The suspended sediment response of different land uses to rainstorm events: Time compression in the Aísa Valley Experimental Station

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INTRODUCTION

Many studies on soil erosion have highlighted that a **small number of short-term erosive events** are responsible for a **large proportion** of the geomorphological effects and the sediment load (see González-Hidalgo *et al*., 2009). This phenomenon is related to "**time compression**", which is defined as the ***shortest temporal interval producing most of the soil erosion or sediment load*** in a catchment during a defined period.

Land use and land management decisions relative to soil erosion and water resources have been most often based on average annual values. However, the frequency distribution of daily event values can give additional information for aiding land management decisions.

The **objective** of this study is to evaluate and compare runoff and sediment data collected in seven plots with different land uses in a Mediterranean mountain area, from a long term database (15 years and 649 rainfall events). Moreover, this study includes **a new statistical approach** from a hydrological and suspended sediment long term database, and the new application of the Gini index to hydro-sedimentological studies.

MATERIALS AND METHODS

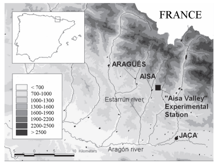
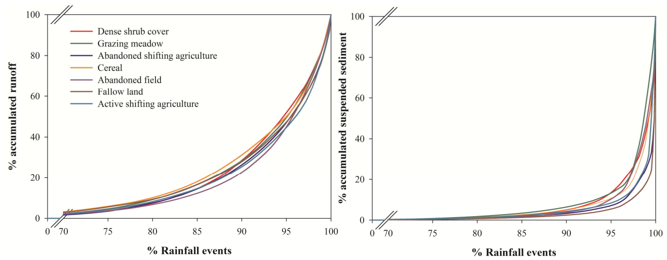


Figure 1. Location of the Aísa Valley Experimental Station

Figure 2. A perspective of the Aísa Valley Experimental Station

- **Aísa Valley Experimental Station** (AVES) is located in the Aísa Valley (Central Spanish Pyrenees) (Figure 1).
- **Climate** is characterized by a mean annual temperature of 10 ºC and mean annual rainfall is 1100 mm; the maximum rainfall values are recorded from November to May; while in summer usually occurs intensive storms.
- **Closed plots** (9) were established at the AVES in 1991 (Figure 2). After each rainfall event 1 l of water was taken from each collector to measure the **suspended sediment concentration and solute** composition in the laboratory.
- **Land uses**: (i) **dense shrub cover**, (ii) **grazing meadow**; (iii) **cereal (barley)**; (iv) **fallow land;** (v) **abandoned field**; (vi) **active shifting agriculture**; (vii) **abandoned shifting agriculture**.
- A **long term database**, consisting of **15 years of runoff and sediment yield records**, was analyzed (initial years were rejected to obtain a uniform database).
- Differences in annual runoff and suspended sediment among land uses were compared using paired t-test.
  - ➢ The time concentration of the hydrological and erosive response in the different land uses were calculated using the **Gini index** (Figure 3). Differences in annual Gini index among land uses were compared using paired t-test.

New methodology



Figures 3. Concentration curves (Lorenz curves) that relate the accumulated percentages of runoff and suspended sediment yield by the accumulated percentage of events. From these curves, Gini indices were calculated for each land use.

RESULTS

Average annual runoff (l m²) and suspended sediment yield (g m²) is shown in Figures 4 and 5. Runoff decreased in the following order: **active shifting agriculture > fallow land > cereal > abandoned shifting agriculture > abandoned field > grazing meadow > dense shrub cover**.

The different land uses can be graded in order of decreasing effect on soil erosion: **fallow land > active shifting agriculture> cereal > abandoned shifting agriculture > abandoned field > grazing meadow > dense shrub cover**.

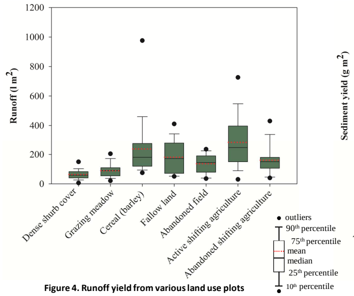


Figure 4. Runoff yield from various land use plots

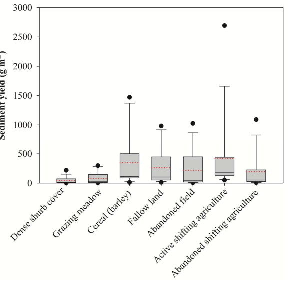
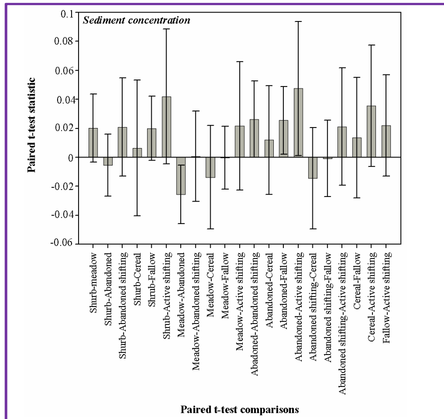


Figure 5. Suspended sediment yield from various land use plots



Figures 7. Paired t test statistics for different paired comparisons between different land uses/land covers for sediment time concentration. Error bars indicate the 95% distribution.

High proportion of runoff and an even higher proportion of suspended sediment yield associated with only a small number of events (Lorenz curves) (see Figure 3).

The different land uses can be graded in order of decreasing suspended sediment concentration (Gini indices): fallow land (0.976) > abandoned shifting agriculture (0.970) > active shifting agriculture (0.963) > abandoned field (0.956) > cereal (0.955) > dense shrub cover (0.952) > grazing meadow (0.944).

However, the statistical analyses (T-TEST) showed that there were **only three significant differences between different land uses** plots related to time concentration for suspended sediment (Figure 7).

Differences were found between:

(i) Sediment time concentration is significantly lower in meadow than in abandoned fields (p = 0.016),

(ii) Sediment time concentration is significantly higher in abandoned field than in fallow land (p = 0.049),

(iii) Sediment time concentration is significantly higher in abandoned field than in active shifting agriculture (p = 0.034).

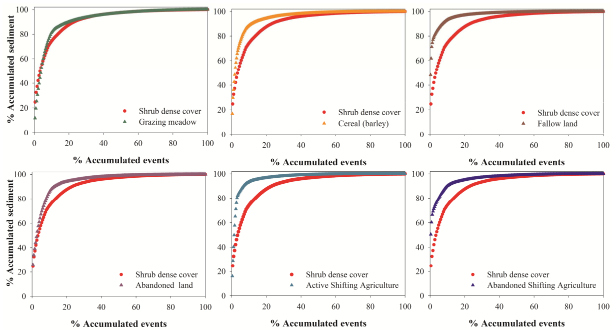


Figure 6. Comparison of accumulated sediment events between the dense shrub cover plot and the other land uses

Figure 6 shows the **accumulated sediment yield events** arranged from the highest to the lowest value, providing a comparison of the dense shrub cover plot with the other land uses.

- a rapid increase in terms of the percentage sediment yield in the initial accumulation events (indicating the concentration of sediment yield into a small number events),
- almost no increase in sediment yield occurred after the first 15-20% of events.
- there were some substantial **differences amongst the land uses**:
  - ✓ the dense shrub cover plot showed the slowest change, indicating that the effect of the extreme events was relatively moderate;
  - ✓ similar results were found for the grazing meadow and the abandoned field plots;
  - ✓ the greatest differences occurred in the fallow land and the active shifting agriculture plots, confirming that few events produced a very high proportion of the sediment yield.

DISCUSSION AND CONCLUSIONS

- ✓ Runoff and sediment yield decrease with an increase in plant cover.
- ✓ A **few rainfall events** caused most of the runoff, and even more, most of the suspended sediment yield.
- ✓ The highest suspended sediment time concentration was recorded in the fallow land, active shifting agriculture and abandoned shifting agriculture.
- ✓ **Traditional cereal cultivation practices** caused high and compulsive runoff and suspended sediment yield response.
- ✓ **Vegetation and land uses** are clearly important factors controlling the **magnitude** of runoff and suspended sediment yield, but no so important in controlling **time compression**.
- ✓ **Gini index** may provide a user-friendly alternative or supplement to complex long-term database, and can help to analyze **the time concentration** in the hydrological and sediment response.

REFERENCES

González-Hidalgo, J.C., de Luis, M., Batalla, R.J., 2009. Effects of the largest daily events on total soil erosion by rainwater. An analysis of the USLE database. Earth Surface Processes and Landforms 34 (15), 2070-2077.

Acknowledgments

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