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Assessing vegetation transitions from peat cores using hyperspectral imaging

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Chronological peat strata provide powerful record of vegetation transitions in peatlands and we explore hyper-spectral imaging methods in order to develop efficient means to identify peat-forming vegetation. String-patterned aapa mires in the north-boreal zone that are potentially subject to abrupt ecosystem transitions due to changes in climate and hydrology. Mineretrophic waters feed fen areas of aapa mires and hydrological change can promote growth of Sphagnum mosses and launch development of new bogs over aapa mires. In the project SHIFTMIRE (Academy of Finland), changes in aapa mire complexes during recent decades are assessed by the use of various remote sensing methods (aerial image time series, satellite data and high-resolution UAV multispectral imaging), and are connected to ground-truthing of vegetation types and peat sampling. The main objective of these analyses is to recognize and quantify changes of main vegetation types, hydrotopographic patterns and peat accumulation. We have a representative sample of aapa mires (n = 120) is selected with randomization after regional partitioning from a full list of large aapa mires in Finland, and additional sites are included from N Sweden and NW Russia.

All multi-proxy data will be supported by analysis of surface peat cores with hyper-spectral imaging. We are currently developing methods for distinguishing changes of peat quality, with particular focus on the transition from the sedge to Sphaghnum peat. This is first developed with selected peat cores from well-defined mire areas with known background. The laboratory data has been collected with several pushbroom spectral imaging cameras, covering the visible to near-infrared range (VNIR 400-1000 nm, FWHM 3.5 nm), short-wave infrared range (SWIR, 1000-2500 nm, FWHM 12 nm) and mid-wave infrared range (MWIR, 2500-5000 nm, FWHM 35 nm). Spectral analysis methods, such as Principal Components Analysis (PCA) are applied to identify the key spectral features corresponding to peat composition (e.g. plant material, bulk density, ash content, degree of humification). Later, spectral properties identified as critical indicators of peat quality will be used in routine application to scan larger amounts of samples. We are considering methodological issues such as the effect of oxidation and water content on the spectral changes of the peat cores. Additionally we are using a portable pushbroom hyperspectral camera for analyzing samples on site (VNIR, Specim IQ, FWHM 7nm). Our first analyses have revealed detailed spectral changes that match well with transitions in peat quality and composition. In addition, hyperspectral data tends to reveal peat quality changes that would easily be overlooked or only found by most laborious conventional techniques, like high-frequency microscopic counting of plant remains. Here, the spectral results can be used to guide sampling for microscopic routines, for example.

Our results with sedge and Sphagnum peat suggest that efficient image-based classification methods for identifying peat transitions, indeed, can be developed. In combination with data collected from other sources (remote sensing, ground-truthing, conventional laboratory analysis), peat spectral analyses prove to give strong inference of changes, such as the susceptibility of northern aapa mires to ecosystem-scale changes.