

Dendroecological analysis of vegetation dynamics on abandoned heath lands in the Swabian Jura, southern Germany

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Introduction

The preservation of floristically rich vegetation types of heath landscapes (*Gentiano-Koelerietum*) that evolved during centuries of formerly practised extensive land use as pasture is presently a tremendous problem for nature conservation (Beinlich & Plachter 1995; Schreiber 1997). After abandonment due to economic changes during the last decades, succession processes take place that include the re-immigration of woody species and the gradual displacement of rare herbs. However, the dynamic of these processes can not be satisfactorily documented and analysed by means of plant sociological investigations, since species of former pasture lands mix with invading woody species. Long-term observations or repetitive mapping are not practicable and cost-effective. Furthermore, it has to be considered that the spatial pattern of shrub distribution largely depends on the different distribution strategies of the invading species. The dendroecological analysis of shrubs does not only allow the exact age determination and hence the establishment of all individuals during the process of invasion, but also enables the reconstruction of species-specific propagation patterns.

Material and Methods

The immigration patterns of invasive woody species were analysed on 4 study plots in the valley of the "Grosse Lauter" in the jurrassic limestone mountain area of the Swabian Alb. All study plots have comparable ecological conditions concerning soil conditions (rendzic leptosols) and former land use as pasture. The exact locations of all individuals on the sampling plots were determined and mapped with the help of a Geographic Information System (ARC View). Stem discs of all individuals on each plot were gained by cutting the shrubs at their base. Larger individuals were cored obliquely at a height of 30 cm to reach the oldest annual rings at the base. After drying, the surfaces of the cross sections were smoothed by sanding or by cutting with razor blades and the numbers of annual rings were counted. Additionally, microtome slices were prepared for selected samples (Schweingruber 2001). In total, 719 individuals of 18 woody species (among them 13 tree species) were examined.

Results and interpretation

Species abundancy

To illustrate the differences of spatio-temporal immigration patterns of woody species in relation to the propagation strategy we show the results of two study plots which were primarily dominated by one species. Fig. 1 shows the portion of species contributing to the shrub population on plots A and B, respectively. Plot A is dominated by the zoochorous species juniper (*Juniperus communis*), whereas on plot B blackthorn (*Prunus spinosa*), which is able to propagate by the formation of vegetative runners, dominates.

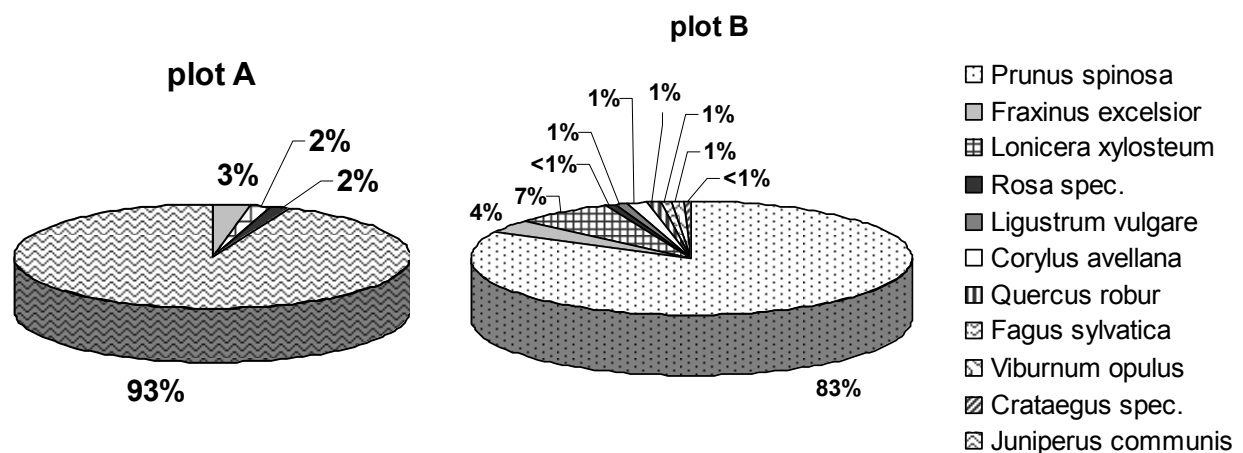


Figure 1: Percentage of different woody species on the shrub population on sampling plots A and B

Plant age and average growth rates

In many cases, the age of a shrub or a tree sapling is only estimated from its height or its diameter. However, the amount of light that a sapling of a light-demanding species receives largely determines the amount of bioproduction and thus the growth rate of the trunk (Table 1). With the exception of *Prunus spinosa* which usually does not occur under extremely shady conditions, the averages of all other species show growth rates of suppressed individuals that amount to between 35 % (juniper) and 18.6 % (ash) of dominant individuals that savour the full sunlight. Fig. 2 shows an example of two young ashes (*Fraxinus excelsior*) of similar size that grew on the open pasture and in the shadow of older trees. As can clearly be seen from Table 1 and Figure 1, the diameter of a trunk can not be used as a reliable estimator of the age of the plant. Careful determination of the real plant age by analyses of the number of annual rings is thus inevitable and the dynamics of vegetation-succession processes are to be studied.

Table 1: Average growth rates of woody species in cm/a of individuals that grew in full light compared with individuals that grew in the shade of older trees or shrubs.

	<i>Prunus spinosa</i>	<i>Fraxinus excelsior</i>	<i>Juniperus communis</i>	<i>Picea abies</i>	<i>Pinus sylvestris</i>
growth rate in the shadow	0,08	0,08	0,06	0,10	0,16
growth rate in full light	0,08	0,43	0,17	0,42	0,40

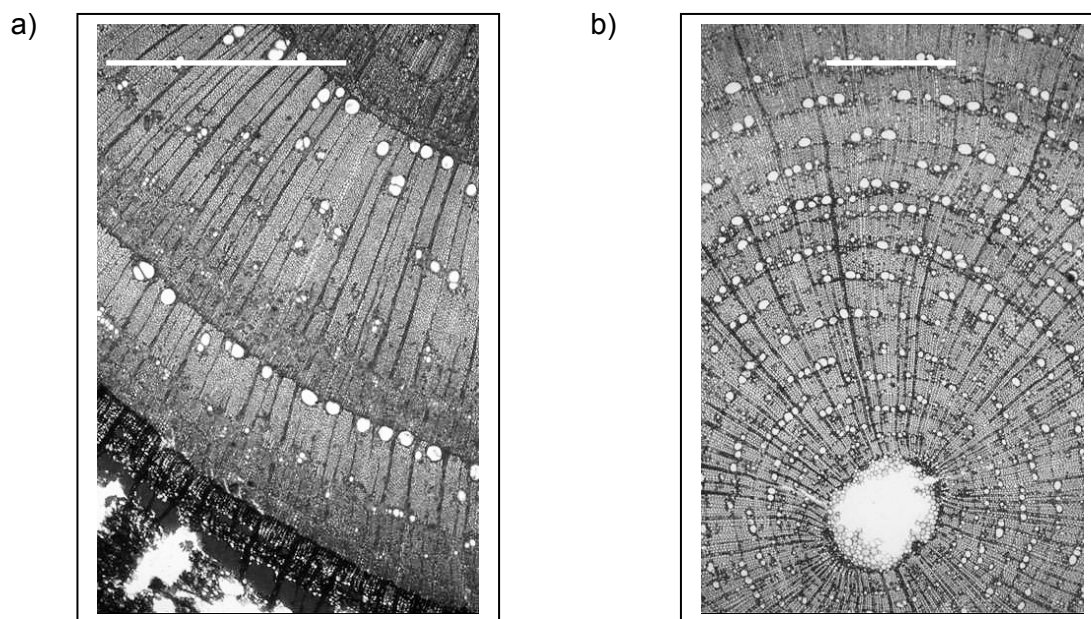


Fig. 2: Microscopic images of ash saplings that were exposed to the full sunlight (a) and that were suppressed by the shade of older trees (b). Individual a) had only 3 rings, whereas individual b) contained 23 rings from the pith to the bark. The length of the white bar in the upper left corner of the photograph represents 5 mm.

Age distribution

The process of dissemination of juniper is illustrated in figures 3 and 5, respectively. During the early stages of the succession, few individuals of juniper are scattered over the plot surface. The dispersion of junipers accelerates after 1972, when the pioneer individuals reach the age of fertility and start to form seeds. The spatial pattern of newly established seedlings is disperse, new individuals mainly establishing in gaps between older individuals, where the light conditions are most favourable. After a period of about 15 years of extensive dispersion, around 1985 the establishment of new individuals drastically decreases. Obviously, the density of shrubs was already too high to allow the germination of additional seedlings of this light-demanding species.

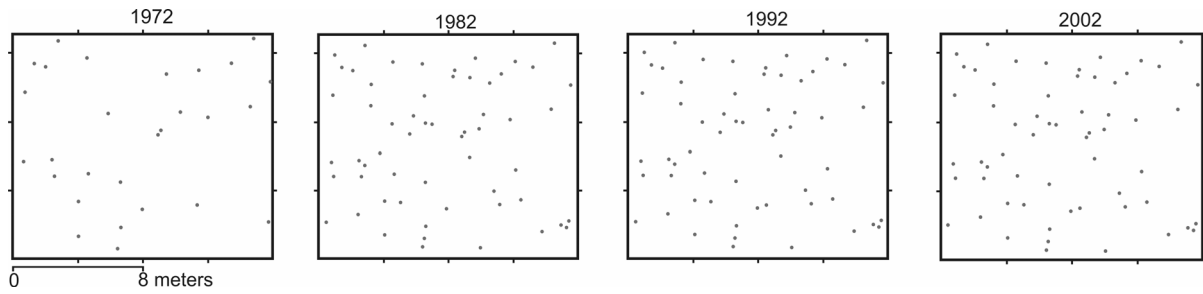


Figure 3: Multitemporal maps of establishment patterns of juniper on study plot A

On the other hand, the establishment of blackthorn starts from a small group of pioneer individuals that obviously has been disseminated by bird dispersal (Figs. 4 and 5). However, the temporal and spatial patterns of dissemination differs from those of juniper. After the young blackthorns reach an age over ca. 15 years, the number of newly established saplings between the pioneer individuals drastically increases. Obviously, these individuals require some years to develop to a stage in which they start to form vegetative runners.

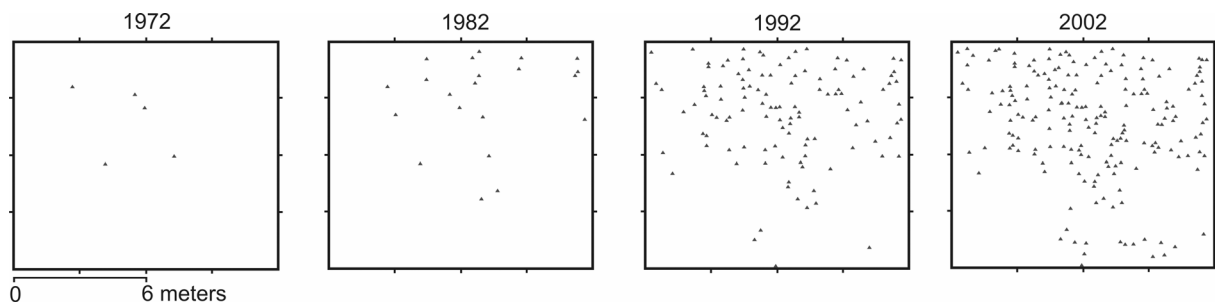


Figure 4: Multitemporal maps of establishment patterns of blackthorn on study plot B

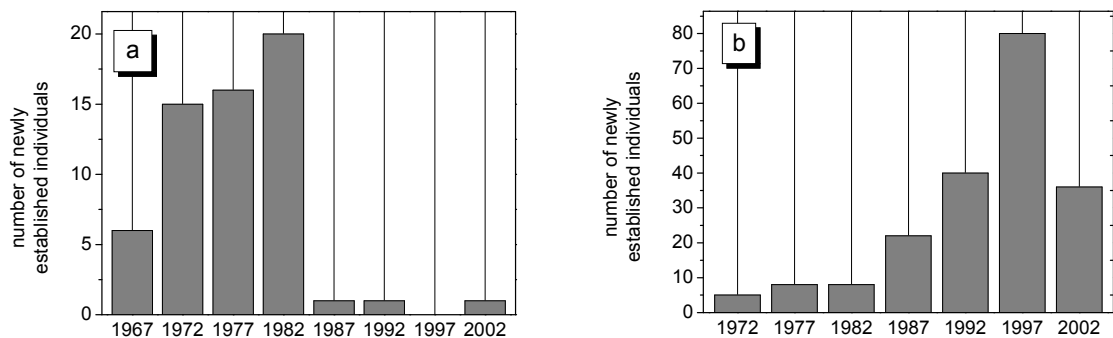


Figure 5: 5-year sums of newly established individuals of juniper (a) and blackthorn (b) on the two investigation plots

Conclusions

The dynamics of secondary succession processes can be studied by dendroecological methods. Different strategies of species propagation (Zoochorie versus Autochorie) can be analysed using the age structure and the spatial distribution patterns of different woody species. In this manner, the spatiotemporal progression of forest succession can be reconstructed.

References

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