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# Application of the Integrated Winter Erosion Model (IWAN) for a Southern Taiga Catchment in Russia

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## Introduction

Phosphorus transfer from agricultural soil to water has attracted increased attention in the last decades. Generally the P detachment mechanisms are characterized as contribution of P transfer in high magnitude but usually short-timescale erosion events perhaps associated with larger sized particles. The spatial distribution of the various source inputs of P across the landscape creates a complex and dynamic mosaic of potential sources because these inputs vary within the year and over longer timescales. However, most of the erosion or nutrient load models are event based and do not reflect these dynamics. Additionally, their application is mainly restricted to rainfall events.

## Material and Methods

The 18.8 $km^2$ Lubazhinkha catchment is located 100 km south of Moscow, Russia in a subhumid southern Taiga region. The valleys are deeply incised into the undulated flat

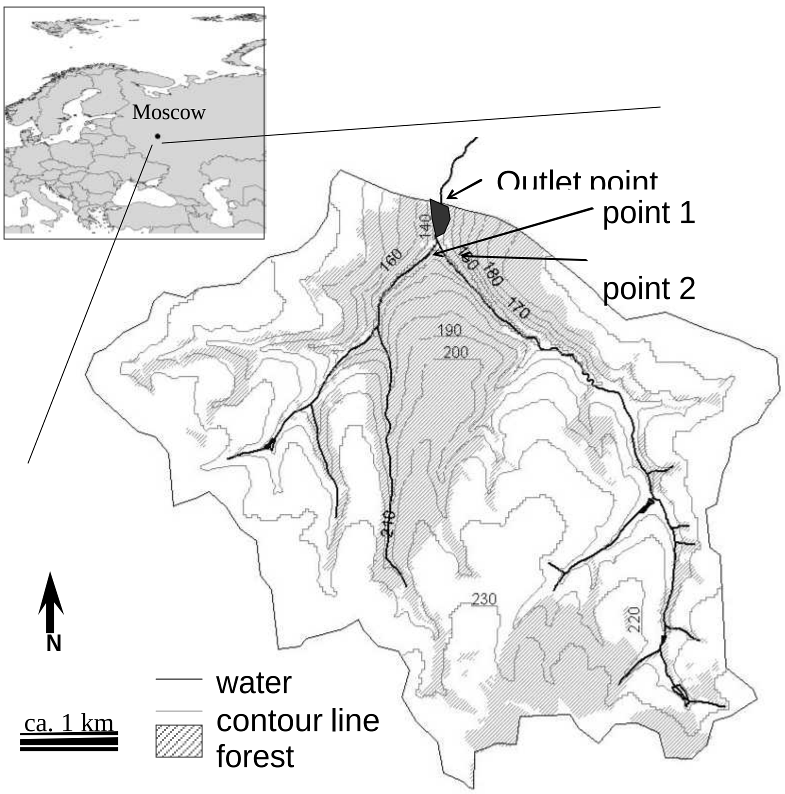


*Fig 1: Characteristics and land use of the 18.8 km² Lubazhinkha catchment, along with an accompanying map that locates the catchment within the European Russia*

interfluves where Greyzems are the dominant soil type. Annual snowmelt in late March early April is the major event during the hydrological year. 55% of the area of the Lubazhikha

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catchment is used agriculturally by three co-operative farms. A small reservoir at the outlet is constructed for flood control and provides water for irrigation. In addition to a data set from the `80th, erosion plot experiments, field observations and river monitoring are conducted at present (Fig. 1).

The integrated winter erosion and nutrient load system (IWAN) was developed to characterise temporal and spatial aspects of runoff generation and snowmelt rill erosion at the catchment scale. It is a system of loosely coupled models that consist of four independent modules and pre- and post-processing procedures. The continuous distributed hydrological model WASIM-ETH version 2 delivers information about water balance and surface runoff generation for the nutrient turnover model ANIMO 3.7 and the snowmelt rill erosion model SMEM. The achieved process based results substitute the empirical estimations of surface runoff volume, soil detachment and phosphorus availability in AGNPS version 5. AGNPS is a raster-oriented event-based model that calculates erosion, suspended sediment and nutrient transport at the catchment scale. Transport capacity is estimated with a modified Bagnold´s stream power approach.

## Results and Discussion

Erosion rate that was measured with experimental plots varies between 0.0 and 2.2 t $ha^{-1}$ for snowmelt events. The occurrence of soil frost during the early snowmelt period is of major importance for the dimension of erosion rates. Soil frost controls the amount of runoff and decreases aggregate stability.

The observed sediment loads at the catchment outlet are characterised by a high variability and can reach up to 0.25 t $ha^{-1}$ for the snowmelt period 2005. Maximum suspended sediment concentration range from 500 to 2000 mg $l^{-1}$ during the years 2003, 2004 and 2005. However, the retention effect of the reservoir at the catchment outlet is clear for the sediment and particulate loads which results in a reduction of approximately 30% for sediment and 10% for total phosphorus (Tab. 1). Although the phosphorus concentrations in the soils are low and the utilisation of mineral fertilizer is limited, the area specific phosphorus load can reach up to 0.3 kg $ha^{-1}$ for the snowmelt events.

*Tab. 1: Retention function of the reservoir for particulate and dissolved loads in 2003*

| | Sediment [t] | Total phosphorus [kg] | DOC [t] |
|---|---|---|---|
| Sum tributaries | 267.8 | 648.6 | 9.83 |
| Load dam | 188.5 | 583.3 | 9.76 |
| Difference | 79.3 | 65.3 | 0.07 |
| Retention % | 29.6 | 10.1 | 0.7 |

The modelled annual water balance and the amount of runoff during individual snowmelt events match the measurements. However, two different parameter sets gave good results, of which only one has a plausible spatial output. Nevertheless, the model system IWAN reflects the individual runoff generating mechanisms and their spatial distribution in the Lubazhinkha catchment. Fig 2 exemplifies the spatial heterogeneity of model results for surface runoff generation, soil detachment and sediment load. Field observations confirm for example the generation of surface runoff in forest areas during frozen soil conditions. Due to the realistic spatial distribution of erosion areas and their individual connectivity to the main stream channel, the simulated net erosion and phosphorus loss of the catchment is close to the calculated loads.

Simulated land use scenarios that include increase of forest area or increase of cattle breeding pastures prove the importance of spatial heterogeneity of runoff generating areas

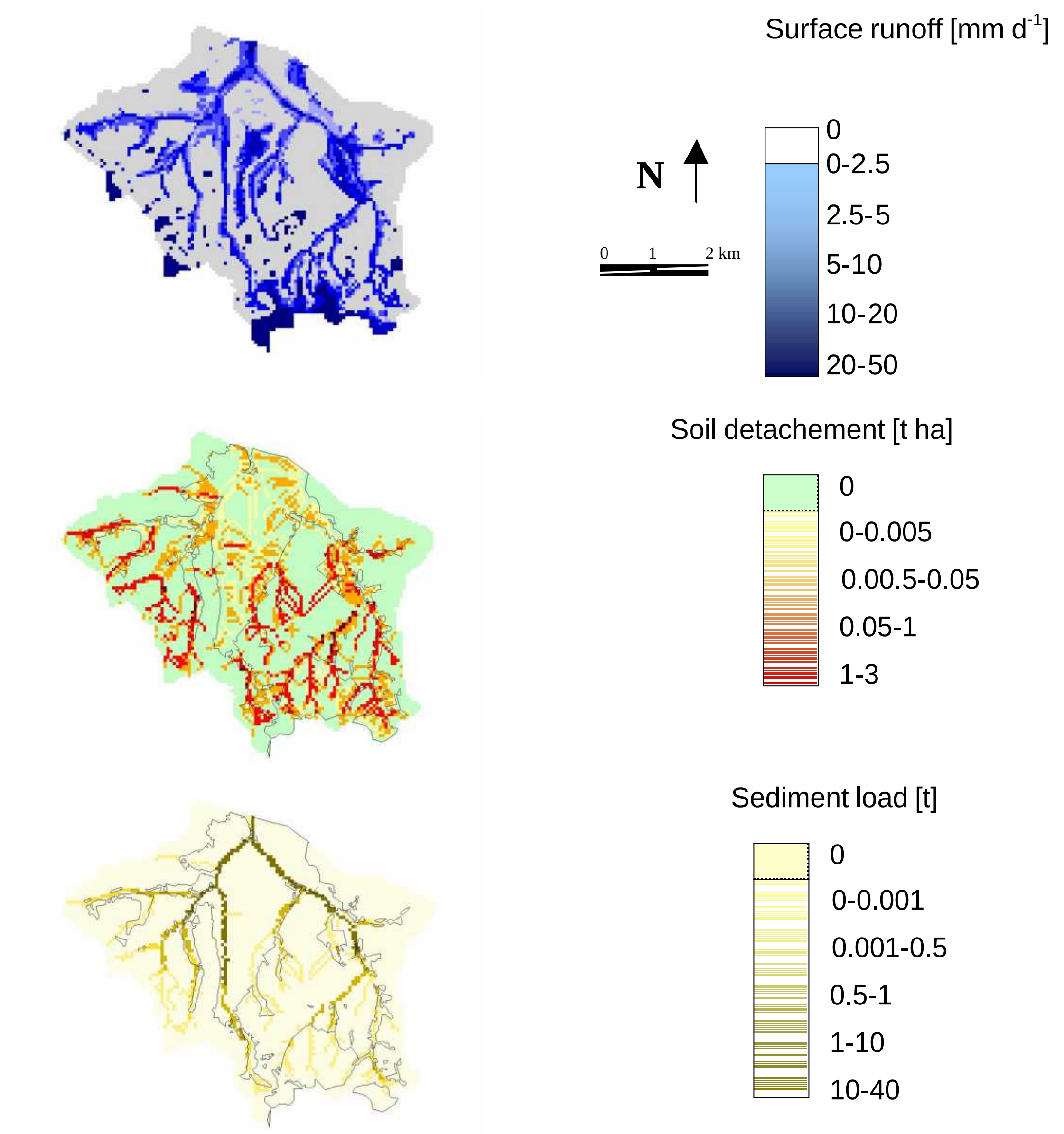


*Fig. 2: Model results for surface runoff, soil detachment and sediment load of the 24. March 2004*

for sediment and nutrient load in the Lubazhinkha catchment. Thus, conventional measures to reduce erosion fail the target of improving water quality at the catchment outlet by reason of connectivity and mobilisation of river sediments.

**Conclusion**

Runoff generation during snowmelt is the major hydrological event that triggers soil erosion in the presented southern taiga catchment. The model system IWAN has the capability to identify important processes and spatial heterogeneity, thus it is suited for scenario calculations and planning of management options. However, the parameter identification was difficult and a transfer to other not well observed catchments may be a problem.