THE USE OF LASER SCANNER IMAGES TO EXPLAIN THE SPATIAL DISTRIBUTION OF SOIL EROSION RATES IN DEHESAS

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INTRODUCTION

The use of Terrestrial Laser Scanner (TLS) for establishing digital elevation models contributes to a better understanding of spatial and temporal variation of processes that shape the terrestrial surface forms. **The aim of the present study is to investigate the relationship between soil erosion rates and the variables that influence erosion processes at microtopographic scale.**

The study areas selected were three wooded rangeland hillsides (B1, B2 and P) located in two farms in Extremadura: Buitrera (B) and Parapuños (P), where in a previous study, a methodology based on semi-exposed roots was developed to estimate soil erosion rates (Rubio Delgado, J. et al., 2014). Erosion rates were estimated under tree canopy overlying two surface models, past and current, and considering the tree ages. **A negative exponential relationship was established between erosion rates and tree ages (R^2=0.2, p<0.05), but with high dispersion (Figure 1).** This relation indicates higher rates for younger trees, while lower rates resulted for the older ones, possibly indicating the consequence of land use intensification during the last century. **Correlation analysis between topographic variables and the residuals of this relationship (Figure 3) was carried out with the aim of explaining spatial variability of erosion rates.**

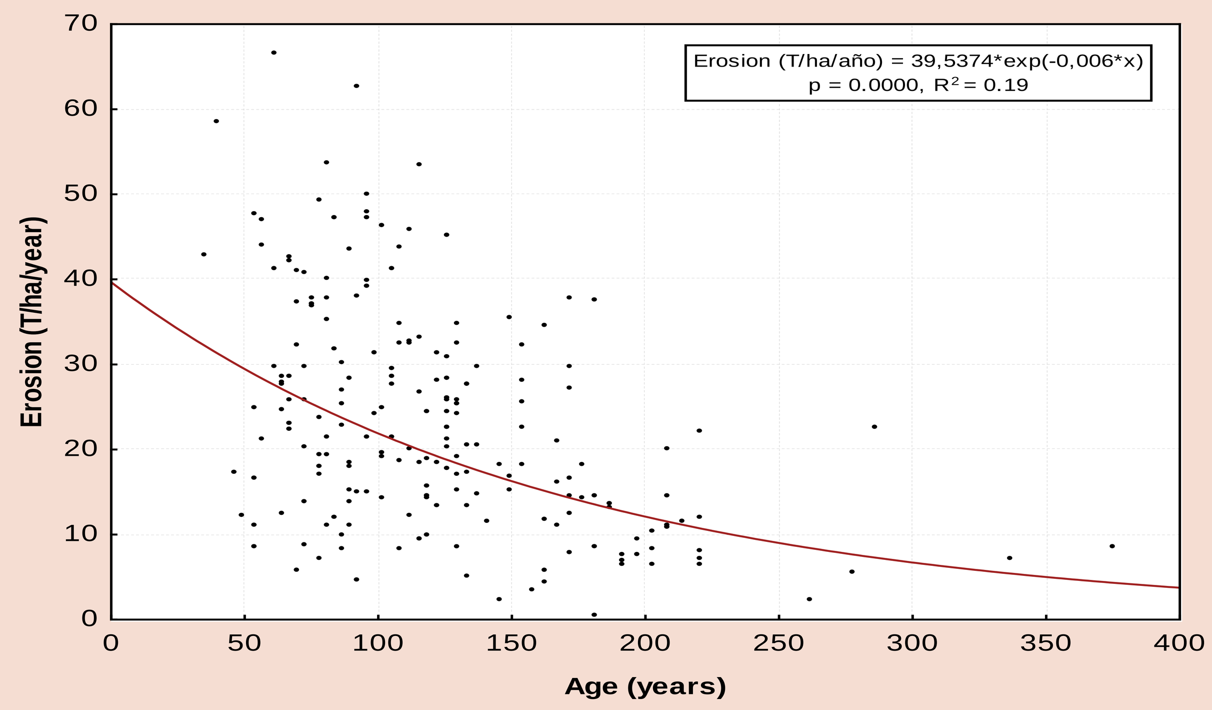

Figure 1. Relationship between erosion rates and the tree ages.

METHODOLOGY

Four Digital Terrain Models (DTM), with different pixel sizes (10 cm, 20 cm, 50 cm and 1m) of the hillsides, were generated using the TLS images and CloudCompare software.

Afterwards, several derivative models were obtained using WhiteBox software:

- S: slope gradient
- C_plan: planimetric curvature
- C_tran: transversal curvature
- SCA: flow accumulation (Figure 2)
- SPI: stream power index
- STI: sediment transport index
- TPI: topographic position index

The last one was generated with ArcGis 10.3 software using different numbers of neighbors (5, 10 and 15), generating three TPI models for each hillside: TPI-5, TPI-10 and TPI-15. The mean and maximum of each topographic variable were calculated for each tree site using 'zonal statistic as table' tool (ArcGis 10.3). Finally, **these parameters were correlated with the residuals of the soil erosion-age relationship (Figure 3).**

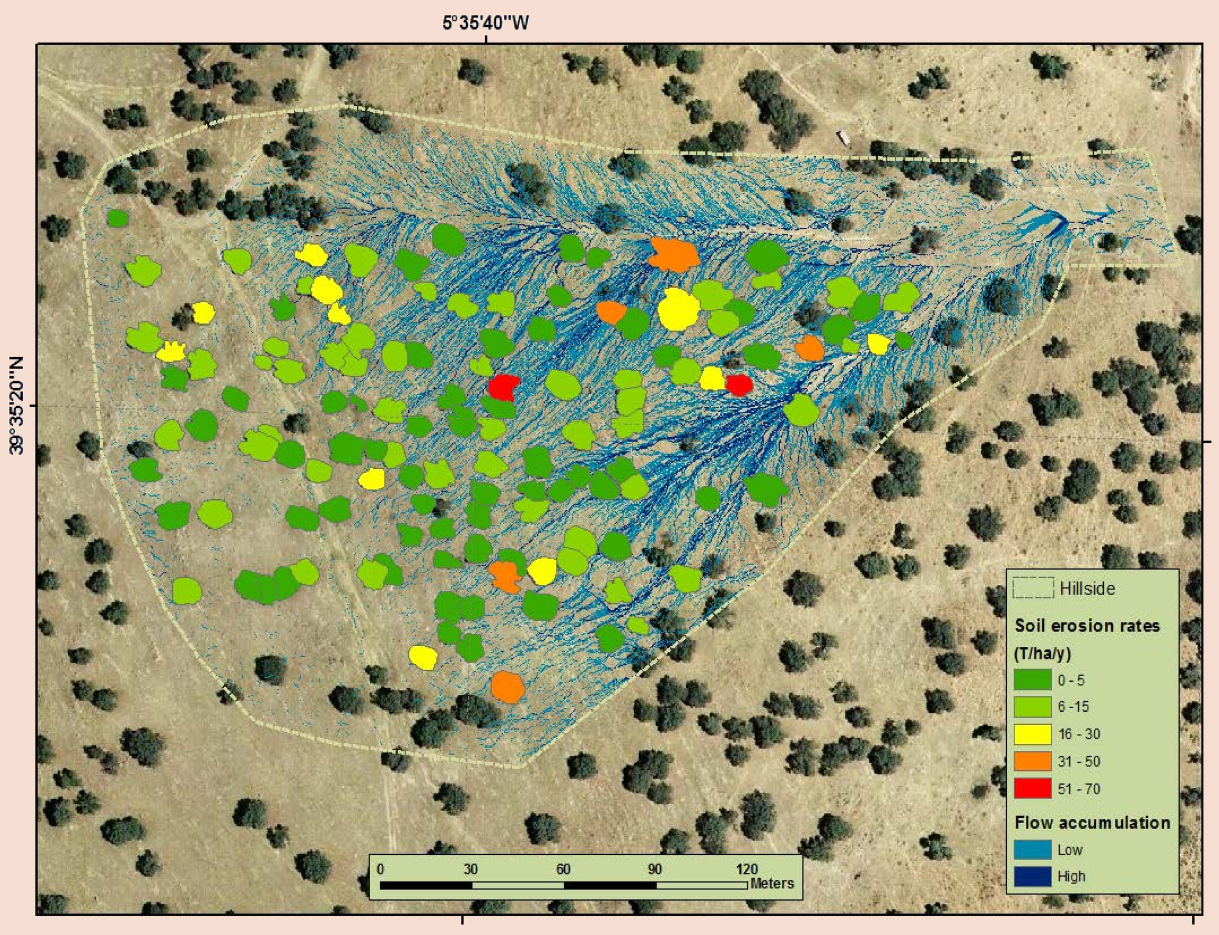

Figure 2. Illustration of the soil erosion rates spatial distribution in the hillside B1. The flow acummulation digital model is superimposed on an aerial photograph.

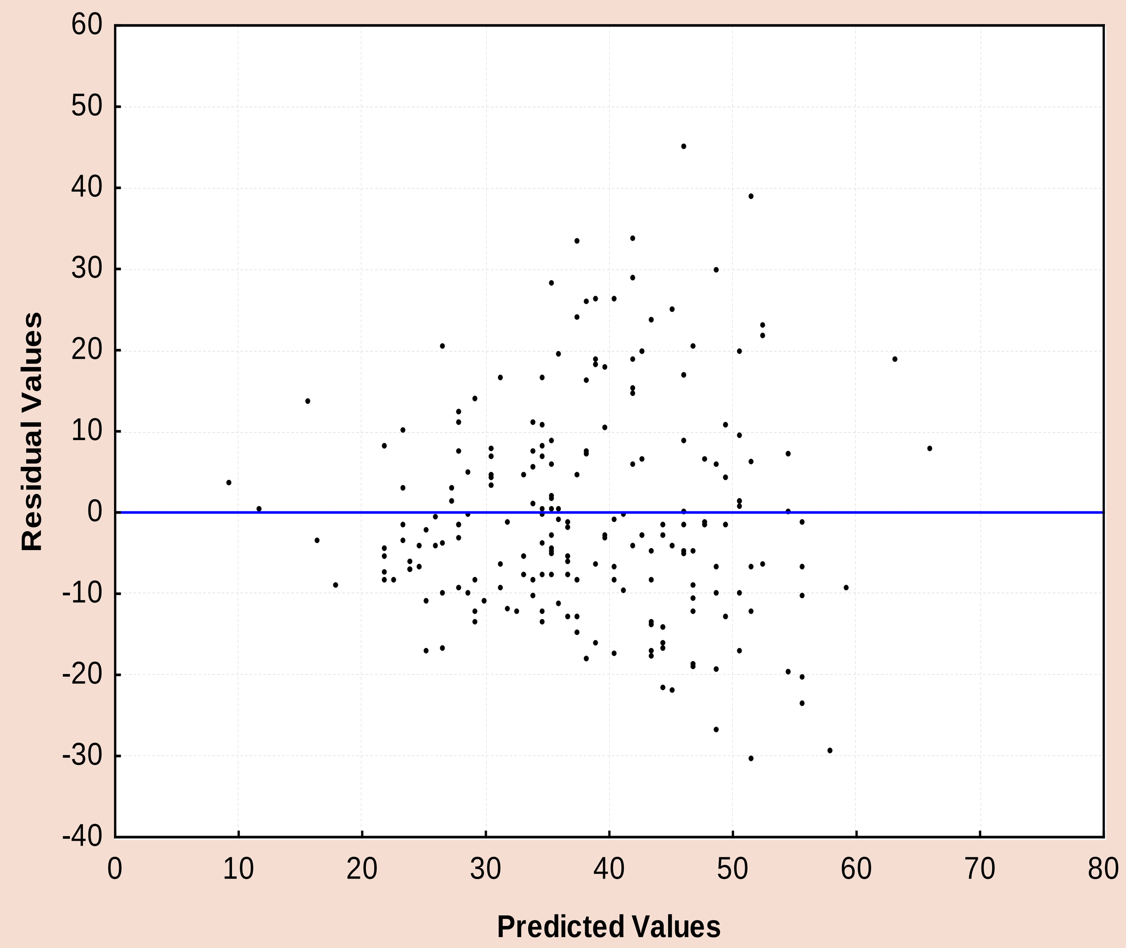

Figure 3. Predicted versus residual values of the relationship between erosion rates and tree ages. Positive residuals correspond with trees that present rates higher than those observed and viceverse.

RESULTS

	1 m	50 cm	20 cm	10 cm
B1	✗	✗	**0.24** S. max; T < 180 Y: **-0.22** SCA. mean/max	✗
B2	**0.30** S. mean	**0.29** S. max; **0.28** S. mean	**0.28** S. mean	**0.28** S. mean
P	**-0.39** C. plan.; **0.42** TPI-10; T < 150 Y: **0.53** C. tran., **0.60** TPI-5	**0.44** TPI-5; **0.41** TPI-10; **0.40** TPI-15; T < 150 Y: **0.54** TPI-5, **0.57** TPI-10, **0.56** TPI-15	✗	✗

* The data presented in the diagram are the result of correlating residuals with different topographic variables using DEMs with different size of pixel. Numbers in bold type correspond with statistically significant coefficients (at a 0.5 signification level). T is tree ages and Y is years.

B1:

- Only was found significant relationship in the case of the DEM of 20 cm.
- A positive relationship exits with maximum slope.
- It was found an inverse relationship between residuals and SCA for those trees younger than 180 years. Probably due to the presence of a denser herbaceous vegetation cover in these depressions or accumulation areas.

B2:

- It was found significant relationship using in all cases.
- A direct positive relationship was observed between residuals and slope.
- Additionally, a direct positive relationship was showed between residuals and maximum slope for the DEM with 50 cm pixel size.

P:

- It was found significant relationship in the cases of 1 m and 50 cm DEM.
- It exists a negative relation with planimetric curvature. In this way, trees with positive residuals are located in concave sites, where the flow is convergent, and trees with negative residuals are located in convex sites, where the flow is divergent.
- Trees with positive residuals are mainly located in sites with higher TPI and vice versa.
- In general, all correlation coefficients were higher for groups of trees younger than 150 years.

CONCLUSIONS

- The analysis shows that the variability of the soil erosion rates not explained by tree ages is partly explained by the topographic variables. However the correlation coefficients are very low. Therefore, it can be concluded that the variability could be related to other factors such as live stock density or frequency of livestock transit.
- Using digital models of higher resolution does not imply an improvement in the results of correlation analysis (i.e. B2).
- Slope is the most explicative variable in B1 and B2. However, in P this relation was not found. This could be because the slope is continuous and low along the all hillside.

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