Changes in spatial pattern of trees and snags in a Norway spruce permanent plot in Paneveggio (Trento, Italy)

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Introduction

Tree spatial pattern may reveal insights about the historical and environmental processes, such as regeneration, climate, mortality and competition, which have shaped current forest structure.

Mortality due to inter-tree competition involves spatial randomly distributed tree, increasing regularity in tree structure (Kenkel, 1988; Wolf, 2005). Opposed to this, allogenic mortality caused by disturbances (e.g. infectious deseases, wind and heavy snowfall) likely creates more clumped deadwood distribution and gaps in the stand structure (Dobbertin et al., 2001). However, past human activities might deeply influence spatial pattern and confound natural dynamics.

We analysed the mortality pattern and structure development in a 1-ha permanent plot in the Valbona Forest Reserve, located within the Paneveggio-Pale di San Martino Natural Park (eastern Italian Alps), at 1815 m a.s.l. The objective of this study was to understand if tree mortality in a 200 years old (established around year 1790, Motta et al., 1999) subalpine Norway spruce stand, developed without significant anthropogenic disturbance since 1940s, was primarily caused by competition or by some allogenic disturbance.

Methods

- The plot was established and sampled the first time in 1994. All live and dead standing trees with dbh > 7.5 cm were measured and mapped. Measurement was than repeated in 2005.
- To individualize heterogeneity in the plot structure we used a kernel function to estimate of the non-constant first order intensity λ (*x*,*y*), e.g. to test Heterogeneous Poisson null model. Analysis were performed using the software Programita (Wiegand, Moloney, 2004)
- To determine change in spatial pattern during the observation period we employed univarate Ripley's *K* point patterns function. Analysis were performed using the software SPPA 2.0 (Haase, 2002)

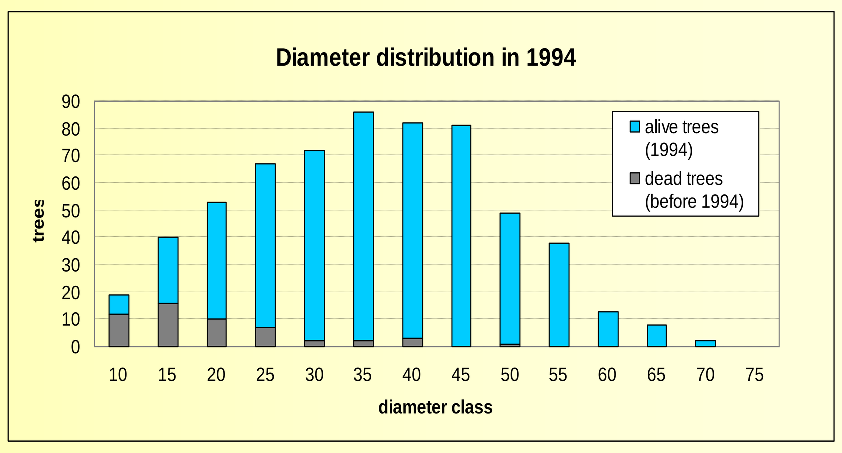
Results and Discussion

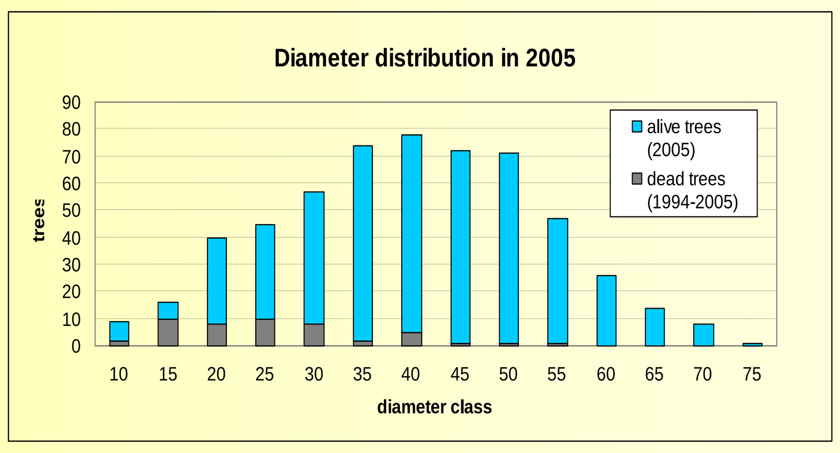
From 1994 to 2005 tree density decreased (from 557 to 510 trees), while the snags density increased from 53 in 1994 (9.3 % of living trees) to 101 in 2005 (19.6 %). In this period mortality involved lower and medium-lower diameter classes, differently than in the previous period. For mortality before 1994 we considered only snags, even if there were logs also. We assumed that logs had been dead before snags, and we did not consider their in our analysis.

First order intensity maps show a decrease of density heterogeneity in the observation period, caused by mortality of 53 (snag before 1994) and 48 (1994-2005) trees. Spatial distribution of snags before 1994 correspond with higher density patches of initial distribution. Trees dead between 1994 and 2005 appear randomly distributed on the plot.

Univariate Ripley's *K* test shows a regularization of structure at small scale (distance), due to mortality of trees that were too close with neighboors. In all diagrams aggregation involves distances of 1-5 meters, but it appears more evident from the first (L(t) = -0.39) to the third (L(t) = -0.68) graphic.

	1994	2005
Trees (n ha^{-1})	557	510
Quadratic mean dbh (cm)	38.8	42.9
Basal area (m^2 ha^{-1})	65.9	73.7
Volume (m^3 ha^{-1})	874	977
Snag density (n ha^{-1})	53	101
Snag volume (m^3 ha^{-1})	21.9	59.9





Before 1994 | **Mortaliy observed in 1994** | **1994** | **Mortality observed in 1994-2005** | **2005**

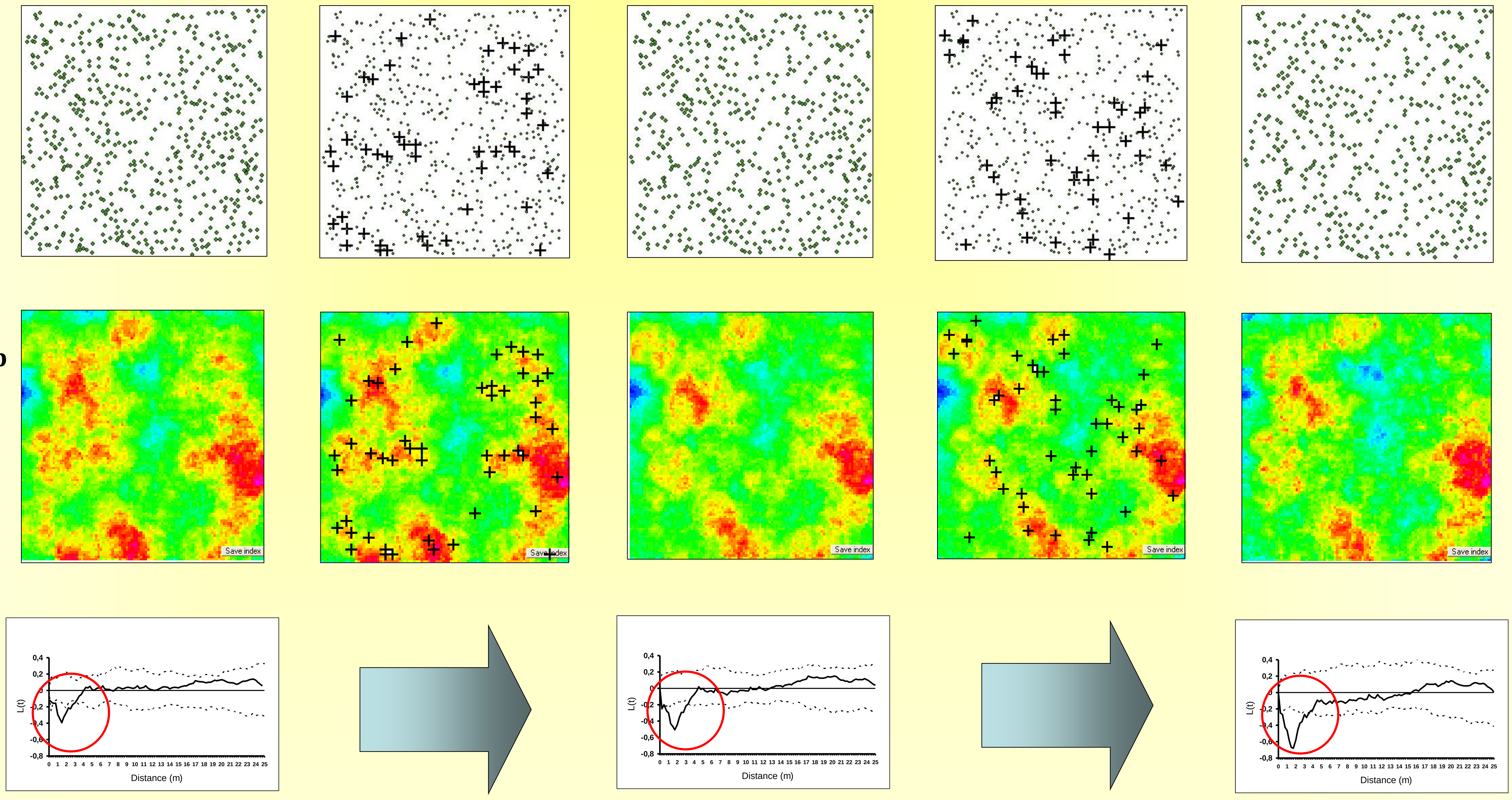
Tree and snag distribution

Alive tree
Snag

First-order intensity map

Max density
Min density
Snag

Univariate Ripley's *K* diagram



Conclusion

Competitive mortality in the plot began from higher density patches (Kenkel, 1988) to the whole stand, creating a more density homogeneous plot and a regular tree distribution. This trend is characteristic of mortality due to inter-tree competition. The spatial analysis of the pattern of dead and living trees during the last decades allowed us to reject the hypotheses of mortality due to allogenic disturbance.

The plot, established around 1790, is developing beyond the stage of Stem Exclusion Phase yet, with mortality process due to competitive dynamics. However, in the winter 2005, on the East edge it was observed a wind uprooting involving 4-5 individual.

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