Departement Umweltwissenschaften

Aggregates reduce likely transport distance of eroded SOC: are our carbon balance correct?

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Fate of eroded soil organic carbon

Transport distance & Settling velocity

UNI
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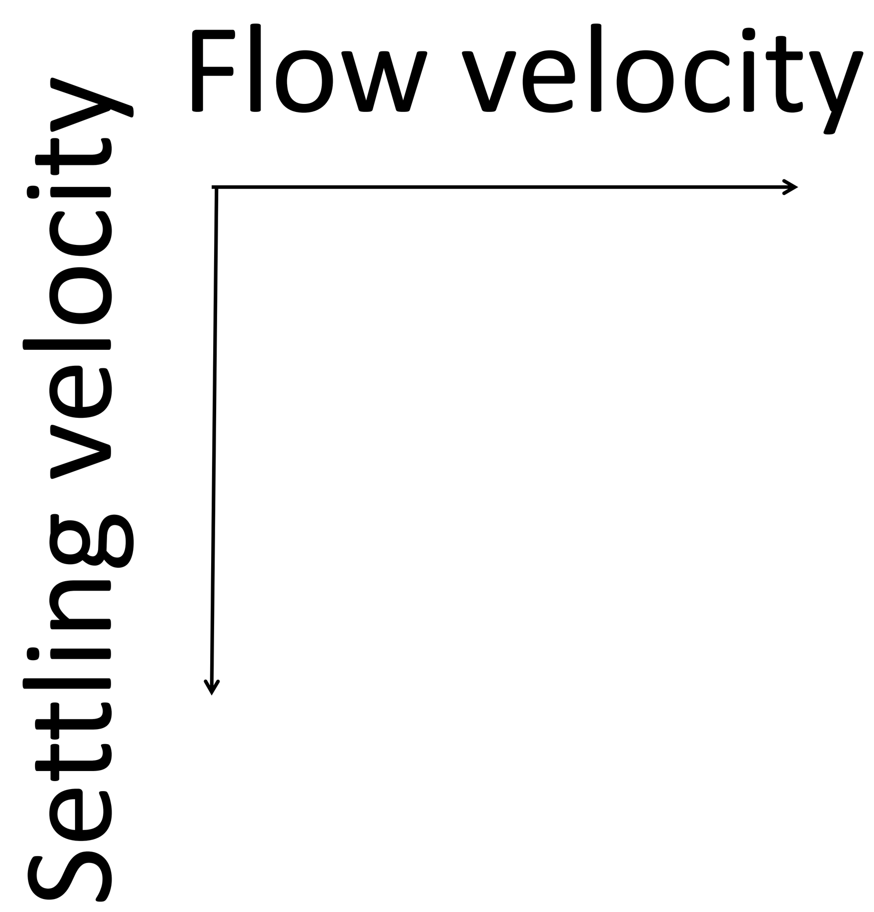
Transport distance

(Kinnell 2001, Earth Surface Processes and Landforms; Kinnell, 2004, Hydrological Processes)

Horizontal vector

Vertical vector

First-step assumption: a given layer of runoff



Settling velocity

Aggregation effects

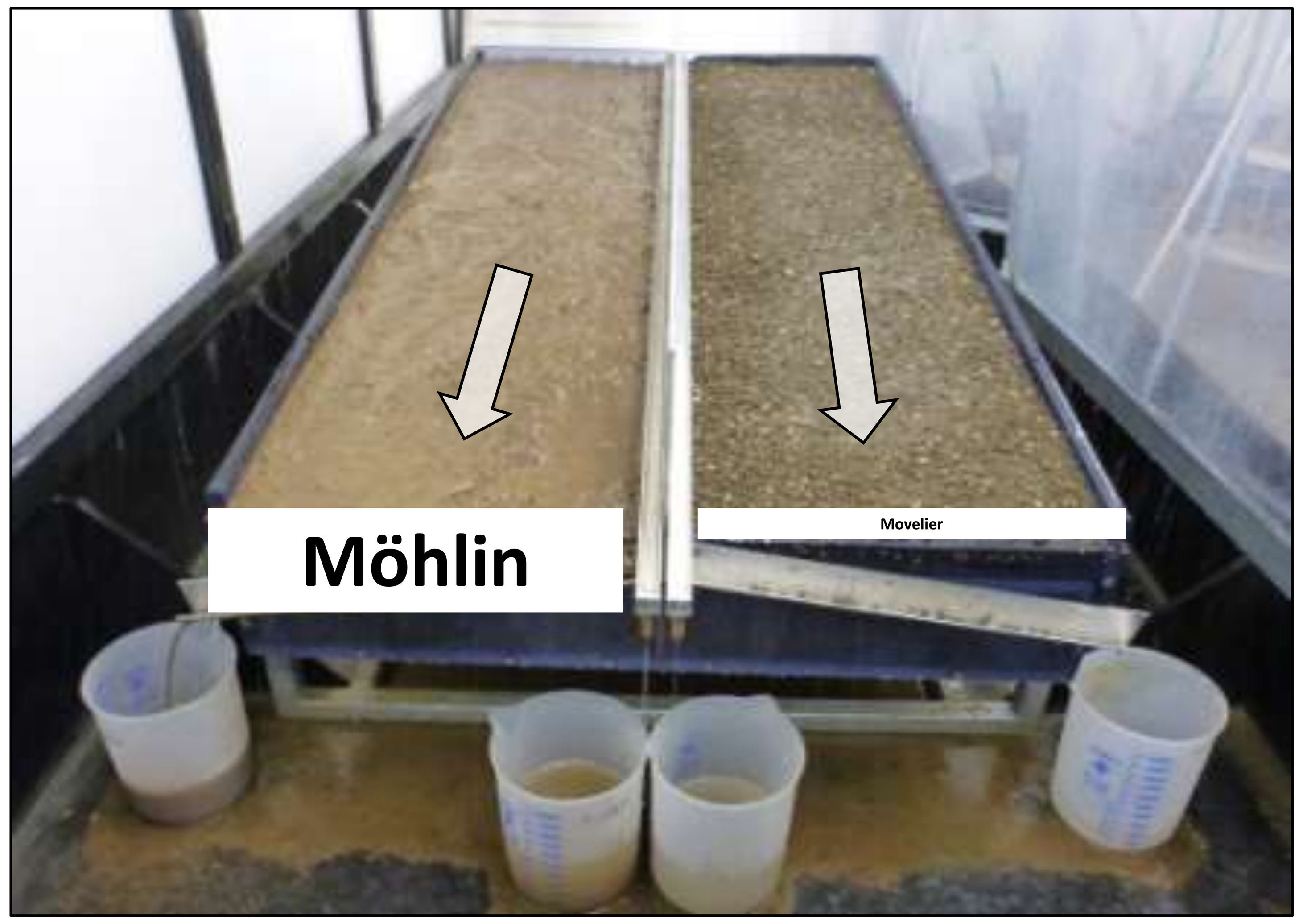
Facilitate settling velocity & reduce transport distance (Hu et al., 2013, BSG)

Pores, shapes, involve organic matter of low density

Equivalent Quartz Size (EQS)

representing the diameter of a nominal spherical quartz particle that would fall with the same velocity as the aggregated particle for which fall velocity is measured (Loch, 2001, Computers and Electronics in Agriculture).

Experimental design



Rainfall simulation

Fulljet ½ HH 50W

multiple-sized drops

100 mm h^{-1}

Sediment

Fractionation by settling velocity

1.8 m long tube

Collect by pre-determined time intervals (next slide)

Repeated 3 times

Each had 3 stages

N = 9

Single rainfall event

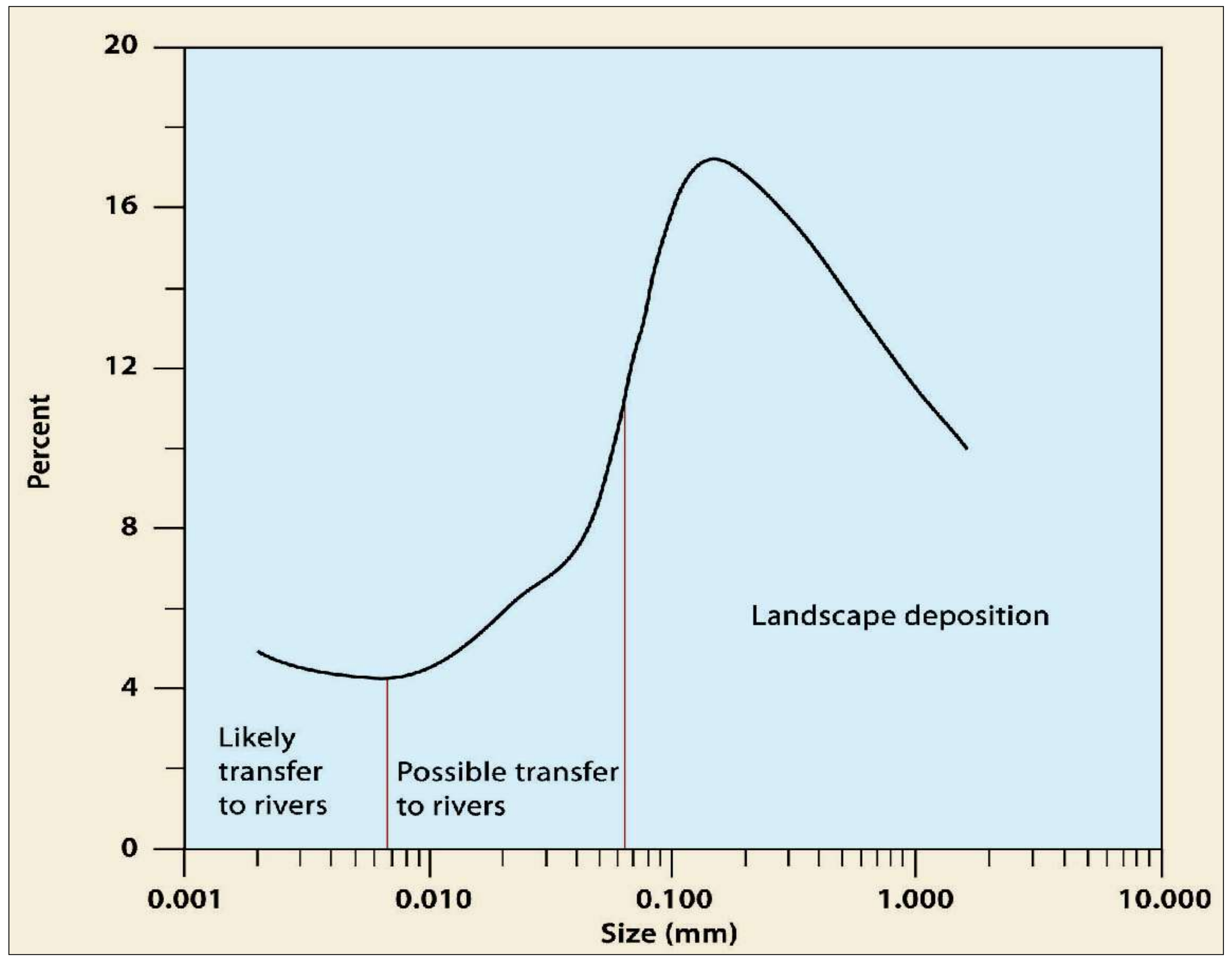
50 days respiration measurement by Gas Chromatograph

Total organic carbon concentration by LECO RC 612 at 550°C

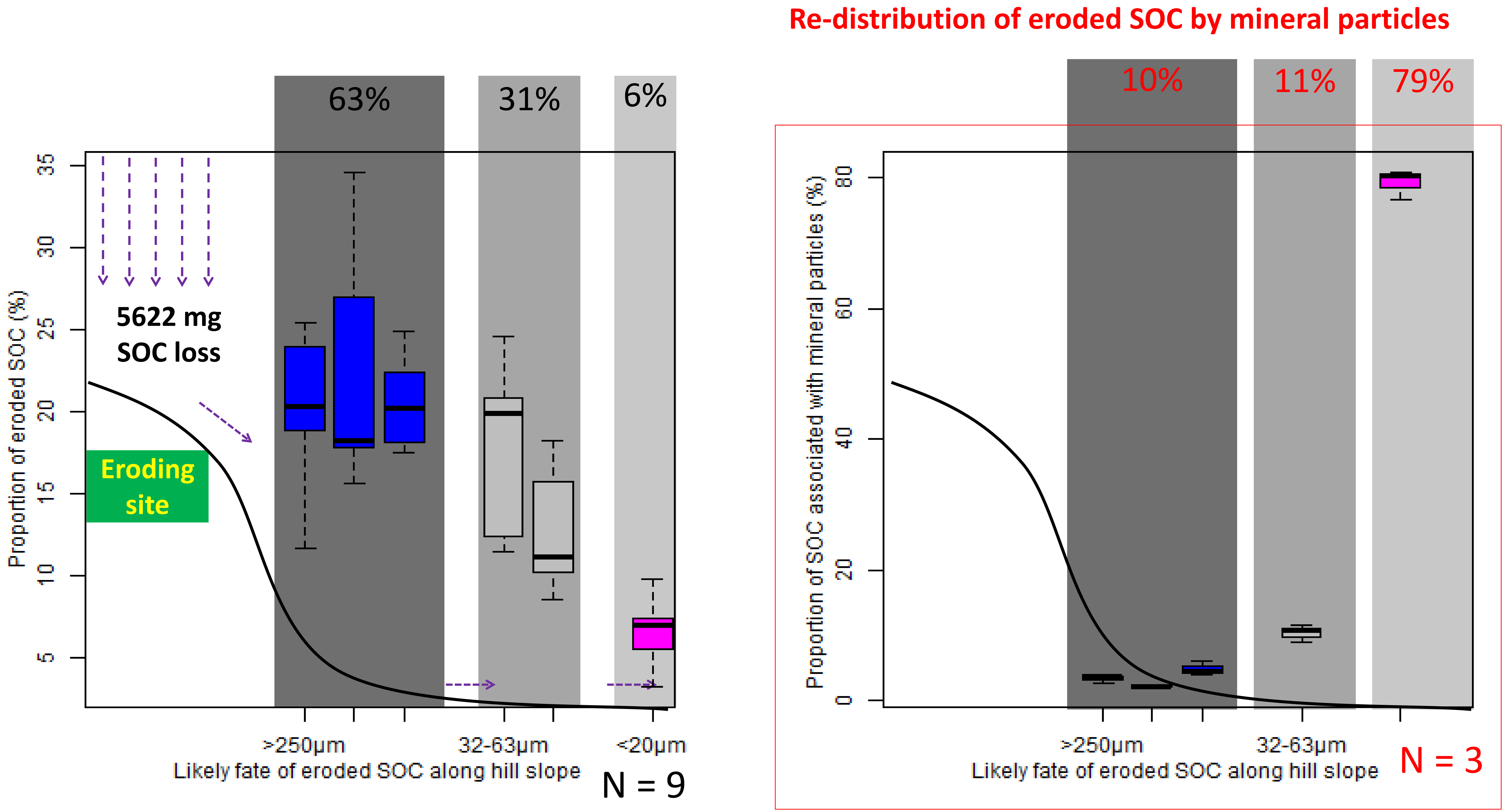
	Texture	General SOC (mg g^{-1})	Aggregates > 250 µm (%)
Möhlin	Silty loam	14.0	67.24
Movelier	Silty clay	42.8	91.37

Settling velocity and likely fate

EQS (µm)	Settling velocity ($m \cdot s^{-1}$)	Likely fate
> 250	$> 4.5 \times 10^{-2}$	Re-deposited along hill slopes
125 - 250	1.5×10^{-2} - 4.5×10^{-2}	
63 - 125	3.0×10^{-3} - 1.5×10^{-2}	
32 - 63	1.0×10^{-3} - 3.0×10^{-3}	Possibly transferred into rivers
20 - 32	$< 1.0 \times 10^{-3}$	
< 20	Suspension	Likely transferred into rivers



Likely fate of eroded SOC along hillslope

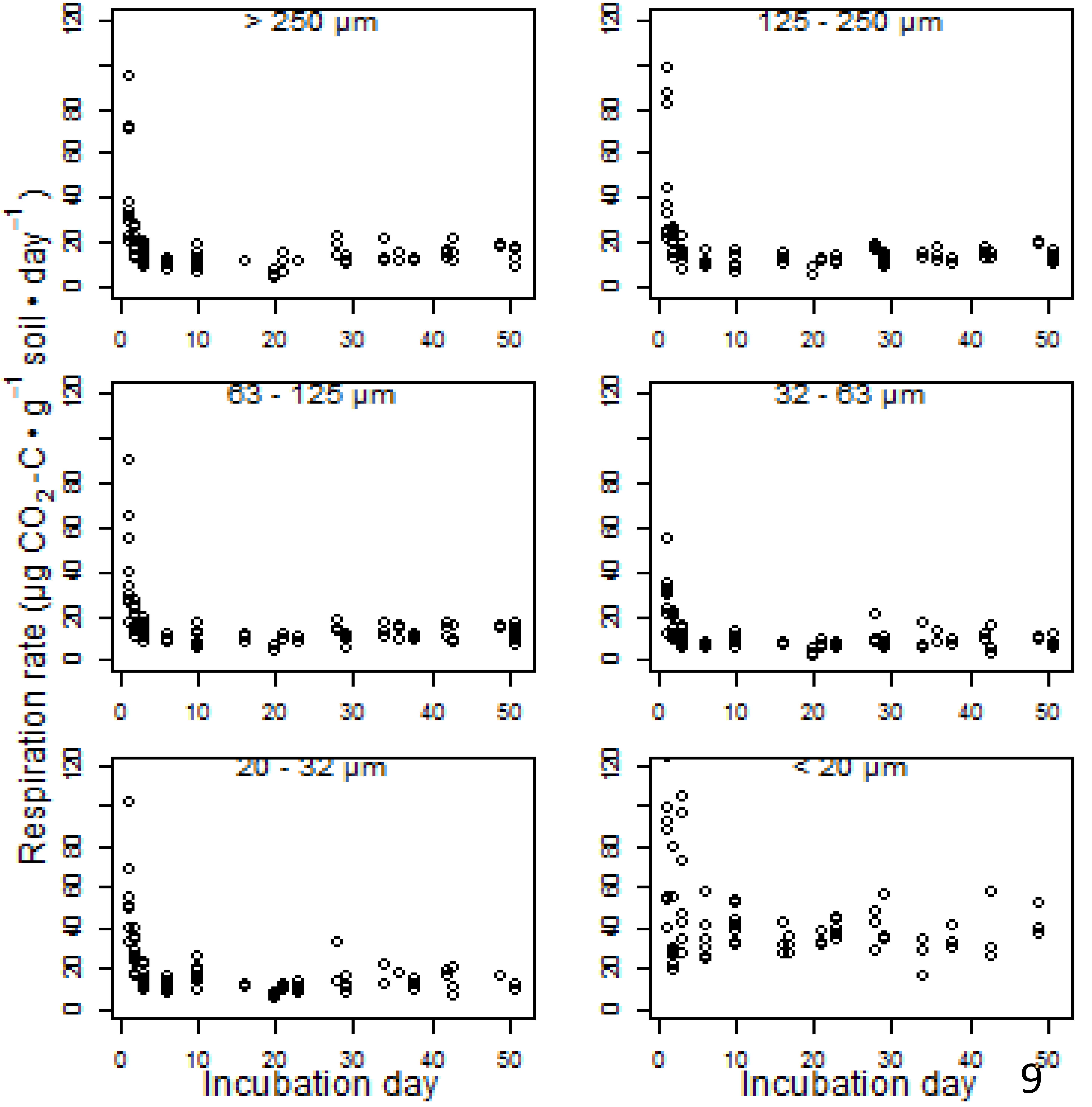


Aggregation of source soil

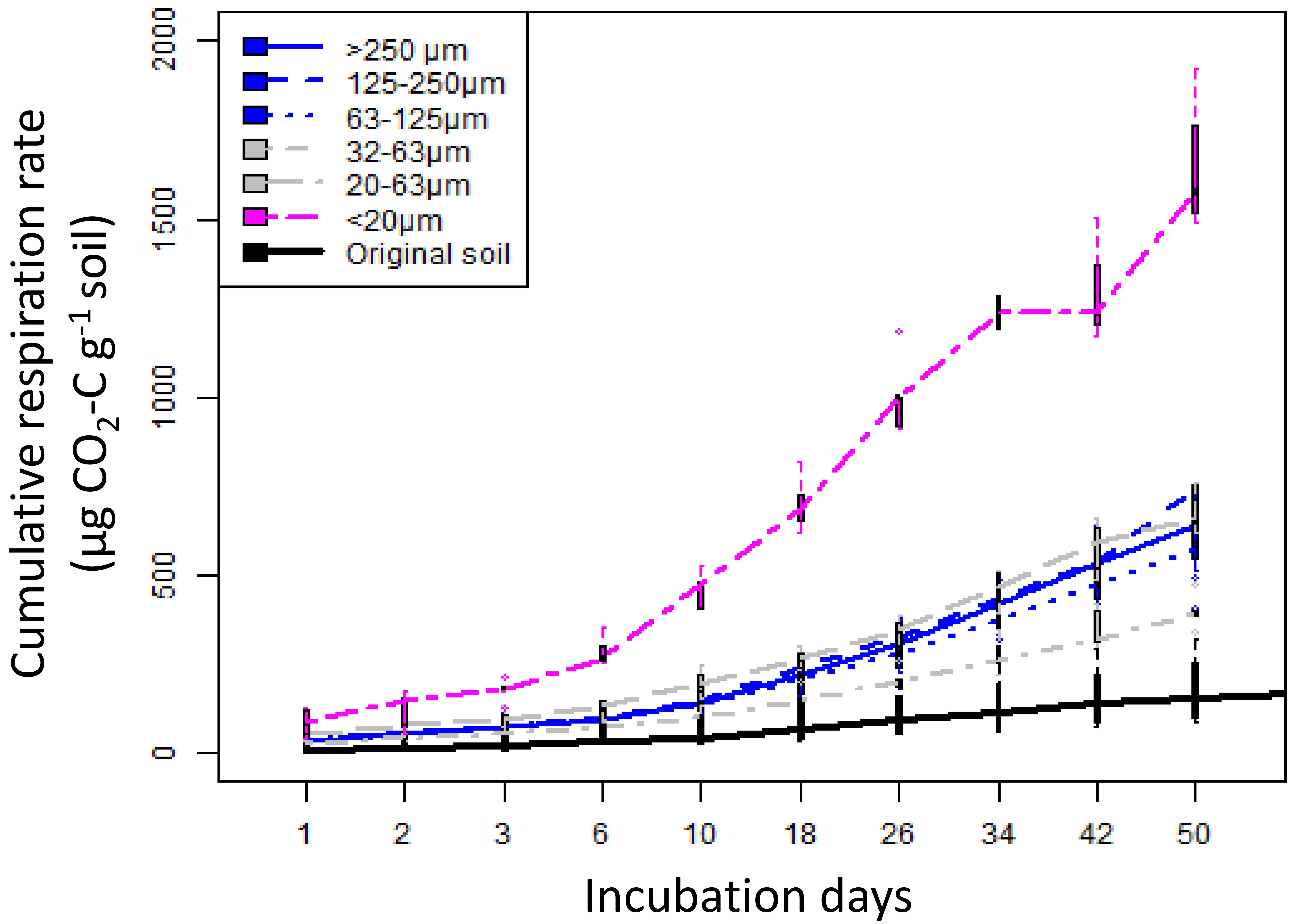
- Considerably reduces the transport distance of eroded SOC
- Skews re-deposition of eroded SOC towards the terrestrial system

Respiration rate per day per gram soil

--- different EQS classes over 50 days



Cumulative respiration rate over 50 days



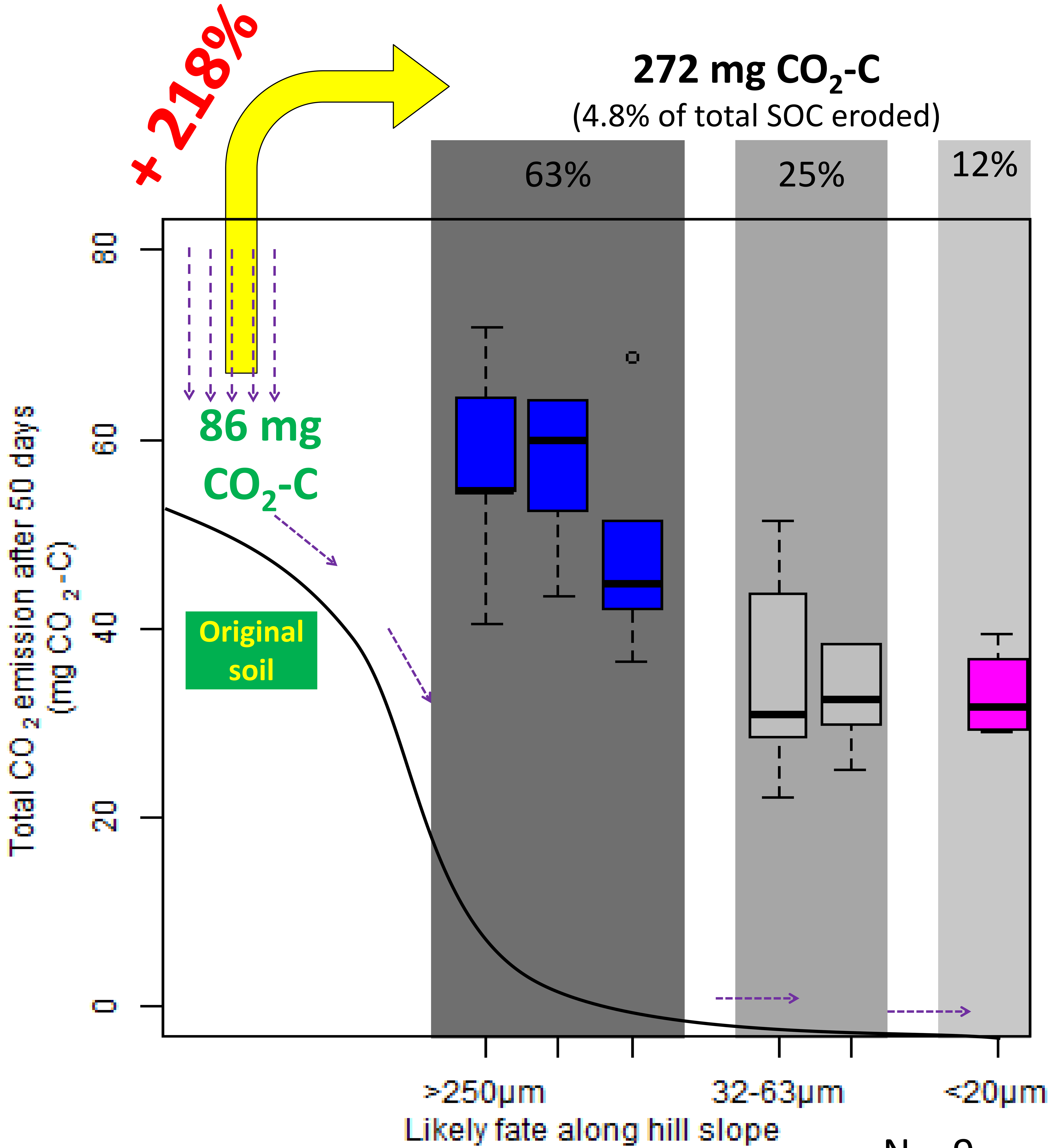
Eroded fractions have higher respiration rates than the original soil (colored vs. black line)

The presumably stable SOC, not any more stable

- in micro-aggregates (63-250 µm, dotted and dashed blue lines)
- with fine particles (< 20 µm, dashed pink lines)

Erosion and transport cause aggregate break down and extra exposure

Potential share of CO_2 emission along hillslope



Sediment: 430 g
Eroded SOC: 5622 mg

N = 9

Result Summary and Conclusion

EQS	Fractions	SOC	CO_2-C
Sediment	430 g	5622 mg	272 mg
Re-deposited along hill slopes (%)	60	63	61
Possibly transferred into rivers (%)	36	31	27
Probably transferred into rivers (%)	4	6	12
Original soil	430 g	-	86 mg
Difference	-	-	+218%

Mineral particle	Fractions	SOC	CO_2-C
Sediment	57 g	3463 mg	-
Re-deposited along hill slopes (%)	10	10	-
Possibly transferred into rivers (%)	29	11	-
Probably transferred into rivers (%)	61	79	-

Aggregation of source soil, and thus that of sediment, considerably reduces the transport distance of eroded SOC, and hence skews its re-deposition towards the terrestrial system.

Erosion and transport processes accelerate eroded SOC mineralization, and thus may contribute extra atmospheric CO_2.

Carbon balances built only on SOC stocks from sites of erosion or colluvial deposition may not adequately consider the potential SOC re-deposition into the terrestrial system.

Related publications: Hu et al. (2013), British Society Geomorphology; Hu and Kuhn, Biogeosciences (accepted)
Youtube: settling tube apparatus

Outlook

Sandy soil?

Rainfall intensity, and multiple rainfall events?

Slope length, gradient?

Soil management, tillage erosion?

Re-aggregation on depositional sites?

Longevity of the carbon quality?

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