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Seasonal variability in discharge from a raised bog affected by surface topography

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Raised bogs of the boreal and temperate zone commonly show striking surface patterns consisting of hummocks, hollows, ridges and pools. Ridges and pools situated between ridges are generally orientated to coincide with the surface contours of the bog and perpendicular to the direction of maximum slope. One explanations for the origin of the striping patterns on raised bogs focuses on feedback mechanisms that exist between vegetation, peat and water. This suggests that patterning affects site water balance through spatial variation in surface and peat characteristics that influence the release of incoming water by overland flow, subsurface flow and evapotranspiration.

It is assumed that the average surface level gradient of a raised bog coincides with the slope of the water table. Therefore, often the flow-net in a raised bog is reflected by the surface level gradient and assumed to be constant over time. This flow-net defines the direction of the horizontal components of subsurface flow in the acrotelm and catotelm, and of overland flow when water level is high. Based on the flow-net a raised bog can be divided into sub-catchments representing the area contributing to discharge at the outlet of the bog. In this study, we investigate the role of ridge-pool patterning on the flow-net and consequently the resulting sub-catchments under different water level conditions. We hypothesize that under drier conditions it is likely that pool-ridge patterning will inhibit water from flowing along the surface gradient. Under wet conditions however pools can become connected and water can move through upper highly permeable layer of ridges.

Our study site is Mannikjarve mire, which is a raised bog located centrally in Estonia and part of the larger Endla Nature Reserve. The size of the bog is approximately 1.9 km^2. Mannikjarve mire is characterized by a surface pattern of different microtopes consisting of ridge-pool, hollow-ridge, hummock-hollow, Sphagnum lawn, and margin forest. As part of a long-term measurement campaign run by the Estonian Meteorological and Hydrological Institute, discharge is measured at four locations situated at the border of the bog using V-notch weirs providing daily discharge values. The weirs are situated at respectively the east, west, north and south-west border of the bog. We divided Mannikjarve mire into sub-catchments representing the area contributing to discharge at the four outlets based on the traditional approach using surface contours. The size of the sub-catchments is respectively 0.6, 0.3, 0.2 and 0.1 km^2 for the western, south-western, northern, and eastern outlet. This suggests that the western outlet should have a larger discharge in comparison to the other outlets. Because the direction of maximum slope is westwards, this also suggest that most of the water should flow through to the ridge-pool zone. We compared the discharges from 2008 to 2009 of the four outlets by calculating ratios between discharges for the entire observation period as well as for the different seasons. We found that discharge from the western and south-western outlet are comparable. Therefore also the sub-catchments representing the area contributing to the discharge should be of comparable size. Discharge from the northern outlet is on average smaller than from the western and south-western outlets, which is in agreement with the size of the sub-catchments found based on the surface contours. However, under wet conditions the northern outlet discharges relatively more water than the western and south-western outlet. This could be explained by presence of lawns at the edges of the ridge-pool zone, which can quickly transport water under high water level conditions. The size of the northern sub-catchment increases to the detriment of the western and south-western sub-catchments leading to a shift in size distribution of the sub-catchments. Catchment sizes, as created based on surface contours, representative for the discharge at the outlets are therefore likely not constant over time.

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