



Example of a near-natural willow shrub on the tidal Elbe – Pagensander Nebelbe (M. Heuner, Federal Institute of Hydrology (BfG))



Example of an older willow mattress (no maintenance) on the Weser – Stolzenau (S. Knopp, on behalf of BfG)

OVERVIEW

Brief description

Willow mattresses are used as protection structures for banks and slopes. Their flexible, dense shoots attenuate wave and current energy and promote sediment deposition from the water column. Their roots stabilise the soil, thus preventing erosion. Willow mattresses usually require regular maintenance, the frequency of which depends on local boundary conditions. However, if positive feedback between sediment deposition and dense willow shoots occurs, terrain elevation can increase, thereby reducing flooding frequency as well as the impact of waves and currents. Maintenance is then no longer necessary. Instead, a floodplain forest with a willow population can develop, offering greater ecological benefits than a continuously maintained willow mattress. It should therefore be regularly assessed whether maintenance is still necessary or whether the bank has stabilised to such an extent that natural development can be permitted.

ECOLOGICAL BENEFITS THROUGH THE DEVELOPMENT OF WILLOW MATTRESSES WITHOUT MAINTENANCE

Hydromorphology

The older willow mattresses become, the more structural diversity is promoted due to the gaps between the aboveground shoots. This can create heterogeneous bank structures which initiate small-scale morphodynamic processes such as sedimentation and erosion, contribute to increased substrate diversity and provide different natural habitats.

Habitats and their connectivity

Compared to technical engineering structures, the use of living measures enhances the connectivity of habitats. As native woody vegetation develops, the structural and species diversity along the water increase. The evolving structures provide valuable habitats for tree-dwelling fauna (e.g. birds, bats and insects) and refuges for aquatic fauna (e.g. macrobenthic organisms, fish). Depending on their characteristics, older willow mattresses are classified as habitat type 91E0 under the Habitats Directive (Council Directive 92/43/EEC) and may be subject to legal protection (Section 30 Biotopes of the German Federal Nature Conservation Act (Bundesnaturschutzgesetz, BNatSchG)).

ECOLOGICAL BENEFITS THROUGH THE DEVELOPMENT OF WILLOW MATTRESSES WITHOUT MAINTENANCE

Vegetation

Banks that are flooded with varying frequency are natural places for willows to grow. The elevations at which the willows become established depend not only on the duration of flooding, but also on the wave, current, wind, salt and ice loads (see *data sheet Willow Mattresses*). In the establishing phase, willows are fast-growing, with a high ability to grow shoots, and they are elastic and capable of regeneration. In just one to two years, they form a dense willow scrub as a shrub layer. Because of these properties, willow branches are suitable for e.g. willow mattresses which are laid close to the ground across larger areas to stabilise streambanks. Without maintenance, the willow mattresses develop into tidal willow floodplain scrubs after several years. Native species include in particular *Salix alba*, *Salix cinerea*, *Salix fragilis*, *Salix triandra* and *Salix viminalis* and, in locations with sandy soil, also the *Salix purpurea* [1]. Without maintenance, the shrubs grow upwards over time and gaps appear at ground level. Depending on root development, bank protection is then not always guaranteed at these points. However, these places favour the development of an ecologically valuable herbaceous layer with the following native species: *Lythrum salicaria*, *Senecio paludosus*, *Caltha palustris*, *Stachys palustris*, *Lycopus europaeus*, *Bidens frondosa* [2]. On the tidal Elbe, the willows also provide a habitat for the strictly protected endemic species (*Oenanthe conioides*) which is threatened with extinction.

After several decades, and without human intervention, willow mattresses form a permanent, stable riparian forest community (tidal willow floodplain forest) with two structurally rich tree layers. The first tree layer is characterised by particularly tall and old trees and is flooded with light. The second layer, which is dense and shadier, is formed by regenerating trees. The mechanical stress caused by the tidal dynamics is important as it ensures that the succession (development of the plant community) of the riparian forests is repeatedly interrupted and new structures can emerge, such as fallen trees with dead and sprouting branches.

Willows have a high ecological value as they provide a habitat in their root, trunk and crown zones, create a diverse microclimate and serve as a source of food. Branches and fallen leaves provide settlement substrate for fungi, plants and animals (see also initial planting in *Alternative designs* section of the data sheet *Willow Mattresses*). In older stands, willows also offer habitats for various moss and lichen species if growth conditions for epiphytic species are optimal with high humidity and relatively undisturbed areas with many dead trunks [2]. The ecological value of the biotopes and their genetic diversity increase when seeds germinate at open, moist sites during seed maturity and can spread generatively with success.

Fauna

Willow mattresses have the potential to provide valuable habitats for many animal species, some of which are specially or strictly protected under the German Federal Nature Conservation Act; the older and more structurally diverse the willow stands, the higher their ecological value and biodiversity. Thus, willow mattresses provide habitats for insects such as *Aphrophora salicina* or *Nematus salicis* and thus strengthen the foraging habitat of bats e.g. *Myotis dasycneme* and birds [3]. The more willow mattresses develop into tidal floodplain forests, the more suitable the living conditions are for beavers. Bird species such as the *Dryobates minor*, *Oriolus oriolus* and *Remiz pendulinus* benefit from the diverse ecological niches created by the mosaic-like interlocking of different development phases in the willow forests. Various insects such as deadwood, flower visitors, e.g. wild bees, hoverflies and butterflies or spiders also benefit from the floodplain-typical habitat structures .

ECOLOGICAL BENEFITS THROUGH THE DEVELOPMENT OF WILLOW MATTRESSES WITHOUT MAINTENANCE

Ecosystem services

Over time, willow mattresses can provide the following ecosystem services compared to bank protection measures such as riprap, revetments, or similar structures:

- Increased habitat provision for riparian vegetation and fauna, as well as for soil fauna, due to greater substrate diversity
- Carbon regulation and storage through the development of riparian-typical vegetation
- Additional erosion protection as further vegetation establishes
- Improvement of the water balance (resource provision) through natural retention and thus better water storage
- Shading of the bank and protection against wind improves the microclimate
- Enhancing recreation function by experiencing more natural landscape

REFERENCES

- [1] Markus-Michalczyk H. & Michalczyk C. (2018) „Make me a willow cabin at your gate“: Legislation and implementation of tidal forest restoration at estuarine upstream sites. *Estuarine, Coastal and Shelf Science*, 210, 1-6, <https://doi.org/10.1016/j.ecss.2018.06.004>.
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- [3] Bundesanstalt für Wasserbau; Bundesanstalt für Gewässerkunde; Wasserstraßen- und Schifffahrtsamt Oberrhein (eds.) (2020): *Versuchsstrecke mit technisch-biologischen Ufersicherungen Rhein-km 440,6 bis km 441,6, rechtes Ufer. Abschlussbericht der Monitoringphase 2012 bis 2017*. BAW-Nr. B3952.04.04.10151; BfG-Nr. 1677. Karlsruhe: Bundesanstalt für Wasserbau, 1-145 + Appendices.

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<https://ufersicherung-baw-bfg.baw.de/aestuarebereich/en>

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