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SPATIAL AND TEMPORAL EVALUATION OF EROSION WITH RUSLE: A CASE OF STUDY IN AN OLIVE ORCHARD MICROCATCHMENT IN SPAIN

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- Studies at plot scale.
- Microcatchment scale: direct measurement, no extrapolation

1. INTRODUCTION

SOIL EROSION

- Higher erosion rates than **50 t.ha/year** expected in mountaineous AGRICULTURAL REGIONS in Spain (CMA, 2007).
- *Andalusia* - 1.48 Mha of **olive orchards** (CMA, 2007) that constitute a key crop in terms of INCOME, EMPLOYMENT AND ENVIRONMENTAL IMPACT.



OBJECTIVES

Spatial Analysis of RUSLE Predictions at microcathment scale

GPS surveys – Exam of heights

Temporal Analysis of RUSLE Predictions at microcathment scale (annual scale)

Frequency analysis of annual erosivity

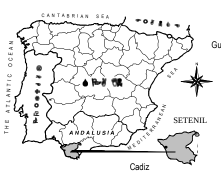


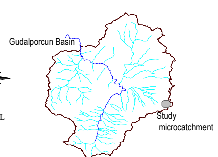
EVALUATION/PREDICTION TOOLS

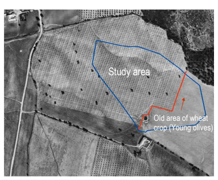
- Models→ required to evaluate and interpret **SPATIAL & TEMPORAL VARIATION of soil erosion.**
- **USLE/RUSLE** → Simple and commonly used equations for estimating soil losses. Attention must be paid to the reliability of the **results since rarely have been accurately verified** (Amore et al., 2004)

2. MATERIAL AND METHODS

2.1. Site of study.







Location		Setenil (Cádiz)
Area (ha)		6.7
Climate	Category	Subhumid Mediterranean
	Annual mean rainfall (mm)	1100
	Annual mean temperature (ºC)	16ºC
Topography	Mean slope (%)	10.3
	Mean height (m)	782.2
Soil type FAO		Luvisol
Management		Non tillage with bare soil

Location of the microcatchment in Spain (up-left) and situation of the microcathment in Gaudalporcun basin (up-right). Limits of the catchment on the aerial orthophotography (below-left) and view of hillslopes (below-right)

2.2. Soil erosion measurements.

CONTROL GRID: EROSION/DEPOSITION POINTS

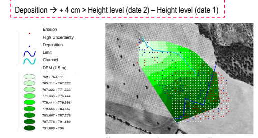
GPS Leyca 1200; Accuracy (RMSE) = 2,0 cm → 67% level of confidence

$$RMSE(level\_difference) = \sqrt{RMSE_2^{\,2} + RMSE_1^{\,2}}$$

Error Gaussian Distribution, 4 cm → level of confidence >80%

Erosion → - 4 cm < Height level (date 2) – Height level (date 1)

Deposition → + 4 cm > Height level (date 2) – Height level (date 1)



Control grid with erosion and deposition points on the digital elevation model in the study catchment

MONITORING SYSTEM (Total measurements – (period April 05- 06)

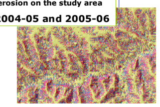
- **RAINFALL** – Rainfall gauge
- **RUNOFF (Flow)** – Flume of critical flow depth; Level ultrasonic sensor
- **SEDIMENT LOADING** – Automatic sampler runoff-sediments

2.3. RUSLE.

$E = R.K.LS.C.P$ Renard et al. (1997). ($t.ha^{-1}.year^{-1}$)

- **R:** Rainfall Erosivity – Functions depending on Pd (Daily rainfall) ($Mj.mm.ha^{-1}.h^{-1}$)
- **K:** Soil Erodibility – Soil samples ($t.h.Mj^{-1}.mm^{-1}$)
- **LS:** Length slope factor – DEM (04-05 and 05-06) – GPS surveys
- **C:** Cover factor - Bibliography
- **P:** Management factor (=1)

Evaluation of erosion on the study area
Campaigns 2004-05 and 2005-06



2.4. Statistical Analysis.

SPATIAL ANALYSIS AND CHARACTERISATION OF SOIL EROSION (Obj. 1)

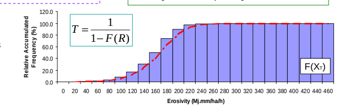
EVALUATION AND COMPARISON STUDY AREA VS EROSION/DEPOSITION POINTS
- DISTRIBUTION MAPS
- STATISTICS
-HISTOGRAMS.

LONG TERM EVALUATION OF SOIL EROSION (Obj. 2)

Analysis of frequency EROSIVITY FACTOR (Data series of 14 years) -> R_T

Analysis of frequency SOIL LOSSES

- Assignation probabilities: Weibúll´s and Gringorten´s equations.
- Distribution Fitting: Gumbel and Pearson type III



3. RESULTS AND DISCUSSION

3.1. Spatial evaluation of soil erosion.

	Erosion ($t.ha^{-1}.year^{-1}$) 2004-05	Erosion 2005-06	R- factor ($MJ.mm.ha^{-1}.h^{-1}$) 2004-05	R- factor 2005-06	LS- factor 2004-05	LS- factor 2005-06	K- factor ($t.h.MJ^{-1}.mm^{-1}$)
Mean	1.47	3.17	340.4	733.9	0.24	0.17	0.030
Dv	1.55	3.28	-	-	0.3	0.26	0.004
Min	0.00	0.00	-	-	0.00	0.00	0.016
Max	10.20	22.10	-	-	2.04	2.18	0.038

- - Mean annual value of erosion for the period 2004-2005 was **1.5 $t.ha^{-1}.year^{-1}$** while **3.2 $t.ha^{-1}.year^{-1}$** were calculated for the period 2005-2006.
- Erosion points were located mainly on zones with a erosion range between 1.5 and 5 t.ha/year, which explains a **higher mean value of soil losses** than study area´s. Deposition, both histograms presented a similar distribution of intervals.

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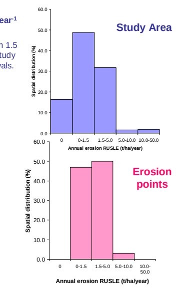
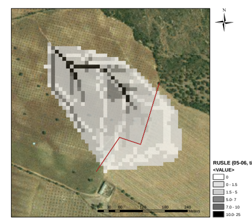
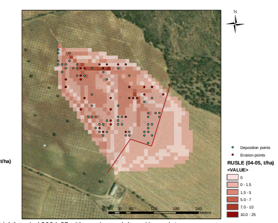
Range ($t.ha^{-1}.y^{-1}$)	Study Area Fre. rel. (%)	Erosion points Fre.rel. (%)	Deposition points Fre.rel. (%)
0	16.29	0.00	1.54
0-1.5	48.70	46.88	64.62
1.5-5.0	31.69	50.00	29.23
5.0-10.0	1.62	3.13	3.08
10.0-50.0	1.70	0.00	0.00
Total (%)	100.00	100.00	100.00
Mean ($t.ha^{-1}.y^{-1}$)	1.47	1.81	1.56
Dv ($t.ha^{-1}.y^{-1}$)	1.55	1.65	1.86
Min ($t.ha^{-1}.y^{-1}$)	0.00	0.22	0.00
Max ($t.ha^{-1}.y^{-1}$)	10.20	8.57	8.30



Histograms of RUSLE estimates (period 04-05) on the study area (up) and on erosion points.





Distribution of RUSLE estimates in the cathment: (left) period 2005-06; (right) period 2004-05 with erosion and deposition points

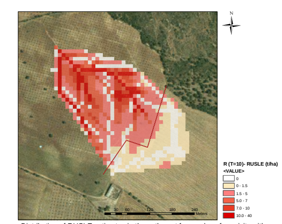
- Erosion points → half of hillslopes and near the stream on zones with **larger K-factor and LS-factor than study area´s.** Depositon points → next to the outlet and on the limit of the field, in zones with lower K-factor and larger LS-factor in study area´s.

-- - Mean total Load of sediments calculated in the catchment (Taguas at al., 2009) = 1.4 t/ha.year → **Mean SDR = 60%;** Total load of sediments calculated in the catchment April 05-06 = 0.8 t/ha.year → **SDR_{0506} → 29%**

3.2. Long term soil erosion

- The function that provided the best fitting of erosivity frequency distribution was **Pearson´s type III** with the values calculated by Gringorten´s equation.
- Annual **R, T=10 years** provokes larger mean annual erosion than 5 t/ha.year with larger values of 10 t/ha.year in 10% of the area.
- **Useful methodology** for areas with high variability of R factor.

Return period- T (years)	R factor ($MJ.mm.ha^{-1}.h^{-1}$)	Mean Erosion ($t.ha^{-1}.y^{-1}$)	Max Erosion ($t.ha^{-1}.y^{-1}$)	Min Erosion ($t.ha^{-1}.y^{-1}$)	Dv ($t.ha^{-1}.y^{-1}$)
2; F(R) = 0.5	473.5	2.0	19.2	0.0	2.7
5; F(R) = 0.8	952.4	4.1	38.5	0.0	5.3
10; F(R) = 0.9	1299.8	5.6	52.6	0.0	7.3
15; F(R) =0.93	1501.2	6.5	60.7	0.0	8.4



Distribution of RUSLE estimates in the cathment for a value of erosivity with a return period of 10 years

4. CONCLUSIONS

- *SPATIAL ANALYSIS OF SOIL EROSION WITH RUSLE:* Erosion points were located on higher intervals of soil losses calculated from RUSLE which can justify its use to evaluate areas with serious risk of erosion. Deposition points did not present any correlations. In addition, total loads of sediments calculated in the catchment and mean erosion (from RUSLE) showed a comparable order of magnitude.
- *TEMPORAL ANALYSIS OF SOIL EROSION WITH RUSLE:* The application of analysis of frequency of annual erosivities allowed a simple long-term exam of soil erosion according to climatological variations. As a result, values of erosivity with a return period of 10 years in the study area provokes larger mean annual erosion of 5 t/ha.year with larger values of 10 t/ha.year in 10% of the area.