

SPATIOTEMPORAL RECONSTRUCTION OF ANTHROPOGENICALLY ACCELERATED SOIL CREEP: BÂLEA GLACIAL VALLEY, FĂGĂRAȘ MOUNTAINS, ROMANIA

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Introduction

Soil creep is a slow gravitational process. It differs from other catastrophic slope processes (e.g. landslides, snow avalanches) in its dynamics and character. However, it can significantly affect tree growth. Creep movements can be analyzed based on the tree rings.

This study analyzed the dynamics of creep in a glacial valley, in the Southern Carpathians (Romania), on an anthropogenic slope based on tree rings. The dendrogeomorphological analysis included 54 Norway spruces (*Picea abies* (L.) Karst.). A total of 118 tree-ring series were obtained, and a 35-year chronology was constructed based on the eccentric growth of tree rings and reaction wood.



Fig. 1. Trees affected by soil creep

Objectives

This study aims to address a gap in knowledge by analyzing the behavior of trees affected by creep movements on an anthropogenic, relatively young slope using dendrogeomorphological approaches. The specific objectives are to: (i) define the spatiotemporal activity of creep and (ii) evaluate its potential determinants and triggers.

Study area

- The study site:
 - located on the northern slope of the Făgăraș Mountains, in the Bălea glacial valley beneath the Transfăgărașan highway,
 - at an elevation of 1280–1300 m a.s.l. (Fig. 1c);
 - is east-facing, with a mean slope of 30.1°;
 - its geology: degraded crystalline schists – mica schists, paragneisses, and amphibolites (Urdea, 2000).

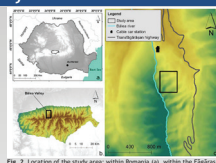


Fig. 2. Location of the study area within Romania (a), within the Făgăraș Mountains (b) and Bălea glacial valley (c).

Methodology

Sampled trees were selected based on visible signs of creep movement – trees with d-shaped stems (Harker, 1996; Šilhán et al., 2022a). In total, 118 wood cores were air-dried and glued to wooden supports.



Fig. 3. Characteristics of soil creep, tree growth anomalies and the identified GDB to stem-fitting

- Creep events were:
 - reconstructed using the event-response (I_t) index (Shroder, 1978),
 - calculated from the occurrence of both reaction wood (RW) and tree ring eccentricity-based GDBs.

- the I_t index was calculated for each year as the ratio of the total number of affected trees in year t to the number of sampled trees alive in year t .

The chronological data from tree rings was compared with precipitation data from the Bălea weather station (3 km from the study area, over a 43-year period (1979–2022)).

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Results

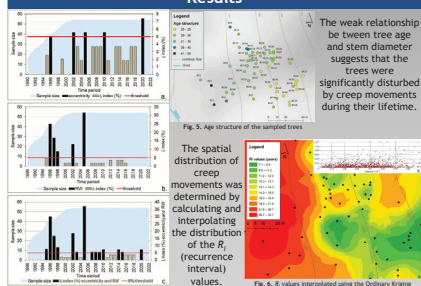


Fig. 4. A. Value for accuracy (A), reaction wood (B), and combined (C). Fig. 5. Age structure of the sampled trees. Fig. 6. Spatial distribution of creep movements determined by calculating and interpolating the distribution of the I_t (recurrence interval) values.

Discussion

The creep movements in Bălea valley were caused by anthropogenic activities, specifically the construction of the Transfăgărașan highway. The forest in the area is expanding in elevation and reclaiming areas previously occupied by the construction of the highway.

In our study area, the wettest months of the year, June and July, caused creep movement on suitable slopes. Creep movement is primarily influenced by wetting-drying cycles during summer and freezing-thawing cycles during winter.

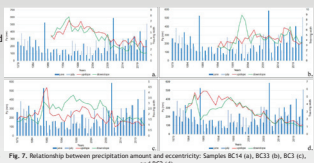


Fig. 7. Relationship between precipitation amount and eccentricity: Samples BC14 (a), BC13 (b), BC1 (c), and BC2 (d).

In 2002 and 2005, there were significant creep movements when humidity in July exceeded the multiannual average.

The slope below the Transfăgărașan highway is an example of anthropogenic involvement and disturbance affecting the forest environment, influencing soil formation and development, and even tourist practices in the area.

Conclusion

- The dendrogeomorphic approach can be a valuable tool for evaluating soil creep, as it is for other slope processes;
- The sampled trees had a 'd'-shaped stems, providing the best evidence of trunks curved by creep;
- the sensitivity of *P. abies* along the stem titling process forms eccentric growth and reaction wood, particularly in young trees aged 10–30 or 40 years;
- Creep is determined by pre-existing factors: the substrate (crystalline shale) the debris blanket arranged in the direction of the slope, the alternating topography of the pits and mounds, as well as causal factors: the slope and the presence of abundant precipitation in June and July intervals with frosty cycles from November–December and January–March.

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