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Mapping Sweden's drainage ditches using deep learning and airborne laser scanning

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Drainage ditches are common forestry practice across northern European boreal forests and in some parts of North America. Ditching helps with lowering the groundwater level in the wet parts of the forest to improve soil aeration and to support tree growth. However, the intensive ditching practice pose multidimensional environmental risks, particularly for degradation of wetland and soil, greenhouse gas, increased nutrient and sediment loadings to water bodies, as well as biodiversity loss. At the same time there is a discrepancy between the potential significance of artificial water bodies, such as drainage ditches and their low representation in scientific research and water management policy. A comparison with a national inventory of Sweden showed that only 9 % of drainage ditches are present on the best avalible map of Sweden. The increasing understanding of the environmental risks associated with forest ditches together with the poor representation of ditch networks in existing maps of many forest landscapes makes detailed mapping of these ditches a priority for sustainable land and water management. Here, we combine two state-of-the-art technologies – airborne laser scanning and deep learning - for detecting drainage ditches on a national scale.

A deep neural network was trained on airborne laser scanning data and 1607 km of manually digitized ditch channels from 10 regions spread across Sweden. 20 % of the data was set aside for testing the model. The model correctly mapped 82 % of all small drainage channels in the test data with a Matthew's correlation coefficient of 0.72. This approach only requires one topographical index, a high pass median filter calculated from a digital elevation model with a 1 m spatial resolution. This made it possible to scale up over large areas with limited computational resources and the trained model was implemented using Microsoft Azure to map ditch channels across all of Sweden. The total mapped channel length was 970 00 km (equivalent to 24 times around the world). Visual inspection indicated that this method also classifies natural stream channels as drainage channels, which suggests that a deep neural network can be trained to detect natural stream channels in addition to drainage ditches. The model only required one topographical index which makes it possible to implement this approach in other areas with access to high resolution digital elevation data.