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IDENTIFYING THE AVAILABLE REVITALISATION POTENTIAL OF DRAINED BOGS

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SUMMARY

Since each drained bog has its own individual structure, the available potential of rewetting differs from one bog to the other. We use the physically-based hydromorphological analysis (EDOM *et al.,* 2007) to calculate the current potential for rewetting bogs affected by drainage, peat extraction or fires like in Indonesia or elsewhere. Only based on a digital elevation model and the annual runoff, future vegetation patterns for the entire bog can be predicted, and different rewetting scenarios can be generated at a moment's notice. With these calculations we distinguish between bogs with a high or low potential for rewetting. Rewetting measures are especially successful in areas with a high potential. In areas with low revitalisation potential, land-use options adapted to low water tables can be considered. We recommend a step-by-step approach, first calculating the potential of rewetting. Afterwards, it is possible to set priorities for the following action planning. This approach focuses on areas where it is possible to revitalise bogs within a reasonable period of time. Being firmly based on the laws of physics, this method can be used for the prioritisation of rewetting areas, action planning, monitoring and evaluation. The hydromorphological analysis is a valuable tool for conservationists, project engineers and politicians to support them in the decision-making process. It will help to allocate resources in a clear and targeted manner, and to avoid unrealistic expectations.

Keywords: *Revitalisation planning, prioritisation, water supply.*

INTRODUCTION

Mutual interactions appear within bogs between water, vegetation and surface relief. For growth, peat-forming species need high water tables close to the surface. Organic plant residues (including dead roots) form peat under anaerobic water-logged conditions. Over thousands of years, this process accumulated thick peat layers of up to 20 m and more. The surface relief of a bog alters slowly over time. Hydraulic properties of the peat depend on the peat-forming plant species. Both the hydraulic properties of the peat and the relief influence the water flow paths and, hence, the distribution of water within the bog.

In pristine bogs, self-regulation processes level off changing environmental conditions like periods of water shortage in contrast to periods of water surplus. During water shortage water loss needs to be minimised, while water surplus must be drained in a gentle way without causing erosion. This regulation takes place in the uppermost layer of the bog (the so-called ‗acrotelm'), and in some surface relief structures like rills and ponds. In the boreal zone, the acrotelm consists mainly of sphagnum-mosses and some small vascular plants. In the tropical zone where precipitation is much higher, trees with buttress roots increase surface roughness. The retention of runoff in the depressions between the trees causes prolonged water availability during dry spells (DOMMAIN *et al.,* 2016).

During the last centuries, many bogs and mires were drained by human activities. This included trenching, peat cutting, logging and conversion to agricultural land. After drainage, the spongy peat slumped down. The former anaerobic upper peat layer was air-ventilated, which lead to a mineralisation of the peat. The peat surface dropped, especially near ditches and peat cutting edges, due to the change of hydraulic properties. In some places peat mineralisation and peatland fires changed the relief and - at the same time - the distribution of water. For successful revitalisation the water table needs to be re-established near the surface. Therefore, the individual structure of the drained bog with its current relief needs to be considered for action planning.

The revitalisation of drained bogs is a challenging task in respect of the long time needed. Furthermore, human, financial and technical resources are sometimes limited. Therefore, it is necessary to focus on those bogs with the best potential for rewetting. This applies both for bogs in Europe, and elsewhere.

METHODS

To calculate the potential for rewetting we use the hydromorphological analysis. EDOM *et al.* (2007, 2010) give detailed mathematical descriptions of this method. Requirements are rather simple; only a digital elevation model (DEM) with a high resolution and the mean annual runoff are required. Mostly we use the LIDAR-DEM, which is generated by airborne laser-scanning of the earth´s surface, with a grid-resolution of 5 metres.

In a natural bog, the water table is close to the surface; so the surface roughly represents the water table. Furthermore, we assume all ditches to be refilled with peat; hence, the calculations represent the potential water flow after optimal rewetting measures. Water flow follows the hydraulic gradient from areas with high water level to areas with low water level, and is directed perpendicular to the contour lines of the surface elevation (water table). We calculate the water accumulation along the flow paths using the relief analysis tools from GIS-software (geographic information system, e.g. ARC-GIS).

RESULTS

As a result we generate a map of the spatial distribution of the potential profile flow. We show one example from the bog "Kleiner Kranichsee" in the mountain range "Erzgebirge" (Ore Mountains, 50°25'3" N and 12°40'25" E) in SO Germany in Fig. 1. In general, profile flow is low on ridges and hilltops (places where accumulation starts), and high in rills and valley-like depressions. Profile flow values higher than 50 l/(s·km) characterise natural or natural-like brooks in this region. Since the wetness of an area depends on both the profile flow and the slope, we need to divide the profile flow by the slope. As a result we get a map of potential transmissivity (Fig. 2). Potential transmissivity is strongly related to the vegetation in bogs. High transmissivity values occur either due to high profile flows, or very low slopes. They identify wet vegetation types. It is possible to translate transmissivity into vegetation types on a regional scale. In the Erzgebirge, transmissivity values of more than 3 cm²/s characterise areas with an open bog vegetation (Fig. 3). Trees are rare and shrub-shaped. Transmissivities less than 3 cm²/s characterise wooded bogs.

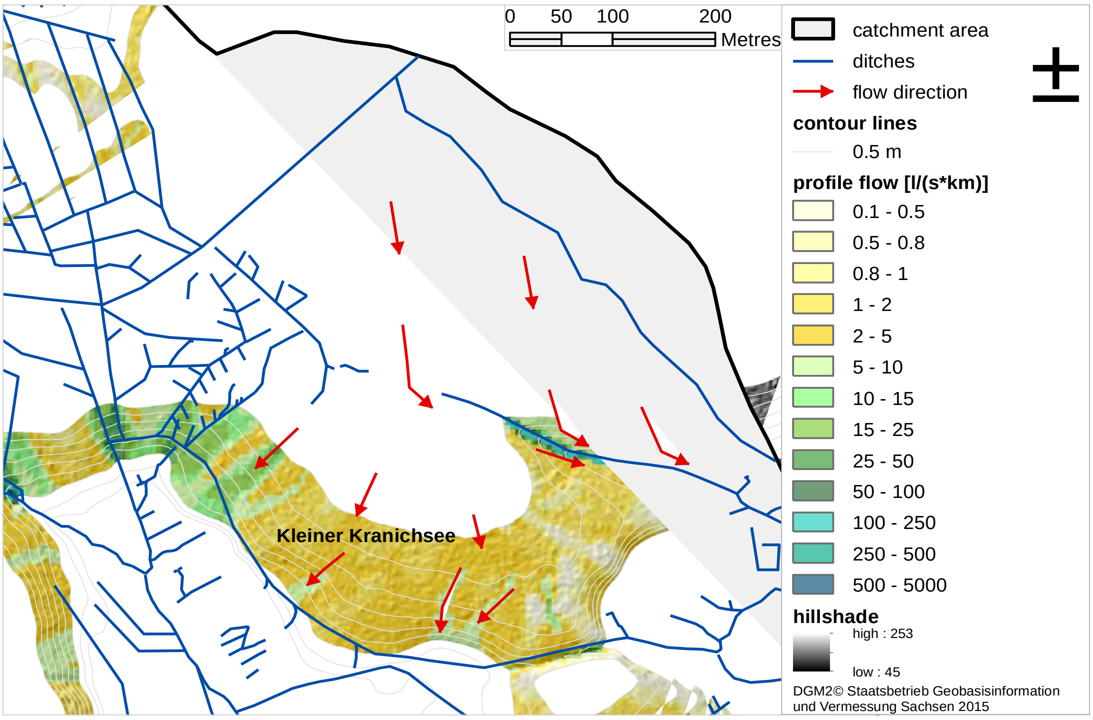

Figure 1: Map of potential profile flow for the bog "Kleiner Kranichsee" in the mountain range "Erzgebirge" (Germany).

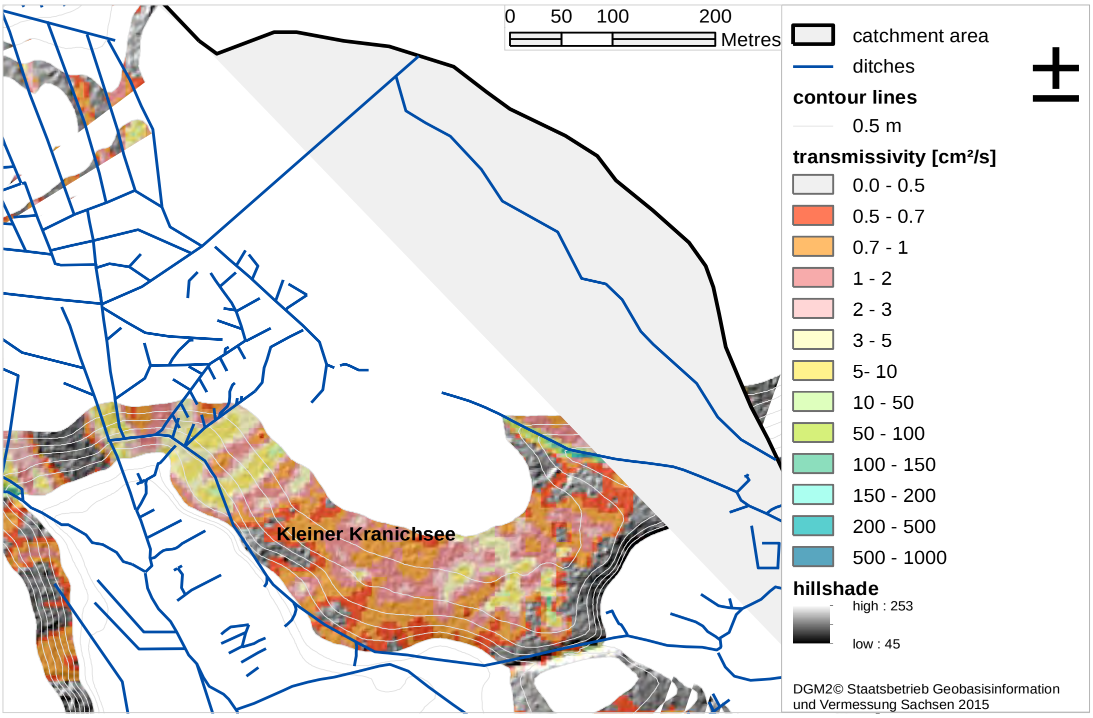

Figure.2: Map of potential transmissivity for the bog "Kleiner Kranichsee" in the mountain range "Erzgebirge" (Germany).

Fig. 3: Hummock-hollow-structure in an area with high transmissivity (> 3 cm²/s) in the bog "Kleiner Kranichsee" in the mountain range "Erzgebirge" (Germany). Foto: K. Keßler, 2014.

In our example, the bog is influenced by mining activities from the 16th-century, peat cutting, and some ditches. Water from the catchment area in the north is drained to the east. The main peat body is relatively dry; only small parts of the former widespread open bog vegetation is preserved, meaning that there are only few areas with transmissivity values higher than 3 cm²/s. Interventions in the water balance of the bog were made a long time ago and there are only a few ditches in the peat body itself. Therefore, the calculations correspond to the current vegetation quite well. In deeply-drained bogs the difference between current and calculated vegetation identifies the direction of succession development after rewetting measures or natural regeneration.

Some more examples will be given in the presentation.

DISCUSSION

In general, we calculate a pattern of dry and wet vegetation-types after rewetting. Because each drained bog has its own individual structure, the available potential for rewetting differs from one bog to the other. Whether or not it is possible to re-establish the former vegetation types depends on the dimension and location of the human impact on the water balance, the current surface relief and the nutrient supply. Sometimes, secondary vegetation types or early succession stages will develop more likely than the original ones. In some bogs, or some parts of them, rewetting is not possible at all, or huge efforts are required. Rewetting measures are especially successful in bogs with a high potential for rewetting, meaning larger areas with high transmissivities. In areas with low revitalisation potential land-use options adapted to low water tables can be considered.

We recommend a step-by-step approach; first calculating the potential of rewetting for several bogs. Then it is possible to set priorities for the following action planning. This approach focuses on bogs where revitalisation is possible within a reasonable period of time.

The calculations of the hydromorphological analysis can also be used for action planning and scenario analysis. The maps contain information about structures and water flow paths within the bog. Artificial drainage ditches should be blocked while natural flow paths and brooks, which can be identified by the profile flow, should be revitalised. In the tropical zone, areas with low transmissivity and low profile flow are preferable places for reforestation with buttressed and mound-forming trees to increase surface roughness and depression storage (DOMMAIN *et al.,* 2016).

It is also possible to calculate the consequences of some measures like removing (or building) barriers for water flow like dams, relief manipulation, or external water supply.

CONCLUSION

Our hydromorphological analysis is a unique tool for conservationists, project engineers and politicians to support their decision-making process before rewetting disturbed bogs. It will help to allocate resources in a clear and targeted manner, and avoid unrealistic expectations about the future of the considered bogs.

The calculations help to understand the effects of hydraulic disturbances on vegetation zones and succession directions. Therefore, they are also a valuable basis for revitalisation planning, scenario analysis, targeted monitoring concepts and the assessment of the resulting development.

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