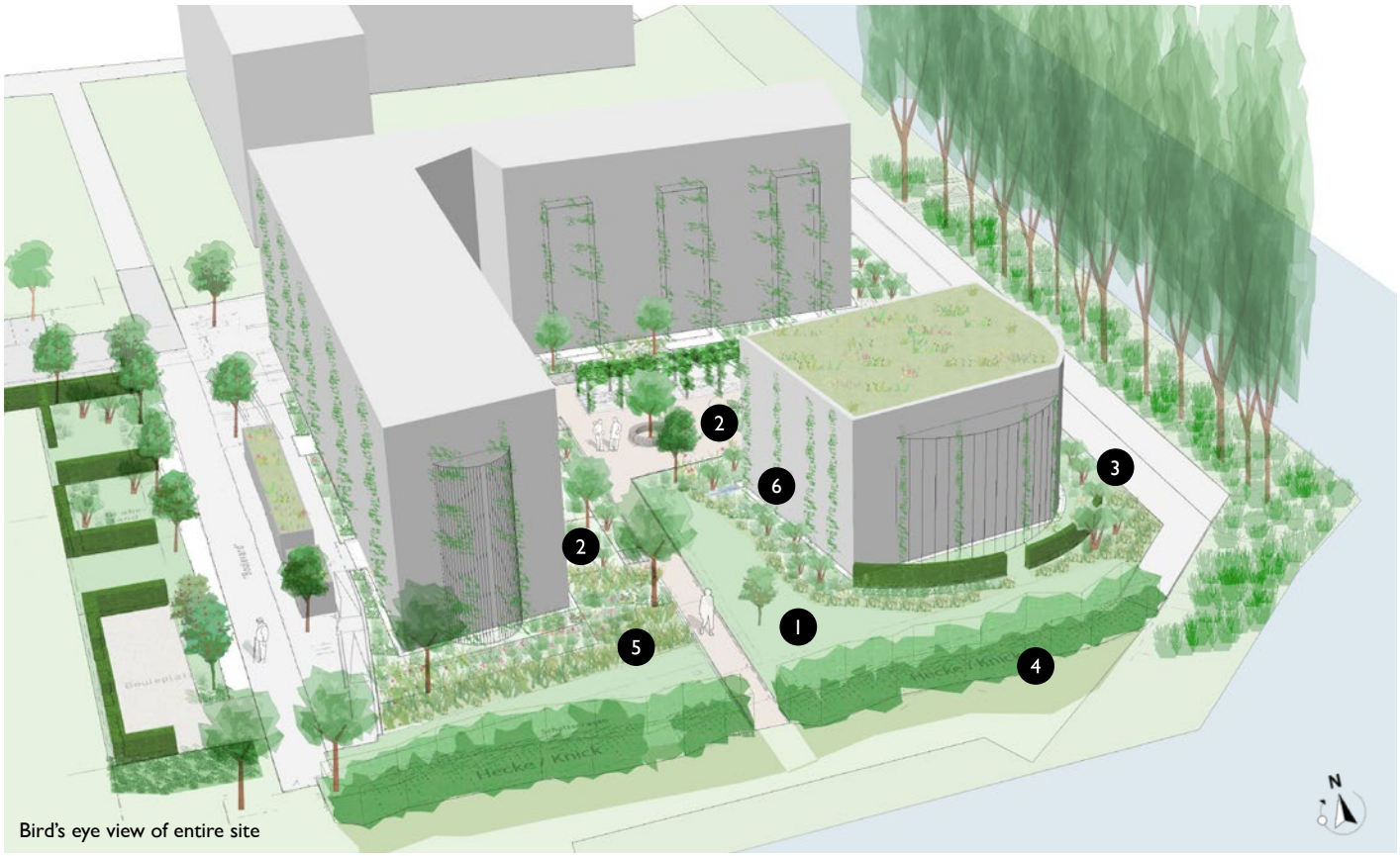
Motivation: The housing cooperative sees itself as an environmentally friendly organization; all measures implemented on their building sites should be carried out in a more targeted and holistic manner; the project should serve as a showcase project for the neighborhood.

Project: The project involves three multi-story apartment buildings built in 2000. They contain both rented and owner-occupied apartments and were constructed in accordance with low-energy standards. New maintenance procedures need to be developed for the open space. A large, centrally located outdoor area includes space for private terraces. Communal open spaces containing vegetable gardens and a boules court can be found in the middle of the adjacent residential area. The three buildings are situated on the banks of the Barmbek branch canal and form part of a larger continuous housing development. There is a community garden and a traditional hedge bank ("Knick") on the south side of the complex. A communal sixth-floor terrace is used for urban gardening as the substantial rabbit population feed on any vegetables or ornamental plants planted in the central outdoor area. Tenants and owners maintain their own private gardens and terraces while a voluntary "green group" is responsible for the maintenance of the communal facilities.

Integration of AAD: Promoting the selected target species offered a good opportunity to introduce new maintenance procedures. The renovation of the façade, which has now taken place, was to be combined with the installation of nest boxes, but it was completed while the study was still taking place. The nesting aids for house sparrows could be mounted on existing climbing aids (cable systems) or balconies. The bicycle shelters' extensive green roofs could be sown with grasses and herbs to enhance their usefulness to the house sparrow and the red admiral. Another option would be to create less frequently mown meadow areas and wildflower strips at the edges of the open spaces in order to encourage insects, which form the basis of the hedgehog's diet. It would be a matter of making relatively small-scale adjustments to an already ecologically valuable site. There were sufficient shrubs and hedges to offer protection and provide areas suitable for hedgehog nests, and there was already an abundance of flowering plants and fruit trees. A suitable location for a nettle border (for red admiral caterpillars) would have to be agreed within the cooperative. The project area borders canals to the south and west; with small interventions at suitable locations, these could be used as water sources. Collecting rainwater via infiltration areas would also be an option; however, this would involve greater effort. The adjusted maintenance procedures could be carried out by the community-organized green group.

Synergies and challenges: The open spaces were already being maintained in an environmentally friendly manner; the green group had sound knowledge in this area. Rabbit wire was being used to protect many planted areas from rabbits, so the open areas had numerous barriers for the hedgehog. The AAD measures would have to be discussed at a general meeting of the housing cooperative, in order to decide how they should be implemented and, above all, the budget that should be allocated. At the meeting, all details about the measures would need to be presented, discussed, and voted on due to the self-governing structure of the organization. The open spaces and buildings are in the immediate vicinity of other housing developments, and the project could thus serve as a role model.

Species-specific design elements for the European hedgehog



Bird's eye view of entire site

1 Lawn allowing foraging for earthworms and serving as an open space for hedgehog mating rituals

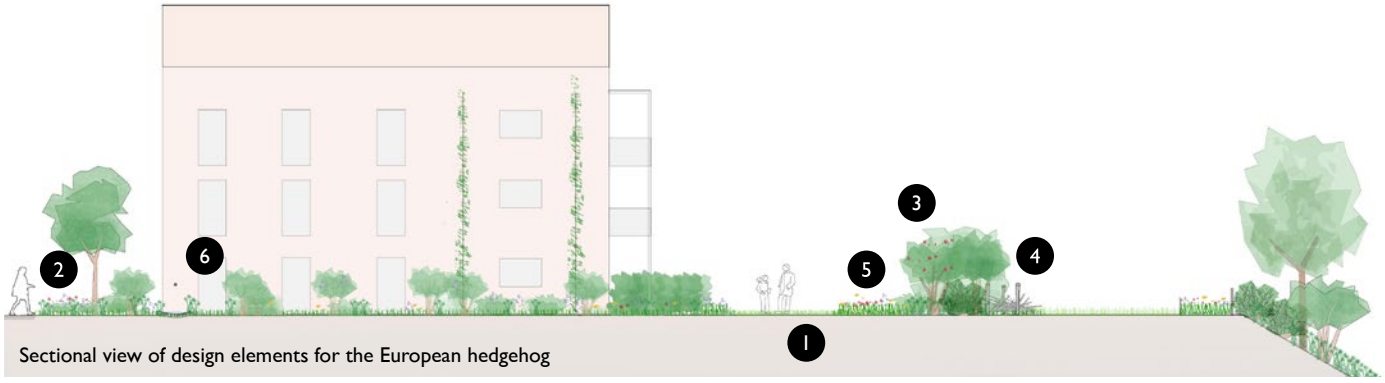
2 A border of perennials and grasses alongside the existing slopes bordering tenants' private gardens and peripheral areas. Development of an herbaceous border outside the rabbit-proof fence.
Areas with long and short grass (rarely mown meadow strips) providing beetles, earthworms, and other invertebrates as a food source

3 Dense ground vegetation, ivy, and native shrubs form an understory beneath the existing trees and shrubs on the hedge bank and along the western edge of the site, offering space for daytime refuges and hibernation

4 Dead wood and leaf fall in the existing fenced-in storage site. Creation of an access point to allow this to be used as a nursery habitat by the hedgehog. There is also a fenced-in pile of twigs, leaves, and green waste near the existing hedge

5 Alternating short and long grass and shrub-rich border vegetation offer refuge and protection in the transitional area between dense and open vegetation

6 Modification of the downpipe to create a water retention basin on top of an impermeable layer, forming a water trough. In dry periods, this would be filled by tenants via the outside water faucet. Alternatively, a hedgehog-friendly access point to the canal could be established

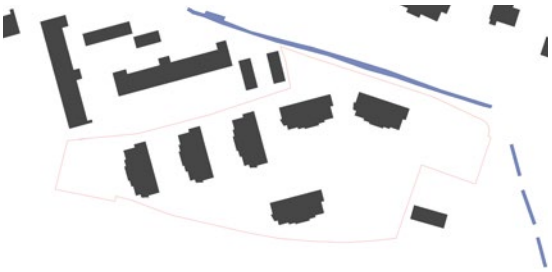


Sectional view of design elements for the European hedgehog

KIRCHHEIM UNTER TECK, HUMBOLDTSTRASSE *Case study 10*

Fig. 19
Kirchheim AAD plan; plan based on draft design by Architektengruppe Rutschmann + Partner

Housing company: VdK-Baugenossenschaft Baden-Württemberg eG (VdK)
Project type: Change to maintenance procedures (66 apartments)
Location: On outskirts of municipal area
Construction type: Single-family houses and / or apartment blocks (size of project area: 10,800 m²)



Motivation: In general, tenants would like more green spaces; the VdK would like to encourage the presence of bees and insects.

Project: The project area is situated on the south-western outskirts of the town of Kirchheim unter Teck. The housing complex consists of six apartment buildings built in 1992. Integrating AAD into modified maintenance procedures is in line with the VdK's desire to increase the ecological value of the open spaces. There are plans for a new housing development in a former freight yard in the immediate vicinity. If the VdK's potential involvement in this neighboring development comes to fruition, options would open up to connect and expand the AAD planning concept into this neighboring area, in cooperation with other planners and the Kirchheim municipal authorities. A stream and railroad line are directly adjacent to the project area. The location is very well-suited for the target species because it is linked to other open spaces. Under the current maintenance procedures, lawns are mown frequently, leaves are swept up and removed as required and when specified by the caretaker, and hedges and shrubs are trimmed once a year.

Integration of AAD: Changing the maintenance procedures in order to fulfill the critical needs of the target species would generally be possible. Dust baths and protective trees and shrubs for the house sparrow were already in place. The attachment of nesting cavities to the façades or the construction of a free-standing tower containing nesting aids was discussed and seen positively. There were many unused open spaces bordering the access road that could be converted into wildflower strips, thus providing the red admiral with a source of food. Mowing much later in the year would preserve seed heads as a food source for the house sparrow. Plans were made to use the green waste resulting from trimming trees and shrubs to create on-site areas suitable for hedgehog nesting. There were relatively protected peripheral areas throughout the housing complex that could be developed as refuges for the hedgehog. Nettles could be specifically permitted in these areas, which would benefit the red admiral by providing a food source for its caterpillars. A water source for hedgehogs and house sparrows could be created by improving access to the existing stream.

Synergies and challenges: There was concern that the installation of nest boxes would reduce the visual appeal of the façades. The VdK was very open to suggestions for alternative maintenance procedures such as less frequent mowing and pruning of shrubs, but emphasized that the end result must meet the tenants' requirement that the open spaces look neat and tidy. In smaller housing complexes like this one, there could also be conflicts of use between the need for lawns as spaces for playing and picnicking and the creation of low-maintenance meadows. The VdK considered the creation of wildflower meadows to be reasonable, especially in areas that are difficult to mow. As such wildflower meadows would only have to be mown a maximum of twice a year, this would imply a lower maintenance requirement than that of lawns. At the same time, wildflower strips help to improve the visual appearance of the housing complex. Many of the AAD measures could create an exciting place for children to play. It turned out that a detailed specification of the maintenance procedures would be necessary to make sure that the planned AAD initiatives would be effective in the long term. The company suggested that, in other possible renovation or new building projects, supplementary planning with AAD could be integrated into the budget.

Species-specific design elements for the house sparrow

Site plan showing design elements for the house sparrow

1 Wildflower strips to encourage insects and other invertebrates, which serve as a food source for adult and young birds. The seeds of flowering plants and grasses provide a winter food source. Mowing in two phases enables this, with one half of the area being mown in the fall and the other in spring

2 Winter food sources include seeds and the berries and fruit of trees and shrubs

3 Nests in nesting aids on the façades of buildings ten, twelve, and fourteen

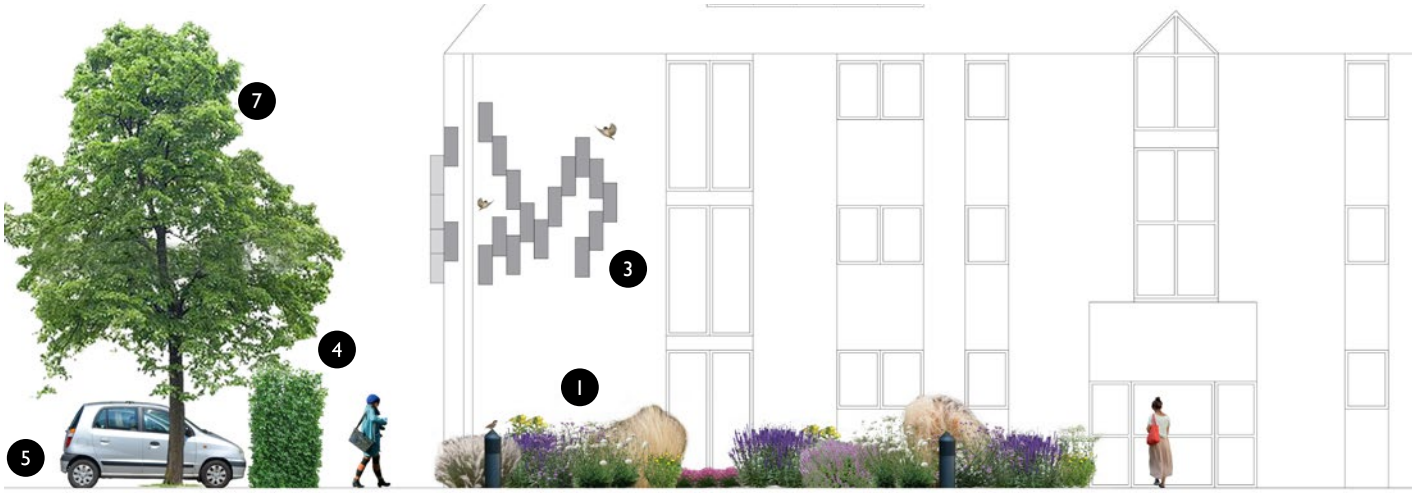
4 Winter roosts in nesting aids and dense hedges

5 Dust baths in sandboxes and in the parking areas, the surface of which is partly made up of gravel

6 Water for drinking and bathing at the access point on the Kegelsbach stream and at artificially created water sources

7 Shelter, roost, and resting places in surrounding trees, shrubs, and hedges

8 Additional winter food sources provided by artificial feeding stations on balconies. This encourages contact between the tenants and the target species



View of the facade nesting aids and wildflower areas

THE SYNERGIES AND CHALLENGES OF APPLYING AAD IN THE LIVING ENVIRONMENT *Conclusions from the case studies*

In all of the case studies, it was shown that the critical needs of the target species could be addressed by adapting measures that had already been planned. The necessary adjustments were sometimes very small and therefore potentially not very expensive. It became clear that it was important for the acceptance of the AAD initiatives that there be synergies between a building project's planning goals and the AAD measures in terms of the multifunctional use of planned elements, which also lowers overall costs. In order to be able to take advantage of these synergies, it is important that the planning and execution of AAD measures are well integrated into the timetable of planning processes. In discussions with the project partners, some challenges in integrating animal needs and some technical aspects were recurring themes. These synergies and challenges are summarized here.

CONNECTING AND NETWORKING

The interconnectedness of the housing complexes with their surrounding neighborhoods, as well as good pedestrian and barrier-free accessibility, are important issues for the housing companies. These human-oriented goals complement the desired linkage of the target species' habitat structures in terms of a biotope network. For example, to enable hedgehogs to settle on a site, both suitable vegetation structures within the project area and a barrier-free connection to existing green areas in the immediate vicinity are required Fig. 20. It became apparent that existing municipal plans for green and blue infrastructure, climate change adaptation plans (addressing microclimate, cold air corridors, etc.), rainwater management plans, and biotope network plans offer chances to achieve connectness for animals.

FAÇADE AND ROOF GREENING

Some of the case study projects aimed to upgrade areas that had previously been designated as single-use or "residual" areas, such as roofs, parking lots, or garage rear walls, by making them green, and to add value to these areas by, for example, improving the microclimate. Such plans are good entry points for AAD measures and allow for multifunctional solutions. Extensive green roofs sown with grasses and wild herbs will provide a food source for animals (red admiral, sparrow) if the appropriate plants are selected, improve the microclimate, and will also improve the appearance of low buildings such as garages and carports Figs. 20, 23. Such multifunctional measures also received a positive reception from project partners who had not been planning to use greening.

Façade greening was another goal shared by various project partners. Green façades have positive effects on the microclimate (cooling, fine dust) and are widely perceived as an aesthetic enhancement Fig. 21. An appropriate choice of plants can make such greening functional for animals. The plants' flowers, berries, and the associated presence of insects provide a food source (red admiral, sparrow) and, in older specimens (especially ivy) with thicker foliage, opportunities for concealment both on the wall and near the ground (sparrow, hedgehog). Both greening with climbing aids and, in some cases, using self-climbing plants (such as ivy or Virginia creeper) or espalier trees were positively received by the project partners as possible solutions.

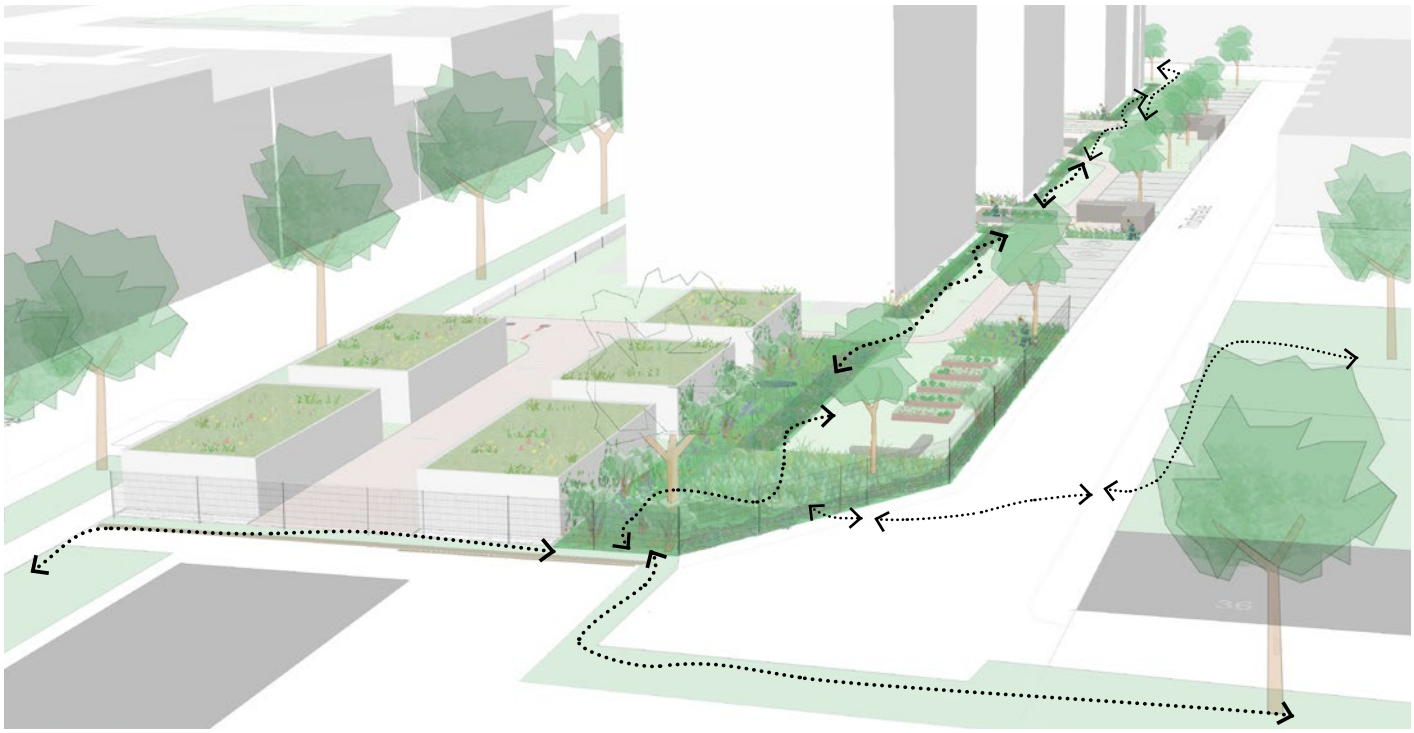


Fig. 20
Design for Kaiserslautern Friedenstrasse: Hedgehog networking route

Fig. 21
Design for Schwarzheide: Facade greening of elevator shafts

Fig. 22
Design for Frankfurt-Leuchte: Green roof

Fig. 23
Design for Ingolstadt: Extensive roof greening

EXTENSIFICATION OF MAINTENANCE PROCEDURES

When altering maintenance procedures for open areas with the objective of reducing the intensive care of the vegetation[29] (e.g. by reducing the mowing frequency on a formerly frequently mown lawn), it is important that this is not perceived by residents as a sign of inadequate maintenance or neglect, an issue frequently raised by the project partners. On the one hand, this can be achieved by providing information on the intended purpose of the new procedures; on the other, by configuring the area in which the new procedures are being carried out in such a way that it is clear that its appearance is intentional.[30] Difficulties will arise if, for example, nettles are not kept in check in the appropriate areas. Nettles can serve as a natural barrier to keep people and dogs away from sensitive areas, e.g., hedgehog nesting areas, while at the same time providing an important food source for numerous caterpillars (red admiral). Marking this out as a conscious decision can be achieved by information signs or through the use of designed elements such as mown edges or border structures. Ideally, a maintenance plan should be developed for the extensification of the maintenance procedures, describing what is involved and which areas are covered. This can serve as a basis for familiarizing the maintenance staff with the new maintenance procedures, which are tailored to the needs of the target species. The new maintenance costs can be calculated on the basis of this plan. Such a plan should include the development of a long-term strategy for the maintenance and development of the vegetation structures. The goals here would be to establish a professional standard of pruning, mowing, and other maintenance measures in order to encourage a rich crop of flowers and berries to serve as a food source for the target species, and to adapt the tree and bush populations to meet other needs of the target species (e.g., to offer protection).

29. Kowarik et al. 2016.

30. Nassauer 2007.

Fig. 24
Design for Ingolstadt: Low-maintenance wooded border

Fig. 25
Design for Salzgitter-Bad: Low-maintenance meadows and wildflower meadows

WILDFLOWER MEADOWS

Many project partners would like to improve their open spaces with flowering plants that require little maintenance. For example, creating wildflower strips or meadows should enrich the appearance of the open spaces for the human residents Figs. 24, 25. Such initiatives can be used to create feeding habitats for pollinators (red admiral and many others) and for other animals that feed on insects (such as the sparrow or hedgehog) or seeds (sparrow).

Since these low-maintenance meadows containing pollen- and nectar-rich plants not only provide food but also offer opportunities for concealment or daytime refuges (hedgehogs), they are a typical example of the synergy effects that can be achieved by combining human and animal needs. There is also evidence in the literature that, if maintenance is carried out and organized correctly, such meadows and nutrient-poor grassland can require less work and thus have lower costs. [31]

31. Biercamp et al. 2018; Kowarik et al. 2016; Witt 2014.

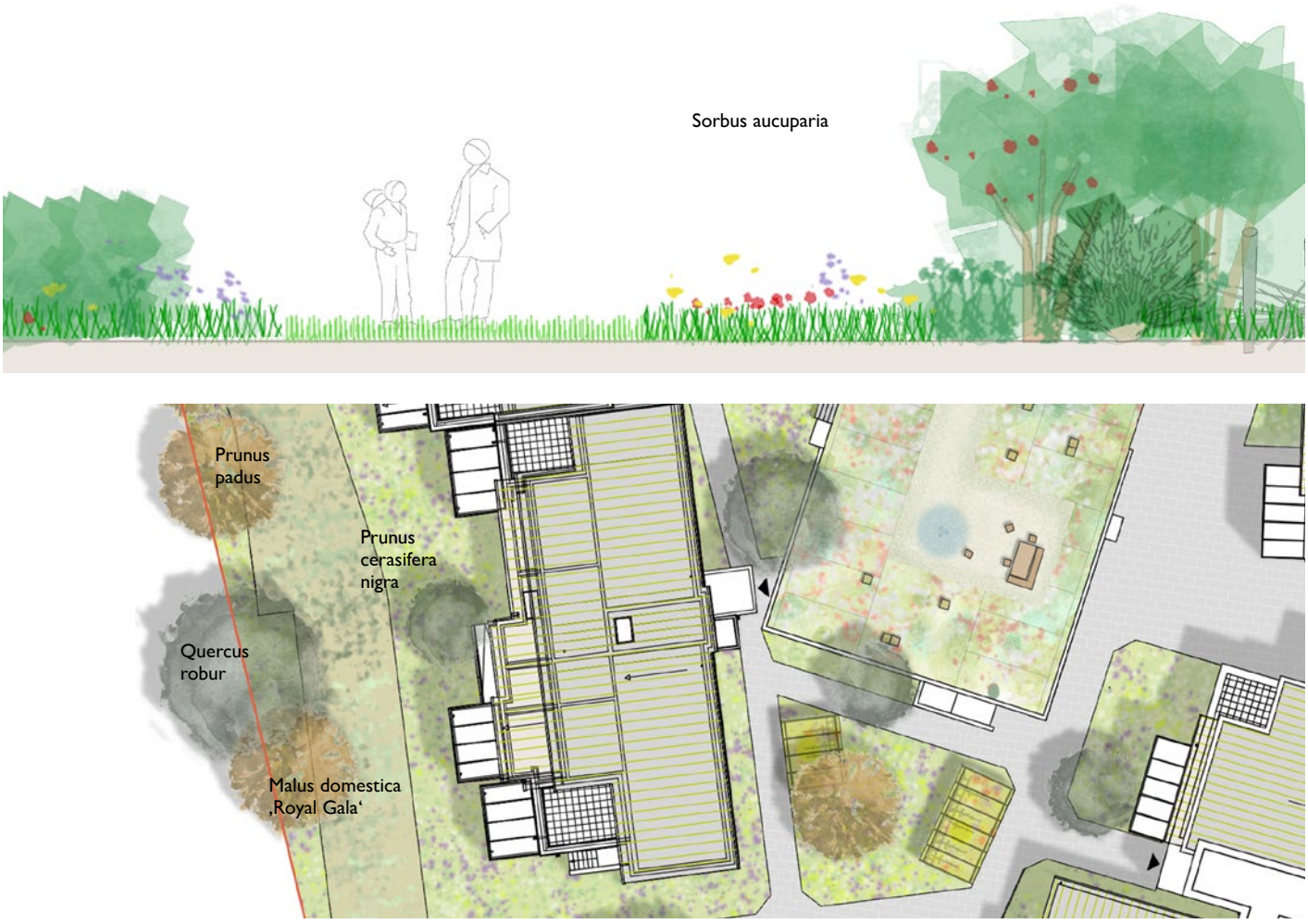


Fig. 26
Design for FFM Leuchte: Selection of fruit-bearing plants for humans and animals

EDIBLE PLANTS

Another example of synergies results from the use of edible plants such as snowy mespilus (garden serviceberry, Amelanchier spp.), elder, or fruit trees Fig. 26. Fruit trees were already present in some of the case studies, or plans were actively being made to introduce them. The project partners saw this as a good opportunity to involve the residents: They would receive added value from the supply of edible fruit and the opportunity to harvest it, while at the same time the trees and their windfalls provide important food sources from which animals would benefit.

HEDGEHOG NESTING AREAS AND "UNTIDY" ELEMENTS

Hedgehog nesting areas in the form of piles of branches and leaves met with a high level of acceptance from the participating housing companies Fig. 27. Cuttings and fallen leaves can remain on-site and be piled up in suitable places to form potential hedgehog nesting areas; the costs associated with their removal can thus be saved. However, the importance of avoiding the impression that these areas are simply being neglected was frequently raised in discussions with project partners; the solution they often suggested was to position these areas, similar to the possible nettle areas for the red admiral, at the edges of open spaces and, where appropriate, label them with an information sign. Initiatives such as wildflower strips and dust baths were not judged to be problematic in terms of perception.

DEAD WOOD / CUTTINGS
On-site collection point for dead wood and vegetation cuttings as possible summer nesting area

HEDGEHOG HOLE
Opening allowing the hedgehog to reach a potential nest

HEDGEHOG NESTING AREA
Artificial winter nesting areas for the European hedgehog

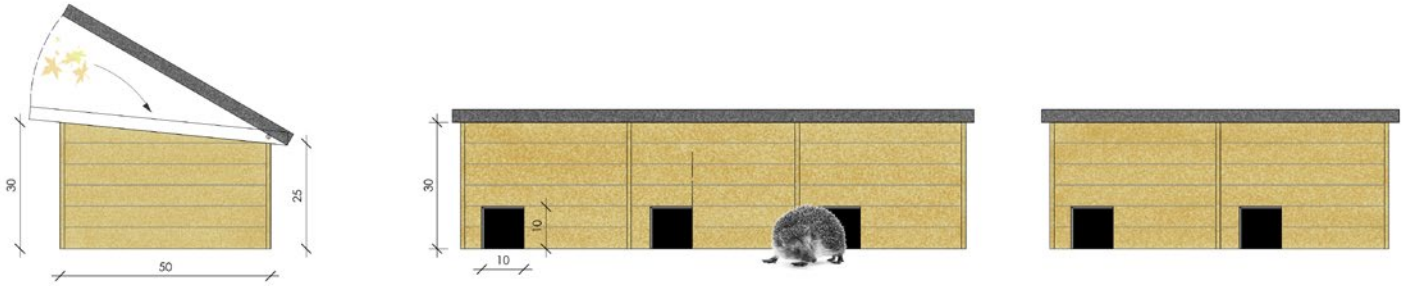
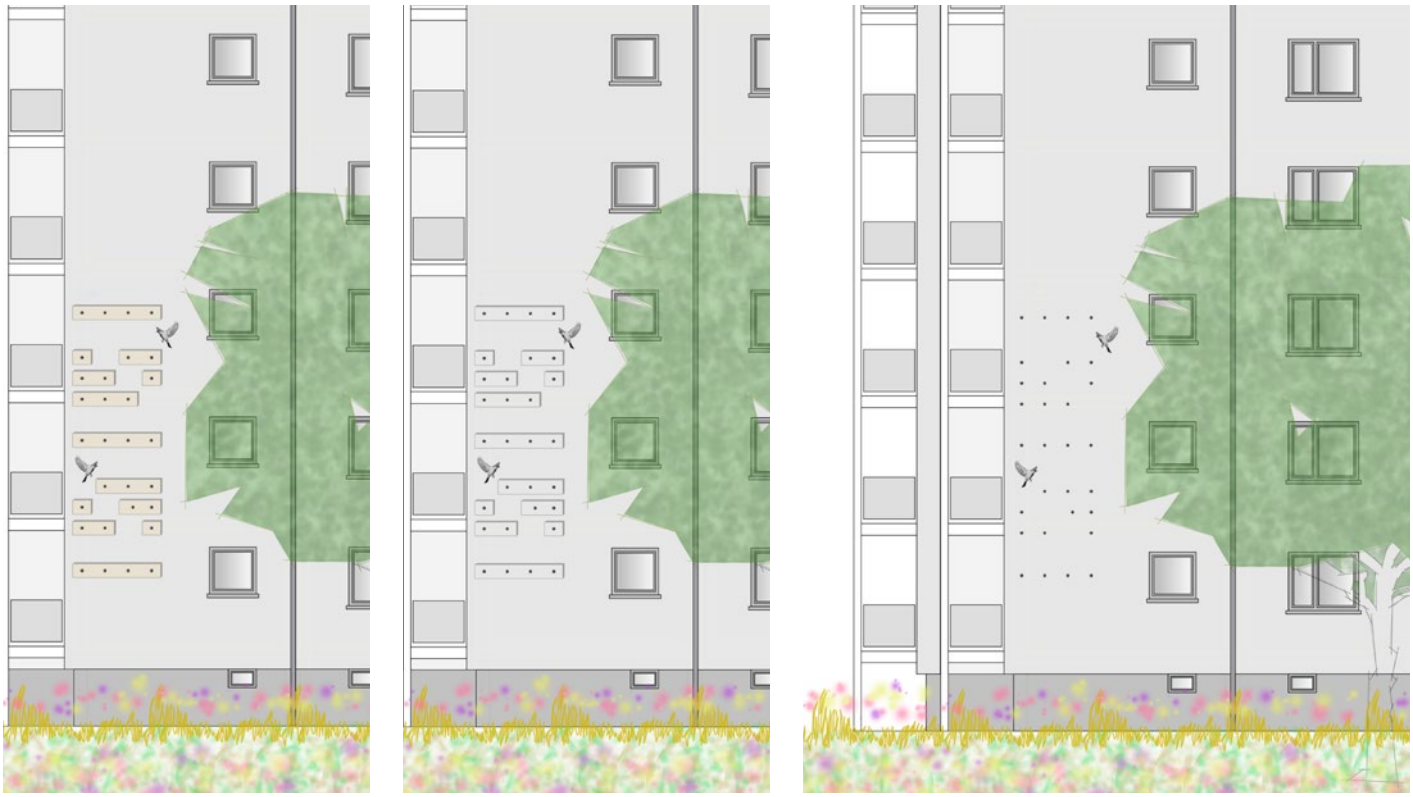


Fig. 27
Hedgehog nesting areas in Hanover Herzkamp and Kirchheim



HOUSE SPARROW NESTING AIDS
with roof fixture for sand bath and water source

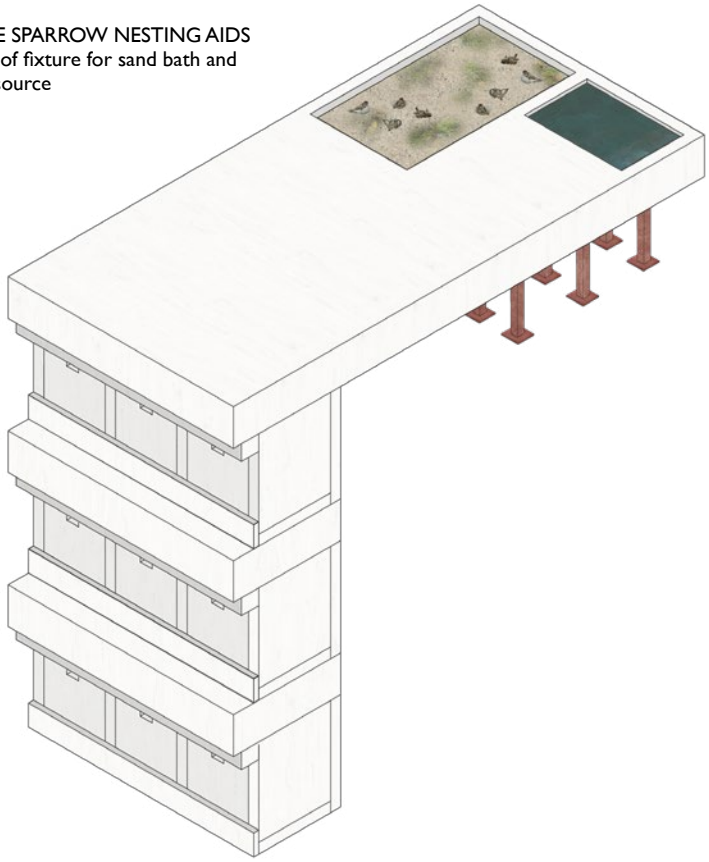
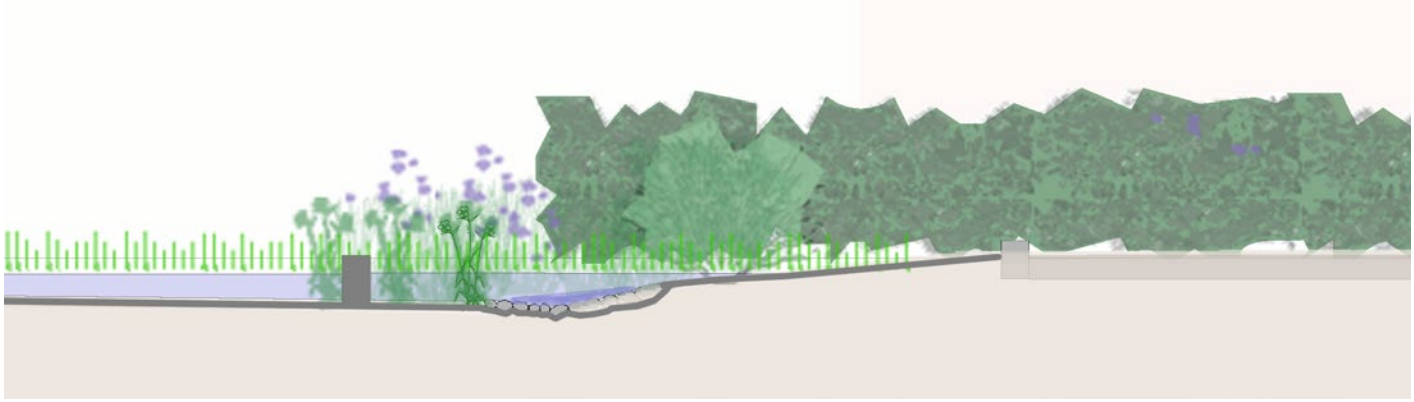


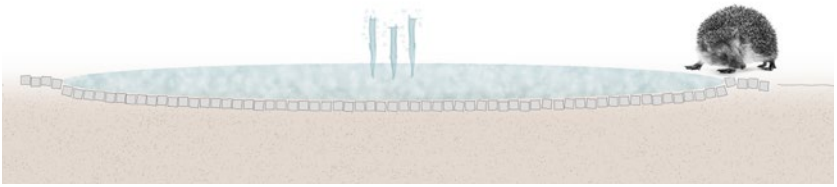
Fig. 28
FFM Leuchte design: House sparrow facade nesting aids

Fig. 29
Hanover Herzkamp: House sparrow design element

FAÇADE NESTING AIDS

Nesting aids that could be integrated into a facade met with general approval for new building projects, as long as suitable structural solutions could be incorporated into the design Figs. 28, 29. However, their installation during renovation projects or projects involving a change to maintenance procedures was rejected because of the extra costs involved. Nesting aids that are attached to the façade from the outside were accepted in principle for already completed facades, but here aesthetic concerns were relatively common. There was also a consensus that nesting aids should not be installed directly above or next to balconies and windows, or above entrances, in order to avoid disturbance from noise, falling nesting material, or animal droppings. The option of a free-standing nesting tree or tower was also frequently discussed; an outdoor structure of this type would allow birds to be observed and accommodated close to the living space of the human residents. This solution was the preferred option in various case studies.





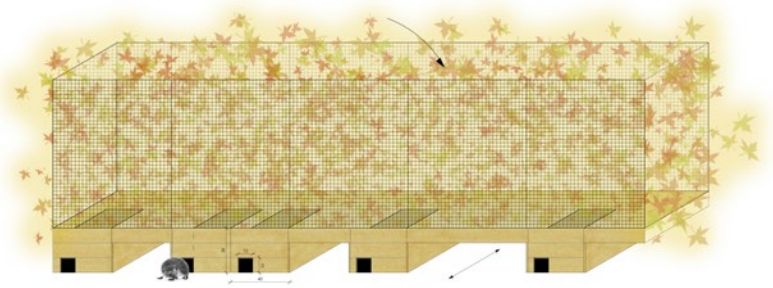


Fig. 30
Design for Hamburg Luettmelland: Retention basin

Fig. 31
Design for FFM Leuchte: Water basin

Fig. 32
Design for FFM Leuchte: Hedgehog winter nesting area

WATER SOURCES

Water sources with a continuous water supply for animals to drink from (sparrow, hedgehog, red admiral) caused the greatest challenge from a technical point of view, and due to hygiene and safety concerns. Although around a third of the project partners did not anticipate any problems and could envisage creating water sources in the form of small ponds or water bowls, the majority were very concerned about the idea of water sources in open spaces due to liability considerations and in view of the risk of children drowning. In addition, such structural elements were judged to be too expensive to construct and maintain. No problems were anticipated with rainwater collection trays. However, these may not collect water in dry periods, which is when the animals would need it the most. Solutions that are attractive for both humans and animals would offer a synergy effect. Animal water sources could also serve as water features or drinking water fountains for human residents and thus function as an attraction and meeting point for the residents. The project partners also considered supplying animals with drinking water by integrating water sources with infiltration and rainwater retention systems or evaporation areas, which make an important contribution to climate change adaptation Figs. 30, 31. Any technical solution would need to either ensure that water would still be available during dry periods or be combined with alternative water sources. With appropriate planting, these systems can also serve as feeding habitats by providing flowering and host plants for caterpillars (red admiral) or encouraging the presence of insects (hedgehog).

FENCES

In most housing complexes, areas such as tenants' gardens, playgrounds for young children, and the outside areas of kindergartens and schools have to be fenced off. On the one hand, this is intended to prevent unauthorized human entry, but it is also designed to keep animals such as dogs, cats, and rabbits out of these areas. Today, bar mat fencing is very often used for cost reasons and because it is easy to install. The bar mats are usually installed in such a way that there is only a very small gap between the mat and the ground. As a result, these fences represent insurmountable barriers for hedgehogs, shutting the animal either in or out. A simple solution was to create hedgehog holes of (at least) 10 x 10 cm by removing some of the bars or to design the fence with a sufficient gap (at least 10 cm) between it and the ground. This would be a workable solution for most project partners Fig. 32.

OUTLOOK

Working with the housing organizations in the ten case studies has demonstrated that the residential environment offers great potential for the promotion of biodiversity and wildlife in urban areas. The level of commitment and interest among the project partners was very high. The survey of residential housing companies in Germany also offers reason to believe that the doors of many organizations would be open to Animal-Aided Design. To take full advantage of this potential, it is essential to understand the housing companies' motives and specific requirements in relation to the spatial and economic development goals they have for their properties, residents' requirements for the housing complexes in which they live, and the routines and constraints inherent in caring for and maintaining buildings and open spaces. The survey and the case studies allowed us to obtain an insight into the development goals and plans of housing companies, as well as the challenges they face. As a result, we have learned that the following topics are important for future Animal-Aided Design collaborations:

AN INNOVATIVE IMAGE

All the project partners share the goal of using AAD to add an innovative aspect to their company's image and the way they are perceived by both tenants and the general public. The businesses sometimes saw their own image as being somewhat outmoded and were interested in enhancing it by applying new approaches and carrying out novel projects. Many of the partners would like to be perceived as innovative companies and therefore aim to position themselves as pioneers in the field of ecological and sustainable construction. As such, they greatly value the opportunity to present AAD projects to the public, for example in the tenant magazines that some of the companies publish. When using AAD, a communication strategy is important, for internal and external communication. Good design and clear communication of the different measures being implemented is required, for example via an on-site information system. Biodiversity and wildlife constitute just one of the many topics that companies can get involved in in the field of sustainability. Most of the initiatives currently being carried out are more technical, for example involving building insulation and energy supply; this is also due to the subsidies available in this area. Wildlife and biodiversity in the residential environment are, however, more visible and emotionally charged than these technical topics. They are therefore likely to receive more attention from the residents and the general public. Public perception of the companies' commitment to increasing biodiversity in the residential environment can be boosted through initiatives such as "Germany is buzzing!" or the UN "Biological Diversity" competition, which is part of the UN Biodiversity Decade.

PERSONAL COMMITMENT AND CORPORATE PHILOSOPHY

Around half of the project partners had already implemented initiatives to encourage the presence of wildlife in their projects and housing stock. They did so by putting in place various individual elements such as nesting aids for wild bees or birds, or purposefully introduced wildflower strips. In contrast, others have not yet implemented any measures but are interested in doing so. For a large proportion of the project partners, their interest in improving living conditions for animals in the organization's open spaces was due to the personal commitment of

particular individuals. These could include the management, owners, employees, or housing cooperative members who were enthusiastic about the presence of wildlife in urban areas, and who want to make a contribution to species and nature conservation, or who set high social and environmental standards for their own work and that of their company. A personal enthusiasm for nature and the chance to do something for specific groups of species that are perceived to be endangered, such as bees, butterflies, and other insects, was an important motivation for implementing AAD. Some of the organizations have put their ambitious social and environmental goals in writing and published them as corporate philosophies. AAD offers an opportunity to put these principles into practice through clearly visible measures. Despite the high level of interest in AAD, however, many of the project partners were very uncertain about how to deal with wildlife in the residential environment because most of the companies had no prior knowledge of doing so. They needed advice on target species selection, process design, how to approach the critical needs of species, and, above all, detailed technical planning. In addition, they expressed a desire for professional support in implementing AAD and in providing information to residents. In principle, there was a willingness to provide financial resources for such services. Additionally, "AAD-oriented training" for maintenance staff was considered particularly important.

INVOLVING THE RESIDENTS

Ensuring tenant satisfaction was one of the most important guiding principles determining all the company's actions. Many of them have tenants who would like to have "more greenery" or improvements to existing open spaces. Many project partners had recognized that encouraging wildlife improves their residents' opportunities to experience nature within the housing complexes in which they live. They emphasized the great importance of involving residents in the planning and implementation of initiatives, as otherwise there may be a lack of acceptance of the changes. The project partners saw AAD as a good way of involving tenants in target species selection and the planning and implementation of initiatives. Above all, the implementation and supervision of AAD initiatives could provide an impetus for community projects within the housing complexes. Residents could get involved in collecting sightings and mapping the presence of species (citizen science). Tenants could "adopt" particular species and the corresponding initiatives, and information on the presence of target species could be disseminated via tenant meetings. When tenants have a good level of knowledge about the target species and identify positively with them, this can prevent vandalism to the provisions that have been put in place and possibly lead to a group of residents looking after these species. A separate information strategy should be developed to disseminate knowledge about the initiatives that have been implemented for the target species via on-site information signs or other media (QR codes, etc.), but which also informs new tenants about the AAD initiatives when they move in, e.g., with a "welcome pack" or via conventional means such as posters on notice boards and information on websites. The project partners attached great importance to the selected species and the initiatives implemented having some connection to the site itself. In this way, the individual qualities of the site and a local sense of identity can be strengthened, and a "sense of place" can be developed through the active involvement of the residents.

Accordingly, the project partners' main concerns about using AAD related to the possibility that initiatives which change the familiar image of the living environment or do not meet conventional aesthetic requirements could cause resentment among residents. In particular, switching to less intensive maintenance procedures is, in the experience of the housing companies, often perceived by residents simply as untidiness and inadequate maintenance of the open spaces. The hope is that AAD can be used to give residents and users clarity on the reasons behind adopting a more nature-oriented management of green spaces in housing complexes.

Similar concerns arise in relation to making provision on / in buildings for species that use cavities and crevices in facades and roofs, such as house sparrows, common swifts, or various bat species. Here, there is often concern that façades, attics, or open spaces could be contaminated by animal excrement. On the one hand, this is seen as having a negative effect on the appearance of the housing complexes; on the other, there is a fear of hygiene problems, e.g., through the transmission of disease. This is a particular

concern in relation to buildings and open spaces used by children, such as day-care centers and playgrounds. In these cases, there is also a fear of complaints from concerned parents. Initiatives encouraging wildlife need to meet the high safety requirements that many residents and parents have. Creating an element such as a body of water must always be done in accordance with both building law and social safety standards. The use of new and non-standardized initiatives raises the specter of being held liable for damage caused in the event of an accident. This is why it is always considered important that residents are appropriately informed about or involved in renovation projects or changes to maintenance procedures. There were fewer concerns with new building projects as the residents usually only move in once the measures have already been implemented, so they are part of the living environment from the very beginning.

CONCLUSION

Our study demonstrated that it is possible to combine urban construction with the promotion of biodiversity. New buildings have the greatest potential, but renovations of existing buildings or changes to maintenance procedures also offer great opportunities to encourage urban wildlife. Difficulties that arise due to the animals' habitat requirements, such as the need for a water source, or problems relating to potential facade soiling can be overcome by innovative solutions. Municipal and private housing companies, which are responsible for a large part of the urban built environment, showed in our survey that they are open to new approaches such as Animal-Aided Design, which combine attractive construction with the creation of ways to experience nature. Structural and design solutions that demonstrate the advantages of people living together with animals have a high chance of being accepted and implemented by residential housing companies.

SPECIES PORTRAIT

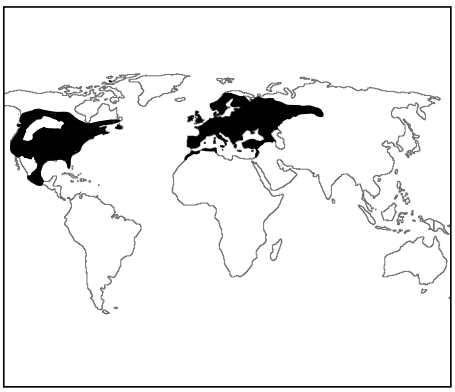
RED ADMIRAL *Vanessa atalanta*

BRIEF DESCRIPTION

Family
Brush-footed / four-footed butterflies (Nymphalidae)

Description
- Butterfly: One of Germany's largest and most magnificent native butterflies (wingspan: up to 6.5 cm); black forewings with orange-red wing bars and white "shoulder marks" (hence the name "red admiral"); hindwings have orange-red wing edge with dark spots. Orange and white bands on the underside of the forewings, while the underside of the hindwings has a light brown pattern. The red admiral is one of the "four-footed" butterflies, in which the first of three pairs of legs is smaller than the others and is used for cleaning, so it often seems to have only four legs rather than six.
- Caterpillar: Coloration varies from gray-yellow to blackish with a yellow, broken line along the sides (this may be absent); short thorn-like growths; up to 4 cm long.
- Pupa: Gray or brown suspended pupa with shiny metallic spots.

Distribution
Europe, with the northern boundary of southern England to Denmark, to west Asia, North America, North Africa, New Zealand, and Haiti. Steadily increasing occurrence in Germany from early summer to fall.



Habitat requirements
- Butterflies occur in almost all habitats with a rich supply of flowering plants up to an altitude of 2,000 m
- Shows a preference for residential areas (e.g., gardens, cemeteries, parks, town squares, orchards)
- Outside of built-up areas, the butterflies can often be found along the edges of woods and fields and in hedges, meadows, forest clearings, waterside embankments, ditches, industrial wasteland, and quarries
- Development from egg to butterfly takes place on nettles, preferably in sunny, relatively damp locations such as along streams, ditches, woodland edges, and roadside embankments

Behavior
- Flight season from March to October
- The red admiral is a migratory butterfly that migrates to Germany from the south from April onwards. The new generation of butterflies returns to the Mediterranean in the fall
- One or two generations are produced between June and September
- Sun-exposed, linear structures (12–24 m long, 4–13 m wide) serve as territories for the males; intruders are chased away
- Territories are only occupied in the late afternoon or early evening and are only used to find partners
- The males wait for a partner in the sun, either sitting on the ground or on vertical structures such as walls, fences, or tree trunks
- Although the red admiral is a diurnal butterfly, it also flies at night, and mating probably also takes place then
- The female lays her eggs individually on the young leaves and shoots of nettles in sunny locations
- The caterpillars hatch from the eggs after one week. They spin leaves together to form protective shelters in which they feed; once there is no longer enough cover because the leaf has been eaten, they move on to a new leaf
- After around three to four weeks, the caterpillars pupate into a suspended pupa surrounded by a protective web that hangs in the vegetation. The butterflies hatch two to three weeks later, immediately fill their wing veins with hemolymph, and allow them to dry
- Butterflies are sexually mature after a few days; in very mild areas there may be a second generation in the same season, otherwise mating will not take place until the following spring

Predators
- Birds eat the caterpillars, pupae, and adult butterflies
- Parasitic ichneumon wasps lay their eggs in the caterpillars

IMPORTANCE TO HUMANS

Perception

- Colorful, attractive butterflies that can be observed especially well when they are collecting nectar from flowering plants
- Territorial behavior of the males: Other males are chased upwards in spirals of 10–18 m in height
- Migration in spring and fall; especially easy to observe in the fall
- In the fall, red admirals can be seen feeding on fallen fruit
- Can be observed later in the year than almost any other butterfly species
- Nettle leaves spun into shelters indicate the presence of the caterpillars

Benefits and conflicts of interest

Benefits:

- Measures put in place for the red admiral also benefit other Nymphalidae with similar critical needs, such as the peacock and small tortoiseshell butterflies

Conflicts of interest:

- Pesticide use
- Nettles are often considered "unkempt" and are removed
- Many caterpillars are wiped out by the mowing of road- and waysides, embankments, dams, etc.
- Prevention of entry and exit into / out of winter quarters (cellar windows closed during the cold season)

Endangerment and legal status

- The red admiral is classified as a migratory species throughout Germany and, as such, does not enjoy any specially protected status

Influence of climate change

In the past, butterflies rarely spent the winter north of the Alps. However, in recent years their migratory behavior has changed due to milder winter conditions. The butterflies now often no longer fly to the Mediterranean region but instead spend the winter in milder parts of southern Germany, France, and northern Italy. In very mild years, eggs, caterpillars (food must be available as the caterpillar slowly continues to feed), or pupae can survive the winter at the breeding site, either on the forage plant or, for adult butterflies, in protected spaces in cavities or buildings

CRITICAL NEEDS FOR EACH LIFE STAGE

Egg laying and larval stage

Egg laying

- Eggs are laid individually on the leaves of the common and small nettle *(Urtica dioica, Urtica urens)*
- Sunny, relatively damp locations are preferred

Larval development

- The entire development from egg to pupa takes place on the nettle
- Nettle leaves serve as a food source
- Mowing should be timed accordingly

Predators

- Birds
- Parasitic ichneumon wasps

Imago (adult)

Flight season

- May to October

Food sources

- Flowering, nectar-rich plants in sunny locations, e.g., boneset, buddleia, goldenrod, clover, alfalfa, blackberry, and thistles
- Fallen fruit (plums, damsons, pears) and ivy blossoms, these provide energy in late summer and fall
- Can also be observed feeding on carrion, animal droppings, or tree sap

Resting places

- Vertical structures (walls, fences) or sunny, open ground areas

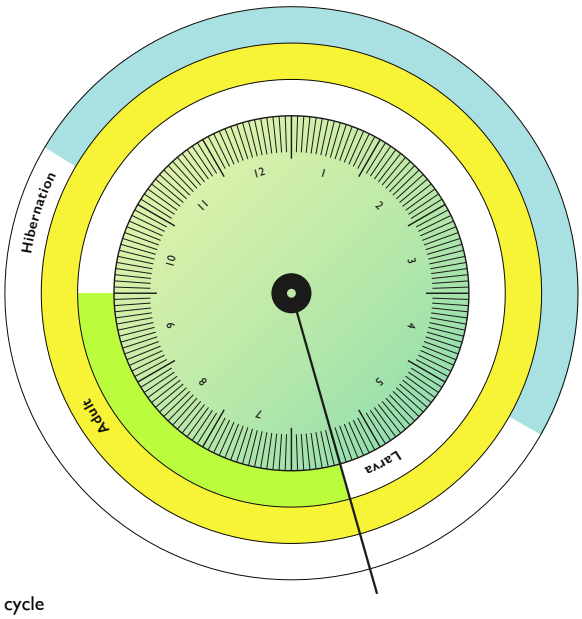
Winter hibernation

Winter quarters

- Migratory butterfly that usually spends the winter south of the Alps
- In mild regions, they can stay at the breeding site for the winter. This requires protected winter refuges in cavities or buildings
- Can, to some extent, survive the winter as an egg, caterpillar, or pupa on the forage plant (nettle)

Mating

- Sun-exposed, linear structures (12–24 m long, 4–13 m wide) serve as territories for the males
- Territories are mostly bordered to the east by higher structures (e.g., hedges, trees, building walls) and are always open to the west (to face the evening sun)
- Males sit in the sun waiting for a partner in vegetation-free areas on the ground or on vertical structures such as walls, fences, or tree trunks



Life cycle

LIST OF PLANTS

I. Plant-based food sources for caterpillars

Common name	Scientific name
Common nettle	*Urtica dioica*
Small nettle	*Urtica urens*
Pellitory-of-the-wall	*Parietaria spec.*

II. Nectar plants for butterflie

Common name	Scientific name
Perennials	
Common milkweed (invasive in EU)	*Asclepias syriaca*
Aster	*Aster spec.*
Summer lilac (invasive in Germany)	*Buddleja davidii*
Cabbage thistle	*Cirsium oleraceum*
Hemp-agrimony	*Eupatorium cannabinum*
Common ivy	*Hedera helix*
Alfalfa	*Medicago sativa*
Phlox	*Phlox spec.*
Blackberry, raspberry	*Rubus spec.*
European goldenrod	*Solidago virgaurea*
Canadian goldenrod (invasive in Germany)	*Solidago canadensis*
Giant goldenrod (invasive in Germany)	*Solidago gigantea*
Clover	*Trifolium spec.*
Other food sources	
Fallen fruit in the fall, mainly from: plums, damsons, pears	

APPENDIX

REFERENCES

Apfelbeck B., Snep R., et al. (2019): Designing wildlife-inclusive cities that support human-animal co-existence. In preparation.

Aronson M. F. J., La Sorte F.A., et al. (2014): A global analysis of the impacts of urbanization on bird and plant diversity reveals key anthropogenic drivers. Proceedings of the Royal Society B-Biological Sciences 281(1780).

Beninde J., Veith M., et al. (2015): Biodiversity in cities needs space: a meta-analysis of factors determining intra-urban biodiversity variation. Ecology Letters 18(6): 581-592.

Biercamp N., Hirschfeld J., et al. (2018): Grünflächenmanagement im Kontext von Klimawandel und Biodiversität, Synthesebericht zum Modul I des Projekts STADTGRÜN. (https://www.ioew.de/projekt/stadtgruen_wertschaetzen) (Zugriff 05.03.2019)

Bjerke T., Østdahl T. (2004): Animal-related attitudes and activities in an urban population. Anthrozoös 17(2): 109-129.

BMUB und BfN (Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit und Bundesamt für Naturschutz) (Hrsg.) (2016): Naturbewusstsein 2015. Bevölkerungsumfrage zu Natur und biologischer Vielfalt.

Böhm J., Böhme C., et al. (2016): Urbanes Grün in der doppelten Innenentwicklung. Bundesamt für Naturschutz (Hrsg.) BfN Skripten 444.

Dallimer M., Irvine K., et al. (2012): Biodiversity and the Feel-Good Factor: Understanding Associations between Self-Reported Human Well-being and Species Richness. BioScience 62(1): 47-55.

Deutscher Rat für Landespflege (2006): Durch doppelte Innenentwicklung Freiraumqualitäten erhalten. Schriftenreihe des Deutschen Rates für Landespflege 78: 5-39.

GdW (Bundesverband deutscher Wohnungs- und Immobilienunternehmen e.V.) (Hrsg.) (2015): GdW Branchenbericht 6, Wohntrends 2030. (http://www.inwis.de/fileadmin/user_upload/team/PDFs/GdW_Branchenbericht_6_Wohntrends2030.pdf)

Gloor S., Bontadina F., et al. (2010): BiodiverCity: Biodiversität im Siedlungsraum. Zusammenfassung. Unpublizierter Bericht im Auftrag des Bundesamtes für Umwelt (BAFU) (http://www.biodivercity.ch/Summary_BiodiverCity_2010.pdf) (Zugriff 14.04.2017).

Hauck T. E., Weisser W.W. (2014): Animal-Aided Design. ISBN 978-3-00-047519-1

Jakoby C., Rogers R., Apfelbeck B., Hauck T. E., Weisser W.W. (2019): Wildtiere im Wohnumfeld – wie werden sie von Wohnungsunternehmen bewertet? Natur und Landschaft 5-2019.

Koch M., Wetzel G., Krämer L. (2019): Gutachten über Möglichkeiten zur Einbettung von Animal-Aided Design in städtebauliche, landschaftsplanerische und natur- und artenschutzrechtliche Planungsverfahren.

Kowarik I. (2011): Novel urban ecosystems, biodiversity, and conservation, Environmental Pollution 159(8): 1974-1983.

Kowarik I., Bartz R., Fischer L.K. (2016): Stadtgrün pflegen, Ökosystemleistungen stärken, Wildnis wagen! Informationen zur Raumentwicklung. Heft 6.2016: 741-748.

Nassauer J. I. (2007): Messy Ecosystems, Orderly Frames, in: Landscape Journal 14(2): 161-170.

Ratcliffe E., Gatersleben B., et al. (2013): Bird sounds and their contributions to perceived attention restoration and stress recovery. Journal of Environmental Psychology 36: 221-228.

Roden V. (2017): Urbane Biodiversität als städtebauliches Nachhaltigkeitskonzept, Tübingen.

Schmid H., Doppler W., Heynen D., Rössler M. (2012): Vogelfreundliches Bauen mit Glas und Licht. Schweizerische Vogelwarte, Sempach.

Shwartz A., Cheval H., et al. (2013): Virtual garden computer program for use in exploring the elements of biodiversity people want in cities. Conservation Biology 27: 876-886.

Soga M., Gaston K. J., et al. (2016): Both direct and vicarious experiences of nature affect children's willingness to conserve biodiversity. International Journal of Environmental Research and Public Health 13(6).

Statistisches Bundesamt, FS 5 R. 3, Bautätigkeit und Wohnen, Bestand an Wohnungen, Wiesbaden 2018.

Turrini T., Knop E. (2015): A landscape ecology approach identifies important drivers of urban biodiversity. Global Change Biology 21(4): 1652-1667.

Turner W. R., Nakamura T., et al. (2004): Global urbanization and the separation of humans from nature. BioScience 54(6): 585-590.

Witt R. (2014): Naturnahe öffentliche Grünpflege, was bedeutet das? Das Haarer Modell. Stadt+Grün 01/2014: 25-30.

REFERENCES – RED ADMIRAL

Carter D J, Hargreaves B. (1987): Raupen und Schmetterlinge Europas und ihre Futterpflanzen. Verlag Paul Parey, Hambutg, Berlin.

Schäffer A., Schäffer N. (2009): Schmetterlinge, Libellen und andere Wirbellose im Garten. Aula-Verlag, Wiebelsheim.

Willner W. (2012): Die Schmetterlinge Deutschland in ihren Lebensräumen. AULA Verlag, Wiebelsheim.

Schweizerischer Bund für Naturschutz (1987): Tagfalter und ihre Lebensräume. Arten – Gefährdung – Schutz. Fotorotar AG, Egg/ZH.

Koch M.(1996): Wir bestimmen Schmetterlinge. Neumann Verlag.

Tolmann T., Lewington R. (1998): Die Tagfalter Europas und Nordwestafrikas. Kosmos Naturführer, Stuttgart.

Ebert G. (1991): Die Schmetterlinge Baden-Württembergs Band 1 Tagfalter. Ulmer Verlag, Stuttgart.

Kudrna O., Pennerstorfer J., Lux K. (2015): Distribution Atlas of European Butterflies and Skippers. Wissenschaftlicher Verlag PEKS e.K., Schwanfeld.

http://www.floraweb.de/pflanzenarten/schmetterlingspflanzen.xsql

http://www.schmetterling-raupe.de

http://mecklenburg-vorpommern.nabu.de/tiereundpflanzen/insekten/schmetterlinge/15446.html

http://www.landesmuseum.at/fileadmin/user_upload/downloads/bio_steckbriefe/tiere/Vanessa_atalanta.pdf

http://www.pyrgus.de

http://schmetterlinge-deutschlands.de/

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Fig. 3 Taken from the Animal-Aided Design research project brochure; edited by T. E. Hauck, Wolfgang W. Weisser, 2015; financed by the Bavarian State Ministry for the Environment and Consumer Protection. Graphic: Sophie Jahnke, Rupert Schelle

Fig. 4 Graphic: Sophie Jahnke

Fig. 5 Graphic: Sophie Jahnke

Fig. 6 Graphic: Sophie Jahnke

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Fig. 8 Graphic: Sophie Jahnke

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Fig. 10 Plans based on draft design by Adler Olesch Landschaftsarchitekten, building: Dieziger Architekten; AAD plan: Christine Jakoby, Jan Piecha

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Cover illustration Sophie Jahnke

IMPRINT

This brochure was created as part of a preliminary study financed by the German Federal Agency for Nature Conservation for the testing and development project: Animal-Aided Design – Integrating Animal Needs Into the Planning and Design of Open Spaces.

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AAD plans
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The editors would like to thank the partners who worked with us on the preliminary study
Gemeinnützige Baugesellschaft Kaiserslautern AG, Wohnungsbaugesellschaft & WBV Wohnbau Betreuungs & Verwaltungs GmbH Salzgitter, VdK-Baugenossenschaft, Baden-Württemberg eG, Stuttgart,
Gundlach, Bau- und Immobilien GmbH & Co. KG, Hannover,
Wohnungsbaugenossenschaft Schwarzheide eG, Baugenossenschaft Hamburger Wohnen eG, Wohnwarft eG, Hamburg,
Gemeinnützige Wohnungsbaugesellschaft Ingolstadt GmbH,
Wohnungsbaugenossenschaft der Justizangehörigen Frankfurt am Main e.G.

The editors would like to thank the members of the project working group for their professional support and advice
Sven Baumung, Derk Ehlert, Stefan Feller, Stefanie Hennecke, Betina Küchenhoff, Herbert Lohner, Andreas Malten, Andreas Mengel, Timm Reinhardt, Volker Rothenburger, Christian Voigt, Barbara Warner, Rudolf Wittmann

With thanks for his suggestions and advice to
Klemens Steiof

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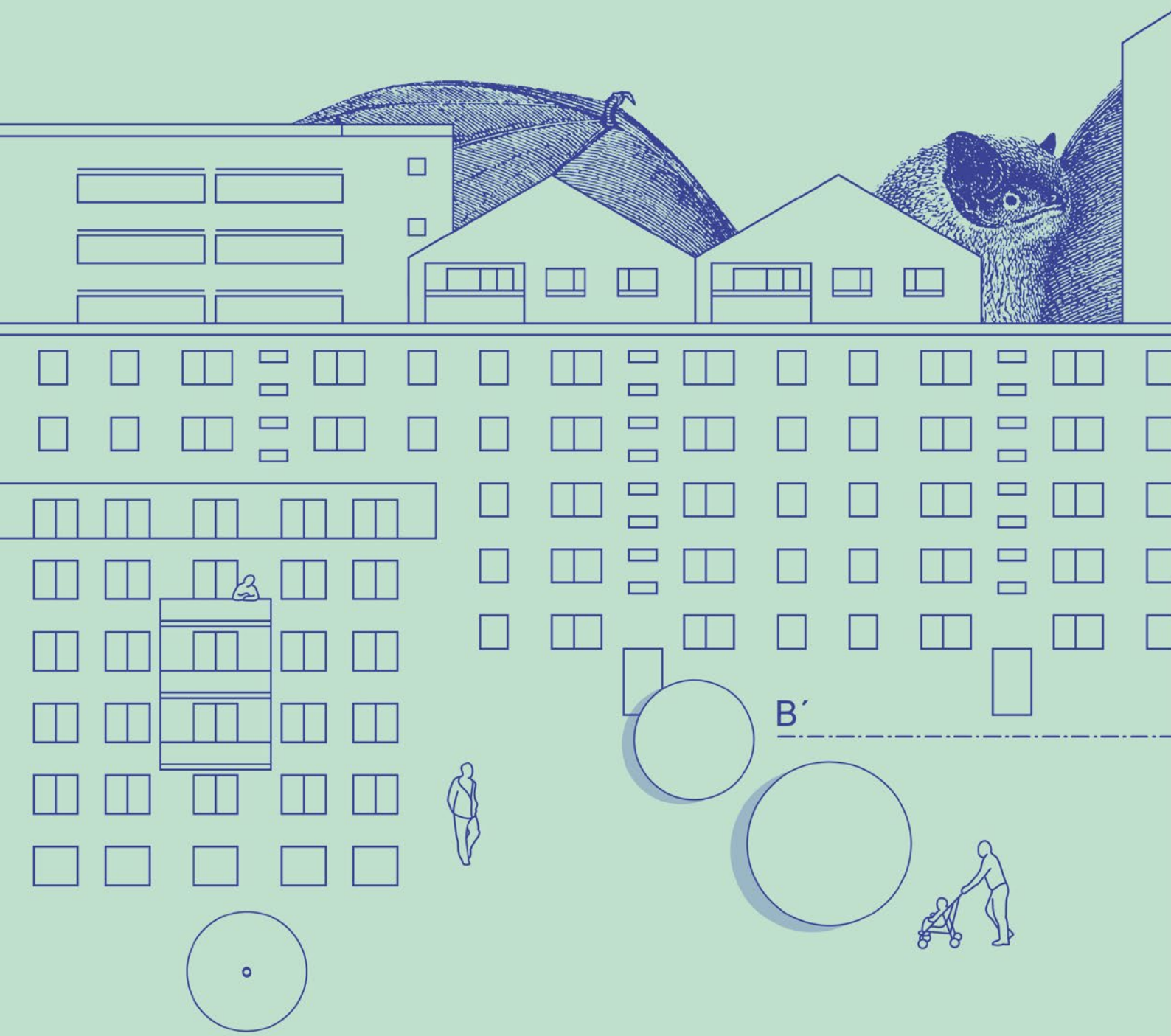

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Gefördert von:

Bundesamt für Naturschutz