Distributed modeling of soil erosion and deposition affected by buffer strips

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Introduction

Soil degradation and environmental impacts due to water erosion are a growing concern. Large parts of Denmark are covered by gently rolling moraine landscape with moderately to locally highly erodible soils where water erosion causes off-site problems in the form of eutrophication of water bodies. Buffer zones can be efficient in terms of retaining sediment and phosphorus transported by water erosion.

Objectives

To parameterize a spatial distributed erosion model to evaluate the effect of different buffer zone properties and dimensions on off site effects of erosion

Materials and Methods

Soil erosion survey

During the period from 1998 to 2000 field campaigns were carried out on a range of agricultural lands in Denmark. On 21 slope units in 9 study areas rill erosion and deposition was surveyed during the runoff season (Figure 1 and 2). Rill erosion was estimated by measuring the rill width and depth at three different points in each rill section. Soil deposition at the fields and in the buffer zones was measured by point measurement of sediment depth. Kriging was used to interpolate between the measurements. In addition, general buffer zone properties were recorded as well (Table 1).

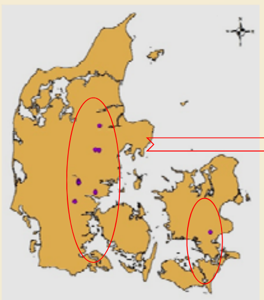

Figure 1. Map showing the Danish study areas

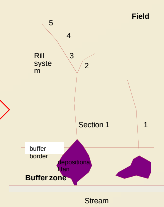

Figure 2. Experimental system of eroding site, buffer zone and depositional fan

WaTEM parameterization

WaTEM (Water and Tillage Erosion Model, Van Oost, 2000) is a spatially distributed model simulating erosion and deposition by water and tillage processes in a two-dimensional landscape. The water component of WaTEM uses an adapted version of Universal Soil Loss Equation (USLE). In WaTEM, the deposition is calculated explicitly.

USLE parameters:

Erosion potential = RK* LS* CP

R: index of kinetic energy of rainfall (Table 1)

K: index of a soil's resistance to erosion (Table 1)

L: topographic index of upslope contributing area

S: slope index

C and P: indices of crop management and mitigation effects

WaTEM uses different LS algorithms to investigate different scenarios (Govers, 1991; McCool, 1987, 1989) based on the rill/interrill ratio. McCool operates with three different rates: low, moderate and high. R and K were obtained from developed Danish maps. In the WaTEM simulation, sediment transport was not restricted at field/buffer zone borders. The transport capacity coefficient was set 80 for all slope units.

Table 1. General buffer zone properties in study areas and variable WaTEM input parameters

Study area	Average Slope (%)	Buffer zone type	Width (m)	Buffer zone break-through	K	R
1	4	Herbs and grasses (50%-50%)	27	Yes	22	0.032
2	7	Herbs and grasses (50%-50%)	52	No	22	0.032
3	2	Herbs dominant (herbs>90%)	15	Yes	31	0.028
4	9	Herbs and grasses (50%-50%)	12	Yes	18	0.032
5	13	Grass (grasses>90%)	27	No	20	0.032
6	9	Herbs and grasses (50%-50%)	16	Yes	21	0.032
7	4	Herbs and grasses (50%-50%)	35	No	11	0.027
8	2	Herbs dominant (herbs>90%)	30	No	20	0.027
9	10	Grass (grasses>90%)	29	No	32	0.023

Results

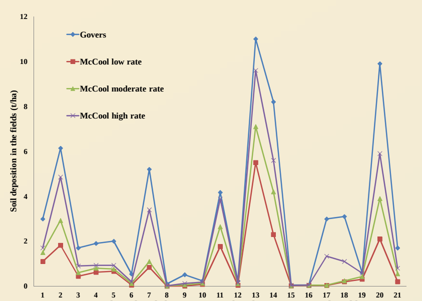

Figure 3. Predicted soil deposition in the slope units simulated by WaTEM using different LS algorithms.

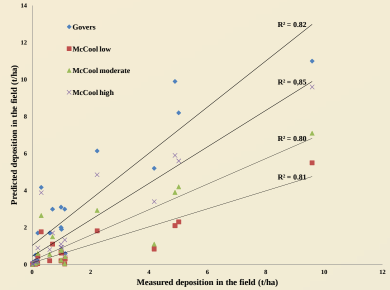

Figure 4. Measured and predicted deposition in the slope units

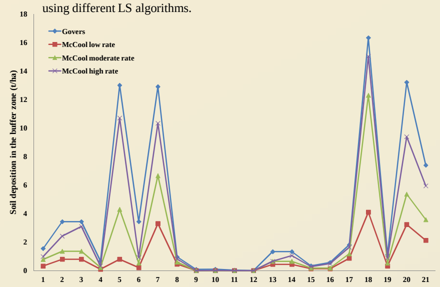

Figure 5. Predicted soil deposition in the buffer zones simulated by WaTEM using different LS algorithms

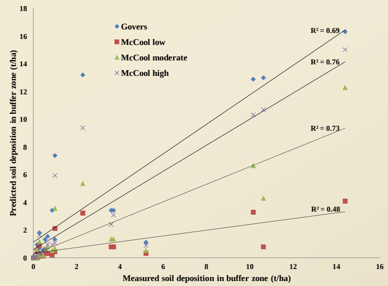

Figure 6. Measured and predicted deposition in the buffer zones

Figure 7. Modelled soil deposition map for study area 1

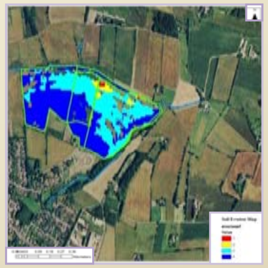

Figure 8. Modelled soil erosion map for study area 1

Conclusions

- WaTEM is broadly able to reflect the measured erosion and deposition patterns
- During the evaluation phase of WaTEM in 21 Danish slope units, suitable parameter sets have been pointed out
- The best LS algorithm predicting the deposition in the field (depositional fan) and buffer zones seems to be McCool high rate (R^2=0.85 and R^2=0.76)

References

K.Van Oost, G.Govers and P.Desmet.2000.Evaluating the effects of changes in landscape structure on soil erosion by water and tillage. Landscape Ecology.

Perspective

Still running the WaTEM model and invesigate the effect of new scenarios on soil erosion and deposition in the experimental system