# Biodiversity and the urban-rural interface: conflicts vs. opportunities - Proceedings of an International Workshop in Linde, Germany

Ulrich Zeller, Gad Perry, and Thomas Göttert (eds.)


Third International Workshop within the project

*"Land use conflicts and edge effects – a comparative approach"*



# Workshop

# "Biodiversity and the urban-rural interface: conflicts vs. opportunities"

## Linde, 24th – 27th September 2018

**U. Zeller[1], G. Perry[2], and T. Göttert[1] (eds.)**

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**DOI:** https://doi.org/10.18452/19995


## Content



# Prologue

*Ulrich Zeller, Thomas Göttert,* Germany

We are pleased to introduce our international workshop entitled "*Biodiversity and the urban-rural interface: conflicts vs. opportunities*", which takes place between the 24th and the 27th of September 2018 in Linde, Germany. This workshop marks the third annual academic event within our project "*Land use contrasts and edge effects – a comparative approach*", affiliated with the Systematic Zoology Division at Humboldt-Universität zu Berlin and supported by the Zwillenberg-Tietz Stiftung (foundation). The event follows on from the discussions and results achieved within the previous workshops of this project, entitled "*Biodiversity and land use – a comparative approach*" (Zeller et al. 2016) and "*Connecting biodiversity and improving human livelihood beyond boundaries – a global perspective*" (Zeller et al. 2017a). Our third workshop aims at comparatively examining interrelations between land use and biodiversity using the example of urban-rural interfaces.

While in 2014, 54% of the global human population lived in urban areas, this proportion is likely to increase to 66% by 2050 (United Nations 2014). Urbanization, a specific form of land use and a strong example for human transformation processes, is often viewed as a threat to global biodiversity (e.g. Grimm et al. 2008). However, there is an increasing appreciation of the positive effects associated with urban biodiversity (Beninde et al. 2015, Goddard et al. 2010), such as high levels of ecological parameters in view of certain taxa (e.g. vascular plant species richness), increasing numbers of formerly reclusive bird and mammal species (Figure 1), as well as immaterial aspects of urban biodiversity (Robischon 2015). Since we are witnessing an alarming decrease in the species richness and population size of several taxa associated with rural areas (e.g. grassland-associated bird and arthropod species) following agricultural intensification (Zeller et al. 2017b), the perspective on urban areas is currently changing in terms of providing potential habitats that may become crucial for the survival of some of these taxa.

However, the interrelations between biodiversity and urbanization cannot be properly understood when focusing exclusively on urban biodiversity. Instead, suitable approaches and study designs are needed, which address the organismic abilities and limitation of taxa associated with urban environments (e.g. spatial requirements, life history strategies), as well as region-specific land use practices and habitat features of the landscapes adjacent to cities, including reasonable spatial scales and carefully selected taxa. Thus, we are dealing with the term "urban-rural interface" in a holistic manner and not solely in terms of a singular research concept. By comparing case studies from different regions, we aim at differentiating between case- or region-specificity of biodiversity-urbanization-interactions on the one hand, and universally applicable phenomena and management strategies on the other hand.

**Figure 1.** Bird species photographed at one-and-the-same structure in Berlin, a Benjes-hedge in the Treptow-Koepenick District. Besides species typically associated with urban areas (upper pictures), such as song thrush (*Turdus philomelos*), common blackbird (*Turdus merula*) and house sparrow (*Passer domesticus*), this structure is also used by species that are associated with open grasslands (lower pictures): red-backed shrike (*Lanius collurio*), northern wheatear (*Oenanthe oenanthe*) and golden bunting (*Emberiza citrinella*). Photos: T. Göttert.

Berlin and the venue of this workshop, the Linde research station, provide a good example for established relationships along an urban-rural interface. The former Linde-estate or Linde-farm (Gut Linde), today a research station, is an ideal location for reflections on the dynamics between biodiversity and land use. The concept of sustainability that characterized former estates (such as Linde) went along with a prosperous development of business activities in the city (Berlin). Another example for urban-rural-relationships between the city of Berlin and the adjacent rural areas is Berlin's waste water disposal system, which was based on Rudolf Virchow's concept of improving urban hygiene standards and which was realized by James Hobrecht`s radial system to pump the water out to irrigation beds ("Rieselfelder") at the city outskirts (Moss 2000).

The city of Berlin and its adjacent landscapes provide a unique scenario with sharp contrasts at the city borders, where densely settled urban habitat types meet sparsely populated rural landscapes, a situation that is strongly linked with the history of the city and the country. Today, a number of protected areas of high value for nature conservation (e.g. Special Protected Areas, SPA) are situated in close vicinity to the city borders (Figure 2). We will give an introduction to selected research projects and associated degree theses supervised at the Systematic Zoology Division. Regional focus is on the surroundings of the Linde research station and the Havelland region. In order to address the urban-rural context and the case-specificity of the city of Berlin and its surrounding landscapes, pilot studies in the city of Berlin were also conducted.

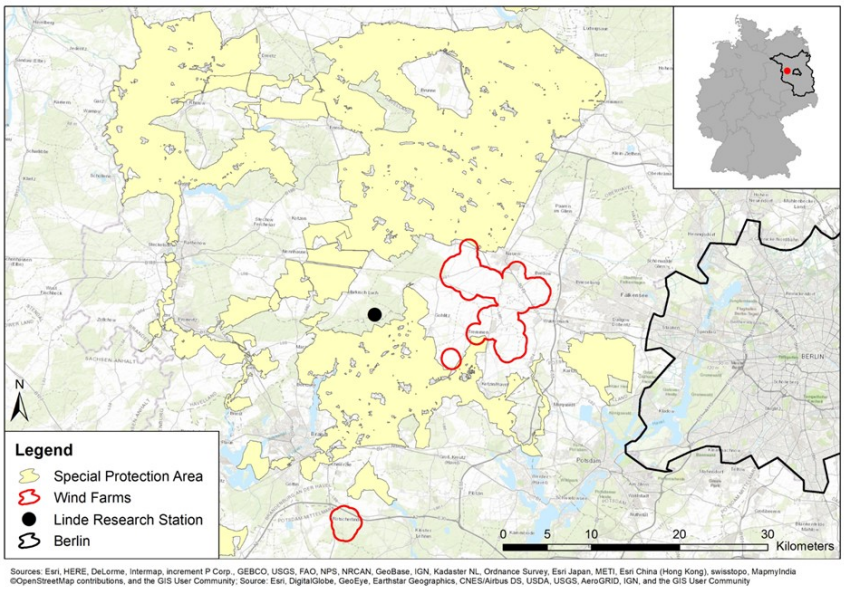


**Figure 2.** Wind farms between Special Protection Areas in Brandenburg and the city of Berlin increase the complexity of interrelations between land use and biodiversity along an urban-rural gradient.

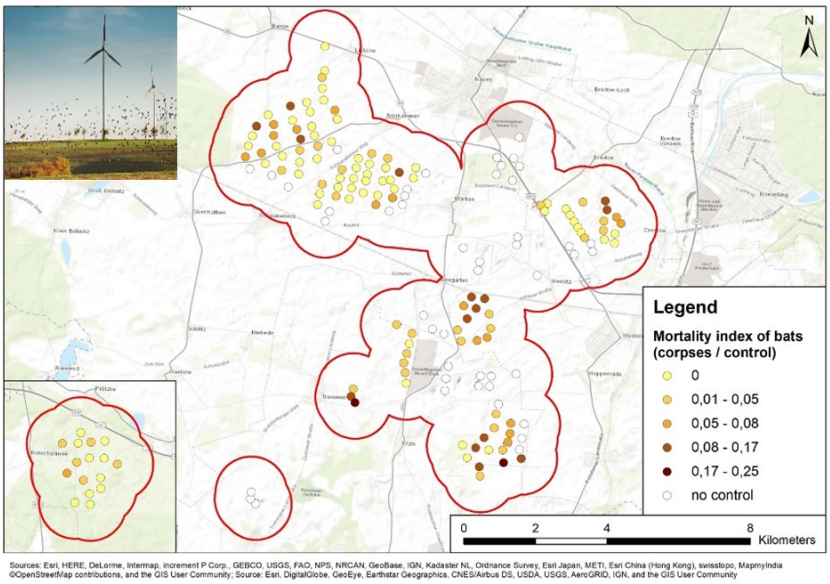


**Figure 3.** Mortality index of bat corpses collected at individual wind turbines of the wind farm "Nauener Platte". Data collection period: Aug 2001– Sep 2010; n = 130 wind turbines; n = 4734 controls; data: T. Dürr, J. Franke, M. Heiß, F. Weihmann, M. Putze, W. Seeker, S. Jakob, E. Abe, E. Glabsch, D. Endlich, S. Bengsch, N. Starik, A. Hohnstein, S. Tiedt, C. Kuhlmann, N. Andreas, M. Schulte, A. Ramm, N. Bunzel, A. Thamm, A. Schatton

A common feature of these projects is an organismic approach – the investigation of ecological response patterns of carefully chosen taxa on an organismic level, including adequate methodological setups and designs regarding the specific requirements of these taxa. Besides birds (Kübler 2005), taxonomic focus is on amphibians (Lissamphibia) and bats (Chiroptera). Owing to their life history strategies and ecological adaptations, these groups appear especially suitable to indicate effects of different types of land use (including urbanization) on biodiversity along an urban-rural gradient using the example of the city of Berlin. Several field studies on the influence of different forms of land use (e.g. wind turbines [Figures 2, 3], agricultural and silvicultural practices) on bat communities in the Havelland region revealed that certain bat species appear suitable to reflect changes resulting from management practices and land use intensity (Blaue 2013, Geschke 2017, Starik 2016, Starik et al. in press). Pilot studies within the city of Berlin confirmed the occurrence of some of these species (Limberger & Rinke 2015) and point towards the applicability of the concept of bioindication using bats. Studies on the occurrence and relative abundance of different amphibian species in the outskirts of Berlin (Ulbrich 2012), as well as inside the city (Sieg 2015, Heinrich 2016, Röwert 2016, Jantzen 2017, Koordinierungsstelle Fauna, Stiftung Naturschutz Berlin 2017), use the suitability of amphibians to serve as indicators for habitat quality along an urban-rural gradient. This is linked with the strong interrelations among the numerous water bodies and river systems that connect the city of Berlin with its surrounding areas (Figure 4).

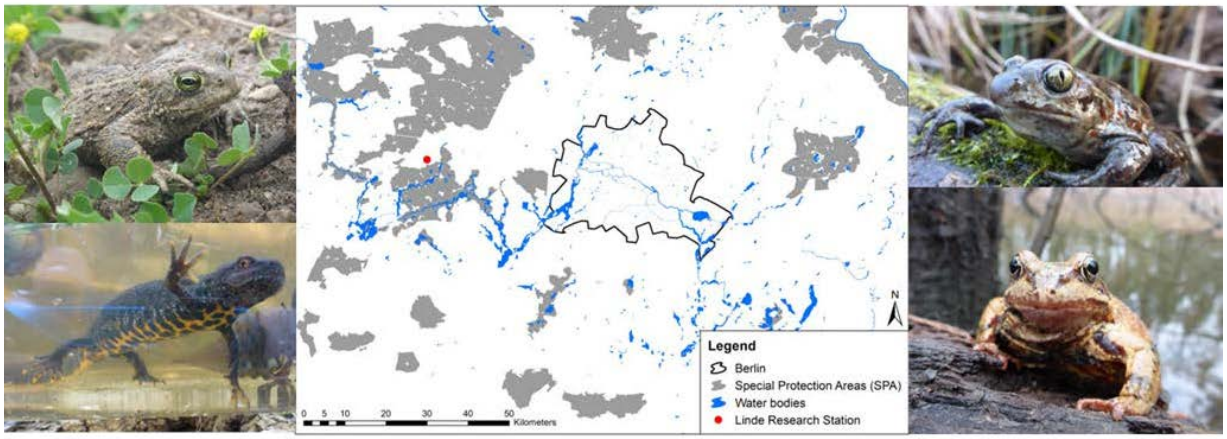


**Figure 4.** Distribution of rivers and water bodies reveals a strong connection between the city of Berlin and its surrounding landscapes, including protected areas. Water-associated taxa, particularly amphibians such as (*Epidalea calamita*), common spadefoot (*Pelobates fuscus*), great crested newt (*Triturus cristatus*) and common frog (*Rana temporaria*) might be used as environmental indicators to address this urban-rural-interface. Map: C. Fiderer; photos: S. Bengsch.

During our workshop, we envisage contributions from a broad community of participants. Among others, the workshop will include the following key aspects:

- Effects of urbanization on biodiversity
- Nature vs. urbanization: conflicting or supporting phenomena?
- Different perceptions towards human-wildlife conflicts among people living in urban and rural areas
- Human–wildlife interactions in urban areas: conflicts, benefits and opportunities
- Urban biodiversity hotspots - protected areas within or at the border of urban areas
- Urban farming and urban gardening
- Biodiversity in megacities
- Increasing intra-urban biodiversity by interlinking urban greenspaces

The goal of our workshop is to achieve a synthesis of research experience concerning both, urban and rural habitat types and elements of biodiversity. The workshop intends to catalyze effective interactions and discussions among scientists and practitioners dealing with the topic of "urban-rural interfaces" in a wider sense - in different geographical and regional contexts and under different ecological conditions. We are looking forward to fruitful discussions in order to verify generally applicable management strategies to address conflicts, benefits and opportunities concerning biodiversity at the urban-rural-interface.

We would like to express our thanks to all participants for their contributions. In particular, we wish to thank Humboldt-Universität zu Berlin and Zwillenberg-Tietz Stiftung.

Berlin, September 2018

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# Programme

*Biodiversity and the urban-rural interface: conflicts vs. opportunities*
*Linde, 24th-27th September 2018*

## Monday, 24th of September

*Arrival*

17.00h *Musical introduction, Humboldt-Quartett (violin: Emi Otogao & Miriam Götze; viola: Matthias Zollitsch; violoncello: Katja Kerstiens)*

**U. Zeller (Germany, HU):** Welcoming notes

*Come together and refreshments*

18:30h *Dinner*

## Tuesday, 25th of September

09.00h **U. Zeller & T. Göttert (Germany, HU):** Biodiversity and the urban-rural interface: conflicts vs. opportunities – an introduction

10.00h **M. Suarez-Rubio (Austria, BOKU):** Effects of urbanization on birds and bats

10.45h *Coffee and Tea*

11.15h **A. Meschede (Germany, HU):** Urban-rural lifestyle – requirements of the greater mouse-eared bat (*Myotis myotis*)

12.00h *Discussions*

12.45h *Lunch break*



## Tuesday, 25th of September (ongoing)

| | |
|---|---|
| 14.00h | **G. Perry (USA, TTU):** Urban ecology research at Texas Tech University |
| 14.45h | **M. Fidino (USA, Lincoln Park Zoo):** Advancing urban wildlife research through a multi-city collaboration |
| 15.30h | *Coffee and Tea* |
| 16.00h | **H. Hoffmann (Germany, HU):** The contribution of Urban Gardening and Urban Agriculture to biodiversity in cities |
| 17.30h | **M. Sultana (Germany, Uni Freiburg):** Collecting citizen's wildlife observations– experiences from two case studies in Freiburg im Breisgau, Germany |
| 18:30h | *Dinner* |

## Wednesday, 26th of September

| | |
|---|---|
| 9.00h | **V.-L. Fraser-Celin (Canada, UofG):** Human conflict over wildlife: exploring social constructions of African wild dogs (*Lycaon pictus*) in Botswana |
| 9.45h | **C. Fiderer (Germany, HU):** Movement patterns and habitat preferences of red foxes (*Vulpes vulpes*) and raccoons (*Procyon lotor*) in a Special Protection Area in the close vicinity of Berlin |
| 10.30h | *Coffee and Tea* |
| 11.00h | **M. Robischon (Germany, HU):** Biodiversity past and present in explorative place-based learning |
| 11.45h | **A. Planillo (Germany, IZW):** Importance of interspecies relationships in urban wildlife communities |
| 12.30h | *Lunch break* |



## Wednesday, 26th of September (ongoing)

| | |
|---|---|
| 14.00h | **L. Martins Fontoura (Brazil, UFRRJ):** Public use and biodiversity conservation in National Parks in Brazil and the United States |
| 14.45h | **L. Martins Fontoura:** How much is green worth: the economic importance of Brazilian protected areas |
| 15.30h | *Coffee and Tea* |
| 16.00h | **M. Willkomm (Germany, Universität zu Köln):** Land use and land cover dynamics in the urban-rural interface of small and medium-sized cities in sub-Saharan Africa: empirical insights from Nakuru, Kenya |
| 16.45h | **T. Rottstock (Germany, HU):** Land use changes and their impact on the agro-biodiversity in Tanzania - A case study from the Serengeti Mara Ecosystem |
| 17.30h | *Discussions* |
| 18.30h | *Barbeque* |

## Thursday, 27th of September

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|---|---|
| 9.00h | Excursion to Westhavelland Nature Park, visiting State Bird Observatory & Field Centre Buckow (Dr. T. Langgemach) |
| 12.30h | *Lunch* |
| From 13.30h | *Departure* |

# Abstracts and extended abstracts of presentations



**Movement patterns and habitat preferences of red foxes (*Vulpes vulpes*) and raccoons (*Procyon lotor*) in a Special Protection Area in the close vicinity of Berlin**

*Christian Fiderer*, *Thomas Göttert*, *Ulrich Zeller*, Germany

In this study, we examined the carnivore community (Carnivora, Mammalia) in a landscape mosaic of urban and rural areas in a Special Protection Area (SPA) near the Linde research station and in close vicinity to the city of Berlin. In order to assess the predatory impact of carnivores on the SPA's ground-nesting bird community, special focus was laid on the movement patterns and habitat preferences of the two most abundant carnivore species: red fox (*Vulpes vulpes*) and raccoon (*Procyon lotor*).

Between August 2015 and June 2017, we carried out a camera- and live trapping of carnivores and used GPS-telemetry for a detailed analysis of spatial behavior of nine adult raccoons and six adult red foxes over a period of 20 months, conducting one of the first GPS-telemetry studies of raccoons in Germany. Animals were captured with baited box traps that were set along obligatory passages such as ditches, fences, lakesides or walls, and retrieved into transfer boxes for immobilisation and further handling.

Camera-trapping (4,684 trap nights) and live-trapping (2,543 trap nights) of carnivores revealed that the SPA hosts virtually all terrestrial carnivore species that occur in Germany. Spatial distribution patterns of both species recovered a strong difference: raccoons showed high site fidelity and a year round preference for reed swamps and shrub swamps, clustering along the fringes of water bodies, while red foxes were more evenly distributed and showed a preference for deciduous forests and reed swamps. Red foxes (and to a lower extend raccoons) partly showed a high nocturnal preference of urban areas and red foxes showed a pronounced level of migratory activity when compared to raccoons.

Long-distance movements of a red fox from rural areas to the city of Berlin and vise versa highlight an existing transition between urban and rural habitats. Moreover, the size of individual home ranges and core areas of red foxes was significantly negatively correlating with the proportion of urban and semi-urban areas regarding the total home range of the respective animals. The results of this study illustrate the role of settlements / urban areas regarding the spatial behavior and movement patterns of carnivores in this study region. These findings will help to get a better understanding of the spatial behavior of red foxes and raccoons in an integrated landscape, in order to derive management recommendations for sustainable land use strategies.


**Figure 1.** Especially red foxes (right photo) and - to a lower degree - also raccoons (left photo) frequently used human settlements. Photos: C. Gossmann

**Advancing urban wildlife research through a multi-city collaboration**

*Mason Fidino, Travis Gallo, Matthew P. Mulligan, Maureen H. Murray, M. Jazmín Rios, L. Lehrer, Seth B. Magle,* United States

Urban wildlife research has the capacity to guide future interactions and co-existence between humans and wildlife in developed and developing regions. Yet, most urban wildlife research is limited to short-term, single-species studies and typically conducted within a single city. As cities around the world vary considerably in size, geography, age, culture, growth patterns, and land use, there is no doubt uncertainty as to whether results from one city generalize to others. To overcome these limitations and determine how variability within and among cities influence urban biodiversity, we have designed a pioneering research network, the Urban Wildlife Information Network (UWIN), where partners collaborate across multiple cities to collect long-term, systematic, multi-species data.

UWIN's research design, which has been implemented in Chicago, Illinois, USA since 2009, is centered on the establishment of research sites along spatial gradients of urbanization. Sites are selected along each city's urbanization gradient and encompass a swath of potential wildlife habitat including nature preserves, city parks, golf courses, cemeteries, and backyard habitat. To date, a central focus has been on monitoring medium and large mammals through the use of motion-triggered cameras, though UWIN's research design is general enough such that sampling for other taxa (e.g., birds, arthropods, amphibians, etc.) is supported.

Here, we briefly present our past research from Chicago, which motivated the development of UWIN, as well as an analysis of mammal communities from seven cities across the United States. This multi-city analysis suggests that common species are similar across cities, but rare species are remarkably different. Further, the relative occupancy rates of urban mammals varies greatly across cities, indicating that a city's size and configuration may influence species distributions within and between metropolitan areas. As UWIN continues to grow it will continue to advance knowledge and improve our ability to plan and manage cities to support biodiversity.

## Revealing 'human conflict over wildlife' through different stakeholder representations of African wild dogs (*Lycaon pictus*) in Botswana, Africa

*Valli-Laurente Fraser-Celin,* Canada

Keywords: Human-wildlife conflict, human conflict over wildlife, African wild dogs (*Lycaon pictus*), Botswana

### The Urban-Rural Interface and Human-Wildlife Conflict

While human-wildlife conflict occurs predominately in rural areas, it is increasingly occurring on the 'urban fringe' (Manfredo & Dayer, 2004). Sub-Saharan Africa, in particular, is undergoing rapid urbanization (Hiemstra-van der Horst & Hovorka, 2008); at the same time, rural spaces hold important resources, such as livestock animals. While livestock are present in urban areas in Botswana (Hovorka, 2006), cattle underpin the rural economy and are prevalent in rural areas throughout the country (Hoon, 2004). Livestock animals are kept at 'cattleposts' either on the urban fringe or outside of urban areas, where they are often left unattended both throughout the day and at night to graze (Valeix, Hemson, Loveridge, Mills, & Macdonald, 2012). Cattle are the backbone of Botswana's national economy and are socially and culturally significant to Batswana (Hoon, 2004). In Botswana, cattle are often referred to as a "God with a wet nose" (Hoon, 2004, p.149) and 40% of households own cattle, demonstrating their socio-cultural and national importance (National Development Plan 10, 2016).

At the same time, wildlife tourism has become an important avenue for rural economic development in Botswana. Wildlife tourism goes hand-in-hand with conservation (Rihoy & Maguranyanga, 2010). The rise of urbanization leading to human encroachment on wildlife habitat, alongside other activities, such as cattle rearing in rural areas where wildlife occur, result in increased contact between humans and wildlife. This contact leads to various incidents of human-wildlife conflict, for example livestock depredation by large carnivores and crop destruction by elephants. The rise of wildlife tourism and conservation in rural areas in Botswana presents: 1) opportunities within the urban-rural interface for broadened diversification of the country's economic development; and 2) conflicts between engaged stakeholder groups.

*Human conflict over wildlife*

Researchers are increasingly recognizing that human-wildlife (HWC) can be better understood as conflict between humans over wildlife. Typically, human conflict over wildlife involves conflict over the management, appropriate place and value of wildlife and over development goals and competing priorities between different stakeholder groups who are either affected by wildlife or who manage wildlife and incidents of HWC (Dickman, 2010; Fisher, 2016; Madden, 2004; Marshall, White, & Fischer, 2007; Peterson et al., 2010; Redpath, Bhatia, & Young, 2015; Yurco, King, Young, & Crews, 2017).

Moreover, rather than focusing simply on quantifying losses and managing wildlife, there has been a growing recognition that effective long-term mitigation strategies must also focus on the political-economic, socio-cultural, and historical drivers of conflict (Bond & Mkutu, 2017; Dickman, 2010; Goldman, Roque De Pinho, & Perry, 2010; Madden, 2004; Madden & McQuinn, 2014; Massé, 2016; Muir, 2009; Peterson et al., 2010; Rust, Tzanopoulos, Humle, & MacMillan, 2016). For example, Rust et al. (2016) argue that wildlife become "peripheral players pulled into the debate of wildlife management by individuals who hold contrasting values, whereas the true causes of the conflict often lie more deeply in cultural, historical, political, and sociological factors" (p.2).

I argue that by exploring the way wildlife are portrayed by different stakeholder groups, we can illuminate the issues that cause human conflict over wildlife and by extension, 'human-wildlife conflict on-the-ground' in the rural-urban interface. I use a case study of African wild dogs (*Lycaon pictus*) in Botswana, Africa to reveal how different meanings given to wild dogs by three stakeholder groups (e.g. agricultural, wildlife tourism, and conservation industries) reflect different political-economic and socio-cultural trends in the country, competing economic development trends at the urban-rural interface, and stakeholder groups' contrasting attitudes, values, priorities, and experiences concerning wild dogs.

*African Wild Dogs (Lycaon pictus)*

Large carnivores, including African wild dogs (Fig. 1), present a threat to cattle and they are often killed or injured in retaliation or as a preventative measure to livestock depredation (Fraser-Celin, Hovorka, Hovorka & Maude, 2017). Primarily because of habitat loss due to urbanization which leads to conflict with farmers, road incidents, and disease passed from domestic dogs, wild dogs are the most endangered large carnivore in sub-Saharan Africa. There are only 6,600 individuals remaining on the continent, 1310 of which are located in Botswana. Wild dogs are therefore a significant conservation concern and conflict mitigation is a conservation priority (Woodroffe & Sillero-Zubiri, 2012).

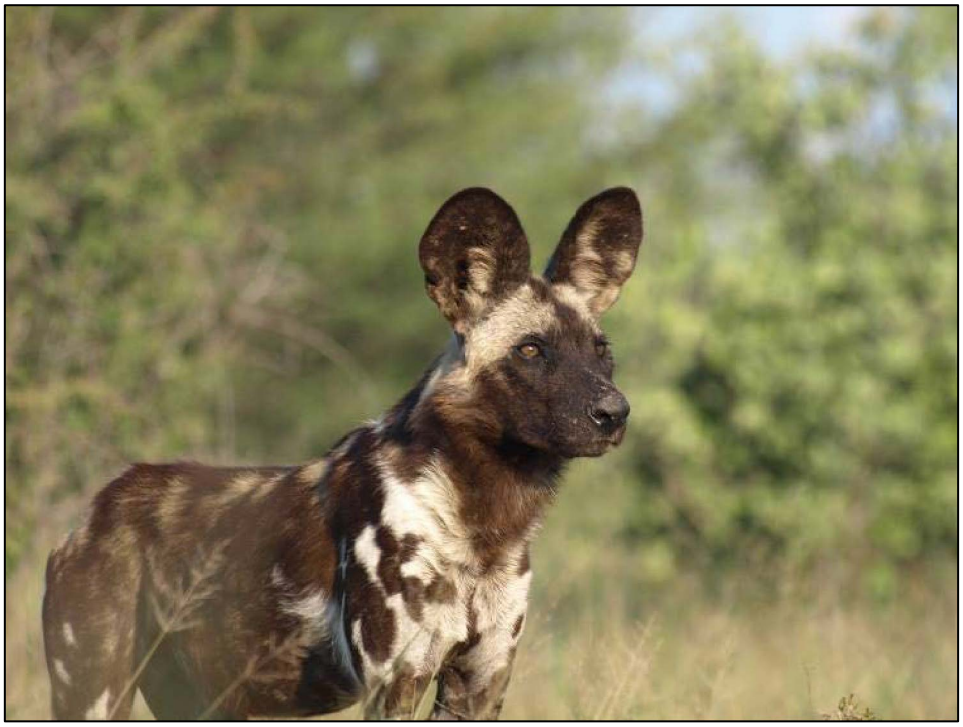

**Figure 1.** African wild dog (*Lycaon pictus*), Photo by Valli-L. Fraser-Celin

Methods Overview: Sampling, Data Collection and Analysis

I conducted 113 semi-structured interviews with stakeholders from the agriculture (n=74), conservation (n=16), and wildlife tourism industries (n=23) in 2013 and in 2015 in four study sites in Botswana (Fig 2). In 2013, I interviewed subsistence and commercial cattle farmers in two study sites (Central Boteti and Kweneng East). In 2015, I interviewed individuals from all three stakeholder groups in two study sites (Maun and the Modisa Wildlife Project). I also used document gathering and participant observation to supplement and triangulate interview data (Flick, 2004). I analyzed the data qualitatively, conducting a content analysis of the interview and document data (Elo & Kyngäs, 2008). I initially used open coding to develop themes followed by selective coding; I used keyword-in-context and word/sentence repetition to further identify themes in the data (Ryan & Bernard, n.d.).

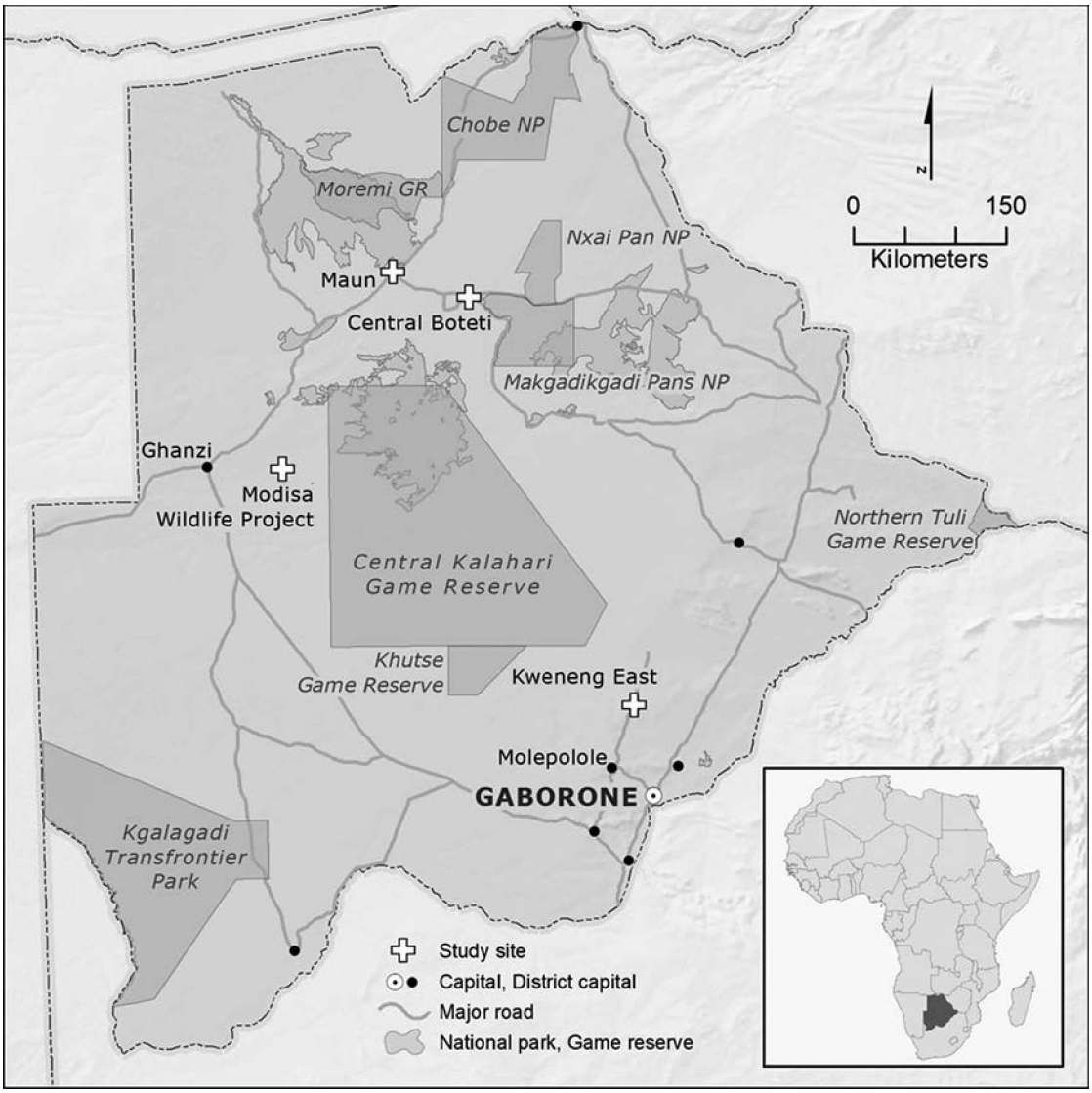


**Figure 2.** Study sites in Botswana, Africa

## Representations of Wild Dogs in Botswana

By exploring different meanings given to African wild dogs (*Lycaon pictus*) by different the three stakeholder groups in Botswana (i.e. individuals in the agricultural, conservation, and wildlife tourism industries), we can see how 'human-wildlife conflict' manifests as 'human conflict over wildlife'. Wild dogs are described as problem animals by individuals in the agricultural industry; as an endangered species by individuals in the conservation and wildlife tourism industries, and as an economic resource by all three stakeholder groups.

*Problem Animals*

Wild dogs were regarded as problem animals by individuals involved in the agricultural sector. Participant experiences were often stressful and participants, especially rural subsistence cattle farmers, often felt helpless: "There is nothing we can do. The destruction is growing" and "They pulled me down by killing three of my cows". Attitudes were therefore predominately negative toward wild dogs with participants using words such as 'poverty' and 'destroy' to characterize wild dogs. Individuals explained that wild dogs should remain in conservation areas, rather than being allowed to roam freely in rural areas where livestock are present.

*Endangered Species*

Wild dogs were regarded as an endangered species by individuals involved in the conservation and wildlife tourism sectors. Human population growth accompanied by urbanized expansions into rural areas creates an urban-rural fringe where humans, their livestock, and wildlife meet, threatening human livelihoods and wild dog lives. As one wild dog researcher explained: "[Wild dogs have] been very successfully eradicated from landscapes in which people have taken over wilderness to use resources for domestic grazing livestock." Habitat conservation and keeping wilderness areas from further urbanization were described as important conservation strategies by participants. Conflict mitigation through conservation education was also described as a way to conserve wild dogs and minimize livestock depredation.

*Economic Resource*

Wild dogs were regarded as an economic resource by individuals across all three industry sectors. Botswana's Vision 2036 recognizes "the multi-functional roles of biological diversity (animals and plants) as economic resources" (Statistics Botswana, 2016, p.22). While individuals in the agricultural sector did express negative attitudes toward wild dogs, they still acknowledge the importance of wild dogs for the national economy through wildlife tourism, as some farmers explained: "[Tourism is] pumping a lot of money into Botswana" and "this money [from tourism] is also being used for development". Individuals in the tourism industry described being 'excited' and 'happy' to see wild dogs on safari. Individuals in the conservation industry described tourism as a way to conserve habitat for wild dogs. Wild dogs, and other wildlife, were regarded as a way to bring money into the country and promote wildlife conservation, which, in turn, benefits the country economically through safaris in Botswana's Game Reserves and Protected Areas.

Discussion

Three trends emerged from this study. First, wild dogs were represented in two competing ways: as problem animals by the agricultural industry and as an endangered species by the wildlife conservation and tourism industries. Second, all three stakeholder groups regarded wild dogs as an economic resource. Third, all three representations of wild dogs are driven by and symbolic of political-economic and socio-cultural trends and competing development strategies in Botswana.

The problem animal and endangered species representations reveal human conflict over wildlife characterized through stakeholder groups' different attitudes, experiences, and conflict mitigation strategies. Individuals in the agricultural industry described keeping wild dogs inside Protected Areas as a way to promote coexistence. On the other hand, individuals in the wildlife conservation and tourism industries discussed habitat conservation and conservation education as a way forward. While the agricultural industry prioritizes livestock and the separation of cattle from wildlife, the conservation and wildlife tourism industries value wildlife and sharing spaces while minimizing conflict. These competing wild dog conservation and conflict mitigation strategies reflect the disconnect among stakeholder groups.

However, all three stakeholder groups represented wild dogs an economic resource, describing wild dogs as beneficial to the country. More specifically, that wild dogs were seen as an economic resource by farmers in particular should be capitalized on through local decision-making and involvement in tourism and conservation (Mbaiwa, 2017). Wild dogs and other wildlife present an opportunity to increase tourism development. This could lead to employment opportunities and increased economic growth, both locally and nationally. Tourism may therefore assist in reducing farmer antagonism toward wild dogs and conservation.

The diverging meanings of wild dogs presented here reveal the human dimensions of conflict that are often the overlooked, yet underlying drivers of human-wildlife conflict. Recognizing these broader social drivers as well as different stakeholder groups' competing interests, priorities, and values as well as feelings of injustice and hopelessness, are important for addressing human conflict over wildlife. Two mitigation strategies – recognizing human conflict over wildlife and integrative management plans – may help in increased and continued meaningful engagement with communities affected by conflict, as well as more collaboration and communication between stakeholder groups (Darkoh & Mbaiwa, 2009; Madden, 2004; Madden & McQuinn, 2014; Redpath et al., 2015).

## Conclusion

Urbanization causes humans and wildlife to come into increased contact, especially at the urban-rural interface, or 'urban fringe' (Manfredo & Dayer, 2004). Mitigating any conflict that may occur is an important conservation strategy, as well as a means of safeguarding people's livelihoods, safety, and well-being in these spaces. However, positioning human-wildlife conflict as conflict between humans and wildlife instead of between different stakeholder groups masks the reality of the broader social drivers of conflict, such as urbanization processes, political-economic and socio-cultural contexts and conditions, and competing development trajectories (Madden, 2004; Peterson et al., 2010). The different meanings of wild dogs described in this paper illustrate human conflict over wildlife, rather than conflict between humans and wildlife, by demonstrating how different stakeholder groups have contrasting values, priorities, and management strategies concerning wild dogs as well as competing economic development strategies (e.g. agriculture versus wildlife tourism and conservation). Portraying human-wildlife conflict as human conflict over wildlife, as well as developing stronger collaborative integrative management planning, are two conflict mitigation strategies that address human conflict over wildlife which may be more sustainable in the long-term.

## Acknowledgements

Thank you to the Government of Botswana, especially the Department of Wildlife and National Parks, as well as the Department of Environmental Science, University of Botswana, and Dr. Glyn Maude from the Kalahari Research and Conservation (KRC) group for their in-kind support and assistance. We are grateful for the information provided by those who participated in the study as respondents and key informants. The research was generously funded by the Social Sciences and Humanities Research Council of Canada.

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## The contribution of Urban Gardening and Urban Agriculture to biodiversity in cities

*Heide Hoffmann*, Germany

Today more than half of the world's population lives in urban areas and cities have become extremely dense. Green spaces in cities, which are natural habitats for flora and fauna, are therefore of particular importance. At the same time, they are particularly endangered by the dense development. Originally, gardens and vegetation in green spaces around and within settlements inspired human history and art. The term “garden” means in Persian ‘paradise’( pairi-daēza), a word for a fenced area.

The vision of paradise has influenced the idea of humanity from the heaven on earth due to the high biodiversity. That means, urban gardening is not a new concept, but it is now more important than ever with climate change and population growth and urbanization.

Today, urban agriculture can be defined shortly as the growing of plants and the raising of animals within and around cities. The most striking feature of urban agriculture, which distinguishes it from rural agriculture, is that it is integrated into the urban economic and ecological system: urban agriculture is embedded in -and interacting with- the urban ecosystem. The city farmers often have no vocational training in agriculture. They are usually not for-profit and their products are distributed along short supply chains.

In industrialized countries, a growing number of community gardeners and start-up entrepreneurs are practicing mainly in allotment gardens and backyard gardens and, more recently, on roofs or in enclosed spaces as Aquaponic plants. In developing countries, urban agriculture is a source of income and self-consumption. In support of developing countries, the FAO launched in 2001 a multi-disciplinary Food for Cities initiative designed to ensure urban people's access to safe food and healthy and safe habitats. Both in industrialized and in developing countries, urban agriculture enhance the biodiversity by diversity of species and ecosystem equally.

Urban agriculture makes use of unused spaces, combines multiple objectives in new ways, and develops new concepts and techniques. It is therefore regarded as innovative, and contributes to sustainable urban development. Today, the urban gardening and agriculture deals with the complex problems of growing plants in urban areas. They provide multiple functions and benefits to urban dwellers and cities. New technologies and methods of farming and gardening in urban environments are being rapidly developed to supplement the current food supply in cities and encourage urban greening to improve the environment.

Challenges for cities are:

- Feeding an increasing population in the cities.
- Creating new services and job opportunities.
- Developing and sustainable resource management, which also includes the biodiversity of a city.

Moreover, it needs green areas and green corridors that connect the cities with their environs, ensuring the creation and future preservation of livable and vibrant cities. The green network for cities includes different forms of urban gardening and urban agriculture, such as community gardens, allotments, backyard gardens, farmyards, vertical farming, school gardens, and roof gardens. There are also other elements such as parks, roadside greening, and rail track greening. These are not only important for the flora, but also for the fauna.

Urban agriculture - including urban gardening - can improve the biodiversity and ecosystem services of a city through targeted, regionally adapted cultivation methods and garden design.

**Figure 1.** Examples for urban gardening activities: community garden in New York City, USA (upper left), hospital garden in Windhoek, Namibia (upper right), roof garden in Berlin (lower left) and allotment sites in Berlin (lower right); photos: H. Hoffmann

**Urban-rural lifestyle – requirements of the greater mouse-eared bat (*Myotis myotis*)**

*Angelika Meschede*, Germany

One of the biggest European bat species, the greater mouse-eared bat (*Myotis myotis*), expanded its range from southern Europe to central Europe after the last ice age by following humans. Usually building nursery colonies in warm natural caves in the Mediterranean region, this species needed adequatly tempered roost sites to raise their young. In central Europe, these were provided by human constructions, i.e. the attics of big buildings.

The presentation will focus on the ecology of this bat species, including roosting and foraging requirements, population dynamics, seasonal movements etc. While female colonies only roost in spacious rooms and therefore need the attics of buildings, solitarily living individuals also settle in tree holes or bat boxes. *Myotis myotis* hunts almost exclusively in forests, even if they are located more than 10 km away from the roosts, making this lifestyle an urban-rural one.

Populations of greater mouse-eared bats in central Europe declined dramatically during the 1960s and 1970s and are only recovering slowly, but not to full sizes from this collapse over the past three decades. Recent nationwide data analyses suggest regionally differing developments. Voluntary bat workers and conservation efforts had a huge impact in the recovery of this species. Like other European bat species, *Myotis myotis* seasonally moves from local summer areas to winter areas for underground hibernation. Summer roosts and hibernacula can be as far apart as 100 km. Underground sites – mostly located in rural settings – play an important role during the reproductive season.

*Myotis myotis* exemplifies species that thrive in Central Europe through the obligatory combination of urban and rural features.

**Figure 1.** Small nursery colony of *Myotis myotis* in the bell tower of the church in the village of Weilheim-Rietheim, May 2011 (Germany, state of Baden-Württemberg). The entire colony encompasses around 130 females. Photo: A. Meschede

**Collecting citizen's wildlife observations– experiences from two case studies in Freiburg im Breisgau, Germany**

*Marufa Sultana*, *Geva Peerenboom, Fanny Betge, Ilse Storch,* Germany

1. General overview on citizen participation in wildlife documentation

A large variety of wildlife species are well adapted to urban life (Oliveira et al. 2011), while some other species struggle with urbanization and are only occasionally found at the margins of a city (Rodewald and Gehrt 2014). Data on presence of wildlife in and around cities gives us important information about their ecological adaptation in relation to urbanization. Such data can serve as a baseline for management decisions. For example, 'number of bird species in built-up area' is included as an indicator to evaluate and monitor urban biodiversity conservation in the 'City Biodiversity Index' (a self-assessment tool for cities) (Chan et al. 2014). However, collecting data on wildlife species in urban areas is more challenging than in rural areas. Because of small property houses and restricted rights to enter those, systematic sampling of wildlife species is often a lengthy and costly process. Here, citizen science projects, in association with citizen scientists, can facilitate large quantities of data collection on urban wildlife across large areas in both cost-effective and time-effective way (Frigerio et al. 2018; Walter et al. 2018).

Integrating citizens in scientific research projects is known as 'citizen science' (Paol et al. 2018), are typically conducted as large-scale data collection initiatives, that also engage public perspectives and knowledges in policy making (Frigerio et al. 2018). Droege (2007) argued the first citizen science project was implemented in 1880s when lighthouse keepers all over the Caribbean documented bird strikes under the initiatives by American Ornithologists Union. Since it evolved in last quarter of 19th century, the number of citizen science projects have increased significantly to date (Droege 2007; Bonney et al. 2009). In the last few decades, web-based citizen science platforms have also flourished intensely because digital platforms add great potential of networking and allow benefit to both project planners and user communities through sharing data and evaluation. Together with this, models for development of citizen science projects have advanced with useful guidance toward data interpretation and statistical analysis (Bonney et al. 2009). Therefore, an increasing number of research and monitoring projects globally take advantage of this approach and ask citizens to contribute wildlife observations. Citizens participating in the data collection may not receive any financial benefit but gain knowledge in taxonomy and scientific methods.

Many existing research studies in European cities already incorporated citizen science approaches to assess urban wildlife. These studies may serve as model examples for researchers during designing similar study in cities where wildlife documentation is lacking.

## 2. Case studies in Freiburg

Freiburg is a moderate-sized city (15,307 hectares) with a total population of 220,500 (Freiburg 2015) located in the federal state of Baden-Württemberg in Germany. The clearly defined landscape plans along with urban forests, well planned public transportation system, and, environmentally designed housing projects make this city exceptional and distinguish it from many other cities (Beatley 2000; Medearis et al. 2012). Freiburg is considered as a model of "green and sustainable cities" within Europe, and green infrastructures are well integrated into every aspect of city planning (Buehler et al. 2011). Medearis (2012) reported 47.1% green space and parks, and 42.4% forest cover in Freiburg. In addition, 6,996 hectares (46%) of the city's land area are made up of landscape conservation areas and 683 hectares (5%) are nature conservation areas (Stadt Freiburg 2017).

In this paper, we discuss two research projects, which used citizen science approaches to collect and improve urban wildlife data in this "green city". In the first section, we present a study which aimed to assess bird species diversity along a gradient of urbanization; we combined standardized and non-standardized citizen science approaches to improve bird species occurrence records in the urban area of Freiburg. In the second section, we present a study which developed an online based platform where citizens of Freiburg can share their wildlife observations as well as human-wildlife conflicts in their neighbourhood, to get baseline information for urban wildlife management decisions. Both projects have specific goals and objectives, which we discuss further along with our experience regarding the advantages and the challenges during project implementation.

### 2.1. Accumulation of citizen's collected data in urban bird diversity assessment

Among all taxonomic groups, birds are the most well documented in city areas and are commonly used as indicators of biodiversity. Many dedicated bird watchers are contributing to the documentation of bird occurrence in vast areas of Europe through available web portals (Such as, EuroBirdPortal[1], BirdTrack[2], Ornitho[3], etc.). This creates opportunities in small to large-scale spatial analysis of urban biodiversity regardless of the fact that these data were often collected by citizens during casual observation in a non-standardised way. This enormous amount of data otherwise is impossible to obtain only through traditional approaches of standardised field observation.

[1] EuroBirdPortal: https://www.eurobirdportal.org/ebp/en/
[2] BirdTrack: https://www.bto.org/volunteer-surveys/birdtrack/about
[3] Ornitho: https://www.ornitho.de/

In the context of an ongoing urban biodiversity project in Freiburg, we collected data on bird species occurrences from two sources: (i) standardised data (field data where local students volunteered for bird observation) and (ii) non-standardised data (readily available data from bird web-portal's). We compiled records on bird species occurrences from these sources to assess bird species diversity along a gradient of urbanization. Our aim was to generate a model example on how standardised and non-standardised data sets collected by citizens can complement each other for documenting bird occurrences in urban areas.

In Freiburg city, we selected three web portals (Ornitho.de, GBIF[4] and eBird[5]) where bird occurrence records are available. Ornitho.de is one of the strongest regional bird data portals in Germany where vast amount of data for available (Figure 1). In contrast, GBIF and eBird are global data portals. We collected and crosschecked bird occurrence records from all three sources. Altogether, we documented 55458 observation records and presence of 232 species of birds along different land-use types in Freiburg.

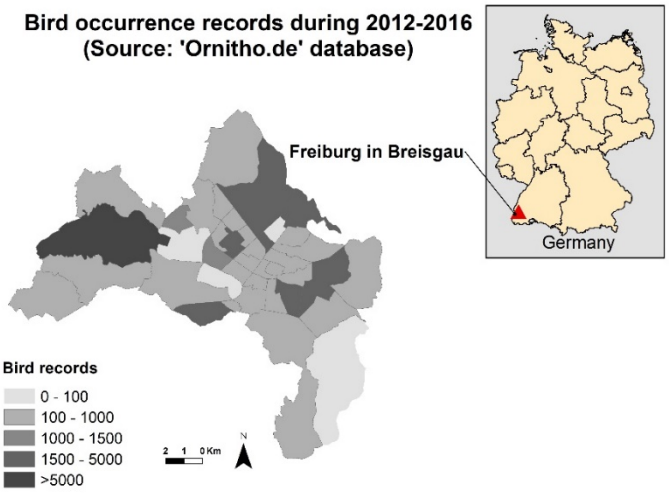


**Figure 1:** Bird occurrence records from available web-portal's database. Example is shown for data collected from 'Ornitho.de' database.

Data from open access databases often lack complete inventories of the species in a survey area (Ladle and Hortal 2013) which is important when mapping of patterns in species richness is targeted (Troia and McManamay 2016). We, therefore, also conducted field observations on birds in a standardized citizen science approach only within urban areas in Freiburg with a special focus to gradient of urbanization.

Local volunteers performed field surveys and collected occurrence records of bird species from 53-point locations to date.

**BOX 1: Bird species diversity in Freiburg**

- ✓ Total number of bird species across different landscapes= 232
- ✓ Number of bird species recorded in urban areas (Excluding forest and agricultural areas) =152

*(Source: Ornitho.de, GBIF, eBird)*

[4] GBIF (Global Biodiversity Information Facility): https://www.gbif.org/
[5] eBird: https://ebird.org/home

These point locations were distributed across 12 plots from high to low urban areas which were identified based on land use categories available in 'Urban atlas 2012' map dataset of Copernicus Land Monitoring service (Figure 2). Through compilation of all occurrence records, collected from both standardized and non-standardised datasets, we confirmed the presence of 152 bird species within urban areas in Freiburg.

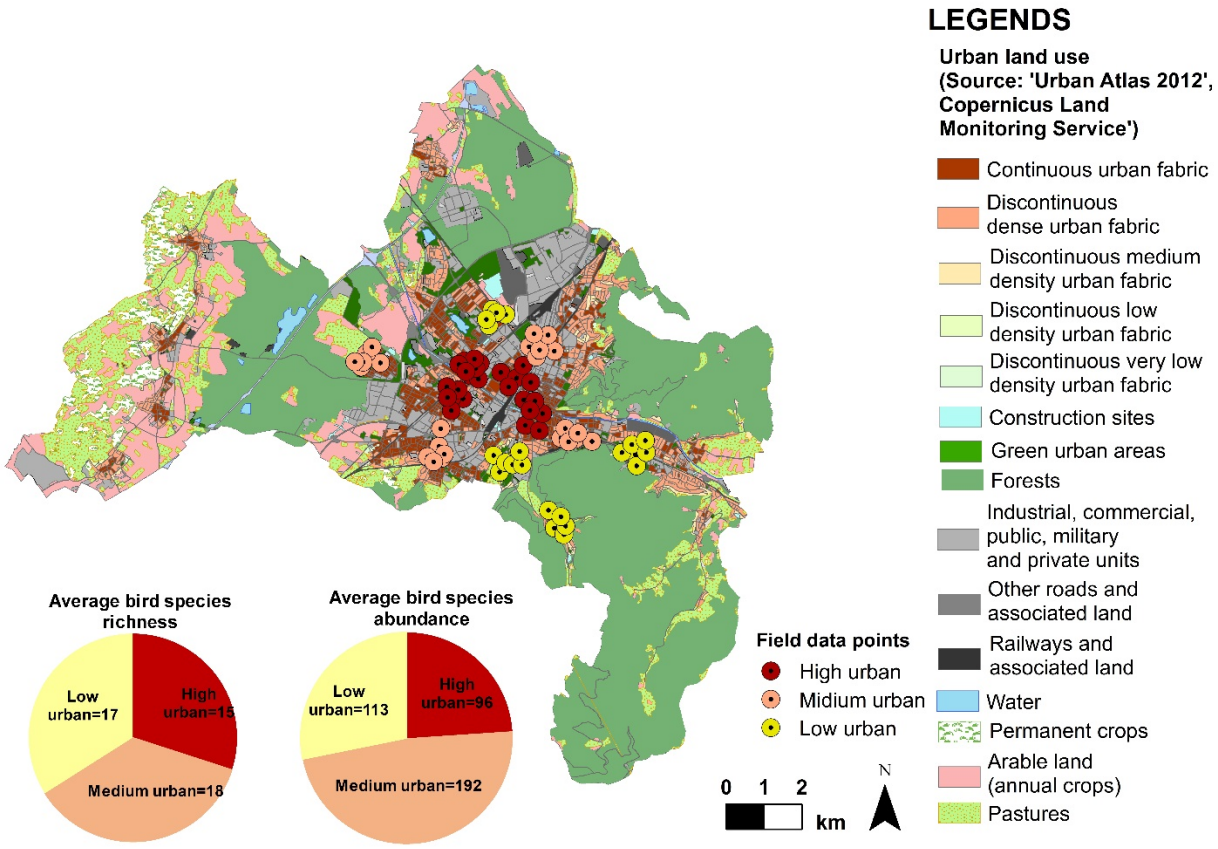


**Figure 2:** Field observation on bird species occurrences by volunteers. Figure shows the field point locations and pie graphs for average bird species richness and abundance along gradient of urbanization in Freiburg.

Variation in average number of bird species recorded among high, medium and low urban areas was low. However, average bird species abundance varied among different gradient of urban and was higher in medium urban areas (Figure 2).

The development of any standardised citizen science project requires appropriate planning and effort during the preparatory phase. In our case, studies of past citizen science projects and previous existing literature were useful to understand challenges and opportunities of our project.

Following existing recommendations, we considered a few critical points during project development: We developed clear research questions; developed a field protocol; defined target sample sizes and identified locations for data collection. As we were aware that most field volunteers lack experience in bird observation, we provided species checklists and training information on bird identification techniques. Our species checklist included probabilities of occurrences as 'high', 'medium', 'low' based on bird data available from web portals.

We further provided the IUCN red list (https://www.iucnredlist.org/) for species specific information; web app information (e.g., Merlin Bird ID and Collins Bird Guide) for quick learning and to cope with challenges during field observation. These preliminary steps allowed us to avoid complicacy during data collection and to compile sufficient amount of bird occurrences in Freiburg city within a relatively short time period. The steps we followed are simple and can be easily replicated in any other cities by researchers if qualitative data collection need to be improved.

### 2.2. "Wilde Nachbarn Baden-Württemberg" – discovering your wild neighbours

Wildlife is adapting to urban environments and an increasing number of wildlife species use human settlements as habitats. City and district administrations need to come up with wildlife management strategies to prevent and lower the upcoming human-wildlife conflicts like damages to green spaces, vehicles and buildings, pollution with faeces and the risk and fear of disease transmission and attacks to humans or pets. On the other hand, the presence of urban wildlife promotes positive impacts to urban citizens, like aesthetic and emotional values. Strategies for urban wildlife management should as well take into account to enhance these positive impacts (Peerenboom et al. 2017).

During the project "Wildtiere im Siedlungsraum Baden-Württembergs" which has the goal to improve urban wildlife management in the federal state of Baden-Württemberg, the city of Freiburg was one of two model regions, where new wildlife management strategies were developed from 2016 to 2019. Throughout the project it became apparent, that the evaluation of management success through a monitoring system is crucial to create a closed, but yet adaptive management cycle (Riley et al. 2012). At the same time, missing knowledge of urban citizens how to deal with and behave at wildlife encounters was identified as a main driver of human-wildlife conflicts in urban areas (Peerenboom et al. 2017). Therefore, a tool was created to provide information about urban wildlife to citizens and to collect information about wildlife encounters. The web platform "Wilde Nachbarn Baden-Württemberg" (www.bw.wildenachbarn.de) was set up in cooperation with the swiss association "StadtNatur" in February 2018 (Peerenboom et al. 2018). On this platform, citizens are given the opportunity to contribute to wildlife monitoring in their hometown by reporting their wildlife observations.

It is possible to report sightings, animal tracks, dens, carcasses and also date and time of the observation. For reasons of data quality, reported observations get checked by platform managers to prevent potential misidentification of species and to test the data for plausibility. Before launching the platform, only conflicts got heard and documented by the city administrations. The platform documents the positive side of urban wildlife encounters as well. People are able to upload photos and discover wildlife observations other people made and inform themselves about wildlife species which occur in urban surroundings. In illustrated portraits short information about the most common species and behavioural tips for wildlife encounters are given to citizens.

In case of conflicts, citizens also have the opportunity to report them on the platform. The type of conflict and the extent of damage can be described, and the actions taken can be documented. Furthermore, news about urban wildlife research, project updates and seasonal campaigns are available. Besides, its function as a monitoring tool to gain knowledge about urban wildlife, the platform is moreover a tool to sensitize the public and to raise their awareness for wildlife species in their neighbourhood. The platform was promoted through press releases, social media and local information campaigns. Since the platform went online in February 2018, about 400 wildlife observations were reported by citizens by end of November 2018, the majority from the city of Freiburg. The most frequently reported species on the platform is the red fox (*Vulpes vulpes*) (Figure 3), which is an iconic species that attracts citizen's attention. On the other hand, reporting's of very common, less popular and highly visible species like corvids were comparably low.

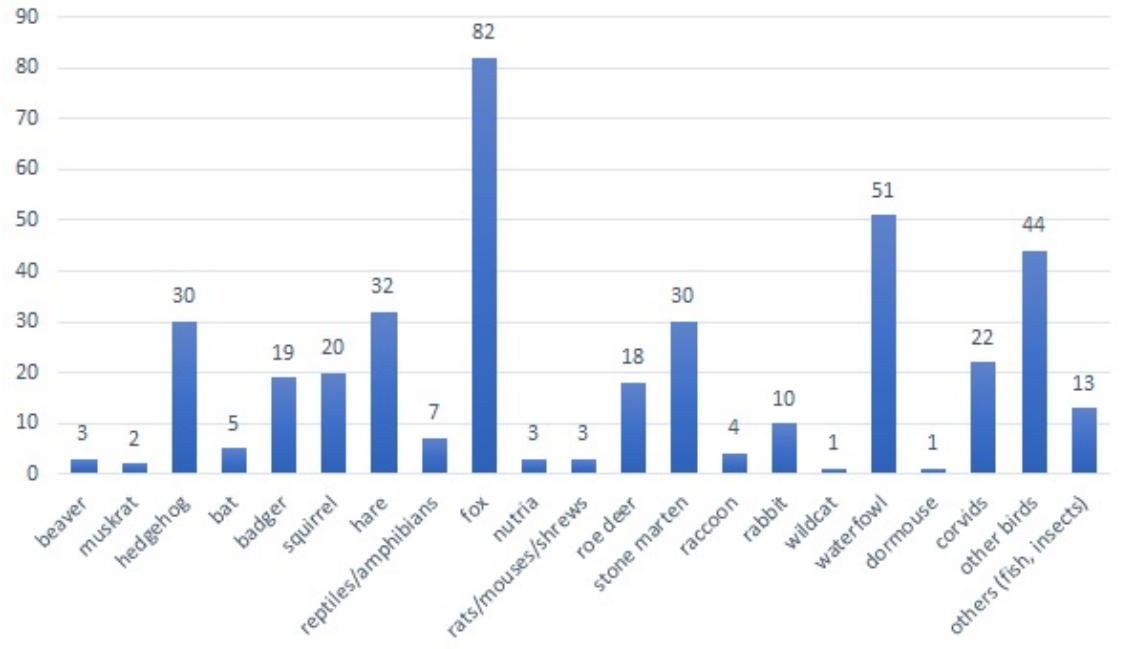


**Figure 3.** Number of observations (Y-axis) reported per species (February to November 2018), n=400.

The platform does not provide a systematic monitoring of urban wildlife species, but still valuable information can be derived from the dataset. The observations provide information of the presence of species, which can be difficult to detect, e.g. badgers (*Meles meles*) in private gardens, or rare observations, like the reporting of an albino roe deer (*Capreolus capreolus*) (Figure 5).

However, as visible in the map of Freiburg shown in figure 4, reported wildlife observations are not evenly distributed over the city and certain areas show substantial data gaps. Closing these gaps is one of the challenges creating a reliable dataset through citizen science (Conrad and Hilchey 2011). To achieve a better coverage of data, a broader involvement of citizens is necessary. In addition, next steps in improving wildlife monitoring in urban areas could be to implement a more systematic scheme of data collection, which is evenly distributed over the area.

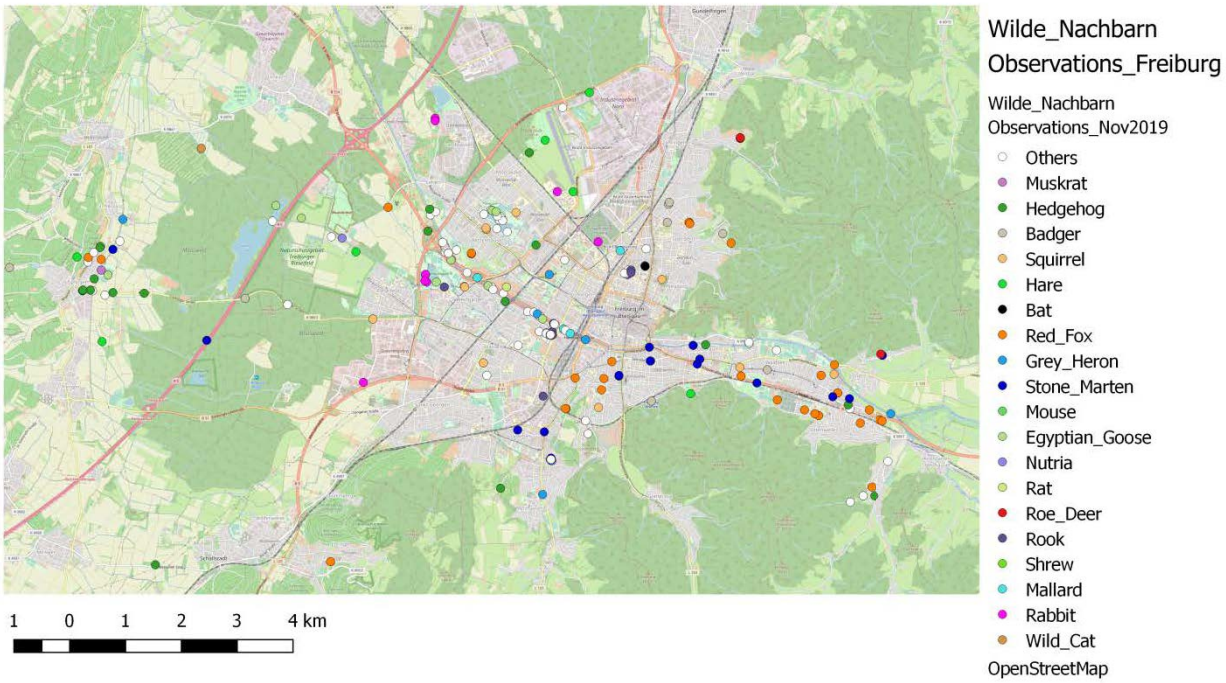


**Figure 4.** Observations reported on the platform "Wilde Nachbarn Baden-Württemberg", February to November 2018

**Figure 5.** Photos of an albino roe deer reported on the platform bw.wildenachbarn.de, © Janine Pabst / wildenachbarn.de

## 3. Discussion

Many wildlife species can be found on the edge of human settlements which ranges from rural fringe to the urban core (CBD 2012).Citizens can provide valuable support through reliable documentation of these species and can contribute to create large datasets within a short time frame (Paol et al. 2018).However, citizen science data can be biased due to unsystematic sampling, differing probability of detection of species, missing taxonomic knowledge of observers, preferences for certain species by observers and tendencies to overlook common species. On the other hand, rare species can fall through the "raster" of standardized surveys and may be more likely detected by a sensitized public.

Thus, the main challenge remains in the integration of data collected by citizens into statistical analysis through ensuring data quality (Paol et al. 2018). Working with volunteers and maintaining their engagement requires additional attention during scientific research to ensure the standard of the collected data.

Several web-based databases make available vast amount of data collected by citizens. Troia and McManamay (2016), investigated completeness and uniformity of species inventories in survey locations among different electronic databases. They suggested that instead of the variation among the databases, the available data can explain human-induced changes in biodiversity when broad scale environmental data layers are incorporated, and appropriate statistical techniques are applied.

While many researchers assessed the quantification of data quality of open accessed electronic data, several others studied available case studies to investigate factors influencing the outcomes of citizen science projects. Shirk et al. (2012) stated the degree and quality of public participation affect outcomes of any project and presented different categories of citizens participated projects. Here, our research projects may be described as contributory projects where scientists design the project and members of the public primarily contribute data and are not involved in the analysis. We conclude with our understanding that readily available databases can be used as a baseline for preliminary documentation of wildlife species in any city. In conjunction, employing local volunteers through a standardised citizen science approach may improve the quality of data. The involvement of local volunteers or citizens into ecological data collection does not only provide benefits to the scientists or management authorities who analyse the data, but also improves the disappearing connection between humans and nature (Miller 2005). Peoples get excited about this kind of initiatives and involved with wildlife on their doorstep (Ulbrich et al. 2013), which can significantly contribute to create a new responsiveness among citizens toward loss of wildlife as well as overall biodiversity in their cities.

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## Urban ecology research at Texas Tech University

*Gad Perry,* United States

More than half of the world's human population now lives in urban settings, and by 2030 the UN estimates that number will be 60%. Both the number and size of cities keep growing, with the fastest growth occurring in Africa and Asia. Although much of the attention is on cities housing many millions, such as Hong Kong or Cairo, there are many more cities with population < 1 million. In the US, some 80 percent of the population lives in one of the 350 largest metropolitan areas. Nonetheless, more than half the population surveyed in the 2000 census lived in areas with fewer than 25,000 residents. Lubbock, with a human populations of about 250,000 and the 11th largest city in Texas, is therefore a more "typical" city and a better model for urban ecology studies. Texas Tech University was established in Lubbock nearly a century ago, with studies of urbanization and its impacts on humans and other organisms regularly carried out across campus.

Examples of ongoing work include research on the ecology and conservation of a variety of organisms, most of it conducted in the departments of Natural Resource Management and Biology; projects on urban design and planning, conducted in the College of Architecture and the Department of Landscape Architecture; research on urban soils and contaminants in the Departments of Plant and Soil Science and Environmental Toxicology; climate-related projects in the Climate Science Center; and even collaborations with the School of Art culminating in an exhibition, The Art and Science of Restoration Ecology, that looks at an urban park.

My own work has focused on urban wildlife and their interactions with urban residents. Projects have looked at urban water bodies and the amphibians in them; urban box turtles; our wildlife rehabilitation center and the mammals, birds, and reptiles brought to it; birds associated with urban yards and neighborhood structure; effects of lights; and the interaction between urbanization and invasive species issues. My talk will be a survey of my own work, as well as that of others working on related issues at the university.

**Figure 1.** A radio-tagged ornate box turtle, (*Terrapene ornate ornata*) looks at an urban road in Lubbock, Texas. Photo: Gad Perry



## Importance of interspecies relationships in urban wildlife communities

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Green areas of cities encompass a large range of wildlife species. In recent years, many studies aimed to understand the environmental conditions that allow for any particular species to settle in an urban area, thereby covering different taxa, from mammals to invertebrates, but mainly focusing on one species or a group of very similar species.
On the other hand, diversity analyses conducted inside urban areas dealing with whole communities so far produced very general results and neglect species identity. This translates into a loss of information that may be vital for management and conservation actions in the city. For example, broadly used diversity measures, such as species richness, do not reflect if species in the community are native or exotic. Also, diversity measures are difficult to compare.

Additionally, studies focusing on particular species or on communities use abiotic predictors to analyze species response to urban conditions. However, wildlife species interact in many ways, i.e. through predation or facilitation, which means that the biotic environment will have a huge impact on community assembly.

As part of the BIBS project (www.bbib.org/bibs-project.html), we focus on wildlife species distribution in Berlin joining data from plants and invertebrates to birds and mammals to model the response of the species to both environmental and biotic conditions. By studying not only the environmental predictors, but also the other species present at each site, we will be able to characterize how strong the interspecies relationships are and therefore, we can anticipate how management efforts addressed at some species may have cascading effects on other species of the community.

## Biodiversity past and present in explorative place-based learning

*Marcel Robischon,* Germany

Living beings in all their diversity provide in addition to numerous other products and services to humans a source of insight and learning. Living beings define and characterize a place and endow it with meaning to observers. Urban environments harbor a collection of organisms that reflect evolutionary history, biogeography and the history of human transporting organisms to new habitats around the globe. The explorative learning exercise shown here takes concepts of place-based and object-based learning to green spaces in inner cities, aiming to raise the awareness for the organisms that surround us in urban spaces and to "read" traces of the human and non-human past and to form hypotheses to be discussed.

**Figure 1.** Fruits of Osage-orange (*Maclura pomifera*) provide a good example for explorative place-based learning. Photo: M. Robischon

## Land use changes and their impact on the agro-biodiversity in Tanzania - A case study from the Serengeti Mara Ecosystem

*Thomas Rottstock*, *Thomas Göttert*, *Ulrich Zeller*, Germany

The extinct aurochs (*Bos primigenius*) represents the common ancestor of European and African cattle, functioning as framework for a PhD thesis (T. Rottstock). Given existing conflicts between cattle farming and nature conservation, here we compare livestock-wildlife interactions in both geographical regions to develop effective management strategies.

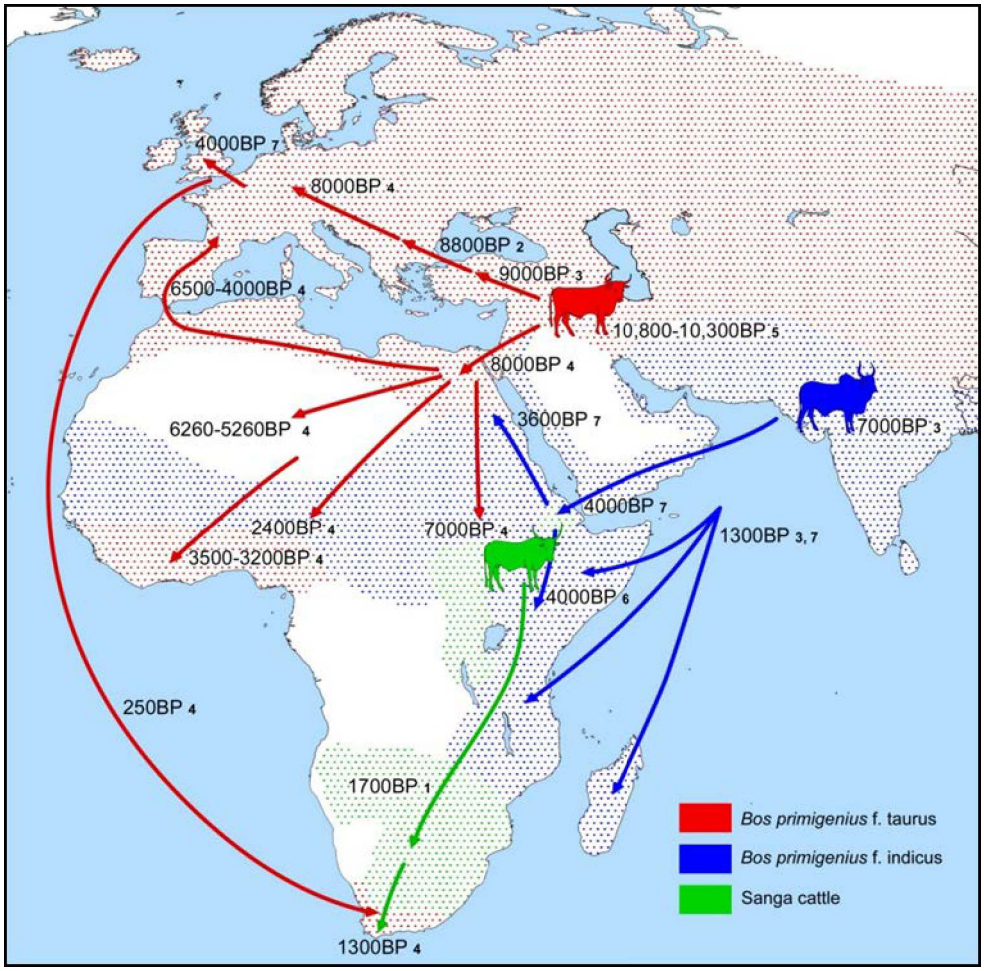


**Figure1.** The common theory about the origin of cattle in Africa and central Europe (1: Denbow and Wihnsen 1986, 2: Edwards et al. 2007, 3: Epstein 1971, 4: Felius 1995, 5: Helmer 2002, 6: Marshall 1998, 7: Porter 1991) and the proximate distribution of taurine, indicine and sanga cattle (modified from Porter 1991, Felius 1995)

This contribution deals with a case study in Tanzania, which was conducted as part of the above-mentioned thesis. The overall goal of this study is to achieve more sustainable grazing of livestock on a transnational scale. Stakeholder interviews and a camera trap survey were conducted adjacent to the Serengeti National Park between October and December 2017. Preliminary results reveal several ecological issues associated with changes of pastoralism as an originally sustainable land use strategy (Niamir-Fuller 1999, Homewood 2008, Notenbaert et al. 2012, Tyrrell et al. 2017).

Competition over limited resources is a major issue along the border of the Serengeti National Park (Ogutu et al. 2009), whereby the rapid urbanization in Tanzania (UN 2017) has strong impacts. Here two phenomena associated with urbanisation are affecting grassland ecosystems in rural areas. There is a trend towards sedentarisation among East African pastoralists (McPeak and Little 2005, Little et al. 2008). Sedentarization on the on hand is caused by policies, which restrict livestock mobility (Niamir-Fuller 1999, Western et al. 2009) and on the other hand by socioeconomic benefits, associated with a sedentary lifestyle (Fernandez-Gimenez and Le Febre 2006, Hobbs et al. 2008). This makes it hard to maintain livestock mobility (Fernandez-Gimenez and Le Febre 2006), particular important for sustainable grazing systems in African savannas (Fynn et al. 2016, Tyrrell et al. 2017). Whereas pastoralists used to move seasonally with livestock according to the availability of resources (Macandza et al. 2012), comparative livestock mobility can only be found sporadically nowadays. The original pastoralism and associated valuable knowledge are endangered, as the land use is changing fundamentally (McGahey et al. 2008).

In addition, livestock farmers are attracted by urban areas, as they offer several socioeconomic benefits (McPeak and Little 2005). Given tribal bonds, migrated former livestock farmers often continuously invest in livestock in their area of origin (McPeak and Little 2005). Its high cultural value makes livestock to a popular source of investment for wealthy people (BurnSilver 2009). Consequently large herds of cattle and associated conflicts occur along the border of the Serengeti National Park, threaten the famous National Park. Moreover the traditional African cattle, particularly adapted to the extreme environmental conditions become endangered, as it is increasingly replaced by breeds from other regions, promising more profit (BurnSilver 2009).

This case study reveals how urbanization can even affect land use and associated agro-biodiversity of rural areas. Given the number of identified regional issues associated with livestock farming there is a desire for more sustainable grazing practices in northern Tanzania.

**Figure 2.** Traditional cattle pastoralism depends on an independent spatial unit. Fragmented savanna landscapes (e.g. through fencing and cultivation) are associated with a decline in wildlife and livestock mobility. Photos: T. Rottstock

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**Distribution and activity of bats along an urban-rural gradient**

*Nicole Starik*, *Thomas Göttert*, *Ulrich Zeller*, Germany

Despite the growing interest in urban wildlife and current initiatives to support biodiversity within urban habitats, relatively little attention has been devoted to investigate the ecology of bats in cities (Gallo et al. 2018). Bats face numerous threats in anthropogenic environments, e.g. wind energy, habitat fragmentation, and pesticide contamination (Kerth and Melber 2009, Stahlschmidt and Brühl 2012, Bayat et al. 2014, Arnett et al. 2016), and also urbanization is generally considered to have negative effects on several bat species (Jung and Threlfall 2018). However, findings from studies in Berlin, Germany (Rinke & Limberger 2014) assume that urban landscapes may nevertheless provide suitable habitats for some bat species. In addition, recapture rates and ringing data suggest a frequent exchange between 'city' and 'rural' bat populations. Moreover, the spatial distribution of the different bat species may be highly variable depending on seasons (summer roosting sites, hibernation sites). Given the important ecosystem services provided by bats (Kunz et al. 2011), the establishment and management of habitats for bats including both urban and rural environments therefore seem to be of high relevance for current biodiversity conservation initiatives.

Based on our results from previous investigations on bats and the effects of land use in the rural surroundings of Berlin (Starik et al. in press), we provide future research directions to better understand what factors determine the diversity and abundance of bat communities in cities and their surroundings. We present a project outlook to study the spatio-temporal distribution and abundance of bats and their habitat use at the urban-rural interface using the example of Berlin-Brandenburg. We aim to compare characteristics of rural areas and urban habitats that influence patterns of bat species distribution and foraging activity. Thus, we focus at investigating the importance of various habitat characteristics at different spatial scales in order to reveal important predictors of species-specific bat activity. In addition, we try to identify various roosts used by local bat colonies during the year (maternity colonies, swarming, migration and hibernation sites) and possibly determine existing connections between them to foster initiatives for bat conservation beyond city boundaries. For data collection, we propose the use of a gradient approach. The gradient approach is usually applied as a measure of distance from the city centre in order to quantify the level of urbanization. In contrast, we here refer to a gradient covering representative urban and rural patterns of land use. Along this gradient, we aim at using different field methods and protocols which are complementary to each other (Battersby, 2010), each adding information on the distribution of the 18 species known to occur within the study area (Teubner et al. 2008). To describe bat species distribution, we intend to use a combination of passive acoustic monitoring systems (Batcorder, Echometer) and mist netting on a representative number of randomly selected sampling sites across the chosen gradient.

To assess species–habitat relationships for bats at different scales we suggest creating spatial buffers of 50m, 1km and 5km around sampling points where specific habitat parameters can be analyzed in order to examine the relationship between different predictor variables and species-specific detection probability with hierarchical occupancy modeling (MacKenzie et al. 2017). Moreover, the collected data may be useful to determine indicator species using a statistical analysis of species occurrence in different habitat types (Dufrene and Legendre 1997, De Cáceres & Legendre 2009). Enhanced knowledge on the interrelations between the ecology and behavior of bats and the effects of land use may facilitate effective conservation measures that can be implemented into regional science-based conservation plans and future urban landscape planning.

**Figure 1.** *Nyctalus noctula* and *Plecotus auritus* both occur in the city of Berlin – two bat species with distinctive ecology and habitat requirements – what factors determine the presence of the bat species in cities and their rural surroundings?

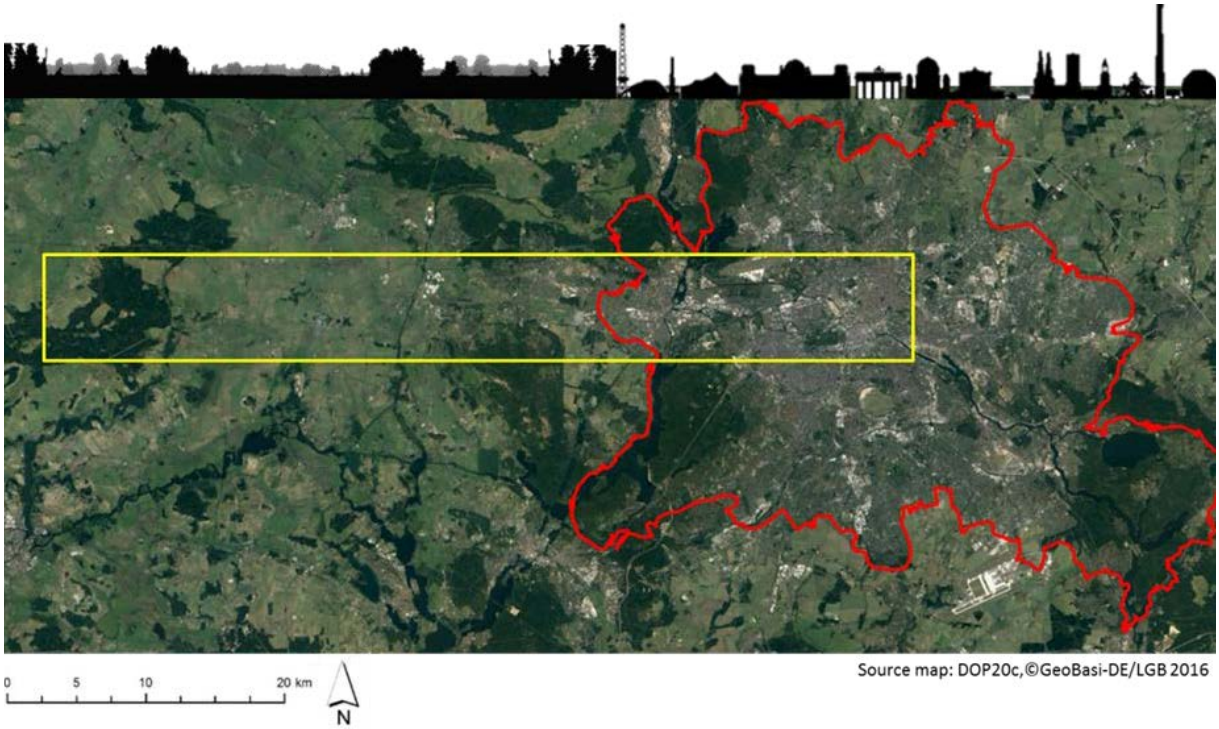


**Figure 2.** Schematic illustration of the envisaged project design: bat species distribution will be investigated along a gradient from Berlin city center to rural habitats on randomly selected sites including a representative number of land use and habitat types

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**Effects of urbanization on birds and bats**

*Marcela Suarez-Rubio*, Austria

Urbanization has profound effects on the Earth's land surface due to its persistence and dissimilarity to the natural land cover. Urbanization has been identified as a major threat to local and global biodiversity because natural habitats are lost, transformed, fragmented or degraded. Commonly, lowest species richness and biodiversity occur in urban core areas and the number of species is less-than-half of the one found in rural areas. Species composition also changes with urbanization. Urban assemblages are similar in species composition than with non-urban assemblages, indicating that urbanization is also a major cause of biotic homogenization. Bird communities are usually dominated by a few, often introduced species, and granivores, omnivores, and cavity-nesting species are favored. Bats response to urbanization is also species-specific and while some species tolerate urban habitats and exploit its roosting or foraging opportunities, others are affected by the loss or fragmentation of key natural habitats.

Although urbanization likely pose a serious risk for many birds and bats, urban green spaces (e.g., woodlots, public parks, gardens, cemeteries) may offer diverse ecological niches, food resources and shelter. Besides promoting biodiversity and sustaining a diverse spectrum of organisms, urban green spaces provide important ecosystem services such as wind and noise filtering, and improve the quality of life. However, urban green spaces may be influenced by its surroundings. Disturbed areas adjacent to urban green spaces may reduce the quality of these spaces despite them not being altered.

Although European countries are currently concern about urban sprawl, in the United States sprawl has risen since the early 20th century. Urban development in rural areas has been prominent since the 1950s and by 2000, 25 % of the United States was already considered exurbia. Exurban development is characterized by low-density, scattered housing units further away from the suburbs but within commuting distance to an urban center. This form of development has outpaced population growth even in areas were human population has declined. Given these characteristics, land conversion into exurban development is a rising cause of concern due to its potential adverse effects on biodiversity and ecosystem processes.

To illustrate the effects of urbanization on birds and bats, I will examine species patterns along urban–rural gradients in tropical and temperate cities. I will also assess the value of urban green spaces and evaluate the ecological condition of these spaces. Finally, to understand the effects of low-density exurban development in the Mid-Atlantic region, USA, I will identify spatial and temporal patterns of this form of development, analyze the drivers or factors that influence the land conversion process, and evaluate the ecological implications of this form of development.

**Land use and land cover dynamics in the urban-rural interface of small and medium-sized cities in sub-Saharan Africa: empirical insights from Nakuru, Kenya**

*Maximilian Willkomm*, Germany

In many places in the world, cities are increasing rapidly due to rural-urban migration and natural population growth. Urban growth leads to significant changes in inner city systems on the one hand, but on the other hand and ever more importantly at the urban fringe, where rural and urban areas clash. Especially in small and medium-sized cities (in particular in the Global South), dynamic transition zones in these areas have arisen. These zones, and the general term of peri-urbanism, are in fact hard to define, but they can at least be characterized through dynamic interactions between rural and urban areas. Recent research has shown that these interactions in the urban-rural interface have an increasing impact on ecological (e.g. microclimate, biodiversity), economical (e.g. employment) as well as social systems (e.g. food security). This talk can be divided into two main parts, namely (1) an introductory overview about basic conceptual thoughts on peri-urbanism and (2) the presentation of empirical multi-temporal land use and land cover data from Nakuru, Kenya.

# Epilogue: synthesis & emerging themes

*Ulrich Zeller, Gad Perry, Thomas Göttert*

The third annual academic event within the project "*Land use contrasts and edge effects – a comparative approach*", covered a broad range of disciplines and perspectives. A wide variety of taxa were discussed, including vascular plants (M. Robischon, H. Hoffmann), amphibians and "reptiles" (G. Perry), songbirds (A. Planillo, M. Sultana, G. Perry, M. Suarez-Rubio), bats (A. Meschede, M. Suarez-Rubio), and terrestrial mammals (C. Fiderer, M. Fidino, V.-L. Fraser-Celin, T. Rottstock), among others. The participants discussed studies from various parts of the world, including central Europe, North and South America, southern Asia, and eastern and southern Africa. We approached the topic of urban-rural interfaces from different perspectives and directions, e.g. in terms of spatial gradients as part of methodological designs (M. Fidino, M. Suarez-Rubio) or in a spatiotemporal framework using the example of Berlin and its outskirts (U. Zeller & T. Göttert). The workshop thus reflected the breadth of interest, wide range of approaches, and urgent need for representatives from different disciplines to collaborate.

Several themes emerged during the meeting that could provide a better understanding of the complex interrelations between urbanization and biodiversity. A crucial cornerstone is that urban settings are artificial settings by definition. Urban environments are tremendously dynamic. Within them, transformation of landscapes and habitat types are common and the organisms associated with urban spaces and urban-rural gradients show a wide range of coping strategies and limitations. Given this, two major themes emerged from attempts to identify the factors driving organismal responses to urbanization during the workshop:

1) The need for the identification of standardized measures of urbanization effects
2) The importance of urban environments for the protection of biodiversity and natural resources – arguments beyond the classic concepts of nature "conservation"

In the following, we will briefly reflect on these themes:

1) <u>The need for the identification of standardized measures of urbanization effects</u>

Several contributors emphasized the urgency to develop innovative approaches for a better understanding of the interplay between urbanization and biodiversity. Although one talk explicitly focused on developing comparative approaches in different regions (M. Sultana), this was a common interest expressed in a variety of ways. Comparative approaches, such as the investigation of responses of phylogenetically and/or ecologically related taxa to land use change such as urbanization in different ecological or geographical contexts, offer a promising way for identifying generally applicable rules (Zeller et al. 2017).

However, the participants also agreed that there is a sizeable area of uncertainty and impreciseness when it comes to standardized sample units and response variables. One example are attempts to define degrees of urbanization. Clearly, the level of urbanization can have pronounced effects on biodiversity. Examples are species diversity and assemblages of bird communities along an urban–rural gradient in Mandalay, Myanmar (Suarez-Rubio et al. 2016) and the negative effects of increasing road density on amphibian presence and species richness in Lubbock, USA (Ramesh et al. 2012). However, areas termed "*suburban*" in Chicago in the US might be even more densely populated by humans than what would be referred to as the "*core center*" in Freiburg, Germany or Nakuru, Kenya. Although the terms used make sense within the context of a single study, they can be very misleading when comparisons are made of patterns in different locations. This makes meta-analysis difficult and illustrates the need for a more standardized definition of terms and a better classification of the matrices investigated (Batáry et al. 2017).

Common characteristics, such as intensity of land transformation and anthropogenic needs and requirements should obviously be addressed in such an effort. But we cannot stop there. The case-specificity of urban areas, for example in terms of temporal effects, needs to also be taken into consideration. For example, Berlin and Chicago share faunal elements with a Holarctic distribution, such as the peregrine falcon (*Falco peregrinus*) we saw on our excursion to the State Bird Observatory & Field Centre Buckow. Berlin (T. Langgemach) and Chicago (M. Fidino) played important roles in providing refuges that allowed this raptor to recover from a dramatic population decline during the second half of the previous century. Yet, although portions of central districts of Berlin might on the surface appear similar to areas in central Chicago, many cities in Europe have been urbanized for hundreds (Freiburg, Berlin) or even thousands of years (Vienna), whereas the transformation process in most cities in the US occurred during much more recent times. Do the temporal differences override the present-day structural similarities? Might longer histories allow at least some species to adapt more gradually to increasing urbanization, resulting in different urban faunas on different continents? And what about the timing of introduction of non-native species? For example, C. Fiderer showed tremendous differences between the spatial behavior and habitat preferences of native red foxes (*Vulpes vulpes*) and invasive raccoons (*Procyon lotor*) in a protected area near Berlin. Despite (or even because of) these different organismic abilities and limitations, both species colonized urban areas outside their native distribution range. While the raccoon is considered an alien invasive species in Germany, the red fox today also occurs in the US, e.g. in Chicago (M. Fidino). Species interact in urban environments, forming artificial ecological communities that interrelate in complex ways (A. Planillo), and these interactions are likely to vary in accordance with the history of assembly and the physical characteristics of each environment.

Comparative approaches will also have to deal with the historical context and the differing degrees of transformation of the landscapes surrounding urban areas. This can be illustrated by the example of protected areas in close vicinity to cities (e.g., Nairobi National Park, Kenya, discussed by several speakers; special Protection Areas in close vicinity to Berlin, U. Zeller & T. Göttert and C. Fiderer). Whether a city borders (Nakuru National Park in Kenya, M. Willkomm) or even incorporates (Tijuca National Park in Rio de Janeiro, Brazil, L. Martins Fontoura) green spaces can make a strong difference to the biodiversity in the adjacent urban core. Moreover, urbanization can strongly affect biodiversity in areas outside the city itself. For example, economic success of urbanites in Dar es Salaam, Tanzania, have led to investment in cattle by city-dwellers and rural relatives receiving financial support, leading to increasing grazing pressure from growing cattle herds grazing in close vicinity to the Mara-Serengeti ecosystem (T. Rottstock).

2) <u>The importance of urban environments for the protection of biodiversity and natural resources – arguments beyond the classic concepts of nature "conservation"</u>

One way to think about urban areas, which are by definition artificial spaces, is as "*insurance banks for biodiversity*". This can be illustrated by the example of the human-tolerant house sparrow (*Passer domesticus*) and common starling (*Sturnus vulgaris*) that today occur – sometimes in numbers so large they are considered pests - in many regions outside their natural range. At the same time, these species have undergone dramatic declines in parts of their natural distribution ranges (IUCN 2018, Robinson et al. 2005). Should the house sparrow or common starling become extinct in parts of their native range, the occurrence of these species in distant urban settings would become consequential. This makes the need for better cooperation between biologists and urban planners more apparent and urgent. Conservationists and urban planners should work towards a paradigm shift by considering the entire range of urban habitats instead of focusing on relict habitats and native species alone (e.g. Kowarik 2011). Of course, they need to also weigh the concern that cities might serve as reservoirs, allowing invasion of outside habitats, including protected ones, by non-native species.

We should also start acknowledging other benefits of urban biodiversity. At first glance, for example, the existence of a diverse bird species community in people's backyards might seem immaterial value. However, it can quickly gain economic relevance, as shown for the positive correlation between bird diversity and house prices in the city of Lubbock (Farmer et al., 2013). When looking at the educational dimension, it becomes obvious that there is a value of the occurrence of a wide range of vascular plant species in cities (M. Robischon), even if these plants are not all native. With massive declines in insect diversity recently reported in protected habitats (Lister and Garcia, 2018), might plant-rich urban setting offer a refuge?

The same holds true for plant varieties that contribute to human well-being (ornamental plants) and local nursery (vegetables) in the fields of urban agriculture and urban horticulture (H. Hoffmann), as urban and peri-urban agriculture can fulfill important social and economic functions (M. Willkomm). Thus, the workshop also suggests the need for a holistic view of the importance of urban areas for biodiversity conservation, one that is broader and goes beyond the traditional focus on green spaces and native species.

A changed perception of urban environments might also contribute to a re-assessment of human-wildlife interactions and particularly human-wildlife conflicts - a topic that was repeatedly discussed during the workshop. For example, tourism and economic development did not negatively affect biodiversity in national parks studied in Brazil and the United States and usually provide economic benefits towards park maintenance and operations. At the same time, protected areas contribute greatly to economic and social development in their regions (L. Martins-Fontoura). Despite this, the relations between protected or urban species and adjacent humans are often adversarial. For example, humans often provide essential habitat, particularly roost space, for bats in settlements, yet people may not appreciate some results of bat presence such as smells, dirt, noise or perceived risk of disease. As work on African wild dogs (*Lycaon pictus*) in Botswana showed, there is a large perceptual component to such interactions, making the study of human perceptions and communication strategies an essential component (V. Fraser-Celin).

We stand at the confluence of three global processes. First, urbanization is increasing on all inhabited continents in countries of highly divergent economic situations. More than half of the world's growing human population now lives in cities, and this proportion is growing annually. Second, the world's population of many other species is in decline, leading some to characterize our era as the sixth mass extinction. Third, global climate is changing at a rate that is unprecedented and to a degree that is generally considered unsustainable, perhaps catastrophic. These three processes are deeply intertwined and together will have profound effects on humans and non-humans alike. Our conference, with its interdisciplinary approach, offers one attempt to reflect on this confluence and begin evaluating the multiple values arising from high levels of species richness within cities in this age of global changes.

Berlin & Lubbock, December 2018

**Figure 1.** Workshop participants, from left to right: G. Perry, M. Suarez-Rubio, T. Göttert, M. Robischon, H. Hoffmann, S. Malcher, J. Müller, V.L. Fraser-Celin, M. Sultana (front row), U. Zeller, M. Fidino, J. Assmann, M. Willkomm, E. Zirk (front row), T. Rottstock, C. Fiderer, A. Kracht, A. Meschede, A. Planillo, L. Martins-Fontoura; photo: M. Wicke

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Workshop:
Biodiversity and
the urban-rural interface:
conflicts vs. opportunities
24th - 27th September 2018, Linde (Germany)