Temporal and spatial dynamics of stool uprooting in abandoned chestnut coppice forests

Vogt, Juliane[1,2]; Fonti, Patrick[1] & Schröder, Boris[2]

[1]WSL, Sottostazione Sud delle Alpi - Bellinzona, Switzerland, [2]Institute of Geoecology, University of Potsdam, Potsdam, Germany

jvogt@rz.uni-potsdam.de, patrick.fonti@wsl.ch, boschroe@uni-potsdam.de

Introduction

Chestnut (*Castanea sativa* Mill.) coppice, a man made forest type, was managed over several centuries in short rotations (approx. 20 years) to produce timber. Since the early 1950s, changes in the socio-economic structure of rural areas and the spread of chestnut diseases have caused a decline in the cultivation of sweet chestnut forests (Pitte, 1986). Chestnut coppices are now over-aged (approx. 60 years), very dense, and monotone. As a result, stools inside these stands uproot (Fig. 1) and therefore become a concern for forest managers.

Figure 1: Uprooted chestnut stools.

Methods

We performed analyses in a 100 ha abandoned chestnut coppice in the Southern Swiss Alps. Forty-five uprooted stools (out of 137) and an equal number of standing coppice stools were randomly selected. A set of topographic, stand and stool characteristics were analyzed in order to build an empirical predictive model to estimate the probability of uprooting events.

Objectives

The aim of this study is to gain a better understanding of the ongoing successional processes in abandoned chestnut coppices in order to evaluate the magnitude of risk involved.

In particular, we intend

i) to describe the temporal and spatial patterns of the ongoing uprooting processes;

ii) to identify the main factors causing uprooting;

iii) to estimate the probability of uprooting.

Results

Stool uprooting was distributed all over the study area, but mainly found in association with hollows and gullies. The uprooted stools are large compared to chestnut coppice standards.

Box plots reveal differences between standing and uprooted chestnut stools using several predictor variables (Fig. 2). To predict the probability of treefall events, we built logistic regression models (Hosmer and Lemeshow, 2000). The final logistic regression model considers four significant predictor variables (Tab. 1a) and has a very high explanatory and predictive power (R^2_N = 0.775 and AUC = 0.966 after internal validation with bootstrapping). Applying a critical threshold probability of P_{fair} = 0.52 the overall correct classification rate, sensitivity and specificity are 91.1% (Tab. 1b).

The regression coefficients and response curves show an increased treefall probability on steeper slopes, concave curvatures and with increasing tree-height (Fig. 3) (Vogt et al., 2006).

Table 1: a) Estimates of the multiple logistic regression model relating uprooting probability to a set of topographic and stand characteristics.
b) Performance criteria for this model.

a)

Predictor	Coefficient	SE	p-value
Intercept	-10.532	4.536	0.0202
Slope	0.244	0.076	0.0013
Profile curvature			
straight	-5.623	2.992	0.0602
convex	-7.849	3.288	0.0170
Plan curvature			
convex	-2.625	1.019	0.0100
Stand height	0.407	0.156	0.0091

b)

R^2_N = 0.775 and AUC = 0.966 after bootstrapping

Confusion matrix for P_{fair} = 0.52

		predicted: uprooted	predicted: standing
observed	uprooted	41	4
	standing	4	41

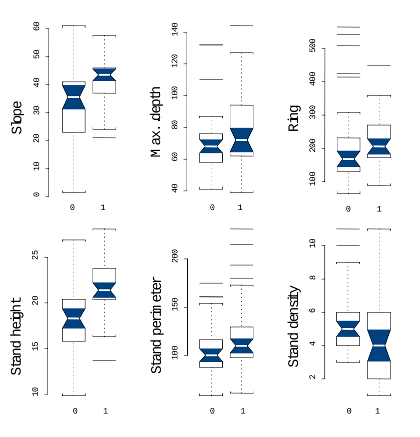

Figure 2: Boxplots showing the differences of several predictors between standing (0) and uprooted (1) chestnut stools.
Slope [°]
Max. depth: maximum soil depth [cm]
Ring: Mean tree ring width [mm]
Stand height [m]
Stand perimeter: Averaged perimeter of three largest stand stools [cm]
Stand density [# (stools) within 8 m radius]

Conclusion

Uprooting is a consequence of static stool instability, which is related to the abandonment and overaging of chestnut coppices. Root anchorage cannot compensate for an aboveground biomass that is now too large and unbalanced. In these cases, environmental events, such as strong winds or wet snow, can be enough to trigger local uprooting. The empirical predictive model estimates the risk of uprooting which allows managers to better understand predisposing factors.

Figure 4: Erosion caused by uprooted trees.

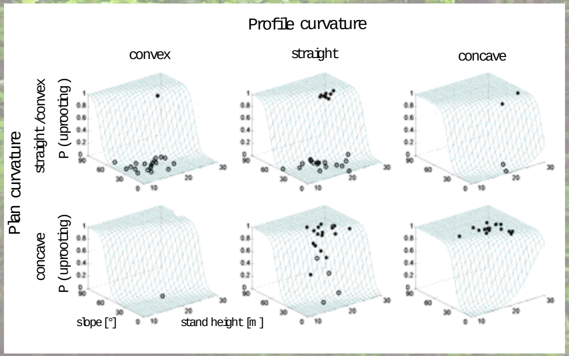

Figure 3: Response surfaces according to the model shown in Tab. 1.
Each response surface represents the predicted probabilities of treefall events (z-axis) for different values of slope (y-axis) and stand height (x-axis) and different categories of plan and profile curvatures. Filled circles refer to uprooted stools, open circles to standing stools.

Implications

Benefits

Uprooting provides gaps for natural forest rejuvenation, leading to a more natural species composition as well as an increase in biodiversity and stability (Conedera et al. 2001).

Detriments

Human infrastructure adjacent to protected forests is compromised by uprooting stools due to mass movements or rockfall (Fig. 4), especially on steep slopes.

Future prospects

Forest managers can apply our model to produce risk maps for treefall events in chestnut coppices as a basis for the prevention of infrastructural damage.

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