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PEATLANDS AFTER-USE IN THE POLISH CARPATHIAN MOUNTAINS – GEOMORPHOLOGICAL AND HYDROGRAPHIC SYMPTOMS OF THEIR RESTORATION

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SUMMARY

Investigation of current changes in the relief and water content of raised bogs after-use is omitted in relation to wider knowledge of human impact on environmental changes of peatlands. Level of knowledge on restoration of peat bogs in mountainous regions in Poland may be considered advanced (peatlands in the Carpathians and the Sudetes). The purpose of this paper is to explain current changes in peat bogs morphology and water retention in peat deposit in the largest peatlands in the Polish Carpathians. The paper is based on an analysis of maps produced over the 20th century, on aerial photographs taken since 1965 and on the newest data (LiDAR). Fieldwork included the geomorphological and hydrographic mapping of specified landforms within peat bogs using GPS methods as well as collecting peat samples in places of various stages of peat bog restoration (depths: 50-60, 90-100, 140-150, 190-200 cm). The maximum capillary water capacity of peat at various depths was assessed in laboratory, and finally the maximum potential water storage capacity was computed for the studied peatlands. Partial peat extraction taking place in the domes has produced major changes in peat bog relief and has substantially reduced peat bog water content (10-95% in individual peat domes) during 200 years economical use of the peat bogs. The increased density of drainage ditches in the area surrounding the remnants of peat domes has led to further drying of the peat bogs. The current stage of peat bogs development is their restoration which started in the 1950`s-1990`s when peat extraction had been halted in most peat bogs and drainage ditch maintenance had been abandoned. Now, stable and very shallow water level (0-40 cm) in acrotelm is the dominant feature of the peat bogs studied.

Keywords*: raised bog, post-peat areas, peat bog after-use, peatland restoration*

INTRODUCTION

Knowledge of current changes in relief and water content of raised bogs after-use as a result of peat deposit extraction and drying is less advanced in relation to wider information concerning the human impact on environmental changes of peatlands. Publications on the human impact on peat bogs pay a lot of attention to peat erosion, peat burning and changes in the physical and chemical properties of peat deposits that indicate pollution in the environment (e.g. Cooper, McCann, 1995; Bindler 2006; Coggins *et al.*, 2006). Compared to other areas of the world, there is a good knowledge on anthropogenic changes in the relief and water content of peat bogs in some areas of Poland. This applies not only to peat bogs in lowland Poland but also in mountains in southern Poland, where peat bogs in the Carpathian Mountains and the Sudetes Mountains are also found. Level of knowledge on restoration of peat bogs in the Polish Carpathian Mountains may also be considered advanced (peatlands in the Orawa - Nowy Targ Basin and in some valley floors in the Bieszczady Mountains) (Łajczak, 2007, 2011, 2016).

The purpose of this presentation is to explain current changes in peat bogs morphology and water retention in peat deposit in the largest peatlands in the Polish Carpathian Mountains. The study on raised bog restoration is the most advanced in the Orawa - Nowy Targ peatland and in valley floors in the Bieszczady Mountains. The study which started a few years ago is focused on changes in relief and water content in anthropogenically degraded fragments of peat domes (Łajczak, 2011, 2013).

METHODS

The presentation is based on an analysis of maps produced over the last 230 years (years: 1780, 1855, 1879, 1900, 1934, 1965, 1978, 1996) as well as on aerial photographs taken in 1965, 1988 and 2006, and the newest LiDAR data. Fieldwork included the geomorphological and hydrographic mapping of specified landforms and water phenomena within peat bogs and surroundings using GPS methods and morphometric terrain data from the last 15 years. Information obtained from local water management authorities and other institutions as well as information gathered by interviewing individuals involved in peat extraction for many years were also included in this research. Peat samples were collected in places of various stages of peat bog restoration (depths: 50-60, 90-100, 140-150, 190-200 cm). The maximum capillary water capacity of peat at various depths was assessed in laboratory, and finally the maximum potential water storage capacity was computed for the studied peatlands.

RESULTS

The dominant landscape element of post-peat areas is scarps, which are created where peat extraction takes place. Scarps are initially vertical or step-type, often forming zigzag-shaped sequences. Another important landscape element is numerous hollows filled with water. Older post-peat areas, deprived of peat cover, are used for agriculture. Younger post-peat areas are more frequently drained by manmade drainage systems than older post-peat areas. Active peat extraction fields that are being intensively dried possess the most diverse and dynamic morphology. Once peat extraction ends and drying of the remaining peat deposits is discontinued, the landscape of a post-extraction peat bog is changed and the thickness of the remaining peat deposits is greatly reduced. This is how peat bogs become post-peat areas. The raised bogs of the Polish Carpathians, located in the Orawa - Nowy Targ Basin and in valley floors in the Bieszczady Mountains, were selected for detailed analysis. The direction and rate of change of landforms typical of younger post-peat areas, such as peat extraction scarps, post-extraction hollows, drainage systems including ditches and regulated stream channels, were analyzed. A special emphasis was placed on the period of time when the restoration of such areas has taken place.

The decline in the total area of peat domes in the study areas began as early as the 13th-17th centuries when settlers arrived in the region. The peat dome range decreased at the highest rate in the 19th century and the first half of the 20th century. Partial peat extraction taking place in the domes has produced major changes in peat bog relief and has substantially reduced peat bog water content (10-95% in individual peat domes) during 200 years economical use of the peat bogs. The increased density of drainage ditches in the area surrounding the remnants of peat domes has led to further drying of the peat bogs. In recent years, the peat dome range has begun to stabilize due to reduced interest in peat deposit extraction and reduced water management efforts. This has led to clearly visible revitalization of post-peat areas. At this time, remnants of peat domes occupy 37% of their original area in the Orawa – Nowy Targ Peatland. In addition, the same area is occupied by younger post-peat areas. Today the total area of peat domes in the Polish part of the Bieszczady Mountains is 27 times smaller than in the Orawa – Nowy Targ Basin. The Bieszczady peat dome range is currently 84% of its original size. The younger post-peat areas that surround them cover only 9 ha.

Peat bog reserves were established in the Bieszczady Mountains. Finally, most peat bogs were included into the Bieszczady National Park and the process of their restoration began. The peat bogs in the Orawa – Nowy Targ Basin, except only one peat dome, are not protected as nature reserves and they are not the subject of economic interest.

The most characteristic element of relief in peat bogs affected by human activity is scarps separating fragments of untouched peat domes from extraction areas and younger post-peat areas. Peat bog scarps are more readily visible in the Orawsko-Nowotarska Basin. Scarps also form in the fringe zones of water management areas, where they separate lower areas of dried peat from those saturated with water. This may also explain the origin of peat bogs scarps in the Bieszczady Mountains. In most cases, the remnants of a peat dome are encircled by one wall-type or step-type scarp. In some cases, two or more scarps can be found. Since peat extraction has been halted in the Orawsko-Nowotarska Basin, rapid changes in peat bog scarp relief can be observed. Old photographs show vertical peat walls up to 6 m high that later evolved into different types of scarps and gently sloping dome sides. The drying of peat within scarp walls leads to the formation of fractures parallel to the scarp edge, with a depth of up to 2 m. The sliding of peat packets leads to scarp recession. In addition, rainfall in the early spring causes peat packets to turn to mud and fill peat hollows at the base of the scarp. Peat hangs over an ever smaller scarp and may fall down over time. As long as a scarp remains partially free of vegetation, it continues to flatten. An old scarp that is completely covered by vegetation assumes a convex-concave shape with a gentle slope. The scarp profile

becomes even gentler over time as a result of the filling of hollows in post-peat areas and an increase in the amount of base material.

Changes in relief in post-peat areas include the flattening of scarps as well as peat hollows and drainage ditches that become shallow or disappear altogether. Hollows in post-peat areas are the result of uneven peat extraction, which leads to a residual peat layer of varying thickness. In the process of peat extraction, landowners fill peat hollows with residual vegetation removed from the peat dome. In the Orawsko-Nowotarska Basin, peat hollows at the base of the scarp are quickly filled with peat mud. Drainage ditches become shallow in an analogous way at the base of scarps, upstream felled trees and beaver dams and manmade dams halting water flow away from peat bogs. Drainage ditches in peat bogs in the Bieszczady Mountains today are entirely covered by vegetation and had started to become shallow starting in the late 1980s. In the Orawsko-Nowotarska Basin, drainage ditches in the external younger post-peat zone and in older post-peat zones have not been dredged in almost 20 years. This is why they are so shallow at a number of locations and have been overgrown with vegetation.

Many streams found close to peat bogs in the two study areas as well as their tributaries draining post-peat areas have been regulated, which was designed to partially dry wetlands being used for agricultural purposes. Another reason for the stream regulation was the desire to dry peat extraction areas. In the Bieszczady Mountains the goal was to dry peat bogs completely and to turn them into pastures. More than half the length of the streams in peat bogs and adjacent areas was regulated by straightening out channels and widening them. In the Bieszczady National Park, several dozen small earth dams were recently built on streams flowing around peat bogs and in the general vicinity of six peat bogs. The resulting reservoirs play an important ecological role in addition to their traditional role as storage pools (Łajczak 2011, 2016). The reservoirs continue to function; however, they are slowly being filled by silt.

In the past the increased density of drainage ditches in the area surrounding the remnants of peat domes has led to further drying of the peat bogs. Unintended consequences of stream regulation are shallower and wider channels that evolve into braided channels with a local tendency to aggradate material. The current stage of peat bogs development is their restoration which started in the 1950`s-1990`s, when peat extraction had been halted in most peat bogs and drainage ditch maintenance had been abandoned.

CONCLUSIONS

Now, stable and very shallow water level (0-40 cm) in acrotelm is the dominant feature of the peat bogs studied. Currently, most of ditches are overgrown with vegetation and are effectively retarding the flow of water. This helps create wetlands in younger post-peat areas, which are now becoming a secondary edge zone. Peat moss takes about three years to colonize fresh peat pits filled with water. The increasing sinuosity of stream channels regulated in the past helps to make secondary edge zones wetter. Beaver dams built near peat bogs provide another means of retaining water in post-peat areas. Small manmade dams perform the same function. The increasingly wet secondary edge zone and the increasingly flat post-extraction scarp help make peat dome remnants more wet, which prevents the drying of peat and facilitates the growth of peat moss.

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