

RESTORING OF WOODED MEADOWS IN ESTONIA: RECOVERY OF SPECIES DIVERSITY VIA NATURAL PROCESSES

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Abstract: Wooded meadows are the most species-rich habitats in the boreal Europe. In Estonia their area is 8000 ha, but communities with distinctive structure are preserved only on 4800 ha. Restoring of wooded meadows in Estonia started in 1990s. (Re)introduction of seeds or planting have not been applied, thus the recovery of species composition relates only to natural processes. We studied recovery of species richness in the restored stands. The total species richness of the restored stands was still much lower than in managed stands. Recovery of the small-scale (0.25m²) species-richness was remarkable after 10 yrs passing the restoration. Our study revealed 37 management-dependant species. These species are the low-growing herbs, with average height less than 40 cm, preferring infertile soils and dry habitats. One third out of the management dependant species have low occupancy in restored stands. These are light demanding species of infertile habitats. Conservation managers and policy makers must notice the difference in recovery times of spatial structure, abiotic conditions and species composition.

Key-words: 6530 * Fennoscandian wooded meadows, land use change, restoration of traditional management, spontaneous succession

Introduction

Small-scale species richness of Estonian calcareous wooded meadows with its recorded maximum of 76 vascular plant species per m² is extremely high both for the temperate vegetation zone but also for the global scale (Kull & Zobel 1991, Kukk & Kull 1997). The wooded meadows persisted till now are only remnants of the habitat's historical distribution. Its total area has decreased all over the Europe due to cultivation, lack of sustainable management and direct physical destroying. Succession towards forest ecosystem starts quickly after abandonment and leads to changes in species richness and composition. Woodlands with closed canopy replaced wooded meadows by 15 years after abandonment in Sweden (Hansson & Fogelforss 2000). However, decrease in species richness did not appear before 8 years. In wooded meadows which were left unmanaged for 100 years the vegetation composition was completely replaced (Mittlacher et al. 2002). Cessation of management of semi-natural grasslands appears to be the main threat for many plant species with conservation need in Estonia (Pärtel et al. 2005). Cousins and Eriksson (2001) have found many grassland species to be habitat specialists. Thus, such species can rely only on grasslands and will be lost from a region's flora when the loss of their suitable habitat meets the critical threshold value. In general the restoration of habitats aims to re-establish the structure of vegetation layers and species composition, as similar to the one existed before the external disturbance as possible. Restoration of semi-natural habitats comprises the re-establishment of continuous management. In Estonia the wooded meadows have traditionally been mown once during the summer, the dry hay has been gathered together and removed from the meadow (Kukk & Kull 1997). Before such management could be reapplied, the invading overgrowth (shrubs and young trees) must be cut and removed from the site. Many formerly abandoned wooded meadows have recently been restored in Estonia. Species composition in such meadows has been established only through natural

succession as neither seed addition nor transplanting have been applied anywhere. In our study we identified: (1) the dynamics of plant species diversity in conditions of different management of wooded meadows: mowing, abandonment, restoration; (2) the species with negative response to abandonment and the characteristics related with such response; (3) the distribution of the management related species in restored stands; (4) the factors limiting the recovery of the management related species in restored stands. Our study concerns both the ecology of the plant communities and the better planning of the conservational measures.

Materials and methods

We studied the restoration of the species-rich calcareous wooded meadows in Estonia. When abandoned, they mostly develop to eutrophic boreo-nemoral forests with significant amount of deciduous tree species in the forest layer (Kukk & Kull 1997). We studied the effect of three different management types on vegetation diversity: continuous management (7 stands), abandonment (9) and restoration of formerly abandoned meadows (11). Area of ca 40 × 40m was sampled in each stand: ten plots with size of 0.25m² (50 × 50 cm) were randomly applied and all vascular plants within the plots were listed. Abundance of all species in plots was recorded. The rest of the species not found from the study plots but present in the sampled area were also listed. We analyzed the response of all herbs of managed stands to abandonment excluding those which occurred in only one stand. We compared the species' frequency of presence in the managed stands and abandoned stands using four classes of frequency: (1) 0–25%, (2) 26–50%, (3) 51–75%, (4) 76–100%. Species belonging to two or three steps lower occupancy group in abandoned stands compared to managed ones were considered as „management dependant species”; species of one step lower occupancy group in abandoned stands as „management supported”. We described the occupancy of all these management related species in restored stands and compared it with that in managed stands. Species within similar occupancy group in both management types formed the group we considered as the „recovered group”. Species belonging to one class lower occupancy group in restored stands formed the one which have not recovered entirely and species with two or three steps lower occupancy the species that have not recovered. We analyzed species response to cessation of management in relation to following features: ecological indicator values of species preference for light, nutrients, moisture conditions and pH (Ellenberg et al. 1992); height (Leht 2007); seed weight (Grime et al. 1986, Eriksson & Jakobsson 1998); clonal spreading: (1) extensive vegetative spreading (>10 cm yr⁻¹), (2) slow vegetative spreading (<10 cm yr⁻¹) (Klimeš et al 1997); distribution in different habitats in Estonia (Sammul et al. 2008); change in distribution range in Estonia during the last 30 years (Kukk & Kull 2005). For statistical analyses of data we used GLM, X² test and non-parametric tests (Kruskal-Wallis test).

Results and discussion

Management type had significant effect on species richness of wooded meadows (Figure 1). Changes in species diversity and composition at small-scale and stand scale have been quick when a meadow is left abandoned. There were in average 10 species less per plot in recently abandoned stands compared to managed ones. Meadows

unmanaged for more than 15 years experienced further significant decline in species richness at the both scales. At the stand level the recovery of the species-richness in the restored wooded-meadows is a slow process. At the small-scale (0.25 m^2), the positive effect of restoration on species richness appears quicker and is more evident, the mean species richness of the meadows restored more than 10 years ago was significantly higher compared to recently restored meadows and long-term abandoned meadows. Consequently, restoration promoted first of all the recovery of populations of the species that persisted in the meadow during the unfavourable period of abandonment. The recovery of species richness in stand level is evidently a slow process and is limited by the availability and re-immigration of species from the surrounding habitats. We obtained that out of the 184 herbaceous species of managed stands 37 were management dependant and 68 slightly promoted by management. These management related species preferred significantly lower soil fertility and drier habitats than species with positive or no response to management cessation ($p < 0.05$; Kruskal-Wallis test). The average height of the management related species – 35 cm – was significantly lower than in the rest of the species. Out of all the different habitats in Estonia the management dependant species inhabited significantly lower proportion compared to the species with no response to lack of management ($p < 0.05$, GLM). Out of the 105 management related species 29 species had not recovered and 43 had not entirely recovered in the restored stands. These species preferred significantly ($p < 0.05$, Kruskal-Wallis test) lower soil fertility and tended to be slightly more light demanding than the recovered ones ($p = 0.059$, Kruskal-Wallis test). Species in the management dependant group which had not recovered had significantly higher light demand compared to the species of the same group that were well-recovered ($p = 0.029$, Kruskal-Wallis test). Neither clonal spreading rate nor seed weight differed significantly between the recovery-groups. We found the lower persistence of distribution range in management related species ($p < 0.05$, GLM).

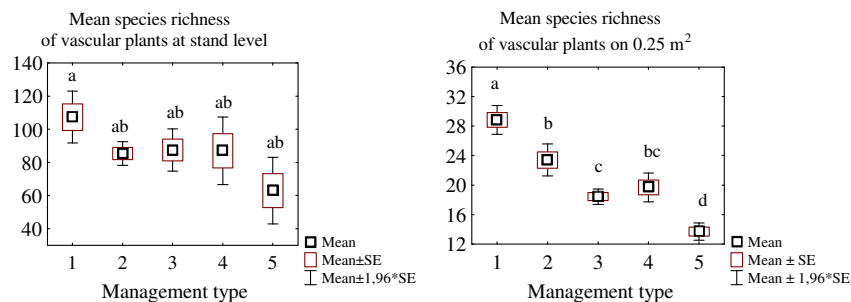


Figure 1. Species diversity in differently managed stands: 1 – continuous management (7 stands), 2 – restored more than 10 years ago (3 stands), 3 – restored recently, 5 years ago (8 stands), 4 – abandoned for nearly 10 years (4 stands), 5 – abandoned for more than 15 years (15-25 years) (5 stands). The letters indicate the results of post-hoc comparisons of means of respective variables.

Conclusions

1. Recovery of the species richness of the meadow ecosystems is much slower at the stand level than at the small spatial scale ($< 1 \text{ m}^2$). Thus, the best spatial scale to monitor the restoration success and recovery of the species diversity in semi-natural

communities is the small scale, i.e. at $\leq 1 \text{ m}^2$. 2. The selection of abandoned stands for restoration should consider the diversity in the stand level and the richness of the management related species persisted in the given stand. The particular attention must be paid to the presence of the species that our study revealed as management dependant (altogether 29 species). It is remarkable that these species, in spite of being still common, already revealed the decreasing trend in their distribution in Estonian vegetation. 3. The management related species were low-growing and preferred open habitats with infertile and dry soils. 4. The increased level of soil fertility evolves due to the lack of sustainable management. It persists evidently longterm after restoration of the open structure of the meadow and re-established management. It is therefore essential to minimise the limiting effect the persisted high soil fertility may have on the recovery of the management related species and to assure the sustained yearly mowing and removing of hay. 5. The management dependant species could be integrated as typical species to monitoring and assessing of the favourable status of wooded meadows. As most of the species are still rather common in vegetation no conservational attention has been paid to them so far. However, this group of species may appear to be the particularly vulnerable one in the flora.

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