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RESTORATION POSSIBILITIES OF VALUABLE NATURAL HABITATS

Abstract: Restoration is a well-known and commonly used active and/or passive protection procedure that is aimed at restoring the original habitat conditions. The choice of restoration methods is closely related to the properties and conditions in a given habitat. The scope of activities carried out as part of the restoration procedure is selected in such a way so as to intervene in the natural environment as little as possible and bring the best results. Such activities are commonly considered difficult to implement and burdened with significant costs, while their usefulness is low. However, practice shows that it is possible to undertake restoration activities at low costs and with positive effects that are visible in a relatively short time. The restoration of valuable hydrogenic habitats, such as the mountain fens of the *Caltho-Alnetum* community in the Babia Góra massif is a great example here. The performed restoration activities proved that with minimal intervention in the environment, with the use of natural local materials or the application of extensive forms of utilisation, the condition of these habitats was improved, the degradation processes were stopped and their natural functioning was restored.

Keywords: restoration of hydrogenic mountain habitats, biodiversity protection, swamps, peat bogs, wetlands

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Introduction

Human activity affecting the natural environment systematically intensified together with the development of civilisation and industry. Centuries ago, man used the environment extensively, satisfying their basic needs, primarily associated with foraging for food. As the civilisation developed, the human needs for food and improvement of the quality of life systematically increased. Over the centuries, during the so-called Neolithic Revolution (10 000 to 4 000 BC), the hunter-gatherer economy moved slowly from hunting and gathering to agriculture and breeding. At that time, the environmental impact of primitive communities was relatively small. However, in order to be able to locate new settlements and acquire land for agricultural crops, it was necessary to occupy more and more space and adapt this space to the growing needs. The rapid conversion of settlements into large agglomerations already resulted in significant changes in ecosystems. Industrial revolutions associated with the use of the steam engine, mechanisation of agriculture and the economy, the invention of electricity and assembly lines, production automation and the use of information and communication technologies in industry, although undoubtedly improved the standard of living, had an enormous impact on the natural environment (Michalski, 2017). Economic development in the eighteenth and nineteenth centuries did not take into account the protection of nature and the environment. The necessity to feed an increasing human population, the development of infrastructure, or the need to obtain natural energy resources resulted in the degradation of the environment. The twentieth century also saw the pursuit of maximum economic growth while neglecting environmental protection (Fiedor & Kociszewski, 2010).

One of the elements of the natural environment that was subject to high anthropopressure in the process of civilisation development was hydrogenic habitats. These habitats closely depend on the presence of water. Many of these habitats around the world have recently been degraded by drainage (Zedler, 2000; Scholz, 2011; Xu et al., 2012; Grand-Clement et al., 2015). Despite the growing public awareness of the role of hydrogenic habitats in the environment, the processes of their degradation continue (Hu et al., 2017). Based on his research, Davidson (2014) found that humans have lost about 87% of wetland areas since the beginning of the eighteenth century. The decrease in the area of wetlands as a result of their dehydration is associated with changes in habitat conditions, a significant reduction in water retention and, consequently, loss of biodiversity. The degradation and devastation of hydrogenic habitats is also contributing to the global acceleration of the extinction rate of species. According to the researchers, the current rate of extinction of species, resulting from anthropopressure, is at least 1,000 times higher than in other epochs. About 100 species extinct during one day, many of which may not yet be described (Aguilera, 2019).

One of the examples of hydrogenic habitats degraded as a result of human activity are the mountain fens of the *Caltho-Alnetum* community in the Babia Góra National Park. These are hydrogenic habitats, the small patches of which occurred in places where groundwater flows onto the surface. These habitats occur in slope locations and despite the fact that they occupy only about 1.15% of the area of the Babia Góra Massif in Outer Flysh Carpathians, Poland, they are included in the Natura 2000 system as priority habitats (*91E0-7 code). The mountain fens of the *Caltho-Alnetum* community is a habitat for many protected species of plants and animals (JoL 2012 No. 0 item 81, JoL 2011 No. 237 item 1419), included in the IUCN Red List of Threatened Species (IUCN 2016). The presence of these habitats has a positive effect on the maintenance of biodiversity.

During the 1960s and 1970s, most of the habitats located on the mountain fens of the *Caltho-Alnetum* community were drained. The drainage was aimed at reconstructing the tree stand in order to introduce tree species other than alder, more valuable in terms of use (Nicia et al., 2017). Today, in order to stop negative changes in hydrogenic habitats, their restoration is necessary (Nicia et al., 2018a; Nicia et al., 2020). This research paper discusses the possibilities of restoration of heterogeneous habitats on the example of mountain fens of the *Caltho-Alnetum* community, by means of taking passive measures of active protection.

Material and methods

The restoration processes carried out on three drained research plots of the mountain fens of the *Caltho-Alnetum* community in the Babia Góra National Park (Fig. 1) began in 2010. These habitats were drained in the 1960s, in accordance with the forest management instruction of 1957, with drainage ditches 0.2 to 0.8 m deep. As a result of the drainage, the topsoil of these habitats was subjected to the moorshing process. In order to restore degraded habitats to a state close to natural, restoration processes were initiated without removing the top layer of moorsh. They involved the gradual raising of the groundwater level by blocking the outflow of water from the degraded habitats. In order to control the irrigation rate of the restored habitats on the research plots, piezometers were installed to monitor the groundwater level. Soil samples were taken from the places where piezometers had been installed to determine the basic soil parameters. In order to determine the influence of the restoration processes on the degraded habitats, water level monitoring, determination of the species composition of vegetation growing on the studied habitats and soil analyses were performed until 2018.

Results and discussion

After drainage, the soils of hydrogenic habitats pass from the organic matter accumulation phase to the decay phase, in which the soil profile is subjected to the moorshing process. As a result of drainage, habitat conditions change, this results in extinction of stenotopic species of plants and animals. It was also the case with the mountain fens of the *Caltho-Alnetum* community located in the area of what is now Babia Góra National Park. These habitats were characterised by a soligenous type of hydrological supply. Before they were protected as the national park, they had been dehydrated by means of ditches draining water directly from the place where it flowed out of the mouth of the aquifers. The aim of the drainage process was to introduce a tree

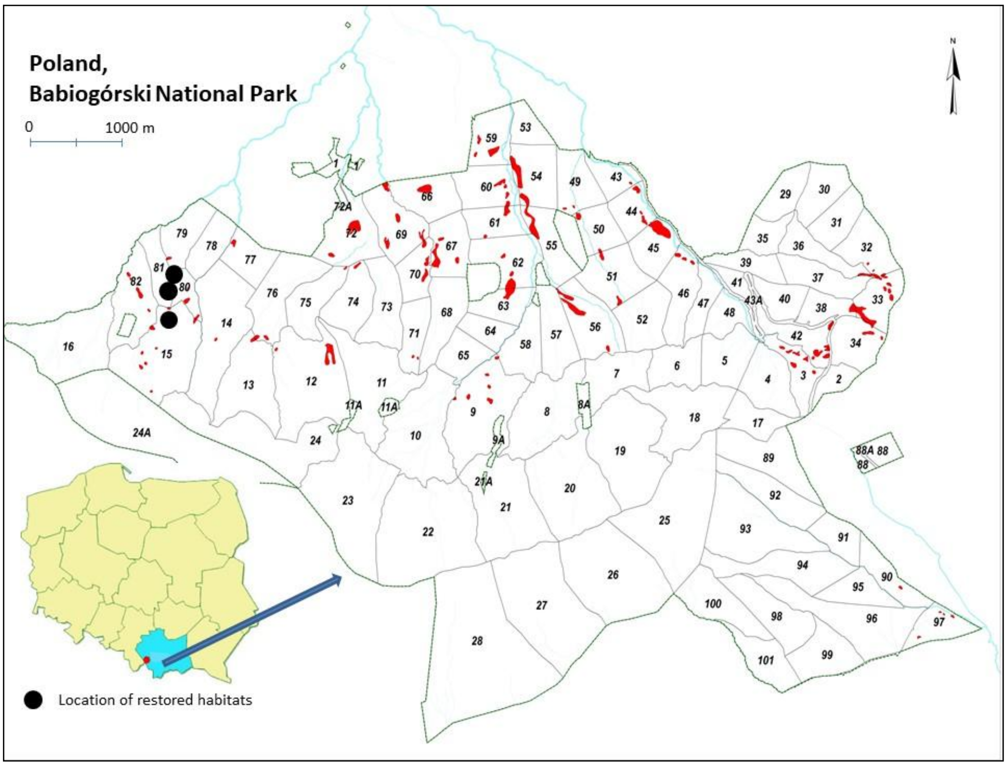

Fig. 1. Location of degraded and restored habitats
Source: Babiogórski National Park

stand of more economic value than the alder to the fens of the *Caltho-Alnetum* community. Spruce and ash were planted there. Cutting off the water supply to these habitats has proved to be very effective. The ditches on these habitats were made perpendicular to the contour lines, which meant that they did not become silted even after several dozen years. The soils of these habitats were drained and passed from the organic matter accumulation phase to the decay phase. In this phase, the soil profile of mountain fens was subject to the moorshing process involving organic matter mineralisation. In the case of the discussed mountain fens, this process progressed very quickly. Currently, about 40 years after the drainage of some habitats, the ground level has lowered even by about 0.8 m due to the decomposition of organic matter (Fig. 2). The drainage process had severe consequences for these habitats, resulting in not only a change in habitat conditions causing extinction of protected plant and animal species, but also posed a serious threat of the possibility of windbreak occurrence in these areas. The vast majority of spruce and ash trees planted there in the 1960s and 1970s died and toppled over.

In order to restore the original state of hydrogenic habitats, it is necessary to carry out active protection restoration activities. This will help to stop further degradation of habitats and, in the long term, bring them back to a near-natural state. The restoration of hydrogenic habitats in lowlands consists in removing the top layer of moorsh and slowly raising the groundwater level. This method of restoring hydrogenic habitats to the natural state cannot be used in protected areas, especially in the mountains. Degraded patches of these habitats are located in hard-to-reach areas with a slope of up to several

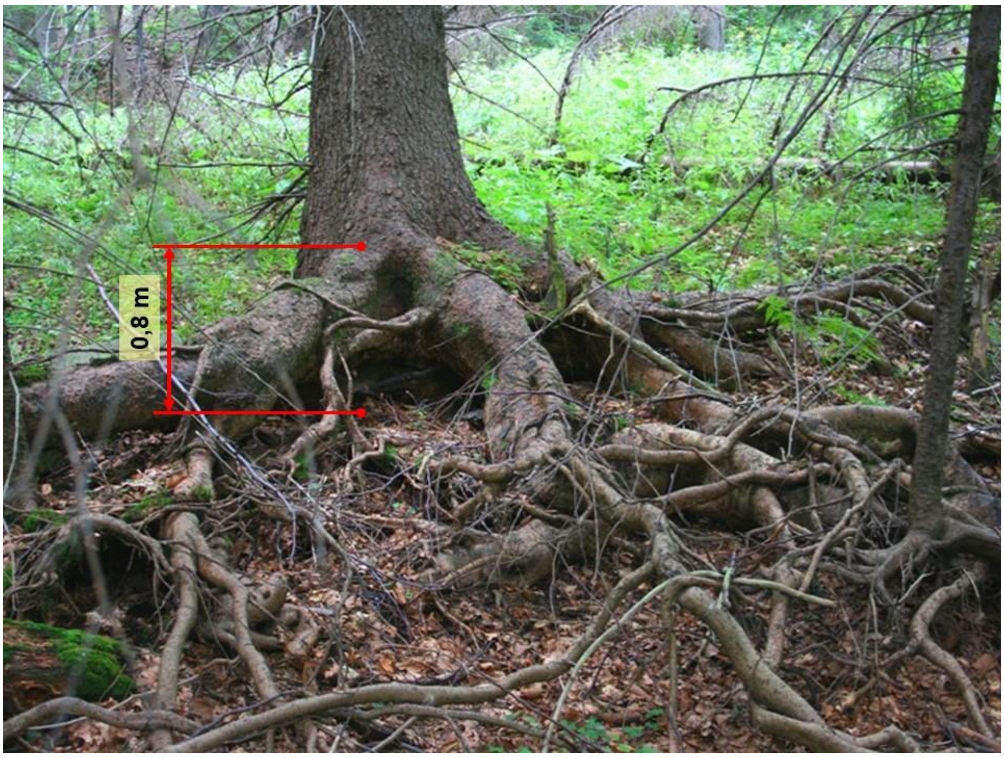

Fig. 2. Example of lowered ground level resulting from mineralisation of dehydrated organic matter
Source: Photo by Paweł Nicia

percent. Moreover, removal of the top layer of moorsh from degraded hydrogenic habitats is technically difficult to perform in such conditions and could lead to degradation of other valuable natural habitats. Moreover, it could trigger erosive processes.

Having analysed the above-mentioned threats, a decision was made to choose a different method of restoration. In order to raise the groundwater level in the dehydrated soils of the habitats, it was decided to gradually block the outflow of water in the drainage ditches. In order to prevent the occurrence of erosion processes, the process of raising the water level was continued slowly over a period of 4 years. The groundwater level was controlled in piezometers installed on the research plots.

Usually, during hydrogenic habitat restoration processes, a system of gates made of materials such as concrete and wood is installed in drainage ditches in order to restore the original groundwater level. In this case, a different solution was selected. Since the mountain fens of the *Caltho-Alnetum* community were protected, the gradual obstruction of the outflow of water from the restored habitats was carried out with the use of available local material – wood from dead trees planted in the 1960s and 1970s on the mountain fens. Most frequently, these were partially rotten trunks and branches of ash and spruce that died in these habitats. In this way, makeshift gates were made. Trunks and branches in drainage ditches slowed down the flow of water and caused their gradual silting. In order to effectively block the outflow of water, it was important to select the appropriate number of such gates. Their number depended on e.g. the topography and the depth of the drainage ditches. In areas with a steeper slope, in habitats drained by ditches 0.8 m deep, the gates were made densely, at distances of about 0.7 to 1 m. In the case of mountain fens located in an almost flat terrain, the distances between the gates were even 3 to 4 meters. Trunks and branches alone would not seal the drainage ditches sufficiently. In the autumn, the gates installed in the drainage ditches were effectively sealed with a significant amount of leaves from beech trees growing in the surrounding area.

The use of such a method made it possible to avoid introducing artificial materials such as concrete or structural steel into the restored habitats. The undoubted advantage of this solution was also the reduction of the costs and the ease of implementation. Blocking the outflow of water from dehydrated habitats was implemented gradually. Raising the groundwater level too quickly could trigger erosive processes in a strongly dehydrated, hydrophobic layer of soil. As a result of raising the water level too quickly, the moorshed layer of soil could slide down the slope, which would cause hardly reversible damage to other valuable natural habitats located below the restored habitats.

The activities aimed at blocking the outflow of water from the mountain fens were carried out until 2014, with the gradual increase of the water level. After 2014, the drainage ditches were silting spontaneously as a result of the slowing down of the water flow. A large amount of organic matter in the form of leaves effectively sealed the gates made of trunks and branches. These leaves came from trees growing in the area around the restored mountain fens. The field surveys carried out at that time demonstrated that the groundwater levels in the restored habitats were increasing until 2018 (Table 1). Currently, the groundwater level has stabilised at the level typical for natural, not dehydrated mountain fens of the *Caltho-Alnetum* community.

The effectiveness of the performed passive restoration activities was so high that the increase in the groundwater level in the restored habitats was noticeable after only a few weeks. Raising the groundwater level also caused statistically significant changes in the chemical properties of soils in these habitats, e.g. raising the pH value and increasing the organic carbon content (Nicia et al., 2018a, 2018b, Nicia 2018 c). Raising the groundwater level changed the habitat conditions, which translated into the gradual appearance of the plant species characteristic for this habitat (Fig. 3).

Table 1. Groundwater level in soils of restored habitats in 2011-2018

Groundwater level depth measured from the soil surface mean value of the three research plots [m]			
2011	2013	2014	2018
0,41	0,19	0,17	0,15

Source: Nicia et al. 2020

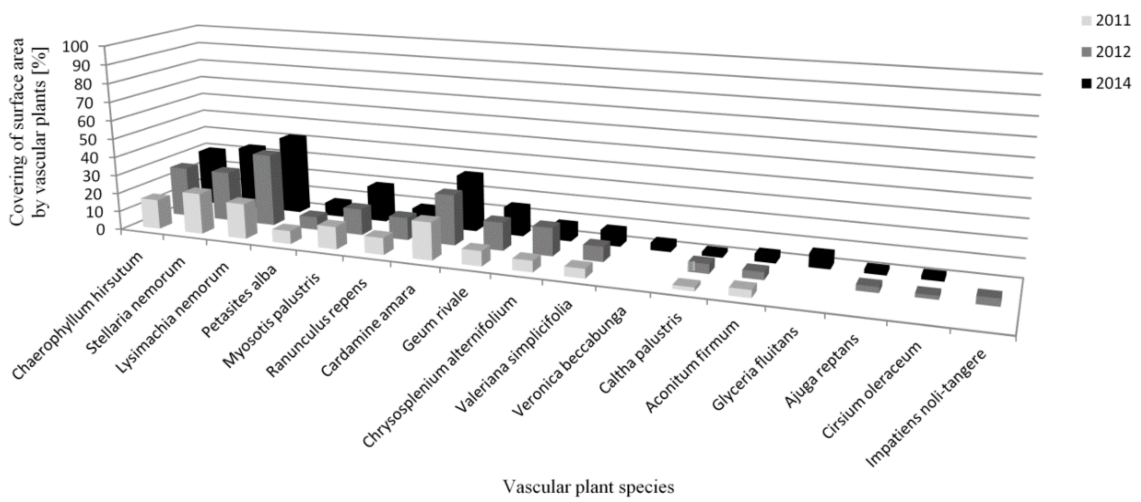

Fig. 3. Covering of studied hydrogenic habitats surface area by vascular plant species in 2011-2014
Source: Nicia, 2018a

Conclusions

The performed restoration activities resulted in the groundwater level rising, reaching the level characteristic of undegraded mountain fens of the *Caltho-Alnetum* community. The restored habitats reacted by changing the species composition of vegetation – the number of species typical for this habitat has significantly increased.

Based on the research carried out in 2010–2018, it can be concluded that the described method of restoration of mountain fens of the *Caltho-Alnetum* community:

- does not intervene excessively in the natural environment thanks to the use of only natural materials such as trunks and branches of dead trees for the assembly of the gates,
- is cost-efficient and easy to implement – the material used to assemble the gates was obtained from the restored habitats, there was no need to transport these materials to hard-to-reach places in the mountains,
- limits the degradation of other valuable natural habitats in the vicinity due to the fact that passive restoration was carried out without removing the top layer of moorsh,
- is highly effective – a positive response from the restored habitats was observed just a few months after the start of the restoration processes.

However, before this method is applied, it is necessary to analyse the possibility of erosion processes that could cause degradation of other valuable natural habitats. Therefore, raising the groundwater level should be gradual and should be monitored by measuring the water level in piezometers installed on the restored areas.

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