Re-evaluating sheet erosion rates in a popular trekking trail located on Central Iberian System, Spain

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OVERVIEW

Degradation of walking tracks, mainly due to sheet erosion associated with hiking activities, damages the natural and recreational value of protected natural areas. Senda Schmidt is a popular trail located on the northern slope of the Sierra de Guadarrama (Central Spanish System), that shows high denudation morphologies on account of accelerated soil-erosion processes basically caused by human influence (trampling by continuous trekking), resulted in exposed roots. Previous works have used dendrogeomorphological methods in this trail to estimate rates of sheet erosion based on the changing morphology of tree rings (from concentric to eccentric) when root is exposed. This study aims to evaluate soil erosion reconstructing the first year of root exposure by analyzing changes in wood anatomical parameters within growth rings. Additionally, different multivariate statistical approaches were used in order to determinate the influence of different environmental factors affecting the variation in velocity of the sheet erosion processes.

STUDY AREA

The research was conducted in the Senda Schmid. This trai passes through the upper part of the Valsaín forest, which is located on the northern slope of the Sierra de Guadarrama (Central Spanish System). Senda Schmid is one of the most popular mountain trails in the Sierra de Guadarrama, which has caused a large number of roots to be exposed due to accelerated erosion as a consequence of trampling from hiking.

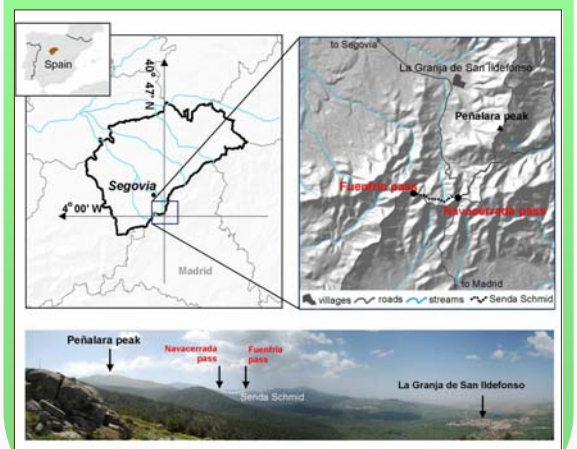
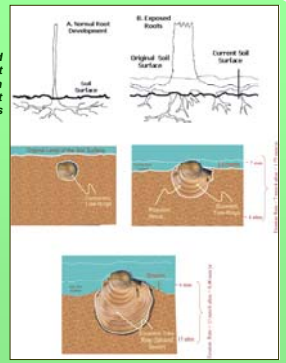


Figure 1. The Senda Schmid is a trail located approximately 60 km northwest of Madrid, Spain.

Figure 2. Exposure of tree roots and associated severe cambial damage in the upper root surface determine that tree-rings shifted from concentric to eccentric growth patterns. It enables to determine soil erosion rates as is shown in this figure (Bodoque et al., 2005).

Figure 3. Exposed Pinus sylvestris roots in the Senda Schmid



ANATOMICAL ANALYSIS. DETERMINATION OF THE FIRST YEAR OF ROOT EXPOSURE

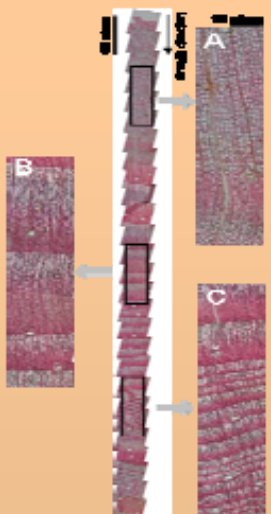


Figure 4. Micro-sections taken from exposed Pinus sylvestris roots. In each micrograph, the three zones are recognized: (A) narrow growth rings which are characterized by scarcely noticeable latewood; (B) After exposure the first growth rings are exceptionally wide. Latewood is clearly distinguishable as it is made up of several rows of thick walled tracheids. There is an major reduction in cell lumina (C) There is no morphological/anatomical pattern that is repeated in all samples.

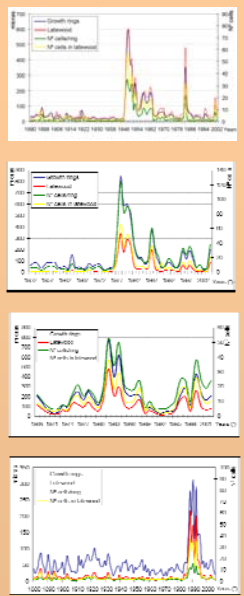


Figure 4. Anatomical growth pattern over time for four selected samples. In all cases there are always an abrupt change in the first year of exposure with regard to the anatomical parameters considered. The age showed can only be considered approximate, since was determined by simple ring counting

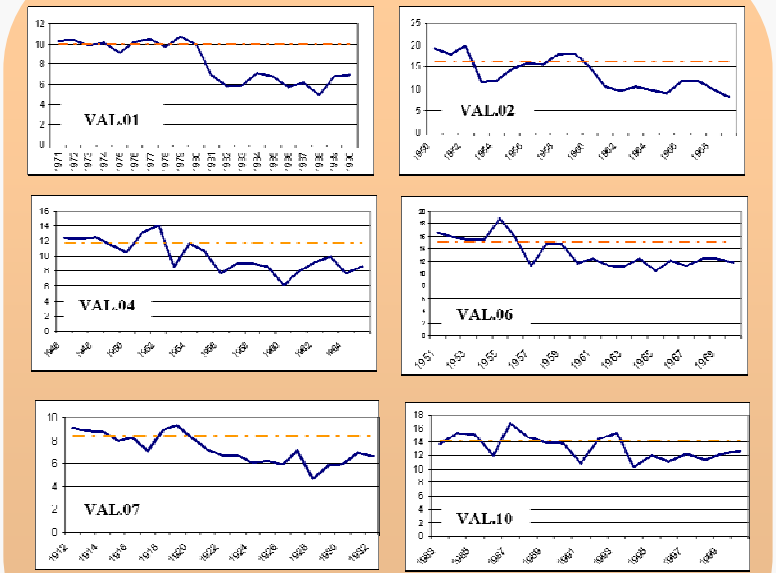


Figure 5. Cell size variations of earlywood tracheids in Pinus sylvestris roots at the moment of exposure. The dotted lines correspond to the mean cell size before exposure. Ordinates are in micra.

STATISTICAL ANALYSIS

Factors	Sum of Squares	d.f	Mean Square	F-Ratio	P-Value
Situation (X-UTM)	0.02	3	0.009	0.04	0.99
Hillside aspect	1.09	3	0.36	1.66	0.22
Local (root) aspect	0.74	3	0.25	1.14	0.37
Hillside slope	0.04	1	0.04	0.20	0.66
Local (root) slope	0.16	1	0.16	0.70	0.40
Approximate age of exposure	2.99	2	1.50	6.90	**0.009**
Approximate of root	0.17	2	0.09	0.39	0.70
RESIDUAL	2.82	13	0.22		
TOTAL (corrected)	10.51	29			

Table 1. Results of the multifactorial ANOVA performed on sheet erosion rates measured on the Senda Schmid. Factor in bold is significant at the 0.05 level.

Level	Count	LS Mean	LS Sigma	Homogenous groups
3 (42-61)	9	1.42	1.27	a
2 (22-40)	12	2.61	1.21	b
1 (6-21)	8	4.53	1.09	c

Contrast	Difference	+/- Limits
1 - 2	*1.79	1.47
1 - 3	*3.15	1.59
2 - 3	*1.79	1.52

Table 2. Effect of the factor approximate age of exposure on sheet erosion rates estimated

CONCLUSIONS

Study findings reveal a trail with major soil erosion problems, with estimated soil loss within the range 1.8-2.9 mm/year.. In contrast, erosion rates obtained from the analysis of changing morphology of tree rings (from concentric to eccentric) is not as reliable. It is as a consequence of that this morphological change is not always clearly noticeable. In addition, the multifactor ANOVA analysis indicated that erosion rates estimated are higher in the last 21 years than before, which seems to be related to an increase in outdoor activities in Senda Schmid during this period.

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