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EROSION AND SEDIMENT TRANSPORT DYNAMICS IN DRAINED PEATLAND FOREST: A CASE STUDY AT KOIVUPURO CATCHMENT, EASTERN FINLAND

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SUMMARY

Ditch network maintenance at peatland forest areas leads to erosion and transport of suspended solids to water courses. The aim of this study is to explore how sediment load is generated within maintained drainage areas. This task is tackled by setting up experiments at Koivupuro catchment, located in Eastern Finland, which has been studied since the initial ditching in 1980s. During the summer of 2011 the ditches in the area were cleaned and a new nested study catchment was established inside the catchment. Both catchment outlets were instrumented with continuous water level and turbidity sensors. Basic hydrological monitoring and different in-situ methods to measure erosion and sediment transport at source areas are also applied and the properties of sediment studied with laboratory analyses.

KEYWORDS: catchment, drainage, erosion, modeling, suspended solids

INTRODUCTION

The maintenance of forest drainage areas causes increased erosion and transport of suspended solids to water courses. There are 48 000 km^2 of peatlands drained for forestry purposes in Finland (Finnish Forest Research Institute, 2010). 600-800 km^2 of the drained peatlands are maintained annually and the target is even higher, 1000 km^2/a (Finnish Ministry of Agriculture and Forestry, 2008). Ditch network maintenance includes cleaning of old ditches and digging of complementary ditches. Both of these treatments disturb soil surface and expose it to erosion. It has been estimated that in Finland the sediment load induced by ditch maintenance is over 70 000 kg/km^2 during the 10 years following ditch maintenance (Finér et al., 2010).

The main objectives of this study are to explain and quantify the sediment load generation processes after ditch network maintenance. The processes are studied at the sediment source areas by using a large range of different methods. For this purpose a new experimental study was started during summer 2011 at Koivupuro catchment, Eastern Finland. Koivupuro catchment has been under active research since the initial ditching of the area in 1983

(Kenttämies and Mattsson, 2006), providing excellent background data of e.g. discharge and water quality for this study.

MATERIALS AND METHODS

The area of Koivupuro catchment (Fig. 1) is 1.1 km^2. It is dominated by peatlands consisting mostly of coniferous forests. Total length of the ditch network is 12 km. At most parts peat layer extends below the ditch bottoms but at the margins of the drained area mineral soil is exposed at the bottom of the ditches.

The outlet of Koivupuro catchment was installed with a V-notch weir in 1978, five years before the initial ditching. Since that runoff and water quality have been monitored. A small nested catchment (0.056 km^2) was established inside Koivupuro catchment during the drainage network maintenance in August 2011. Both outlets were instrumented with new water level and turbidity sensors having a measurement frequency of 15 minutes. After the drainage network maintenance an extensive in-situ measurement campaign was launched to study erosion and sediment transport processes at their source areas.

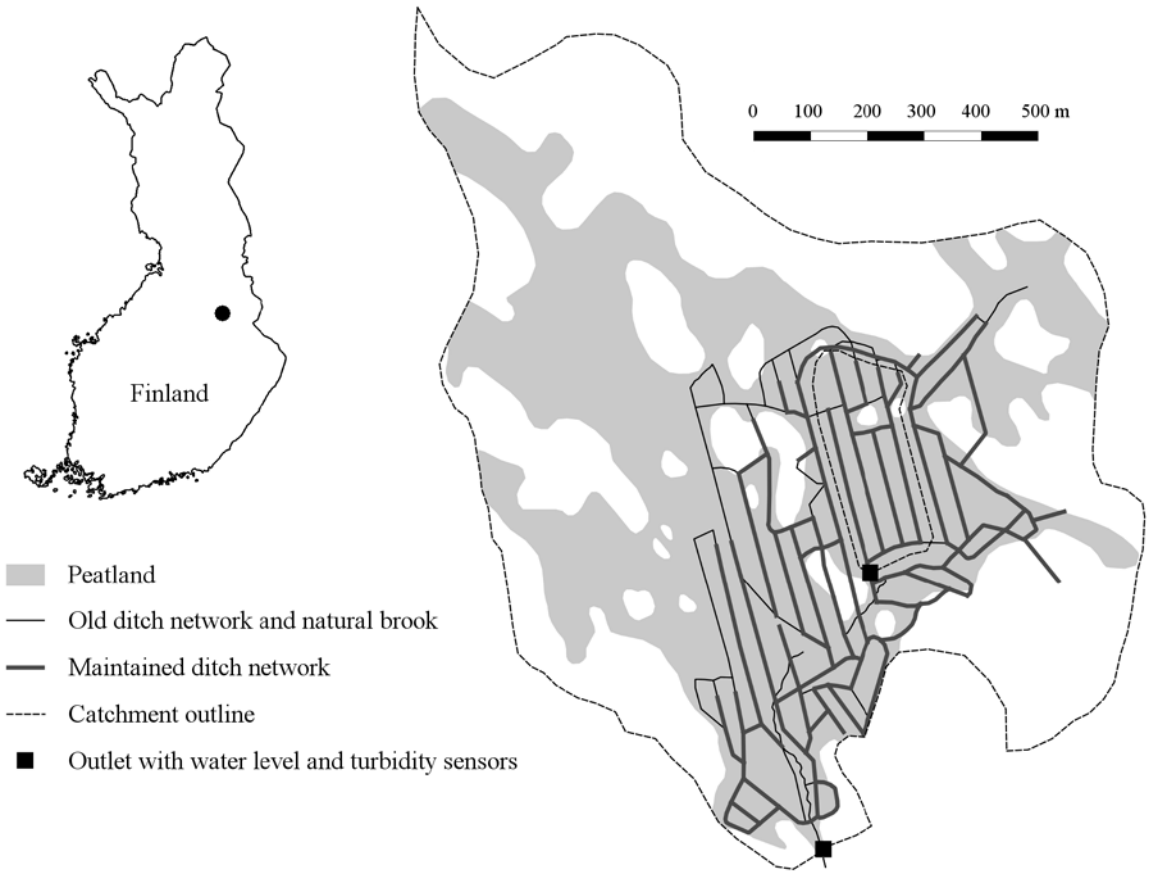

Fig. 1. Catchment of Koivupuro.

Hydrologic measurements

In addition to water level measurements at the two outlets, water level in the ditches is measured at nine different locations and groundwater level at six locations with TruTrack

water height sensors (WT-HR). Precipitation in the area is monitored with TruTrack tipping bucket rain gauge. Other weather data, including e.g. air temperature, relative humidity, and wind speed, are obtained from Iso-Kauhea catchment located ca. 3 km from Koivupuro. Snow depth measurements at 12 different points and snow water equivalent at three points are made along a snow course.

Monitoring erosion and sediment transport

Erosion at ditch bottoms and sidewalls is quantified with several methods. Pin meter (Fig. 2) is used to monitor the microtopography of four ditch sections. Each section is four meters long and there the cross-sections of the ditches are measured at 20 cm intervals along the ditch. Laser scanner (Leica ScanStation 2) was used at two of the pin meter measurement sites to measure the local topography with a resolution of less than 1 cm. Erosion and deposition are estimated by calculating the changes in the microtopography between the successive measurement occasions. The results of the laser scanning and pin meter measurements are compared. Changes in ditch bank and bottom elevations are also monitored with single erosion pins. Pin meter, laser scanning and single pin measurements are made during intensive campaigns at least twice a year. Basic leveling is used to track the elevation changes at ditch bottoms at the catchment scale.

Fig. 2. Pin meter measurement setup.

Sediment collectors are applied to sample material entrained with water (Fig. 3). Eroded and transported material is collected with sidewall and bottom collectors. Suspended solids are collected with time-integrated mass flux (TIMS) collectors. The spatial variation in the

erosive properties of peat is assessed by using in-situ cohesive strength meter to obtain critical entrainment stresses.

Water is sampled automatically once a day with ISCO sampler from both catchment outlets for analyzing sediment. Relationship between turbidity level and the actual sediment content is evaluated.

Fig. 3. TIMS-collector for suspended sediment (a) and ditch sidewall collector for eroded soil (b).

Preliminary results and analyses of the data

The data are used to study erosion and sediment transport processes as well as mechanics of particle entrainment during the first years after the ditch network maintenance. Special attention is paid to the spatial distribution of these processes at the ditch network level and the seasonality of the sediment transport. In-situ measurements also provide data for erosion and sediment transport modeling at ditch and catchment levels.

Figure 4 shows discharge and turbidity at the Koivupuro catchment outlet 5 weeks before and in both catchments 9 weeks after the ditch network maintenance. The turbidity responds to ditch cleaning during the high discharge periods but less during the low discharge. Dissolved organic matter and the high color of stream water affect the turbidity data. The data need to be calibrated against the sediment concentration measurements before the sediment load can be estimated. Since the area of ditch network maintenance is large, it is clear that the volume of material entrained and transported inside the catchment is much larger that the load measured at catchment outlets. The intensive measurements will be applied to quantify the sediment load potential of the maintained ditch network and compare it against the observed load from the catchments.

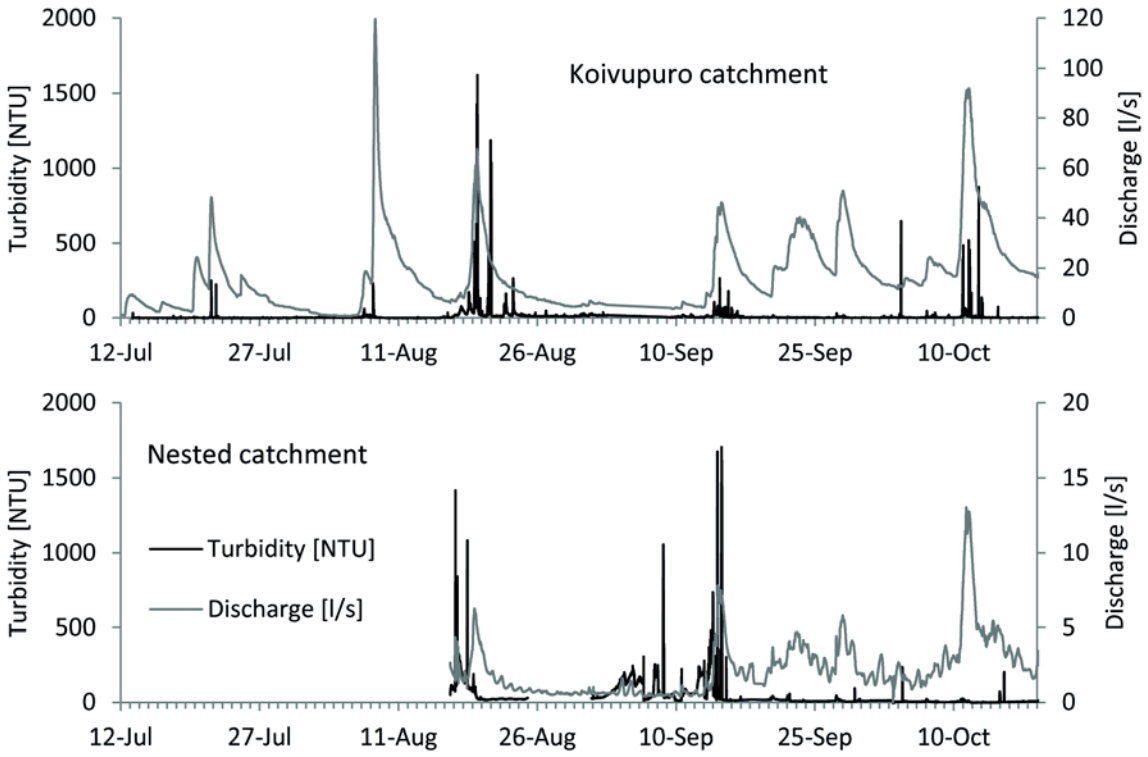

Fig. 4. Discharge and turbidity data from both outlets.

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