The Effect of Beaver Activity on Artificial Impoundment on the Braszcza River in the Białowieża Primeval Forest

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Abstract

In Poland in recent years, the number of engineered and technical structures in forest areas has increased, and these have in turn affected water conditions. The purposes of these structures include protecting habitats, enabling rehabilitation of wetland areas, and protection of biodiversity. In addition to the State Forests National Forests Holding, numerous other organisations and associations have taken part in work to improve water conditions. One of these organisations is the Polish Society for the Protection of Birds, which, at the beginning of the 21st century, worked to improve the habitat conditions of birds. This effort was made by constructing dams on watercourses in the Białowieża Forest. As part of this work, several structures were built on the Braszcza River. One of these dams has been monitored since 2004 to assess the impact of the structure on water level. This dam has become an ideal location for habitation of the beaver, which was first noticed in the spring of 2006. Beaver activity has increased the height of the dam by approximately 50 cm. In this study, we analyzed changes in water level prior to the arrival of beavers, during their stay, and after they left their lodges.

Keywords: beaver, water level, the Białowieża Primaval Forest

Introduction

At the turn of the 21st century, water deficits were observed in Polish forests, including water shortages in forest soil and decreases in water surface level. This resulted in a decrease in the humidity of forest habitats. The underlying causes of this were both man-made and climatic ones, caused by warm winters that had an adverse impact on water resources. These changes also affected the Białowieża Forest, which resulted in lower water resources (Czerepko et al. 2007). The best conserved lowland forests of Europe have suffered due to water shortages, in particular wet deciduous and mixed forests that cover approximately 14.5 % of the Białowieża Forest.

To improve water availability, attempts to change this situation were undertaken. The North Podlasie Society for the Protection of Birds (since 2006 the Polish Society for the Protection of Birds, PTOP) began cooperating with the Regional Directorate of State Forests in Białystok to develop small scale water retention systems. In 2001, on initiative of the North Podlasie Society for the Protection of Birds, the construction of small scale water retention elements was started within the Białowieża Forest area. By 2005 a total of 33 structures had been built in the Łutownia River basin.

The dams, or weirs, built by the PTOP created a perfect location for beaver settlement. Built upon the existing manmade dams, beaver dams resulted in flooding of surrounding areas. This has resulted in a dilemma as to what measures, if any, should be taken in such areas to protect animal species, habitat, or vegetation. The aim of the study is to identify and assess the impact of beaver dam on shifts in hydrology within the vicinity of these dams during the entire lifespan of the dams.

Materials and methods

Study area

The weir that was studied is located in the northern part of the Białowieża Forest, approximately 4 km east of Narewka village, in the 82nd compartment of the Browsk Forest District. The weir is situated on the Braszcza River, which is the right bank tributary of the Narewka River. The length of this tributary is approximately 9 km, and the catchment area is 40.3 km^2. The shape of the catchment area is irregular; the upper part of the catchment area is wide, with a maximum width of 7 km, and in the lower region the river narrows to a width of 1.3 km. Braszcza, as with the majority of the forest's rivers, originates from wetlands located northward of Masiewo village and does not

have a typical source. Since the middle of the 20th century, beavers have extensively dammed the Braszcza River. The forest cover in the catchment area is 74.7 %. The woodlands, forming part of the catchment area, are characterized by high heterogeneity, and it is difficult to discern which group of habitats is important within the catchment area. Fresh forest sites constitute 36.1 % of the area, whereas moist and marshy sites comprise 38.6 % of the area.

Methods

We studied a stone weir, on which, in 2006, beavers added their lodge. As a result, they increased the original damming height by approximately 45 cm, which has resulted in the formation of a reservoir. Two monitoring wells were placed in 2004 on the test surface. One was situated in the river (well 1), and the other at a distance of 40 m from the first well (well 2). The wells were fitted with equipment to record water surface level at 6-hour intervals, and a mean daily value was determined based on these measurements. Figure 1 illustrates the design of the weir that was investigated in this study. Beavers built a dam at the highest point of the weir. Placements of the wells and the weir, including topography, are shown in Figure 2.

To determine the changes in water surface level depending on the presence of beavers, the measurement period was divided into three phases. The first phase, in the absence of beavers, was from 1/04/2004 to 31/07/2006. The second phase covered the period of beaver settlement in the structure, between 1/08/2006 and 30/06/2008. The third phase was the period of time when no beaver activity was observed, between 1/07/2008 and 30/06/2013. The dates for the third phase were determined based on field observations, including the condition of the beaver lodge (no new elements and current repairs), signs of feeding (no new felled trees and shrubs) and changes in the elevation of the ground water table (Figure 3).

Results

In the first period between 1/04/2004 and 31/07/2006, that is, in the absence of beaver activity, the level of the water table showed greater variability in the well located 40 m from the watercourse. There were greater water level rises as well as drops in the periods without precipitation. Therefore, the presence of the weir caused discernible changes in the water level. The greatest difference between the maximum and minimum values in the eleva-

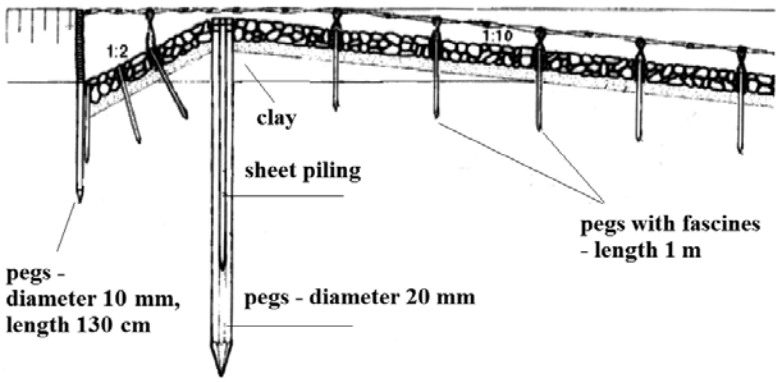

Figure 1. The design of the weir

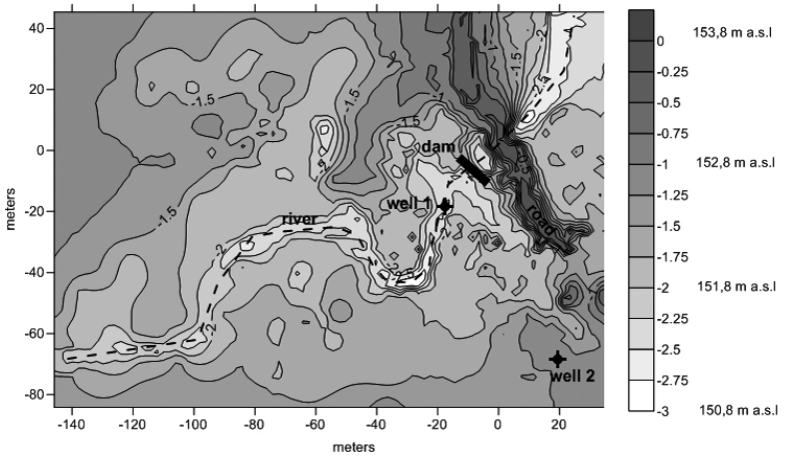

Figure 2. The topography of the studied surface in the 82nd forest compartment of the Browsk Forest District (reference level 153.8 m a.s.l.) with landmarks

tion of water surface level in the watercourse was 63 cm, while at a distance of 40 m from the watercourse it was 77 cm. In the second phase, from September 2006 until the middle of 2008, the level of the water table in wells 1 and 2 was affected by the beaver dam. The impact of the beaver dam resulted in a "smoothing" of changes in the water table, resulting in limited fluctuations compared to the situation prior to beaver settlement. In the second phase between 1/08/2006 and 30/06/2008, the largest difference between the maximum and the minimum values of water table level in well 1 was 55 cm whereas at well 2 it was 59 cm. Taking into consideration the fact that these periods were designated in a rather subjective manner, the differences may be less pronounced. This was the case in 2007, midway through the second measurement period, when the beaver dam was fully operational; during this period the differences amounted to 22 cm for the watercourse, and 31 cm at a distance of 40 m from the watercourse (Figure 3). During the third period between 1/07/2008 and 30/06/2013, when the beavers left the area, water fluctuations appeared to be similar to that observed prior to the beavers' arrival. However, comparison of measurements at phase 1 and phase 3 revealed that the water level was slightly higher after the beavers left the dam. This was most likely due to the remaining elements of the beaver dam remaining in an unrepaired state, which produced the relative increase in water surface area. After the beavers left the structures, the differences between the highest and lowest water surface elevations were 63 cm for the watercourse and 66 cm at a distance of 40 m from the watercourse.

The mean water table levels in the watercourse for well 1 during the designated periods are shown in Figure 4. Prior to the beaver dam being built, this was 151.85 m a.s.l. The minimum and maximum levels were 151.44 m and 152.07 m a.s.l., respectively. In the second phase, when the beavers were present, the mean water level increased by 60 cm to reach a mean height of 152.45 m a.s.l. The difference between the minimum and maximum values during that period was 55 cm. However, in 2007, when the beaver dam was fully developed, the difference between the maximum and the minimum levels was only 22 cm, and the mean water level was 152.48 m a.s.l. This shows a significant reduction in fluctuations of the water level associated with the presence of the beaver dam. When the beavers left the structure, the water level did not return to its previous state. The existing, damaged dam still exerted an influence on the mean level of water, which was found to be 152.18 m a.s.l., or 33 cm higher than the mean value at phase 1.

At a distance of 40 m from the watercourse, the mean water table levels were higher than those recorded in the watercourse. Additionally, at well 2, the differences between the maximum and the minimum surface water elevation were greater. The mean levels of the water table during 3 periods are presented in Figure 5. In the period when the beavers were absent, the mean height was 152.09 m a.s.l., with a 77 cm difference between the extreme values. During the period of beaver activity, the water level increased by a mean height of approximately 50 cm to reach 152.58 m a.s.l. The minimum and maximum levels were 152.16 m and 152.76 m a.s.l., respectively. As had been done with watercourse measurements, taking into consideration the fully developed dam in 2007, the difference between the minimum and maximum levels was only 31 cm. In the period after the dam had been abandoned by the beavers, the

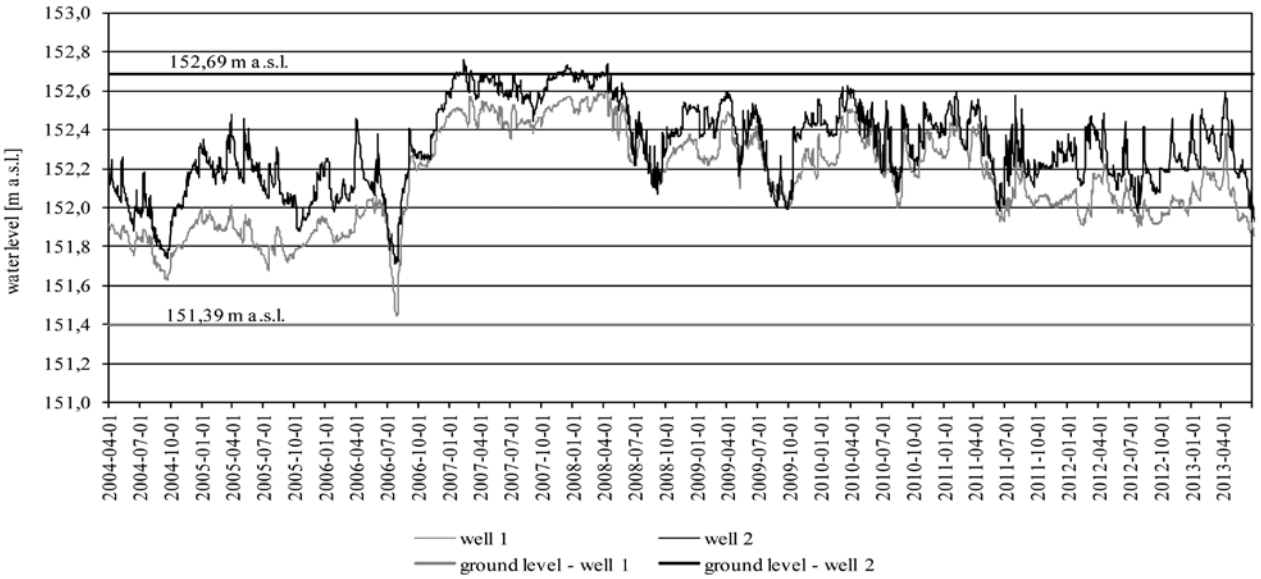

Figure 3. Time course showing the changes in the level of water table in the 82nd forest compartment of the Browsk Forest District

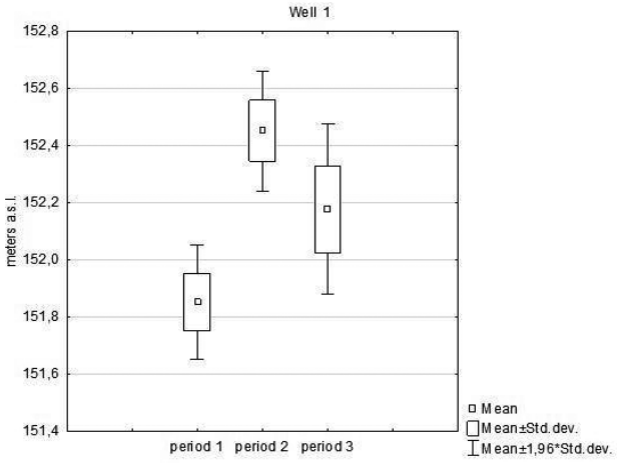

Figure 4. Mean water levels in well 1 for the individual periods

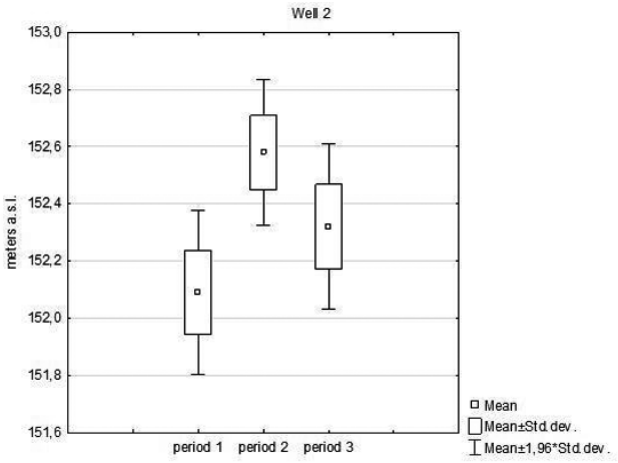

Figure 5. Mean water levels in well 2 for the individual periods

mean water level fell to 152.32 m a.s.l., which was still 23 cm higher than the original value at phase 1.

As a result of beavers settling in the structure a reservoir was formed, which covered an area of over 4.5 ha. This caused certain trees to die and the entire flooded area was left for the natural succession.

Discussion and conclusion

The subject of this study is of local importance, and it fits with the general view that beavers usually settle into watercourses that are shallow and not very wide (Czech 2000). In this case, beavers built a dam on the artificial damming structure, which facilitated the construction process. Commonly applied construction materials were used, such as tree trunks, branches, mud, soil, and turf. (Czech 2000).

The height of a beaver's dam seldom exceeds 1.5 m (Gurnell 1998). Measurements performed in the Bory Tucholskie region indicate that the mean height of a dam is approximately 0.8 m with a span of 0.3-2 m (Rurek 2013); similar results were obtained on a stream in the Ojców National Park (Medwecka-Kornas and Hawro 1993). The studied beaver dam in the Białowieża Forest also fits into these dimensions, as its height is approximately 0.5 m. Typically, a reservoir of 0.5 to several dozen of hectares is created as a result of a beaver dam construction (Czech 2000); generally larger and shallower ponds are located in the lowlands and smaller and deeper ones in the uplands and in the mountains (Johnston and Naiman 1987). The studied site conforms to these generalizations, as the studied location exceeded an area of 4.5 ha. The dam in this study was constructed in the middle of 2006, and after it was abandoned by beavers it continued to impact water levels. Researchers have estimated the mean time of operation for a single dam to be approximately 10 years (Knudsen 1962, Remillard et al. 1987, Fryxell 2001). However, in the Appalachian Mountains, more than 20% of dams last for more than 11 years (Fryxell 2001). Researchers have conducted observations on beaver dams as old as 56-year-old ones (Bonner et al. 2009). The watercourses transformed by beavers have increased water retention capabilities. In addition, larger water surface area increases transpiration; however, it is substantially lower than the volume of retained water (Woo and Waddington 1990). Beavers are, therefore, the source of site disturbances that can last for up to 50 years (Wright et al. 2002, Terwilliger and Pastor 1999); however, the mean duration of the cycle of site changes (e.g. the process of habitat changes from scrubland to flooding to meadows and back to scrubland) lasts between 10 and 30 years (Remillard et al. 1987). Widening of the riparian zone (McKinstry et al. 2001) and rising of groundwater level (Gałek and Woch 2011) are also observed. At our site, the rise in groundwater level reached an average of 50 cm at a distance of 40 m from the watercourses in the stand. Tree growth decreased, and within two years of the pond formation nearly 80 % of trees died (Boczoń et al. 2009). Artificial damming was not found to impact birds. However, after settlement of the site by beavers, flooding increased surface area several times inundating the terrain that was intended for birds. During the settlement of the site by beavers, the water level stabilized and the amplitude of fluctuations declined significantly. However, this occurred at levels causing significant damage to vegetation. Beaver protection status in Poland forbids both the destruction of their dams and the hunting on them. Modification of their dams can possibly mitigate damage caused by beavers. Pipes placed in beaver dams can equalize the water level regardless of the height of the dam (Taylor and Singleton 2014), however this technology is not very popular in Poland yet. This option is one of the simpler and cheaper solutions.

In Poland, beavers are under strict protection, and as their population continues to grow additional conflicts

will probably arise between beavers and human interests in the coming years. In 1976, the estimated number of beavers was 500, but by 2012 this number had reached 89,000 (Witkowski 2013). Undoubtedly, beavers serve an important role in increasing biodiversity through the erection of dams and the formation of impoundments. Beaver impoundments significantly contribute to the abundance and diversity of mammal species. Animals from small pigmy shrews to larger species, such as roe deer, are able to benefit from beaver activities in ways that suit their own survival needs (Janiszewski et. al 2014). Beavers play an important role in water retention and maintenance of soil moisture content; nevertheless, in forest areas they may cause local extinction of tree stands in river valleys, which may result in the formation of deforested valleys and the halting of typical forest riverside communities.

The results of the study indicate that beaver dams can significantly influence hydrological conditions in the watercourse and its surroundings. The water surface level in the watercourse at the studied site increased by more than 60 cm, whereas at a distance of 40 m from the watercourse the water table increased by 50 cm. A reservoir covering an area of over 4.5 ha was formed, which interrupted the growth stages of local flora and caused tree stand to die. One recommendation for the builders of artificial weirs is to carry out a more detailed analysis on the extent of the potential reservoir. This should be conducted with regard to the likely increase in water level caused by beavers, and careful planning should be employed to try to minimize the possible adverse effects of flooding.

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