VARIOUS FUNCTIONAL STRUCTURES OF WOODY VEGETATION - A BASE OF THE PROPOSAL OF NEW FUNCTIONAL LANDSCAPE

Petr Kupec, Petr Pelikán, Ondřej Hemr
Mendel University in Brno, Faculty of Forestry and Wood Technology, Department of Landscape Management, Zemědělská 3, 613 00 Brno, Czech Republic

https://doi.org/10.11118/978-80-7509-831-3-0431

Abstract
The article presents the results of a case study, which was processed in the catchment area of the water source Nová Ves u Pohořelic owned by BVaK, a.s. The mentioned area consists of about 20 ha of floodplain landscape on mostly Quaternary sediments. The site, originally covered with mature coniferous forest, was deforested due to the drought, which had an immediate effect on the quality of the water in the water source, especially by a significant increase in nitrogen content. The purpose of the study was to design such a structure of the landscape, consisting mainly of elements of woody vegetation, which, by its existence, will ensure the re-achievement of the ordered water quality. The article presents the principles of this proposal, which are based mainly on the ecological possibilities of the proposed tree species and their use for remediation of undesirable substances in water, as well as the proposal itself.

Key words: Catchment area of water source, Woody vegetation functions, Bioremediation, Nová Ves u Pohořelic

Introduction
The area is located in southern Moravia, approximately 25 km south of Brno (Czech Republic). It is a fenced water source area located near the settlement of Mariánský Dvůr, about 3 km southeast of the town of Pohořelice. The altitude ranges from 176-179 m above sea level, the area is flat with a slight slope to the east. In the past the area was forested, mainly with spruce and pine, today most of the area is not forested. Deforestation has occurred in several stages over the last 6 years. The reason for this has been the decline of coniferous stands, mainly due to bark beetle infestation. Today, deciduous trees, groups of original coniferous trees and most of the rest of the area is overgrown with dense vegetation. There is a mixture of grassland and scrubby woody vegetation. The total area of the site is 20.24 ha. The surrounding land consists of fields, forest, occasional groves, and there are also several ponds in the vicinity.
On the basis of the analysis of available relevant documents and extensive field work, a solution for restoration of the area of interest was proposed (Kupec et al., 2022). Due to the specific functions required of the vegetation, the knowledge of phytoremediation, which refers to a series of technologies that use photoautotrophic vascular plants to remediate sites contaminated with inorganic and organic contaminants, was applied (Reichenauer and Germida, 2008).

Materials and methods
The concept of the solution for the revegetation of the water source area is designed in such a way that the proposed vegetation structures help to improve the chemical state of the water drawn from the area, or in such a way that they permanently guarantee the removal of certain elements (especially nutrients) from the soil and thus prevent the potential mixing of surface water with the water of the aquifer of the water source area. The basic principle used for this in the proposal is bioremediation. Bioremediation simply means the removal of certain substances from one medium (water, soil) into another medium (biomass) and the subsequent disposal or transport of this biomass away from the remediated site. The principle of bioremediation is that plants (herbs, woody plants) consume certain substances (e.g. nutrients) for the construction of their plant tissue, taking up these nutrients through water they obtain from the soil environment. If plants or parts of plants are then removed from the site, these substances are not returned to the environment and their concentrations in the soil (soil colloids) decrease in the long term.
The second principle of the solution for revegetation of the water source area is the creation of a green wall, the aim of which is to slow down the flow of subsurface water in the direction of the hydraulic gradient by means of both a mechanical root wall and the suction pressure of the root systems (which significantly slows down the subsurface flow) of the proposed tree species in this wall.
The third design principle is the use of tree species that are native to the site, taking into account the history and current condition of the site and, in particular, the expected impacts of climate change.

The final principle used in the design of the revegetation of the water source area is to maximize the use of the current vegetation on the site and its successional potential in the context of both the potential technology for managing this succession and in the context of the design of the site as a whole (functionality, aesthetics).
A case study containing the formulation of the target state of the vegetation of the water source area and the technological basis for planning the implementation of its restoration was prepared using GIS and CAD software.

Results

The solution concept consists of access to the site through a service road network and a proposal for segmentation of the area according to the structures of woody vegetation, including their purpose and goal (Fig. 1).
The road network consists of the unbound roads with operational reinforcement (main roads) and unpaved tracks. The existing main access road (Trasa I) is 360 m long and has operational reinforcement (aggregate). The access roads allowing approach to the interior of the area (Trasa II, III) are designed for a total length of 748 m, with operational reinforcement (aggregate). Detailed access roads (Trasa IV to XIV) provide access to the core of the water source area and are designed as unpaved (grass cover) for a total length of 2,340 m + 106 m of the unpaved section of Trasa I. The extraction tracks are designed primarily to provide technological access to individual woody vegetation structures for a total length of 1,044 m, grassed cover (Linka I to XII). The cumulative length of the road network is 4,598 m (access roads and tracks).
Segment A - Line planting (1.17 ha). The target condition is perimeter planting of the northern, western and southern boundaries. This is a combined linear plantation consisting of poplar and oak (*Populus alba, Quercus petraea*) with addition of pioneer shrubs. The main road (Trasa I) will be accompanied with the alley of cherry trees. The purpose is to divide the site and provide a service corridor for maintenance of the fencing.
Segment B – Coppice remediation stand (4.29 ha). This consists of sections of poplar (*Populus alba, Populus nigra*) altered with sections of ash (*Fraxinus excelsior*). The central section adjacent to the woodland is based in a linear mixture of oak, elm and ash (*Quercus petraea, Ulmus minor, Fraxinus excelsior*). The segment is constructed of trees with replacement potential - the stand is maintained as a low coppiced stand. The biomass of the stand will be used to export nutrients from the subsurface soil water, the root system will serve as a wall to slow the flow of soil water in the direction of the hydraulic gradient.
Segment C – Forest steppe (3.76 ha). Transitional plant community between extensive communities of natural succession and the intensive coppice remediation communities. Another purpose is to provide habitat for small game and specially protected insect species (praying mantis). The target condition is a meadow with solitary woody plants or groups of woody plants and shrubs (*Pinus sylvestris, Crataegus monogyna, Ligustrum vulgare, Prunus insititia, Pyrus pyraster, Quercus robur, Rhamnus cathartica, Rosa canina*), divided by an extraction tracks.
Segment D - Controlled succession stand (7.35 ha). The purpose is to provide permanent cover of the subject parts of the site with shrub or tree type vegetation. Shrub plantations in the north-eastern part of the site – closed canopy stand fragmented with autochthonous species (*Cornus mas, Cornus sanguinea, Crataegus monogyna, Ligustrum vulgare, Prunus insititia, Rosa canina, Rubus sp., Sambucus nigra, Viburnum opulus*). In the south-eastern and eastern part of the area, there is a higher stand of forest trees dominated by poplar (*Populus alba*) at the canopy and oak (*Quercus petraea*) and the corresponding shrub species in the forest floor.
Segment E – Forest stand (0.75 ha). The segment is located in the eastern part of the site and is covered by forest with a mixture of autochthonous species (*Fraxinus excelsior, Quercus robur, Prunus avium*) with shrub cover (*Cornus sanguinea, Ligustrum vulgare*). The target condition is the transfer to holding designated for forest functions (PUPFL) and management according to Act No. 289/1995 Coll., on forests.
Segment F – Cherry-tree orchard (0.42 ha). The segment will serve as an aesthetic element near the water pump station building. It will be logically connected to the cherry-tree plantation along the access road. It will be a fruit-bearing aesthetic element with cherry tree planting and the use of native tree forms of *Prunus insititia*.
Segment G - Power Line Protection Zone (0.15 ha). The target condition of the segment should meet the requirements for power line operation. Currently there is a rich tree and shrub cover (*Cornus sanguinea, Crataegus monogyna, Euonymus europaea, Ligustrum vulgare, Prunus insititia, Pyrus pyraster, Quercus robur, Rosa canina, Rubus caesius, Sambucus nigra*).

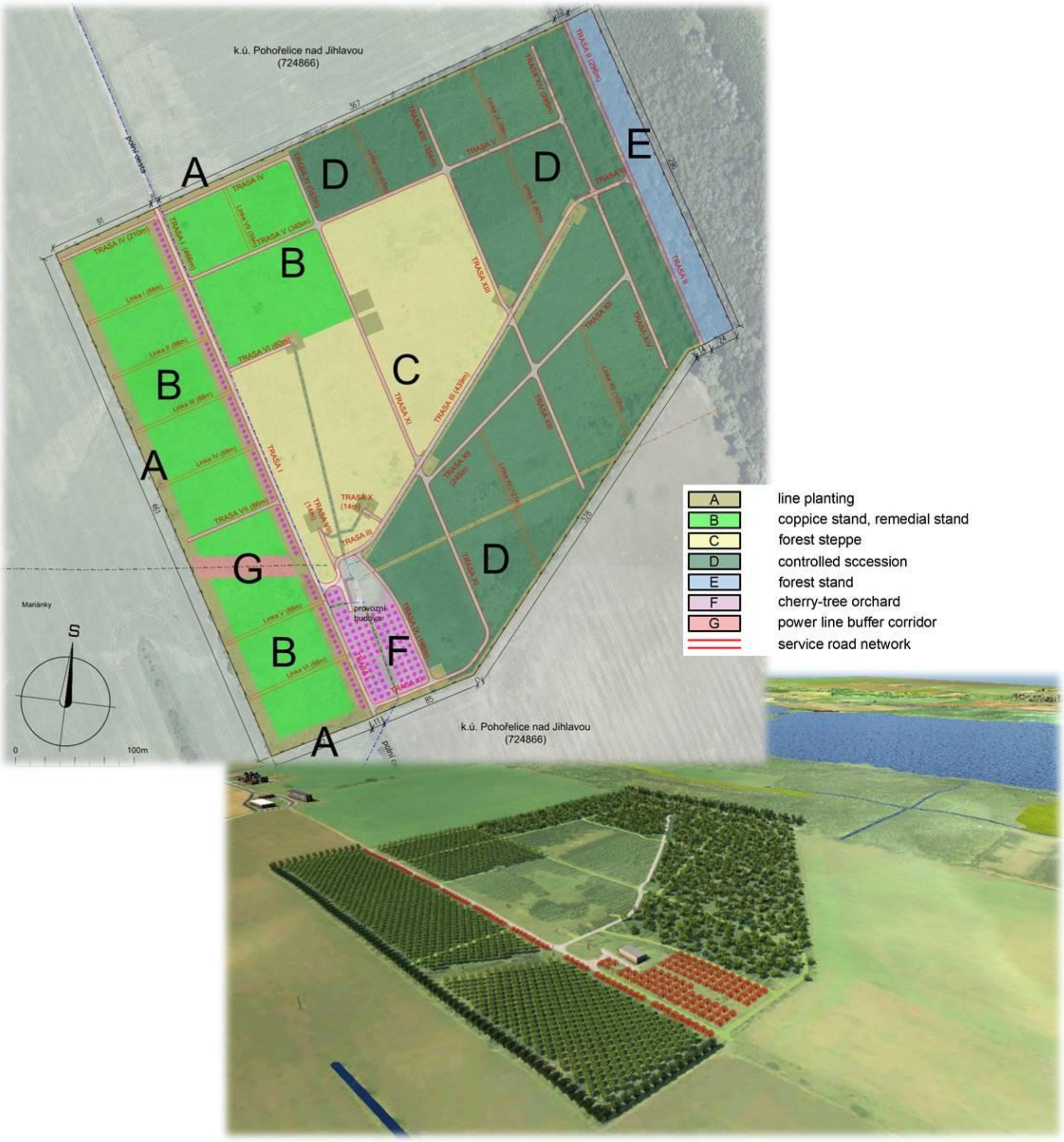

Fig. 1: Functional structures of woody vegetation and service road network

Discussion

The concentration of nitrates in natural waters is increasing as a result of population growth and agricultural activity (Hubačíková et al., 2020). The primary function of the vegetation on the revitalized site is bioremediation, in our case phytoremediation or phytodegradation. This takes place in plants via rhizobacteria, takes time and allows plants to use nutrients for growth, integrate contaminants into their cellular structures or metabolize contaminants directly (Reichenauer and Germida, 2008). Ancona et al. (2019) report that in the case of poplar trees (whose coppicing capacity is used in the proposal), pollutants accumulate mainly in root systems during bioremediation. The remediation purpose of stands requires a specific approach to the design of the species composition of the stands. For example, only biennial straight-rooted material in a 1.5×1.5 m spacing will be used for the area planting of trees in Segment B. The quantity of planting material in the segment amounts to 4,450 pcs/ha. Planting of approximately 18,000 trees is proposed throughout the area, which will be carried out after mechanical preparation of the site. Successful remediation of the vegetation is dependent on consistent post-planting care and implementation of the proposed management plan for the entire site. However, the potential attractiveness (aesthetic quality) of the site has been taken into account in the overall revegetation concept, although the assessment of aesthetic quality, particularly of natural features, is an inherently subjective task (Junker and Buchecker, 2008). The restoration of the area was designed in accordance with the principles of ecological integrity - sites with poorer levels of ecological integrity are perceived as less aesthetically appealing compared to sites that abound with higher levels of ecological integrity (McCormick et al., 2015). The cherry-tree orchard is then a special part of the proposal, which will act as a dominant feature of the area once the cherry trees have grown back (Deutscher, 2014). Later in the growing season, it can support the aforementioned ecological integrity of the area by increasing the food and habitat supply for animals. The public's aesthetic perception of revitalization projects is strongly positively related to the extent to which the revitalization meets public needs (Junker and Buchecker, 2008), and therefore we hypothesize that the site would be perceived overwhelmingly positively in a qualitative aesthetic investigation. Addition of utility structures at the site would be appropriate to increase recreational potential (Vallecillo et al. 2019). The site is accessed by a service road network approximately 4.5 km in length; no other types of structures are proposed (Hrůza and Procházková, 2017). It has also been found that although in some cases ecosystem restoration may lead to reduced recreational opportunities, revegetation represents an increase in functional diversity as well as more opportunities to experience nature, which may be the ultimate revegetation goal (Funk et al., 2020).

Conclusion

The case study of the revegetation of a catchment area focuses on the application of bioremediation knowledge. Optimally designed species composition and structure of vegetation will play a key role in reducing nutrients in the soil horizon and improving subsurface water quality.

References

Ancona, V., Barra Caracciolo, A., Campanale, C., De Caprariis, B., Grenni, P., Uricchio, V. F., & Borello, D. (2019). Gasification treatment of poplar biomass produced in a contaminated area restored using plant assisted bioremediation. Journal of Environmental Management, vol. 239, pp.137-141. doi:10.1016/j.jenvman.2019.03.038

Deutscher, J. (2014). The visual beauty of linear green-structures in the rural landscape, principles of aesthetic evaluation and its application in landscape management. Public Recreation and Landscape Protection – with Man Hand in Hand? Conference Proceeding, pp. 304-307.

Funk, A., Tschikof, M., Grüner, B., Böck, K., Hein, T., Bondar-Kunze, E. (2020). Analysing the potential torestore the multi-functionality of floodplain systems byconsidering ecosystem service quality, quantity and trade-offs. River Research and applications. vol. 37, pp.221-232. https://doi.org/10.1002/rra.3662

Hubačíková, V., Pokrývková, J., Marková, J. (2020). Change of Hydrological Regime and Water Quality Due to Reduced Wastewater Discharged into Surface Waters. Pol. J. Environ. Stud. Vol. 29, No. 4 (2020), 2661-2668. https://doi.org/10.15244/pjoes/111440

Hrůza, P., Procházková, P. (2017). Definition of the forest road according to Act No. 13/1997 coll., on roads and its public access in the Czech Republic. In Public Recreation and Landscape Protection - Hand in Hand : conference proceeding. Brno: Mendelova univerzita. ISBN 978-807509487-2.

Junker, B., Buchecker, M. (2008). Aesthetic preferences versus ecological objectives in river restorations. Landscape and Urban Planning, vol. 85, pp.141-154.

Kupec, P., Pelikán, P., Ohryzek, D. (2022). Obnova vegetace jímacího území Nová Ves u Pohořelic – the study. Mendelova univerzita v Brně.

McCormick, A., Fisher, K., Brierley, G. (2015). Quantitative assessment of the relationships among ecological, morphological and aesthetic values in a river rehabilitation initiative. Journal of Environmental Management, vol. 153, pp. 60-67

Reichenauer, T. G., Germida, J. J. (2008). Phytoremediation of organic contaminants in soil and groundwater. ChemSusChem, vol. 1(8-9), pp.708-717. doi:10.1002/cssc.200800125

Vallecillo, S., La Notte, A., Zulian, G., Ferrini, S., & Maes, J. (2019). Ecosystem services accounts: Valuing the actual flow of nature-based recreation from ecosystems to people. Ecological Modelling, vol. 392, pp. 196–211. https://doi.org/10.1016/j.ecolmodel.2018.09.023

Acknowledgement

The study was prepared with the consent of BVaK, a.s., Břeclav.

Souhrn

Článek prezentuje výsledky případové studie, která byla zpracována v povodí vodního zdroje Nová Ves u Pohořelic. Lokalita, původně porostlá vzrostlým jehličnatým lesem, byla v důsledku sucha odlesněna, což se bezprostředně projevilo na kvalitě vody ve vodním zdroji, zejména výrazným zvýšením obsahu dusíku. Cílem studie bylo navrhnout strukturu krajiny, tvořenou především prvky dřevinné vegetace, která svou existencí zajistí opětovné dosažení požadované kvality vody.

Contact
doc. Ing. Petr Kupec, Ph.D.
E-mail: petr.kupec@mendelu.cz