Non-linear environmental response to the agro-pastoral transition in north-western Europe

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BACKGROUND

- Environmental response to human occupation is scale dependent, and therefore probably non-linear
- North-western Europe has been step-wise deforested as a result of the agro-pastoral transition that started at ~6.3 ka BP
- After deforestation, soil erosion increased, and deposition of colluvium and alluvium increased in many catchments
- In small catchments, increased alluviation is dated to the early Iron Age (ca 2.7 ka BP).

THIS STUDY AIMS TO:

- 1. Quantify the amounts of fine sediment (suspended load) that were delivered to the Rhine trunk valley and delta during the last 6000 years.
- 2. Determine the moment when the suspended load of the Rhine had changed on a catchment scale.

DATA AND APPROACH

i) Sediment delivery (SD) is related to the amount of sediment stored (SS) and the trap efficiency of the area (TE): SD * TE = SS

ii) SS is a volume of sediment with a certain bulk density (ρ): \sum Storage (mass) = $\sum \rho * [THICKNESS * AREA]$

iii) TE mostly depends on accommodation space. TE of the delta is estimated to be 70%, and 15 % for the trunk valley. Both are approximately constant in time.

NOTE: all values are corrected for preservation and internal reworking

Input data for area calculations: palaeogeographic maps



Input data for thickness calculations: cross-sections (# 16)

- Coring data: ~270.000 boreholes
- Time control: \sim 1400 ¹⁴C/OSL dates, archaeology
- Time lines bound sediment bodies





DISCUSSION: NON LINEAR RESPONSE?

- Suspended load delivery is increasing in all three study areas, this is catchment-wide trend.
- The magnitude of increase is related to the size of the stretch and the duration of the time slices. Concerning the timing: between 3 and 2 ka the increase starts, but it is only significant after 2 ka. • Such an increase can only be explained as a result of the ongoing deforestation of the Rhine catchment, although subtle intra-Holocene climatic changes may have accelerated erosion and sediment transport
- Considering travel times, the increased sediment delivery to the delta at 2 ka BP must be pre-Roman.
- The response to deforestation is step-wise: colluvium deposition increases after 4.1 ka BP, alluvium deposition increases after 2.7 ka BP in tributaries, and after 2 ka BP in the trunk and delta system
- This suggests a time lag in response of several millennia – although the time lag between the upstream tributary systems and the trunk valley/delta system is modest

CONCLUSIONS

ONE: The agro-pastoral transition in the Rhine catchment triggered increased sedimentation at a catchment-scale. Prehistoric land use was already extensive enough to modify the sedimentary system of a sizable river such as the Rhine. TWO: The response was non-linear in timing, due to storage of sediment in the upstream part of the catchment. Most of the time lag is due to colluvium deposition on the hillslopes, the downstream part shows response only once the colluvium sinks are by-passed. THREE: The amount of arable land cumulatively increased over time, and it is therefore impossible to attribute the human-induced increase in suspended load downstream in the catchment to a single archeological culture/period.



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Reference:

Erkens, G., 2009. Sediment dynamics in the Rhine catchment - quantification of fluvial response to climate change and human impact. Published PhD-thesis Utrecht University. Netherlands Geographical Studies 388, 278 pp.