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Using machine learning to generate high-resolution soil wetness maps for planning forest management

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Open peatlands are a recognizable feature in the boreal landscape that are commonly mapped from aerial photographs. However, wet soils also occur on tree covered peatlands and in the riparian zones of forest streams and surrounding lakes. Comparisons between field data and available maps show that only 36 % of wet soils in the boreal landscape are marked on maps, making them difficult to manage. Wet soils have lower bearing capacity than dry soils and are more susceptible to soil disturbance from land-use management with heavy machinery. Topographical modelling of wet area indices has been suggested as a solution to this problem and high-resolution digital elevation models (DEM) derived from airborne LiDAR are becoming accessible in many countries. However, most of these topographical methods relies on the user to define appropriate threshold values in order to define wet areas. Soil textures, topography and climatic differences make any application difficult on a large scale. This complex landscape variability can be captured by utilizing machine learners that uses automated data mining methods to discover patterns in large data sets. By using soil moisture data from 20 000 field plots from the National Forest Inventory of Sweden, we combined information from 24 indices and ancillary environmental features using a machine learning known as extreme gradient boosting. Extreme gradient boosting used the field data to learn how to classify soil moisture and delivered high performance compared to many traditional single algorithm methods. With this method we mapped soil moisture at 2 m spatial resolution across the Swedish forest landscape in five days using a workstation with 32 cores. This new map captured 79 % (kappa 0.69) of all wet soils compared to only 36 % (kappa 0.39) captured by current maps. In addition to capture open wetlands this new map also capture riparian zones and previously unmapped cryptic wetlands underneath the forest canopy. The new maps can, for example, be used to plan hydrologically adapted buffer zones, suggest machine free zones near streams and lakes in order to prevent rutting from forestry machines to reduce sediment, mercury and nutrient loads to downstream streams, lakes and sea.