

FRAXINUS ANGUSTIFOLIA VAHL. IN CENTRAL EUROPEAN ALLUVIAL HARDWOOD FORESTS OVER 40 YEARS.

CAN IT SURVIVE IN THE ABSENCE OF FLOOD DISTURBANCES?

David Janík*, Dušan Adam, Kamil Král, Libor Hort, Pavel Unar, Tomáš Vrška, Pavel Šamonil

The Silva Tarouca Research Institute for Landscape and Ornamental Gardening, Department of Forest Ecology, Lidická 25/27, CZ - 602 00 Brno, Czech Republic. *Corresponding author: Tel.: +420 541 126 262; Fax: +420 541 246 001; E-mail: david.janik@vukoz.cz; www.pralesy.cz

Objectives:

The main focus of this paper is the dynamics of *F. angustifolia* populations after a sudden change in the disturbance regime, i.e. disappearing flooding events, especially as regards competition with *C. betulus* and *A. campestre*, the most rapidly expanding species in alluvial hardwood forest in Central Europe. This topic is closely related to the question whether the current character of Central European alluvial forests, in which *F. angustifolia* is one of the main constituents, will remain the same. To address the main aims of this study we asked the following questions:

- How did *F. angustifolia* populations develop over the past 40 years in comparison with other tree species?
- How did *F. angustifolia* and other tree species utilize the available growth space after the decay of oak and elm layers?
- How did the less frequent occurrence of floods and decrease in the ground water table level affect the tree elevation distribution of ash populations?
- What are the characteristics of the tree spatial pattern of *F. angustifolia* in comparison to *A. campestre* and *C. betulus*?

Methods:

The study areas were located in an alluvial forest complex at the confluence of the Morava and Dyje rivers, in the south-eastern region of the Czech Republic (Fig. 1). The surveys were performed in the Ranšpurk and Cahnov national nature reserves, which contain the best preserved old-growth forests of this complex.

The formation of soils was affected by regular inundations that brought flood sediments over the centuries. Mean annual inundations on the Morava River from 1807 to 1962 lasted 49.8 days per year. A levee system on the lower reaches of the Morava River was constructed in 1976 and regular inundations in the floodplain ceased.

Analyses were carried out for datasets from the 1970s, 1990s and 2000s (Průša 1985, Vrška et al. 2006). All standing and downed trees of DBH ≥ 10 cm within the core areas of the two localities have been mapped and the DBH recorded. The resulting stem position maps (Fig. 2) with linked databases provided detailed data about stand structure to be used in these analyses (in total 14 567 trees on 36 ha).

We used standard methods for calculating recruitment, mortality and population change (Condit et al. 1999). To investigate the spatial relationship between trees, we used the pair correlation function and its extensions to multitype point patterns (Stoyan and Stoyan 1994). Bootstrap methods (Efron and Tibshirani 2001) were used to construct the confidence intervals for the mean values of $g(r)$.

All spatial analyses were conducted using the packages "spatstat" (Baddeley and Turner 2005) and "bootstrap" in the statistics software R. Statistical levels lower than or equal to 0.05 were considered significant.

Results:

Over the past 40 years, *F. angustifolia* populations were characterized by stagnation in the number of individuals, while at the same time the number of *C. betulus* and *A. campestre* trees increased (Fig. 2, Fig. 3).

The results of our analysis of the response of *F. angustifolia*, maple and *C. betulus* populations to the availability in growth space showed that new recruits of *F. angustifolia* had the strongest connection to the position of dead trees (Fig. 4). In comparison to *A. campestre* and especially to *C. betulus*, *F. angustifolia* appeared to be markedly light-demanding.

Our results suggest release of spatial relations between species population densities and the 1 m elevation gradient and the expansion of species across micro-topographic gradients, especially populations of *F. angustifolia* and *C. betulus* (Fig. 5).

Spatial analyses showed that *F. angustifolia* had the highest clustering of trees with DBH > 10 cm to a distance of at least 12 m. *A. campestre* is clustered to 10 m and *C. betulus* to 5-7 m. These results suggest that negative density dependence may not be the reason behind the stagnation or decrease of *F. angustifolia* populations. Recruits also reflect the generally clustered distribution of *F. angustifolia* (Fig. 6).

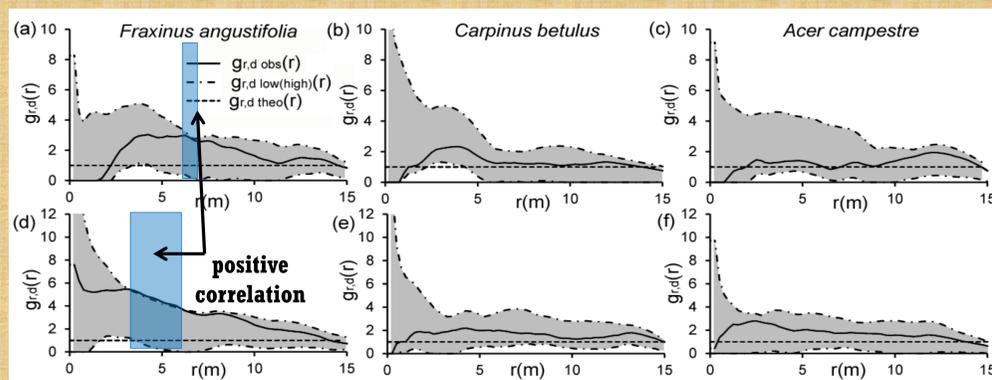


Fig. 4 Cross-type pair correlation functions $g_{r,d}(r)$ show spatial relationships between Recruits of 1973-1994 and Large-sized dead trees of 1973 at Ranšpurk (a) and Cahnov (b). Large-sized dead trees – dead trees with minimum DBH of 75 cm. Recruits - newcomers that reached the minimum DBH of 10 cm in 1994. $g_{r,d} \text{ obs}(r)$ – observed functions, $g_{r,d} \text{ theo}(r)$ – theoretical value of the independence of components hypothesis. $g_{r,d} \text{ low/high}(r)$ – the pointwise envelopes resulting from 99 simulations obtained by random shifts of sub-patterns (Recruits, Large-sized dead trees), independently of each other. The variable "r" refers to distance.

Conclusions:

The results of our study suggest that in the absence of regular floods, *F. angustifolia* comes into direct competition with *C. betulus* and *A. campestre*, which have better abilities to mature under a closed canopy. By contrast, *F. angustifolia* is more successful under an open canopy, which, however, is limited after the decay of old oaks. It appears that in the future, the alluvial forests studied here are likely to turn into mixed broadleaved forests with dominant *C. betulus* and *A. campestre*. In such forests, *Q. robur* will be completely absent and *F. angustifolia* will occur as an admixture species.

Acknowledgement:

This research was funded by the Czech Science Foundation (Project No. P504/11/2301).

References

- Baddeley A, Turner R (2005) Spatstat: an R package for analysing spatial point patterns. J Stat Software 12: 1–42
 Condit R, Ashton PS, Manokaran N, LaFrankie JV, Hubbell SP, Foster RB (1999) Dynamics of the Forest Communities at Pasoh and Barro Colorado: Comparing Two 50-ha. Philos T Roy Soc B 354: 1739-1748
 Efron B, Tibshirani RJ (1993) An introduction to the bootstrap. Chapman & Hall, New York, USA
 Průša E (1985) Die böhmischen und mährischen Urwälder – Ihre Struktur und Ökologie. Academia, Praha
 Stoyan D, Stoyan H (1994) Fractals, random shapes and point fields: methods of geometrical statistics. John Wiley & Sons, Chichester, UK
 Vrška T, Adam D, Hort L, Odehnalová P, Horal D, Král K (2006) Dynamika vývoje pralesovitých rezervací v České republice – Sv. 2, Lužní lesy – Cahnov–Soutok, Ranšpurk, Jiřina. Academia, Praha

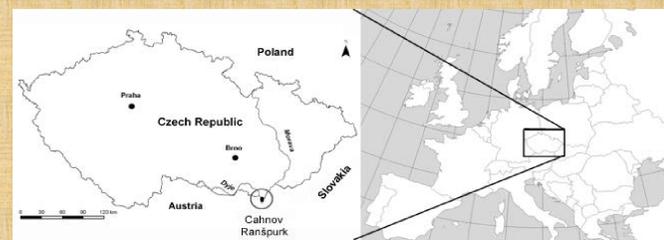


Fig. 1 Location of the study sites

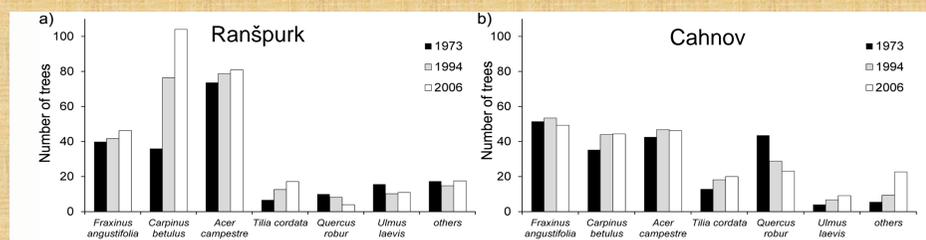


Fig. 2 Number of trees at the Ranšpurk (a) and Cahnov (b) localities in the period 1973-2006.

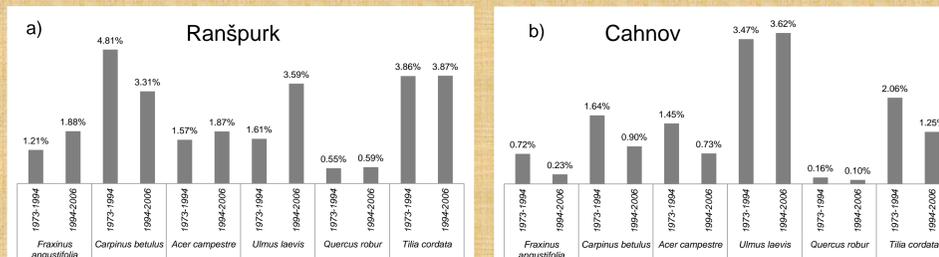


Fig. 3 Recruitment rates at the Ranšpurk (a) and Cahnov (b) localities in the periods 1973-1994 and 1994-2006.

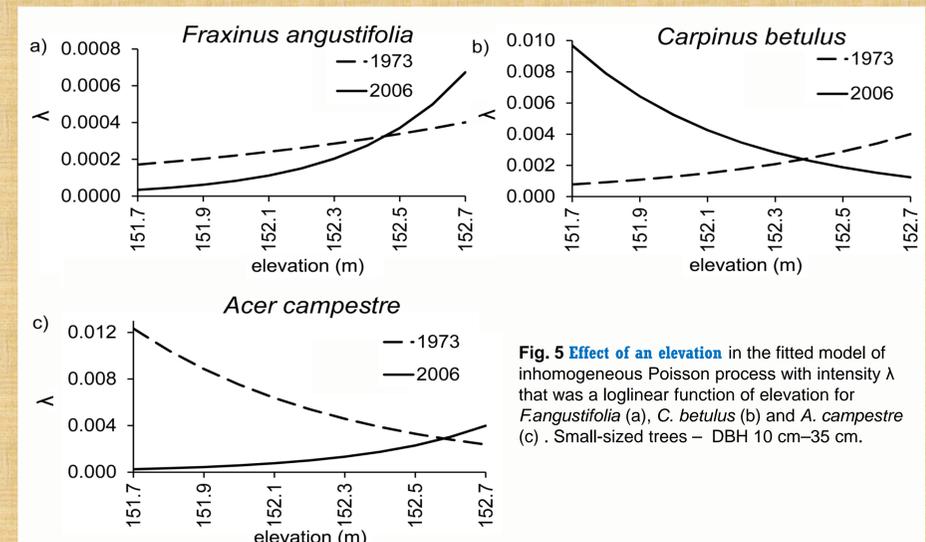


Fig. 5 Effect of an elevation in the fitted model of inhomogeneous Poisson process with intensity λ that was a loglinear function of elevation for *F. angustifolia* (a), *C. betulus* (b) and *A. campestre* (c). Small-sized trees – DBH 10 cm–35 cm.

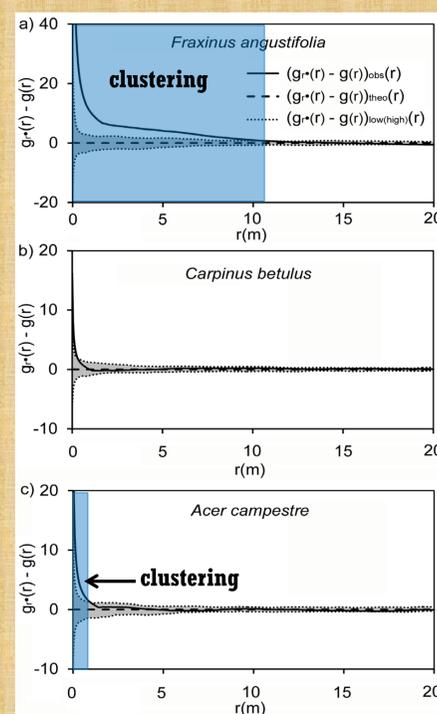


Fig. 6 Test statistic for random labelling of Recruits in 1994. We used the 'i-to-any' summary $g_{r,d}(r)$, which is an analogue of the pair correlation function. Under the null hypothesis of random labelling ($g_{r,d}(r) = g(r)$), then $g_{r,d}(r) - g(r) = 0$ is valid. We generated 99 simulations of our null model to obtain pointwise critical envelopes for this model. The variable "r" refers to distance.

