SOIL QUALITY = WATER QUALITY?

SOIL EROSION MODELING AT A CATCHMENT SCALE

Nikki J Baggaley, Allan Lilly, Marie S Castellazzi and Ruth Walker • n.baggaley@macaulay.ac.uk
The Macaulay Land Use Research Institute, Craigiebuckler, Aberdeen, AB15 8QH, UK

INTRODUCTION

Soil erosion is seen as a threat to sustainable agriculture and good water quality. We used the PESERA model to assess soil erosion in a temperate catchment in eastern Scotland (The Lunan Water) which is under intensive arable agriculture and subject to multiple pollution pressures. This catchment is being studied as part of the MLURI, SAC, SEPA monitored priority catchment partnership. The PESERA model has previously been applied on a 1 km grid with European and national scale data sets. It has also been shown to work at catchment and plot scales with higher resolution data and has potential to be used as a land use planning tool. However, the modelled erosion rates should be treated with caution, particularly at the model default monthly time steps. We evaluate the potential of the model to be used as a tool to assist in producing management guidelines to minimise soil erosion under changing land use and projected changes in climate. The ultimate aim of this work is to link the predictions of soil erosion in the catchment to stream water quality.

PAN EUROPEAN SOIL EROSION RISK ASSESSMENT MODEL

PESERA is a process-based, spatially distributed model that assess soil erosion by overland flow.

The dominant processes are: Runoff generation based on a storage threshold model and sediment transport based on runoff, soil erodibility, and topography.

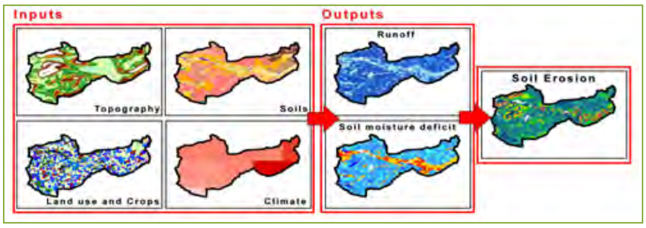

Figure 1: Schematic of the inputs and outputs of PESERA

Climate Monthly PE, temperature and rainfall (1971 to 2000)
Soils From the 1:25,000 scale soil series map
Land use scenarios (1) Constant across the catchment
(2) Current crop mosaics simulated using SIACS (Scottish Integrated Administration and Control System) data
Topography Calculated from Ordnance Survey PROFILE® DTM

THE LUNAN WATER

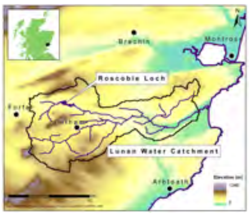

Figure 2: Lunan Water

Area – 140 km^2
Dominant arable crops – Spring cereals (29%), Winter cereals (19%), Root crops (9%)
Parent material – Till derived from Old Red Sandstone, Lavas; Fluvio-glacial sands and gravels

Major soil sub-group	Series	Area (%)	PESERA texture
Brown earth with gleying	Balrownie	39	Medium
Humous-iron podzol	Forfar	22.4	Medium
Humous-iron podzol	Aldbar	18.3	Medium
Humous-iron podzol	Corby	14.1	Coarse
Brown earth	Garvock	11.9	Medium
Humous-iron podzol	Vinny	9.5	Medium
Mineral alluvial soil	Undifferentiated Alluvium	8.8	Coarse
Non-calcareous gley	Mountboy	4.6	Medium
Humous-iron podzol	Boyndie	2.2	Coarse

Table 1: Major soil series

MODEL TESTING

Scenario 1: Changing crop type with topography and soil (Balrownie series) constant.

Results: Changing crop type from winter cereal to:

- Root crops increased erosion rates by 17%
- Spring cereal increased erosion rates by 24%

Scenario 2: Changing soil series with topography and crop type (winter cereal) constant.

Results: Coarse textured soils showed much greater erosion rates than those classified as medium textured.
This appears to be driven by both the texture derived inputs in the model and the limited soil water storage capacity of gravelly soils.

CLIMATE CHANGE

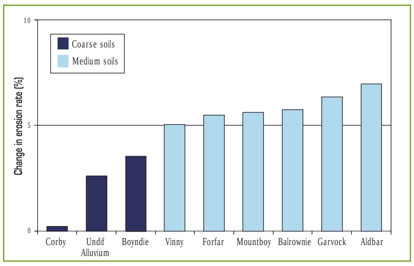

Figure 5: Percentage change in erosion rate when using UKCIP09 average rainfall for eastern Scotland

Scenario 4: Winter cereal using UKCIP09 predicted changes in average rainfall (88% rainfall in summer and 110% in winter) compared to the present day climate.

Results: Only a small increase in erosion for all soils, with the greatest change in the medium textured soils (Figure 5).

LAND USE CHANGE

Scenario 3:
Changing crop types within the Lunan Water catchment (Figure 3)

Results:
The modelled erosion patterns show the greatest changes in erosion rates in coarse textured soils adjacent to water courses (Figure 4).

Mixed land use shows a patchwork of erosion risk across the catchment.

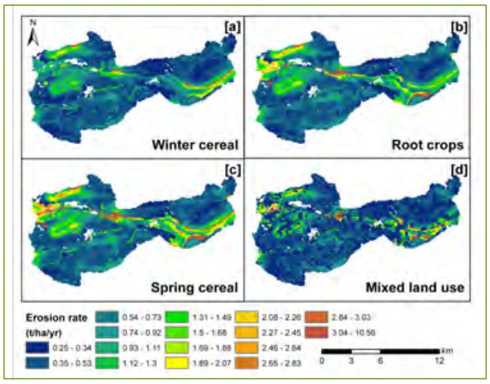

Figure 3: Model simulations for various crop combinations

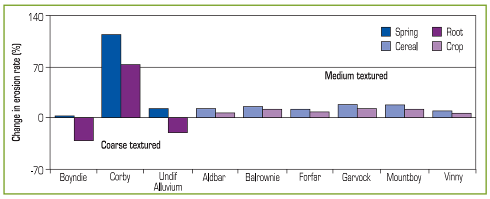

Figure 4: Percentage of change in erosion rate when changing crops from winter cereal to spring ceral or root crops

CONCLUSIONS AND FUTURE WORK

The PESERA model is sensitive to changes in land use, soil properties and climate and therefore has the potential to be used as a land use planning tool to mitigate against the risk of erosion under a changing climate.

The model appears to be more sensitive to land use change than climate variability.

Future work will:

(1) Investigate the soil and land use dynamics that lead to the modelled changes in erosion.
(2) Test the model sensitivity to soil texture derived parameters using measured aggregate stability.
(3) Integrate PESERA outputs with a land use model to develop spatially targeted cropping systems to mitigate soil erosion within the Lunan Water catchment.
(4) Link soil erosion predictions to stream water quality.

This work was funded by the Rural Environment Research and Analysis Directorate of the Scottish Government (RERAD)