

Effectiveness of winter cover crops, tied-ridging, and conservation tillage at controlling runoff and soil loss in Europe

A meta-analysis

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Background


 Sediment-laden runoff from agricultural land causes infrastructure & environmental damage

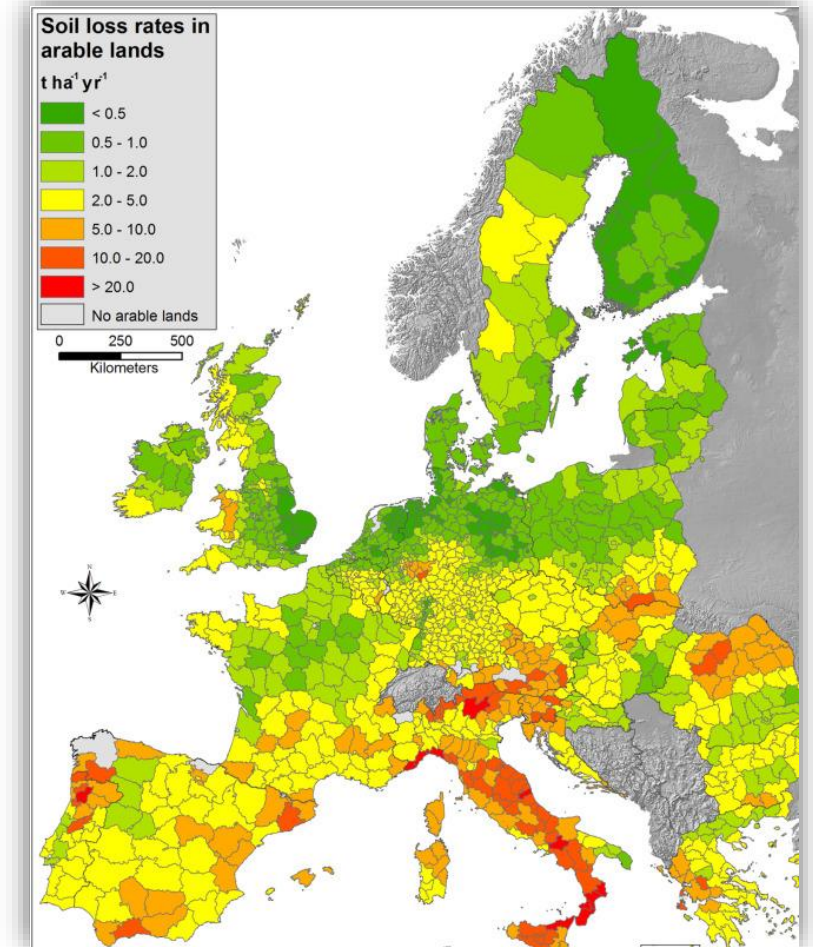


Source : C. Bielders

Background

 Sediment-laden runoff from agricultural land causes infrastructure & environmental **damage**

 **Soil loss rates** under « conventional » agricultural practices are sometimes not sustainable



Mean soil loss rates for arable lands in the EU (Panagos et al., 2015)

Goals


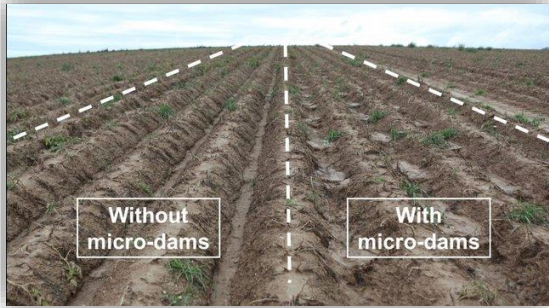

A wide range of soil and water conservation practices have been developed to control soil erosion in Europe, BUT :


 How effective are they ?

 How do environmental & management conditions affect their effectiveness ?

→ Meta-analysis for winter cover crops, tied-ridging, conservation tillage

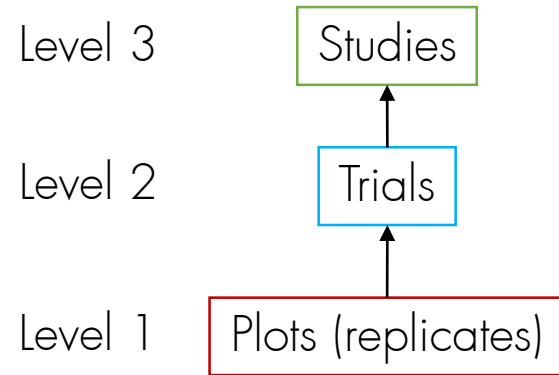
Systematic literature search

	Winter cover crops	Tied-ridging (potato)	Conservation tillage
Definition of control vs. conservation practice	 <p>Source : Laloy & Bielders, 2010</p>	 <p>Source : Olivier et al., 2014</p>	 <p>Source : T. Clement</p>
# relevant studies for runoff / erosion	7 / 5	7 / 7	21 / 17
# trials	36 / 29	25 / 17	178 / 165
Moderator variables	Climate – Crop and rotation – Soil – Topography – History – Tillage		
	Sowing and destruction Vegetation cover	Tied-ridging equipment Spring rainfall (max. daily)	Conservation tillage type : depth, implement intensity, # passes Presence of residues


Effect size : $\ln(RR_{erosion}) = \ln\left(\frac{Erosion_{conservation}}{Erosion_{control}}\right)$

Meta-analysis by random effects models

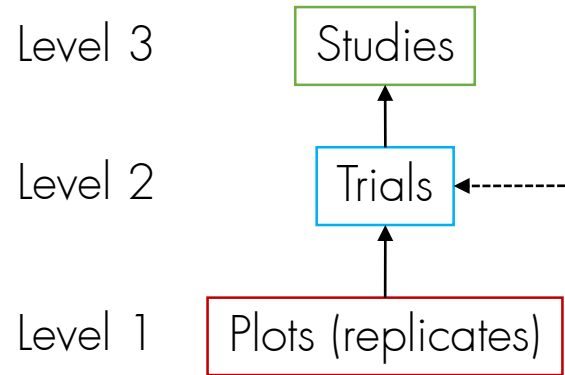
= Multi-level linear model



$$\ln(RR_{erosion})_{ijk} = \alpha_{000} + u_{00k} + v_{0jk} + \varepsilon_{ijk}$$

Meta-analysis by mixed effects models

= Multi-level linear model



Fixed effects

$$\ln(RR_{erosion})_{ijk} = \alpha_{000} + u_{00k} + v_{0jk} + \epsilon_{ijk} + \beta_1 X_{1jk} + \beta_2 X_{2jk} + \dots$$

Encoded moderators



Tested moderators



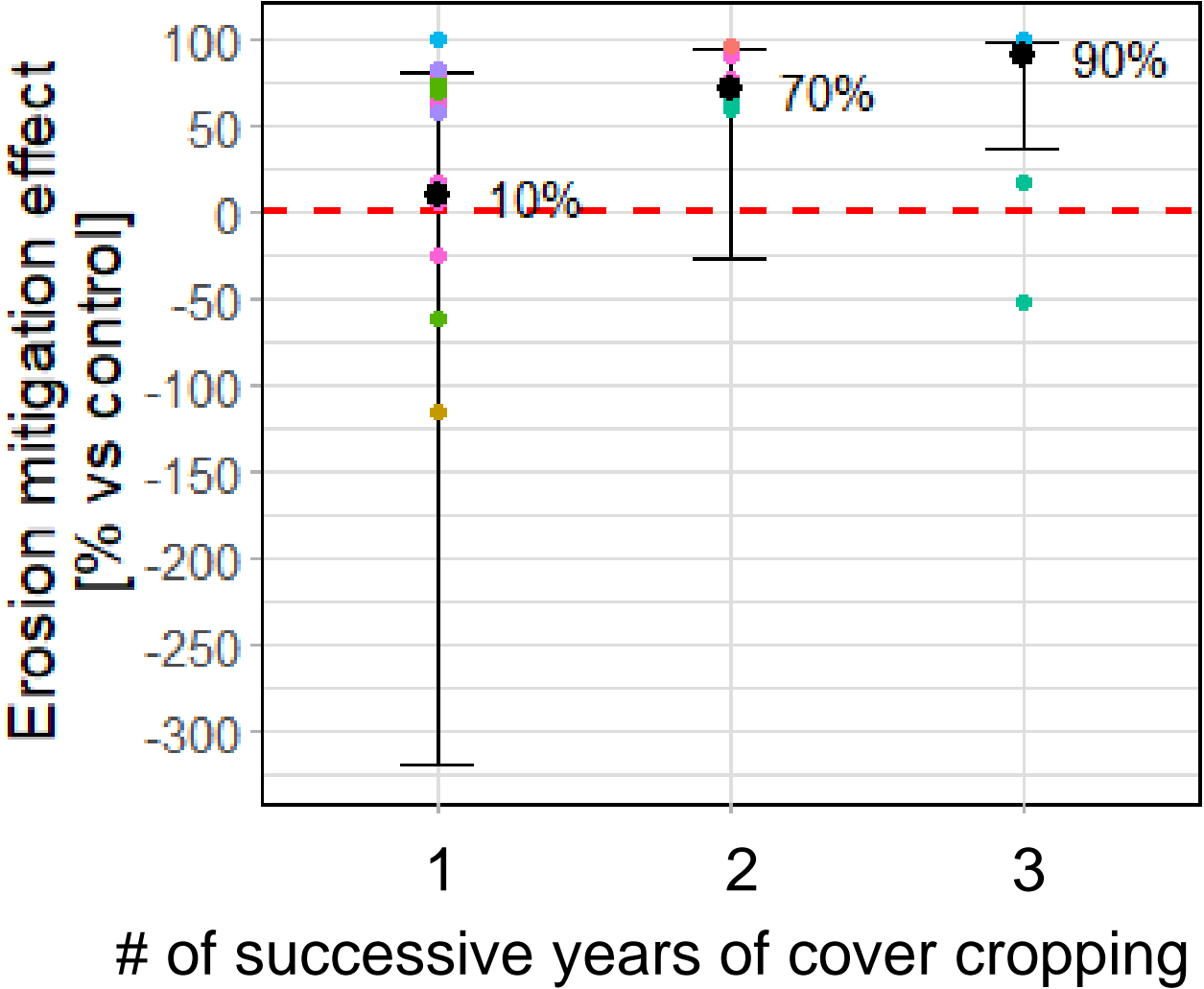
AIC

$$\begin{aligned} \ln(RR) &= \mu \\ \ln(RR) &= \mu + \beta_1 X_1 \\ \ln(RR) &= \mu + \beta_2 X_2 \\ &\dots \\ \ln(RR) &= \mu + \beta_1 X_1 + \beta_2 X_2 \\ &\dots \end{aligned}$$

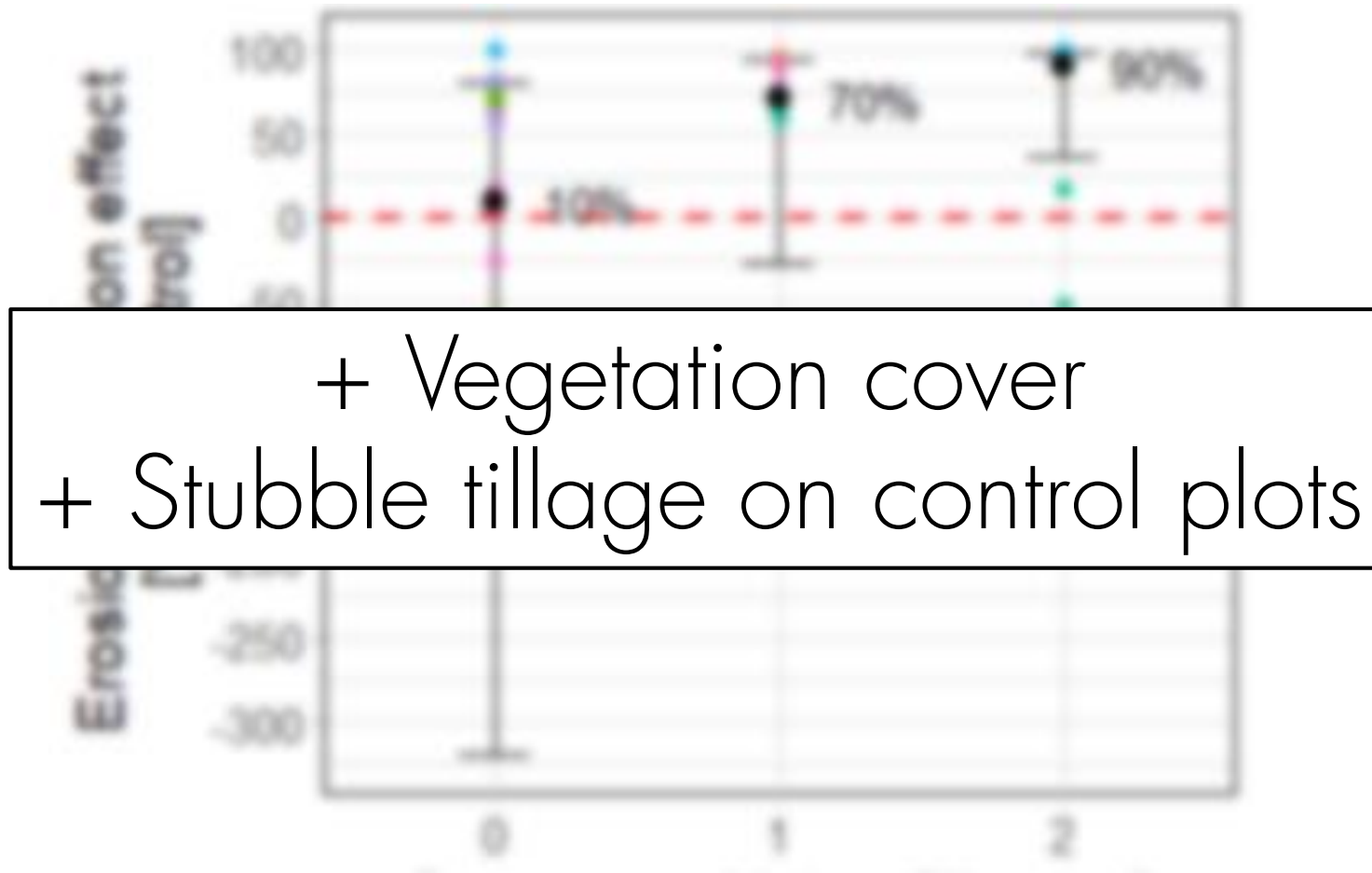
Significant moderators

Meta-regression for winter cover crops

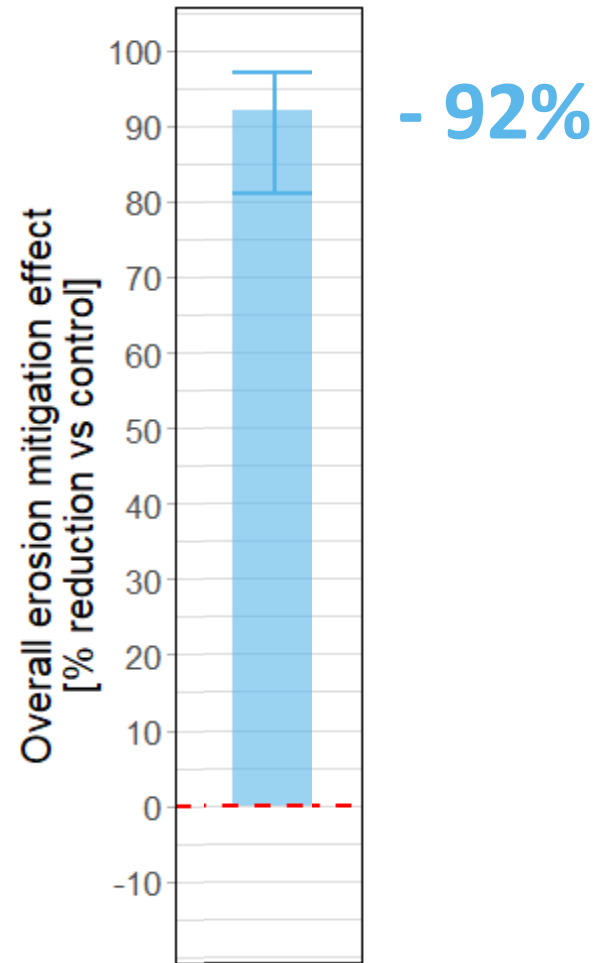
Overall erosion mitigation effect = - 72%



Meta-regression for winter cover crops

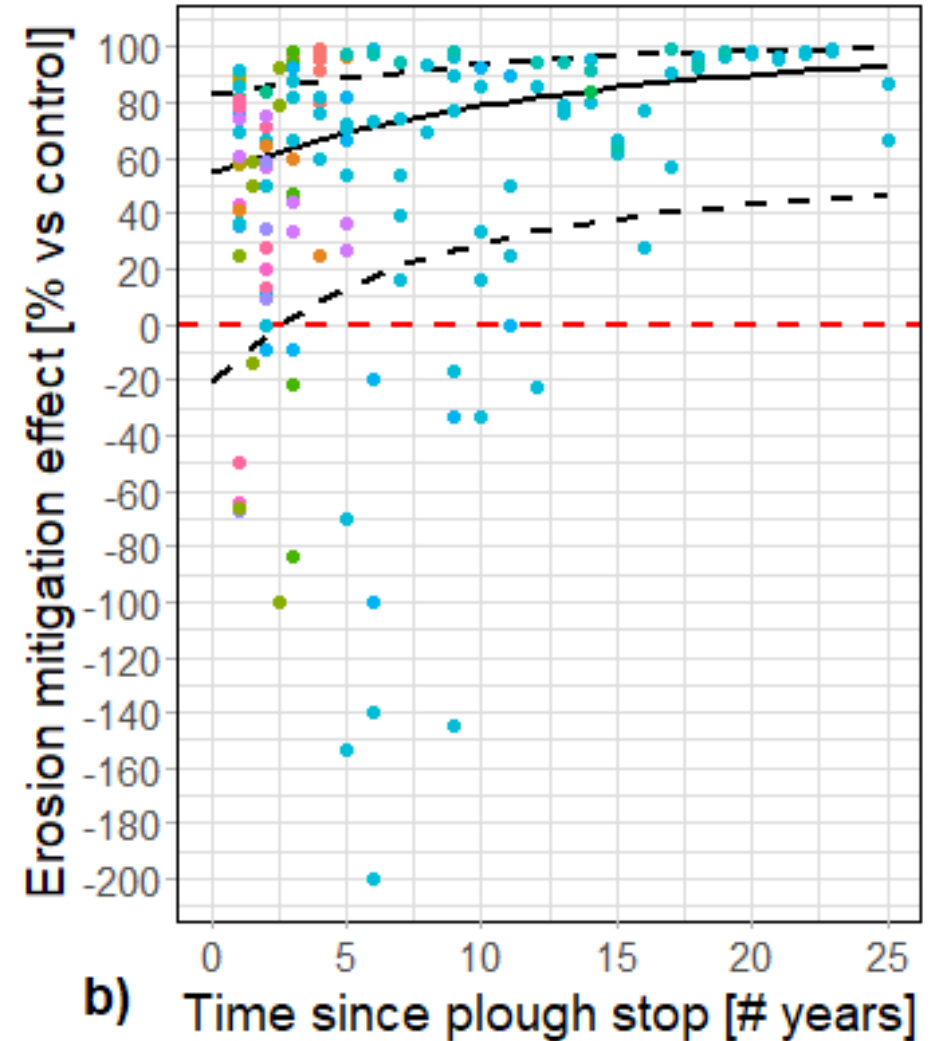


Meta-regression for tied-ridging

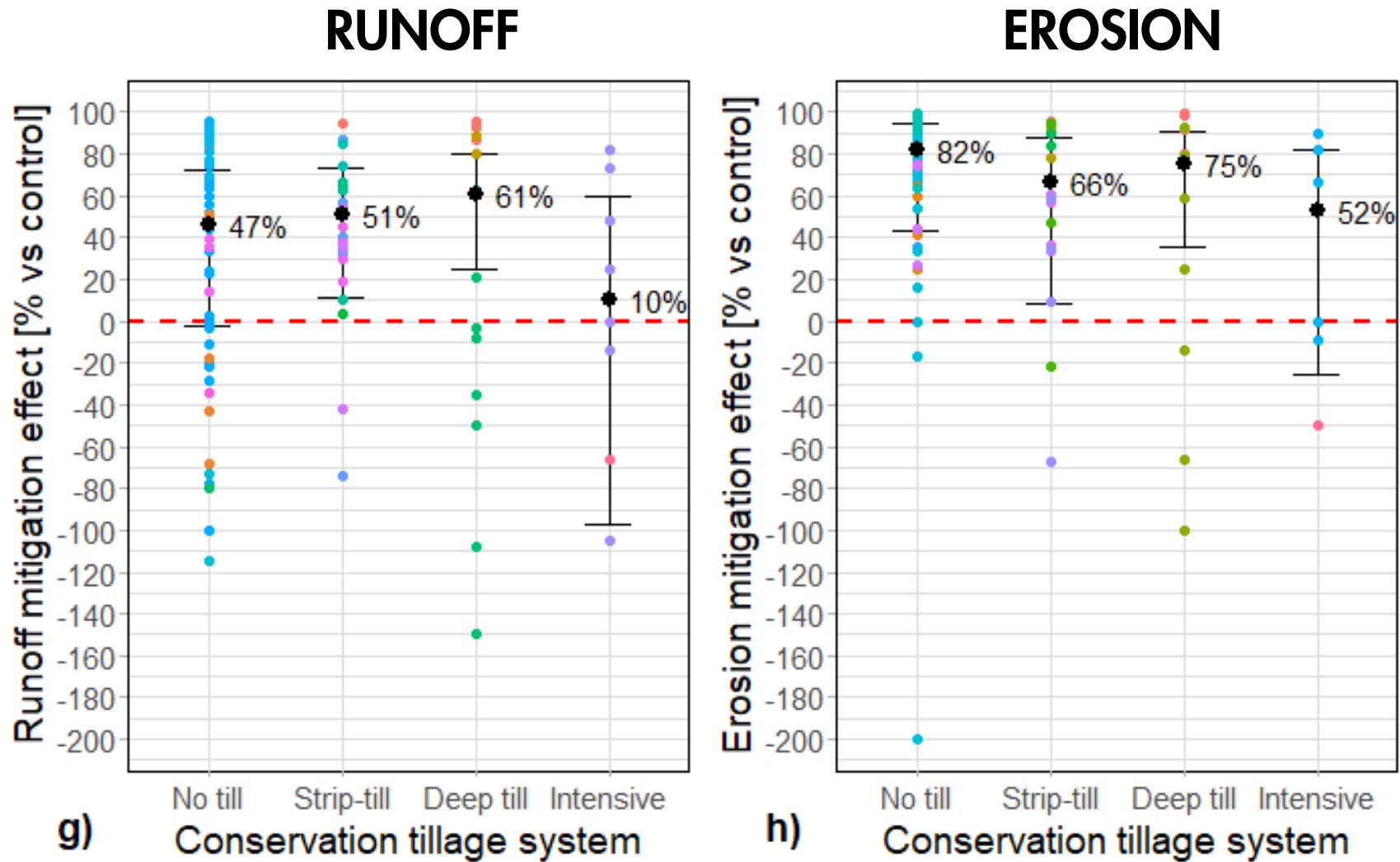


Meta-regression for conservation tillage

Overall erosion mitigation effect
= - 66 %

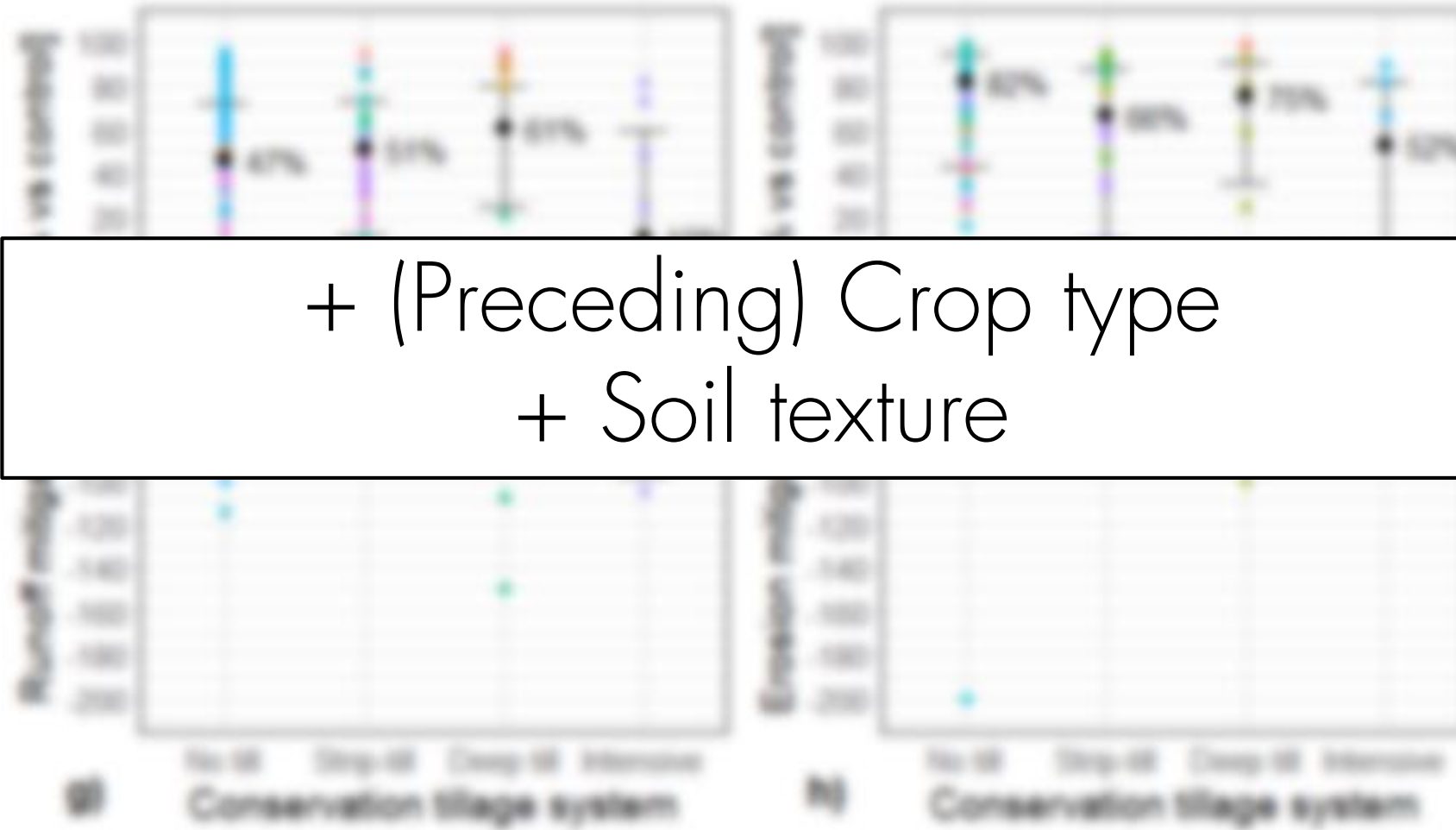


Meta-regression for conservation tillage



Meta-regression for conservation tillage

+ (Preceding) Crop type
+ Soil texture



Conclusion

 Conservation practices are **more effective at reducing erosion** than runoff

 Risk of **publication bias**, hence effectiveness overestimation

 **Management factors** are key to explain the mitigation effectiveness, especially the **history**, the **crop rotation**, and the **tillage scheme**

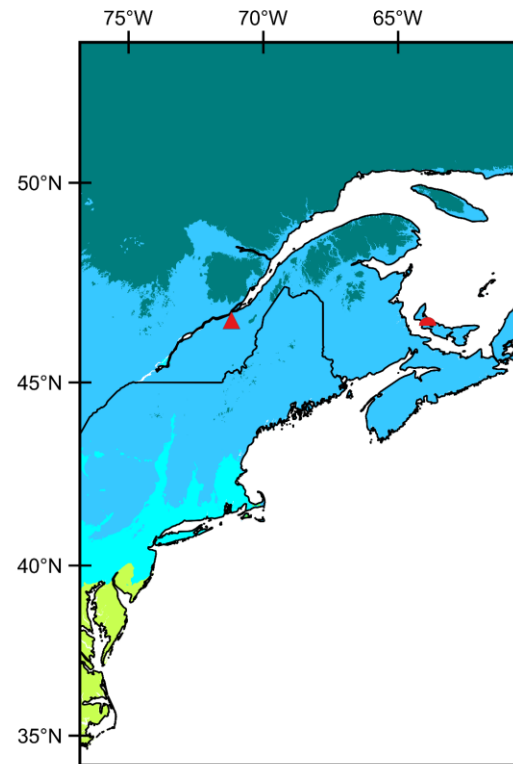
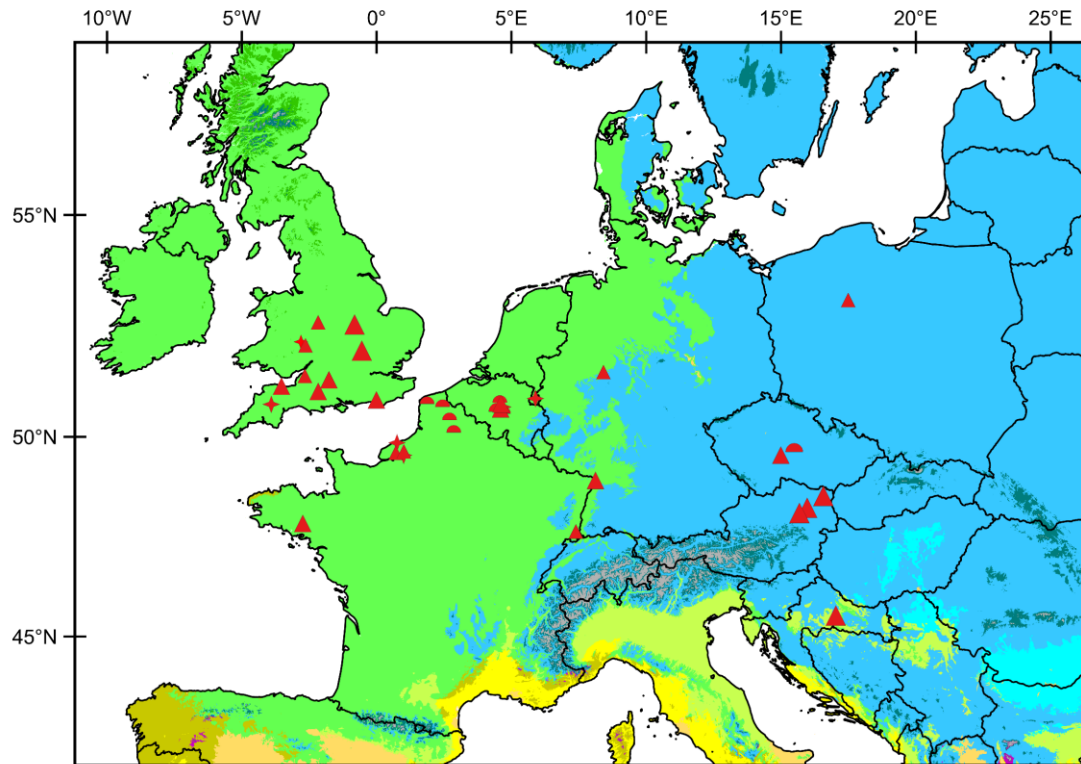
 High « **between-trials** » **variability**, hence additional **explanatory potential...**

- Absolute magnitude of surface flows
- (Residues of) cover crops ?
- Soil moisture conditions at tillage ?

Thank you for your interest !

Supplementary material

Meta-database



Primary studies

- ◆ cover crops; 1-3 trials
- ◆ cover crops; 4-9 trials
- ◆ cover crops; ≥ 10 trials
- ◄ tied-ridging; 1-3 trials
- ◄ tied-ridging; 4-9 trials
- ◄ tied-ridging; ≥ 10 trials
- ▲ conservation tillage; 1-3 trials
- ▲ conservation tillage; 4-9 trials
- ▲ conservation tillage; ≥ 10 trials

Köppen-Geiger climate class

- Arid, steppe, cold
- Temperate, dry summer, hot summer
- Temperate, no dry season, hot summer
- Temperate, no dry season, warm summer
- Temperate, no dry season, cold summer
- Cold, no dry season, hot summer
- Cold, no dry season, warm summer
- Cold, no dry season, cold summer
- Polar, tundra

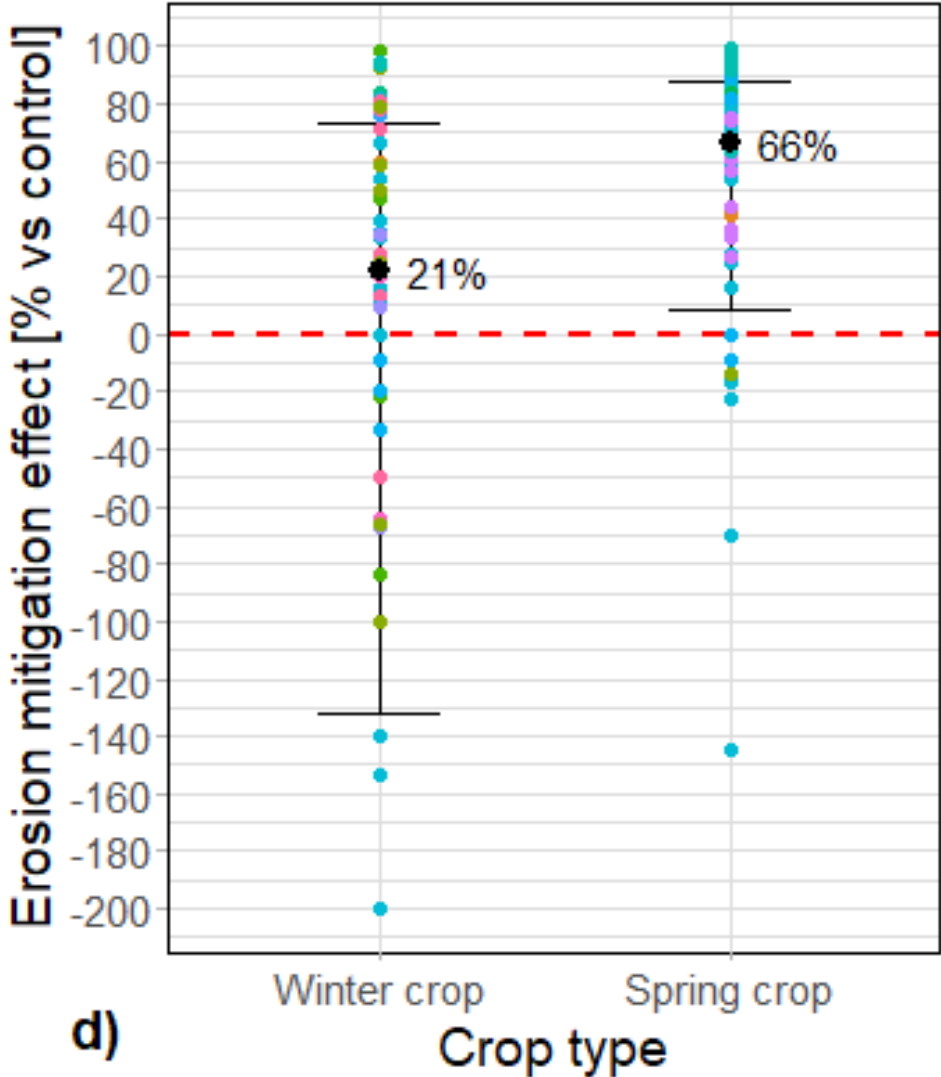
0 500 1000 km



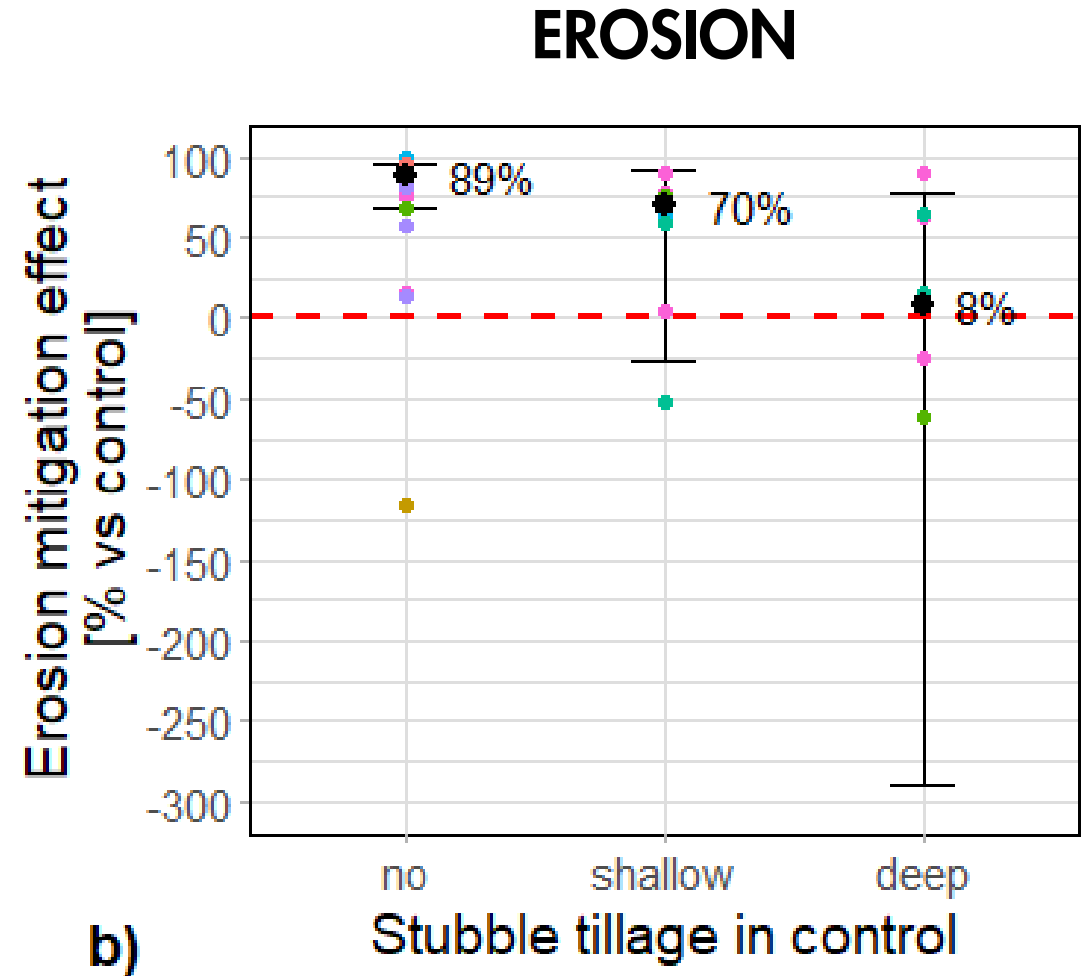
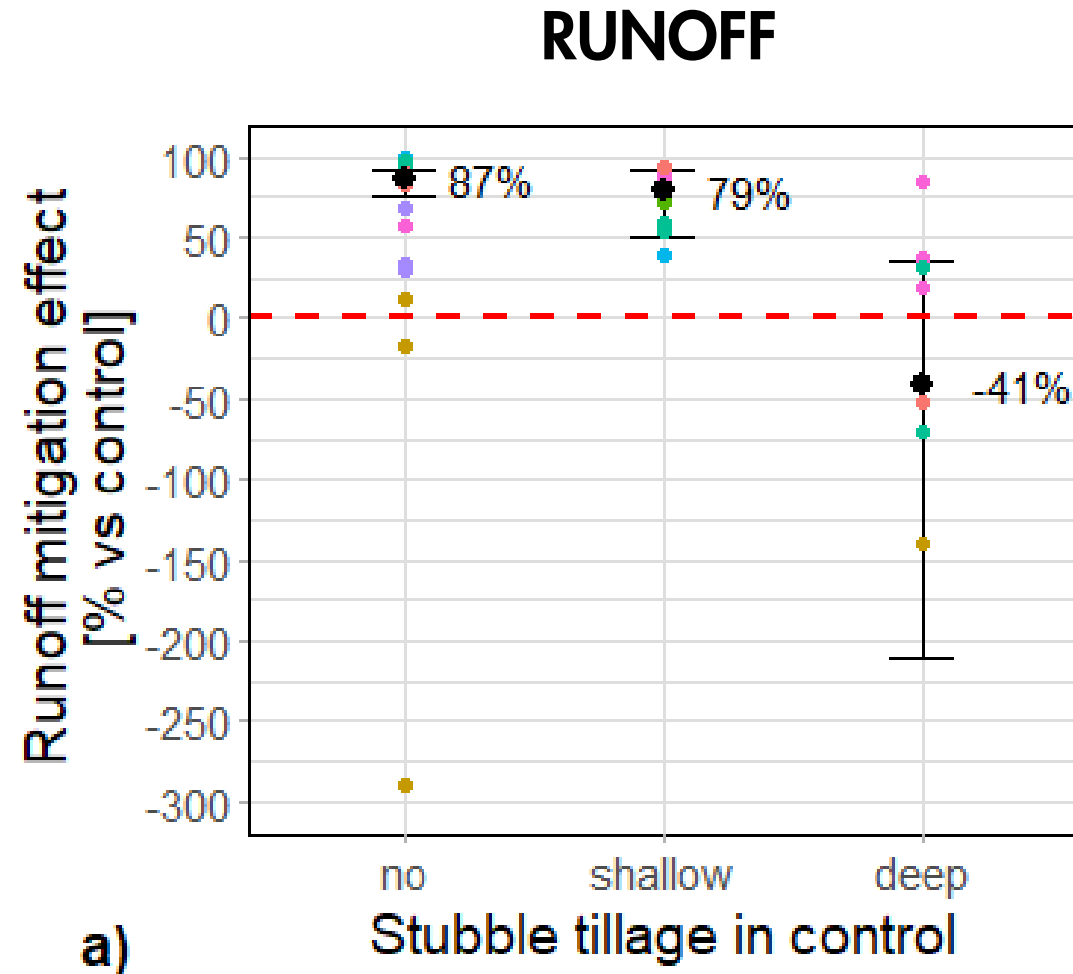
Coordinate system : WGS84

Data source for Köppen-Geiger climate classification :
Beck et al., 2018

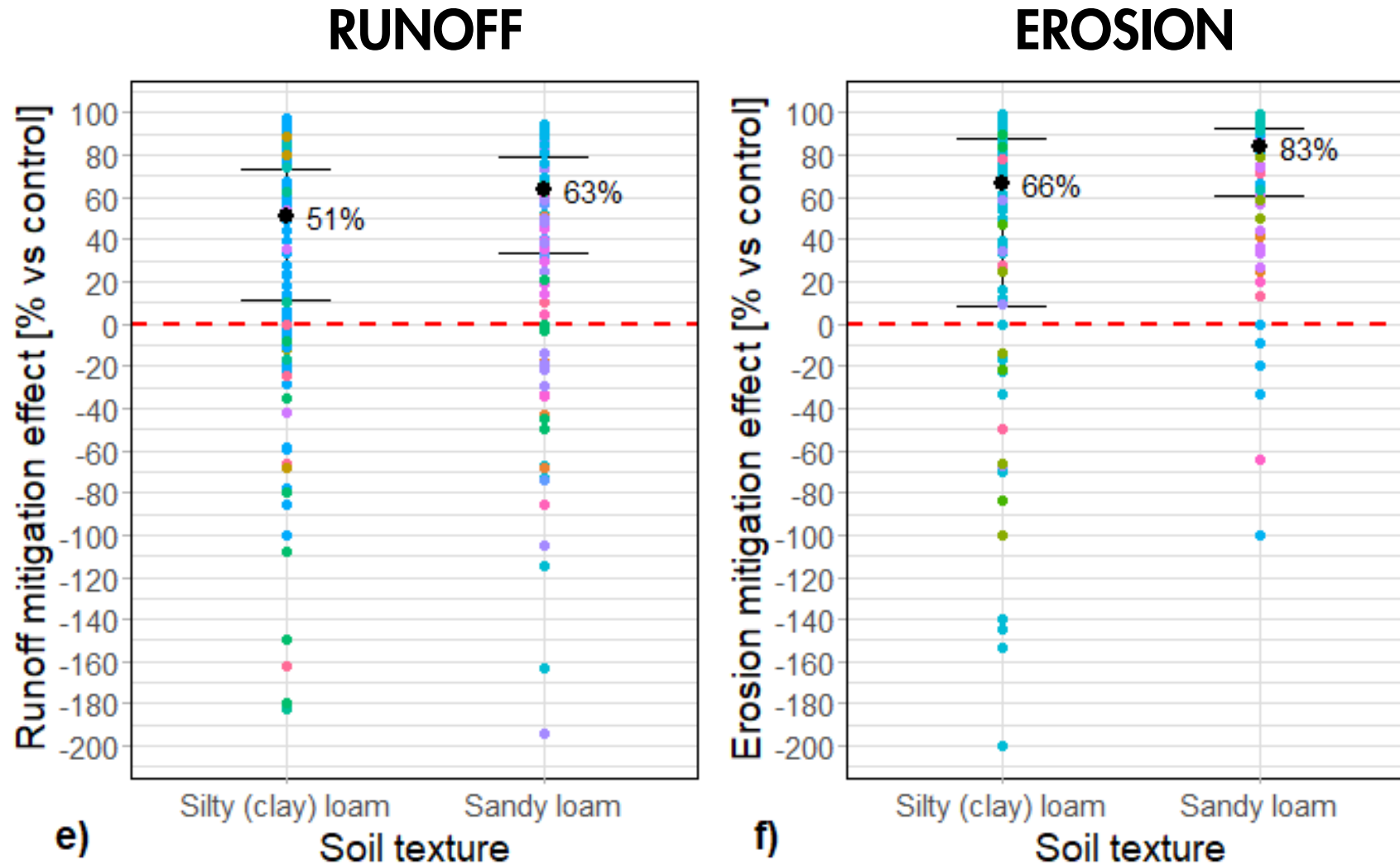
Meta-regression for conservation tillage



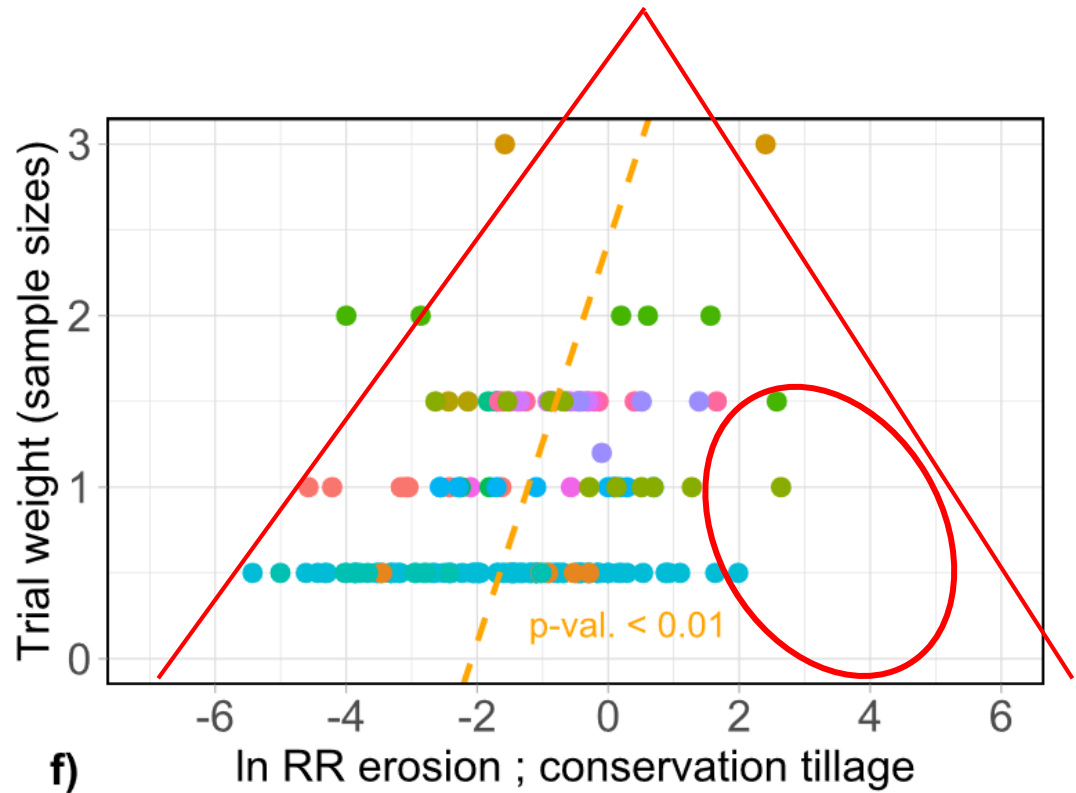
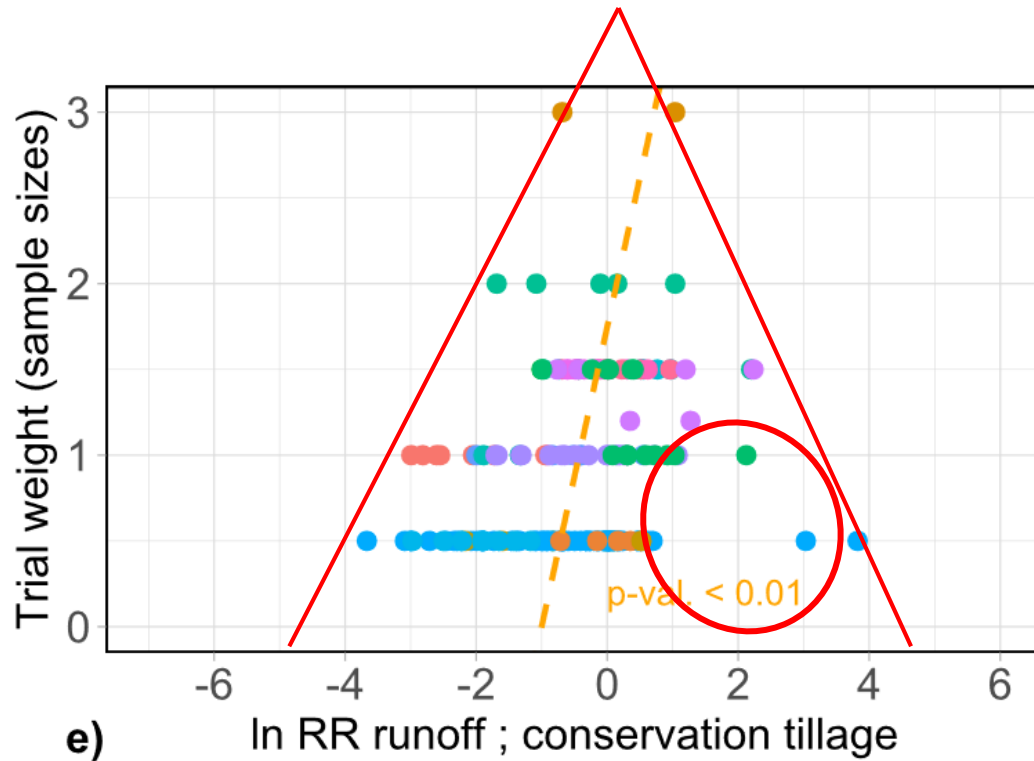
Meta-regression for winter cover crops



Meta-regression for conservation tillage



Publication bias



Missing data

- Retrieving data from graphs
- Recomputing SD from CI, p-val., SE
- Contacting authors
- Imputing data
- Extract data from public databases