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Beaver Dams in the Context of a Factor Shaping the Hydromorphological and Hydrological Conditions of Small Lowland Streams

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Abstract

Beavers are responsible for creating temporary water reservoirs, that significantly impact the environment and local river hydrology. This study focused on the possibility of determining the impact of beaver (Castor spp.) dams as a method to support water retention in the environment. Studies carried out on three small lowland streams in central Poland revealed that beaver dams, even in modified riverbeds, aid the creation of shallow floodplains and ponds by improving instream retention. Innovative analyses considered the construction materials of the dams and their impact on river hydromorphology and sediment transport. The results highlight the importance of beavers in water retention processes, stabilisation of water levels during low flows and protection of biodiversity. The study demonstrated that beaver dams locally, these structures influence hydrology, improve ground moisture, extend water retention times and create habitats for many new species improving biodiversity. The collected data highlights the potential of beaver dams as a tool to help manage water resources in the context of climate change. Further research may provide guidance for the sustainable utilisation of beavers in conservation strategies and landscape planning.

1. METHODOLOGY AND MATERIALS

Analyses of the influence of natural damming on hydromorphological, hydrological, and environmental conditions were carried out on the example of selected lowland rivers located in the Wielkopolska region, Poland. The studied streams inhabited by beavers include the Kończak River (Stobniczka), Mogilnica, and Cybina.

The water table configuration in the riverbed near the beaver dams was determined based on elevation measurements conducted during fieldwork. Detailed measurements of the riverbed were conducted, taking into account the geometry of the riverbed and the water table level. Data for analysis and calculations were obtained from field studies conducted between 2020 and 2023. Geodetic equipment such as an optical level and RTK GPS were used for elevation measurements. Water flow velocity in river channels was measured using a Valeport Model 801 electromagnetic. To determine the discharge of water, the results of velocity measurements were utilised. In each cross-section, several hydrometric verticals were identified, located both downstream and upstream of the structure.

The determination of the material used to construct the beaver dams (Scamardo at al. 2022; Butler 2012) was carried out based on field studies and measurements of the diameters of the branches that made up the structure of the dam. The measurements were made using a digital calliper with an accuracy of 0.5 mm. The granulometric composition of the sediment samples was determined using the sieving method, according to the standard procedure described in the national standard PN-EN 933-1.

For hydrological analyses, the SCALGO Live software was used, which is considered a very useful tool for determining surface runoff paths and a better understanding of the impact of land use on hydrological conditions in the catchment area. SCALGO is based on a digital terrain model obtained through Airborne Laser Scanning (ALS). According to the available information, the models take into account the detailed microrelief of the terrain, including buildings, road embankments, and drainage ditches. A Digital Elevation Model (DEM) was used to create a three-dimensional representation of fragments of the studied catchments. The terrain model was built with a raster resolution of 1×1 meters. The program was used, among other things, to determine the surface area and volume of the beaver ponds and the extent of the backwater, which was verified by field measurements.

2. RESULTS

Measurements of the type and properties of the dam material have been made based on 103 samples. The largest percentage of all measured samples consisted of branches with a diameter of Ø 5 cm (22.14%). Branches with a diameter of Ø 4 cm accounted for 19.08%. Branches with diameters ranging from 2 to 5 cm accounted for as much as 74.05% of all branches used in the construction of the dams. The dam, in addition to the wooden material, was also constructed with mud (which sealed the structure) and was partially covered with herbaceous vegetation. The construction material consisted of willow shrubs (Salix alba L. and Salix fragilis) and branches of black alder (Alnus glutinosa (L.) Gaertn.), with trunks and gnaw marks identified on the banks of the stream.

The SCALGO program was used to estimate the volume of beaver ponds and to represent the areas that will be covered by water as a result of the rise in the water table in the stream. Due to the capabilities of the software, these results were presented assuming a constant water level elevation. The estimated increase in retention volume was calculated based on the increase in the cross-sectional area of the stream resulting from the rise in the water level (considering the water level before the beaver dam and after the beaver dam, treating the latter as the pre-dam construction level) and the length determined using the Digital Elevation Model (DEM) of the backwater formed as a result. Due to the decrease in the water level as a result of the cessation of the backwater effect created by the beaver dams, it was assumed that the backwater would decrease uniformly along its length, halving the estimated increased retention volume.

Based on field measurements of the rise in water level resulting from the construction of beaver dams, the change in the water level elevation was estimated. Figure 1a shows the extent of the backwater associated with the rise in the water level on the Kończak River. The impact

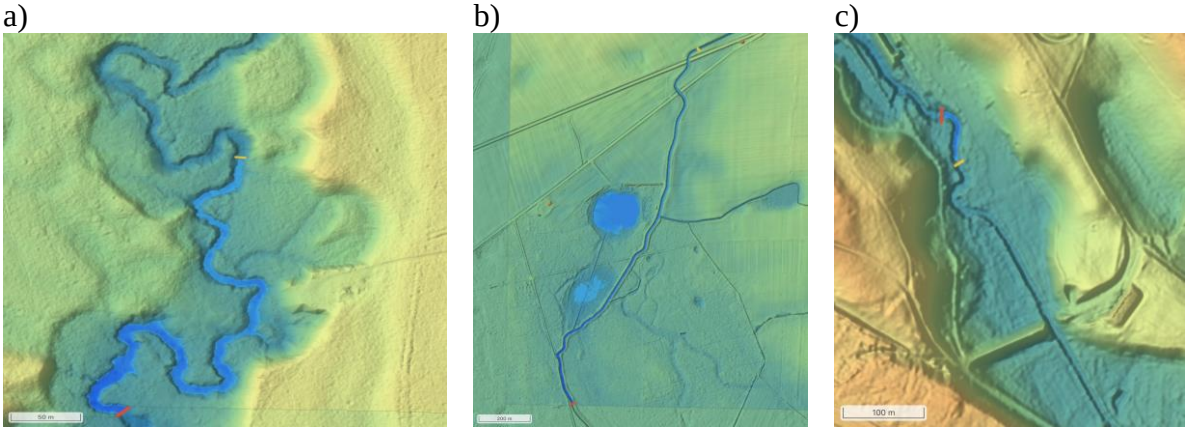

Fig. 1. The extent of backflow due to the construction of the Beaver Dam on the: a) Kończak River (WL 54.22 m a.s.l. – damming 0.31 m); b) Mogilnica River (WL 76.16 m a.s.l. – damming 0.74 m); c) Cybina River (WL 60.52 m a.s.l. – damming 0.37 m) (The red line represents the location of the beaver dam, and the yellow line indicates the extent of the backflow at the specified water level elevation).

of the backwater in this case is 510 m. Figure 1b shows the extent of the backwater associated with the rise in water levels on the Mogilnica River, which reaches as much as 1.8 km. Additionally, as a result of the rise in the water level, two depressions in the terrain were filled with water, forming two ponds. The additional retention volume of these two ponds is approximately 6,500 m³, with a water level elevation of 76.16 m above sea level. In Figure 1c, the reach of the backwater effect related to the rise in the water table on the Cybina River is shown. In this case, due to the terrain surrounding the river and the slope of the riverbed, the reach of the backwater effect was approximately 80 m.

3. CONCLUSIONS

Studies conducted on three small lowland watercourses located in central Poland have shown beaver's influence on shaping local watercourse hydromorphology and water retention. Even in the case of transformed, narrow troughs (e.g. on the Mogilnica River, where channel retention was relatively low and the valley layout did not directly affect the formation of beaver ponds) the extent of beaver dam accumulation allowed the formation of shallow floodplains and ponds in field depressions hydraulically connected to the main watercourse. The novelty of the research is the detailed analysis of dam construction material and the study of the impact of beaver dams on river hydromorphology, including changes in the grain size of the debris. Precise data on the size of dams and their impact on water retention and sediment transport have been obtained, enriching knowledge of the role of beavers in ecosystems. Despite the numerous ecological benefits, there are still research gaps regarding the comparison of beaver dams with other anthropogenic water bodies. This includes their impact on farming and forestry. The results also underscore the potential importance of beaver dams as a tool in water management in the context of climate change. The magnitudes of flows during low periods clearly indicate that only the additional effect of beaver damming in the channel allows the water table to remain relatively stable.

Further research into their activities could provide valuable insights into the effective use of beavers in sustainable development.

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