Supplementary Material

Use of rare earth oxides as tracers to identify sediment source areas for agricultural hillslopes

Clare Deasy and John N Quinton

Number of pages: 6
Number of figures: 4
Number of tables: 2

S1. Data Analysis Equations

Event runoff yields for each hillslope length were calculated by:

$$Y_R = \frac{R}{10000\,A} \quad (1)$$

Loads of sediment eroded from each hillslope area were calculated from measured sediment concentrations and measured runoff volumes as follows:

$$L_{SS} = C_{SS} \times R \quad (2)$$

Suspended sediment load data were combined with hillslope length areas to calculate event sediment yields:

$$Y_{SS} = L_{SS} / A \quad (3)$$

Loads of REE eroded from each hillslope area were calculated from sediment loads and measured concentrations of REE in the collection tanks as follows:

$$L_{REE} = C_{REE} \times \left(\frac{L_{SS}}{1000000} \right) \quad (4)$$

The erosion rate (depletion rate) for each hillslope contributing area (percentage of total mass of depletion of an element to mass of the applied element for a hillslope area) was calculated by comparing the total REO in each hillslope area (mass of REO applied as tracer and mass of REO in background soil) to the amount of eroded REE collected in the tank:

$$E_x = \frac{L_{REE}}{\left(M_{REE} + B_{REE}\right)} \times 100 \quad (5)$$

The mass of sediment eroded from each hillslope length was proportioned out between contributing areas to determine the actual load of eroded sediment for each contributing area:

$$L_x = \frac{RE_x}{\left(RE_a + RE_b + RE_c + RE_d\right)} \times L_{SS} \quad (6)$$

The actual erosion rate for each contributing area was calculated from the load of sediment eroded from each area and the size of the contributing area:

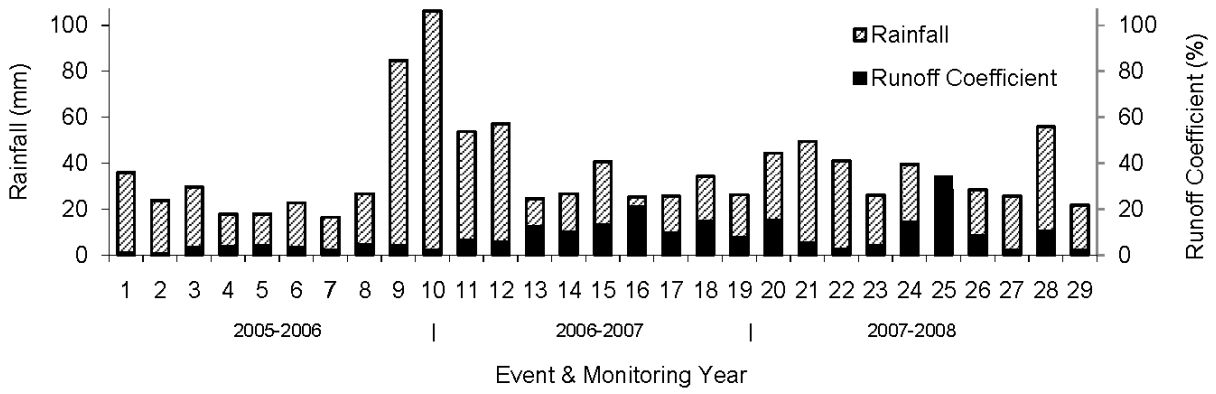
$$AE_x = \frac{L_x}{\left(S_x\right)} \quad (7)$$

Where Y_R = runoff yield in mm, R = tank runoff in l, A = area of hillslope length in ha, L_{SS} = tank sediment load in mg, C_{SS} = tank sediment concentration in mg l^{-1}, L_{REE} = tank REE load in mg, C_{REE} = tank REE concentration in mg kg^{-1}, E_x = erosion rate for each hillslope area in %, M_{REE} = mass of applied REE to contributing area in mg, B_{REE} = background REE mass in contributing area in mg, RE_x= relative erosion rate for contributing area (x = a, b, c or d) in %, L_x = sediment load eroded from each contributing area (x = a, b, c or d) in kg, AE_x = actual erosion rate (x = a, b, c or d) for contributing area in kg ha^{-1}, S_x = size of contributing hillslope segment area (x = a, b, c or d) in ha.

45 ***Figures***

46

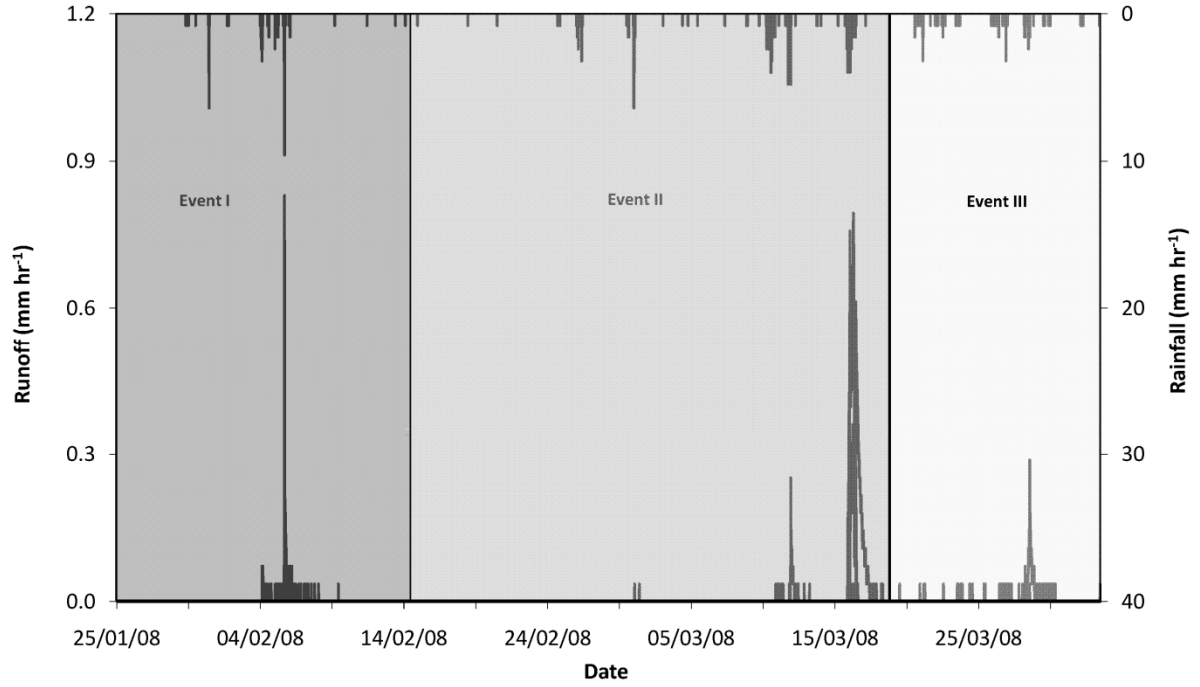
47 FIGURE S1. Spraying rare earth oxide (REO) powders onto the hillslope at Loddington in suspension using a
48 calibrated knapsack sprayer (a). REO tagged areas were clearly visible, for example Nd_2O_3 applied to the wheel
49 track areas (a), and Pr_6O_{11} on the midslope and Sm_2O_3 applied to the downslope areas (c).



50

51 FIGURE S2. Characteristics of events monitored in three study years at Loddington. Runoff coefficients are
52 averages for all mitigation treatments trialled in Deasy et al. (2009). Events I, II and III used in the REO tracer
53 experiment are events 27, 28 and 29 in this figure.

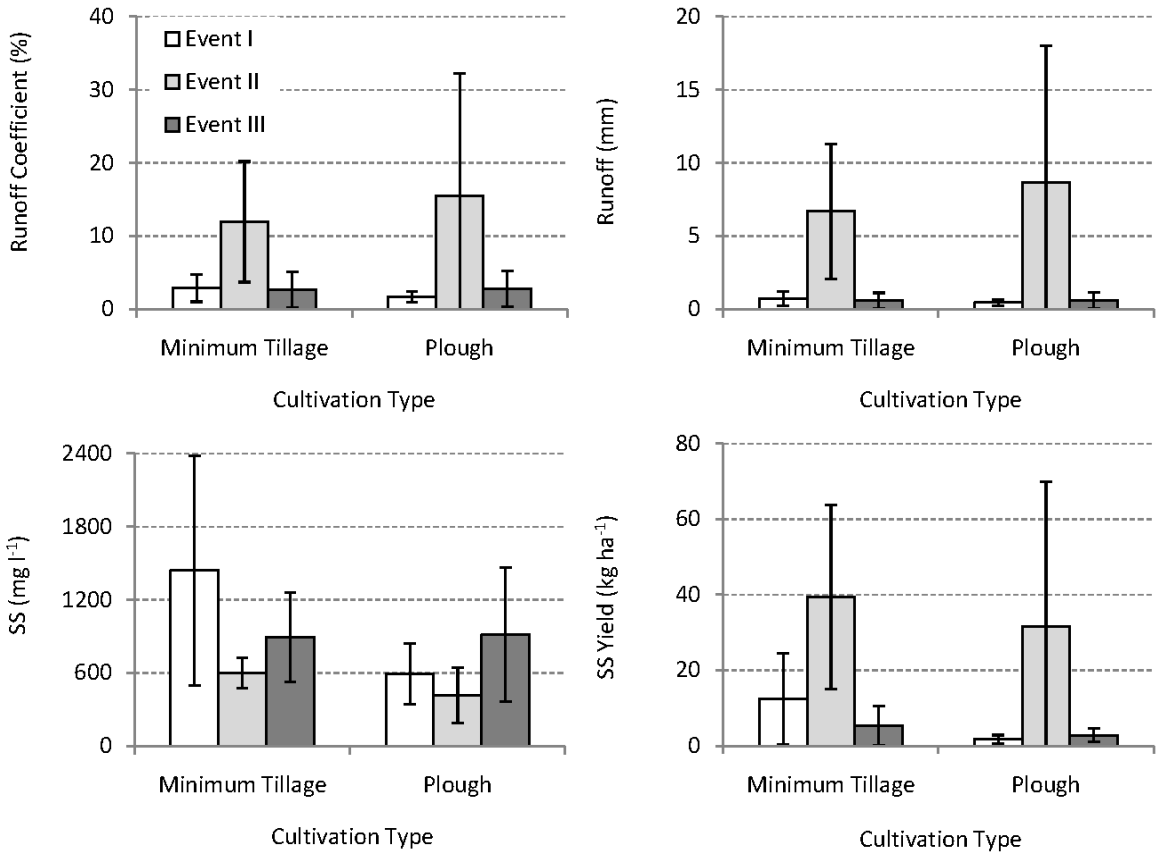
54



55

56 FIGURE S3. Runoff responses to rainfall for monitored hillslope lengths after application of rare earth oxide
57 tracers. Events I, II and III indicate runoff which was sampled on three occasions.

58



59

60 FIGURE S4. Differences between runoff and sediment transport characteristics for different cultivation types for
61 three events monitored at Loddington during the rare earth oxide tracing experiment. Values for minimum tillage
62 and plough plots are averages for five hillslope lengths in each cultivation treatment. Error bars shown indicate
63 standard deviations. There were no significant differences between cultivation treatments for any of the runoff or
64 sediment transport variables ($p<0.05$).

65

66

67

68

Tables

TABLE S1. Characteristics of all events monitored in three study years at Loddington. Events monitored for REO tracer experiment occurred in year 3.

Year	Rainfall in monitoring period (mm)	No. of events monitored	Mean rainfall event size (mm)	Rainfall event size range (mm)
1	383	10	38	16-106
2	360	10	36	24-57
3	316	9	35	21-56

TABLE S2. Concentrations of REE in sediment collected from tanks.

	Eroded concentrations for each element for tagged plots (mg/kg)			
	Upslope	Midslope	Downslope	Wheel Track
Event	Gd	Pr	Sm	Nd
I	667.7	90.84	24.49	5346
II	130.9	29.69	7.76	1186
III	145.1	17.71	8.57	1076

Values are averages of all 4 hillslope lengths used for the experiment.
N.B. the contributing area for the wheel tracks is around three times greater than for the other hillslope segments.