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# Litter raking as restoration management in an oak forest in Podyjí National Park

Ondřej Vild, Radim Hédl & Jesse M. Kalwij

| | |
|---|---|
| Location | Podyjí NP; 48°48' N, 15°57' E; elevation 370 m |
| Conservation status | NP, SPA, SAC |
| Restored area | 1 ha |
| Financial support | 0 |

## Abstract

Raking of leaf litter used to be a common activity in European forests. We employed an experimental method to evaluate the impact of this management on the forest understorey, and its potential for the restoration of forest vegetation biodiversity. We monitored 45 plots (7 × 7 m) for seven years. The most pronounced change was an increase in the diversity of annual plants, most of them considered ruderals. Continuation of the experiment will be needed to evaluate the long-term impact.

## Site description

The forest stand has a heterogeneous age structure (Fig. 1). It consists mostly of sessile oak (*Quercus petraea* agg.) admixed with *Pinus sylvestris*, *Carpinus betulus* and *Tilia cordata*. The dominating bedrock is granite. The soil type is oligotrophic cambisol with a pH of 4.0–5.5 (measured in water suspension). The relief is homogeneous, with slopes gently descending southwest. Grasses such as *Avenella flexuosa*, *Poa nemoralis*, *Festuca ovina* and *Melica uniflora* dominate the understorey. In more open places, *Trifolium alpestre*, *Galium verum* and *Lychnis viscaria* occur. We can rarely also find here some endangered species, e.g. *Platanthera bifolia*, *Fourraea alpina* and *Monotropa hypopitys*.

## Initial state

The entire region was formerly intensively managed by man. Grazing by domestic animals was very common until the 19th century, and trees were only scattered. Here, as well as in other open lowland forests in the region, the effects of eutrophication and vegetation succession are most obvious. These processes are partly driven by increased atmospheric deposition of nitrogen. Additionally, abandonment of traditional, nowadays banned management types is a contributing factor. Litter raking is one of such types of management. In the past, this management exported significant amounts of nutrients from the forest ecosystem (Sayer 2006). As a result, competitively strong species such as *Calamagrostis epigejos* and *Arrhenatherum elatius*, have expanded at the study site. Simultaneously, plants of oligotrophic habitats, including many endangered species, have disappeared.

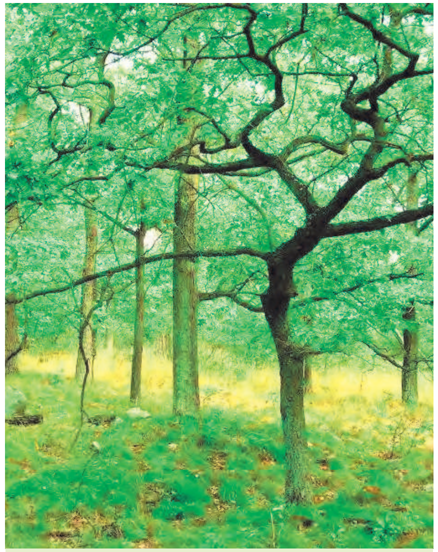

**Fig. 1.** Sessile oak (*Quercus petraea* agg.) is the dominant tree species at the site. (O. Vild)


**Fig. 2.** Experimental plot. (O. Vild)

## Restoration objectives

The aim of litter removal is to decrease the eutrophication processes and ecological succession. It should lead to a decrease in competitively strong and expansive species, whereas competitively weak species of oligotrophic habitats should be supported by it.

## Measures applied

Leaf litter was removed with rakes in 30 permanent plots in 2010–2016.

## Monitoring methods

We established 45 permanent plots (7 × 7 m; Fig. 2) in 2010. One third of them are control plots, while litter is removed in the rest of the plots using rakes each year. In the middle of each plot, we recorded a relevé (5 × 5 m) consisting of a list of all plant species of the understorey with cover/abundance estimates using the modified Braun-Blanquet scale. The first survey was carried out before the experimental management started, and then repeated each following year.

## Results

An analysis of vegetation data in the R program (version 3.2.3, available at http://www.r-project.org/) showed that litter raking resulted in a significant increase in species per plot (repeated measures ANOVA, $F = 4.153$, $p = 0.0424$; Fig. 3). Differences between treatments started to be clear already in 2012.

It is worth noticing that the inter-annual fluctuations in species richness are considerable. Further analyses showed that these are mostly the result of inter-annual differences in precipitation and temperature in the winter season (Vild et al. 2015). When conditions are suitable, annual species are

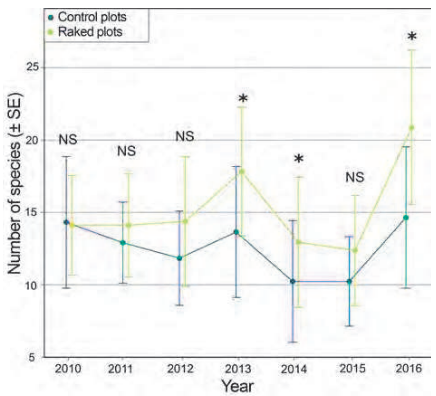


**Fig. 3.** Comparison of temporal changes in the number of species per plot between experimental treatments. The symbols mark significance of the difference between treatments: asterisk: $p < 0.05$.

able to germinate. Many are typical of ruderal habitats, i.e. habitats strongly influenced by man. Germination of some species, such as *Moehringia trinervia*, *Geranium robertianum* and *Fallopia convolvulus*, was probably supported by mechanical disturbances (Baskin & Baskin 2014). The germination of other species, present only in the seed bank, was probably induced by the missing litter layer normally functioning as a mechanical barrier.

## New insights and recommendations

Experimental removal of leaf litter had a positive impact on the species richness in the oak forest. Mostly ruderal species increased in the short term. This result can be partly attributed to the agricultural character of the region and history of the locality and its surroundings characterised by grazing until the 19th century. Many ruderal species have thus probably been able to survive in open places. However, these are mostly competitively weak annual species with a low cover, not able to pose a threat to other species of the herb layer.

The lack of effect of litter raking on other species can be attributed to (1) the fact that most of them are perennial species, and (2) the soil buffering capacity, which prevents soil chemistry from fast changes and thus from a decrease in eutrophication level. In order to be able to describe the impact of litter removal on these species and other, more resistant components of the ecosystem, the experiment is planned to continue. This will also help us to assess whether target species characteristic of the habitat in question are able to colonise the plots.


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**Fig. 4.** Litter raking in autumn 2015. Approximately 20 kg of dry leaf mass is removed from each plot yearly. (O. Vild)