Cost-benefit relationships of biodiversity-promoting measures in urban areas

This information sheet on the ecological effectiveness and cost efficiency of various measures to create and enhance urban biodiversity provides an overview based on existing literature and expert surveys. It is aimed at informing practitioners, interested professionals and laypeople.

We collected and reviewed existing evidence on the restoration tools that can be used to ecologically improve urban green spaces and assessed their effectiveness in increasing native biodiversity in relation to the respective costs (based on costs for implementation, i.e. construction and management). Figure 1 shows nineteen different biodiversity-promoting measures that can be implemented to ecologically enhance urban ecosystems. The measures are ordered according to the expected biodiversity-enhancing effect and labelled with information on the respective implementation costs. The biodiversity-enhancing effect is shown by the length of the bar, whereby an effect of “1” means a low biodiversity-enhancing effect and an effect of “5” means a high biodiversity-enhancing effect.

The level of implementation costs is illustrated by coin symbols, whereby one coin symbol indicates no or low implementation costs and three coin symbols indicate high implementation costs. The information on the biodiversity enhancement and the implementation costs are to be understood as relative values and are based on various sources and expert estimates[1–3], but depict a simplification of the complex reality. The assumed values are considerably influenced in particular by the way of implementation, local climatic and other environmental conditions, anthropogenic disturbance, maintenance intensity, and the use of suitable maintenance techniques[3].

The two measures with the potentially largest ecological effects are the creation of new still water bodies such as near-natural ponds and the establishment of a species-rich extensive meadow using local seed sources or similar methods like the transfer of hay from donor sites. However, these measures are associated with rather high installation costs due to the labor and materials required. The creation of near-natural ponds, for example, requires extensive work and planning as well as specific materials, for example for a sealing layer that ensures water retention[1]. The expected high level of biodiversity promotion results from the fact that water bodies in urban areas provide an important habitat for animals such as birds, insects and amphibians as well as for various plants. They also offer drinking opportunities for several insect and animal species and can be used for stormwater retention[1,2].

Various small-scale structures such as stone piles, heaps of leaves or deadwood have medium biodiversity-enhancing effects at low construction costs[1–3]. Small-scale structures primarily promote different animal groups by providing shelter, hibernation or nesting sites[1]. The rather low biodiversity-promoting effect of annual flowers is due to the fact that few animals can settle in the habitat because it only exists for one year [2]. Moreover, such seed mixtures often contain non-native species, reducing the biodiversity-enhancing effect. In addition, the implementation costs of this measure are rather high because of the need for regular sowing including soil preparation. However, if composed of native and potentially even endangered plant species such as those belonging to rare arable weed communities, such annular seed mixtures could in the future also achieve a significantly higher contribution to urban biodiversity conservation.

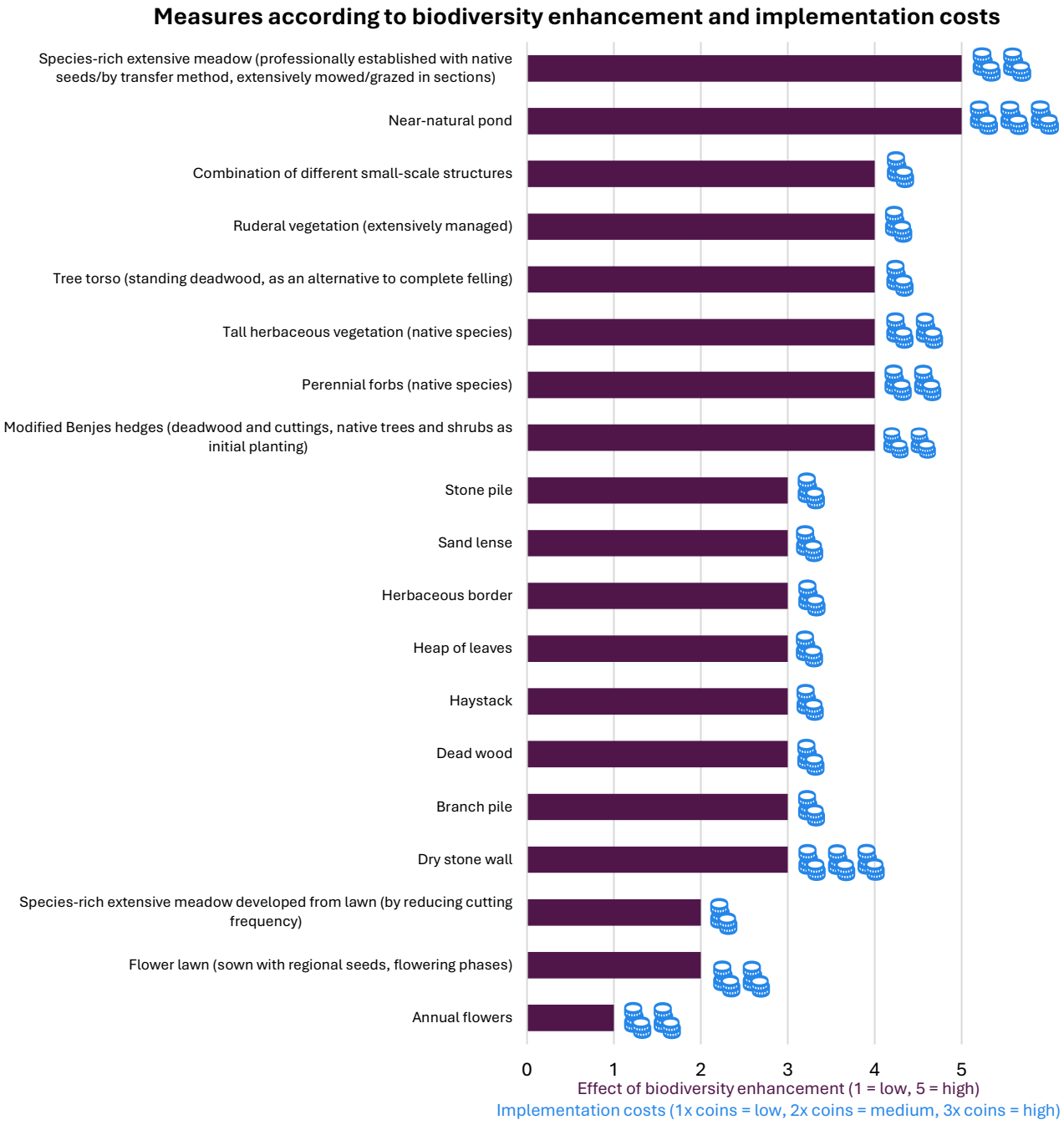

Figure 1: Cost-benefit relations of implementation of biodiversity-promoting measures.

Figure 1 provides a broad overview of the costs and benefits of the measures. The ecological effect will be influenced, among other factors, by the surrounding environment - both positively and negatively. It serves as an overview of the measures presented, even if these have context-dependent implementation costs and biodiversity gains. For small-scale structures, a combination of different structures, e.g. deadwood, rock piles and sand lenses, in close proximity to each other can enhance expected benefits[2]. If structures are installed with species-rich ecosystems in the surrounding area, these serve as a source for migrating species. Intensive use by recreational visitors, on the other hand, can negatively impact the biodiversity effect of the measures. Yet, this does not have to be the case for all habitat types, especially when the ecosystem is adapted to disturbance (e.g. ruderal vegetation)[2]. Depending on the specific measure, the effect on biodiversity may also vary with regard to the size of the area. For example, flower meadows promote biodiversity to a greater extent when they reach a minimum size of 10 m^2 or are even larger[3].

Maintenance and management are crucial for a positive long-term biodiversity effect and should follow a near-natural approach[3]. The location and site conditions in which the measures are implemented will have an impact on the level of biodiversity enhancement. For example, ruderal vegetations or perennial plantings in sunny locations are particularly species-rich[1].

The actual implementation costs of the individual measures depend on the existing equipment and the choice of seed or material. For example, the costs for the establishment of flower meadows vary depending on whether only the mowing frequency of lawns is reduced or whether native seeds are used for restoration, requiring soil preparation prior seeding. However, the use of native seeds achieves significantly better results for biodiversity than simply extensifying (de-intensifying) the management of a grass-dominated lawn, particularly in the case of species-poor and nutrient-rich sites. When investing in biodiversity-enhancing measures, it is generally important to consider not only the implementation costs but also the long-term costs and benefits[3]. An additional substrate replacement or the incorporation of low-nutrient substrates may be expensive at first; however, it can be cost-effective in the long term due to the reduced maintenance costs (less growth, lower risk of weed encroachment). The installation of small-scale structures is often particularly affordable when required materials are sourced locally (e.g. leaves or dead wood)[1].

In summary, the measures presented above achieve different levels of urban biodiversity enhancement at different construction costs. Complex and elaborate measures such as the creation of ponds are particularly beneficial to biodiversity but are also cost-intensive. However, the gain in ecosystem services such as water retention might justify the costs and many cost-effective measures such as small-scale structures are further available, achieving a medium but still significant ecological impact. Site-appropriate planning and the utilization of existent materials can be critical for the effective promotion of biodiversity in relation to implementation costs. To ensure a sustainable ecological design of cities, various measures must therefore be combined and connected with a biotope network[4].

Literature:

1. Stadt Baden Stadtökologie (Eds.), Wildbiene + Partner GmbH, naef landschaftsarchitekten. Maßnahmenkatalog. 2015. LINK
2. Insekten.lu. Flächenumgestaltung, 01-Alle Umsetzungen. 2025. LINK
3. ZHAW Zürcher Hochschule für Angewandte Wissenschaften. Faktenblätter. fokus-n. Wissensportal für naturnahe Freiräume. 2024. LINK
4. Breuste J. Was sind die Besonderheiten des Lebensraumes Stadt und wie gehen wir mit Stadtnatur um? In: *Stadtökosysteme. Funktion, Management Und Entwicklung*. Springer Berlin Heidelberg; 2016.

Authors:

- Prof. Dr. Valentin Klaus (Urban Ecology and Biodiversity, Institute of Geography, Ruhr University Bochum, Germany)
- Ann Solveig Krouthén (Department Environmental System Science, ETH Zürich, Switzerland)

Acknowledgements:

We thank the following experts for their valuable comments and suggestions: Dipl.-Ing. Sanda Dullau (Hochschule Anhalt), Dr. Sonja Knapp (UFZ Leipzig), Jonas Renk (Kommunen für biologische Vielfalt).