# DIFFERENCES AND SIMILARITIES IN ROAD VERGE AND PASTURE VEGETATION – THE EFFECT OF MANAGEMENT

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**Abstract:** Semi-natural grasslands like pastures and hay meadows represent great nature values but land use changes throughout Europe propose serious threats to these habitats. Concurrently, road verge area tends to be expanded. Given proper management, road verge vegetation may provide refugia for declining grassland species, but research is needed to evaluate road verge management regimes in this respect. We studied the effect of various management regimes on road verge and pasture vegetation in a western Norwegian agricultural landscape. The road-verge treatments included control (no treatment) and mowing once or twice a year with or without hay removal. The pastures were spring- and autumn grazed with or without annual mowing, and different raking intensities were evaluated. Over the four years of the study, we observed significant change of species richness and floristic similarity, but only richness differed between treatments. A DCA ordination, however, revealed no co-ordinated vegetation change over the years along gradients, giving little support for any treatment effect on vegetation composition. Different evaluation methods hence vary in their sensitivity to vegetation change, suggesting that they may be used in concert. The apparently large short-time resistance of road verge and pasture vegetation to change should be tested by longer-term experiments.

**Keywords: Fennoscandian lowland species-rich dry to mesic grasslands; Vascular plants; Land-use change; Restoration of grazing and other traditional management techniques; biodiversity policy**

## Introduction

Semi-natural, dry grasslands like pastures and meadows represent great nature values, but ongoing land use changes have put these varied and species-rich habitats at great risk throughout Europe (Bennie *et al.* 2006; Hellström *et al.* 2006). Concurrently, the area of certain grassland habitats – road verges – tends to be extended. The potential of properly managed road verges to resemble traditional semi-natural grasslands has led to a growing interest in identifying reinforcing road verge management regimes (Cousins 2006; Jantunen *et al.* 2007). A variety of characteristics may be inspected to evaluate the management effect; species richness, floristic dissimilarity relationships, and measurement of coordinated vegetation change along gradients using ordination techniques being amongst the most widely used (Rydgren *et al.* 2004). To what extent may the different variables reveal how grassland vegetation develops?

## Materials and methods

We studied the effect over four years (2003-2006) of various management treatments on the vegetation of three road verges and three closely situated pastures (formerly hay-fields) in a fine-scale agricultural landscape (see Fig. 1) of western Norway. Road-verge treatments included present management regime [V1; mowing twice (June and August) without removal of hay] and mowing twice with removal of hay (V2), mowing once a year (August) with hay removal (V3) and no treatment (V4). The treatments of the pastures included present treatment (P1; spring and autumn grazing and no mowing), or simulation of traditional management; spring and autumn grazing with single mowing (August) with normal (P2) or hard (P3) raking. The treatments were replicated in a hierarchical design with 124 plots in 36 blocks nested in six sites (Auestad *et al.* 2008). All plots were analysed annually, but due to misplaced mangagement some plots were

*Figure 1*. The study sites are situated in a fine-scaled agricultural landscape, often with road verges and pastures adjacent to each other. Species like *Lychnis viscaria, Avenula pubescens and Galium verum* are commonly found in these dry, semi-natural grasslands. (Photo: Inger Auestad)

excluded, giving a total number of plot analyses over the four years of 492. We recorded the abundance of vascular plant species as subplot shoot frequency (prior to cutting, using 16 subplots per plot) in the 0.25 $m^2$ plots. Ninety-three species were recorded during the study. We recorded species richness as the plotwise species number per year, and calculated Bray-Curtis floristic dissimilarity for each plot between the initial year (2003) and each of the following years. Data were zero-skewness transformed and standardized prior before testing differences between years and treatments by a linear mixed-effect model (LME; Pinheiro & Bates 2000). We summarized vegetation variation along main gradients and compared the vegetation development between treatments by means of DCA ordination of the total subplot frequency data set. The primary axis (DCA axis 1) was interpreted as a gradient in management regime, separating road verges from pastures, and DCA axis 2 as a gradient in soil moisture and soil element concentrations, in line with a previous DCA analysis of the 124 2003-plots (Auestad *et al.* 2008). The axis scores of these plots in the two analyses correlated strongly (primary axis: $\tau$=0.86, p<0.0001 and secondary axis $\tau$=-0.59, p<0.0001). All statistical analyses were performed using R versions 2.6.0 (Anonymous 2007; Oksanen *et al.* 2007).

**Results and discussion pt 10**

*Species richness.* Over the four years of the study, the species richness increased significantly ($F_{3,347}$=30.1; P<0.0001), and to different extents among the seven treatments ($F_{6,82}$=2.2; P=0.047), see Fig. 2a. The species richness generally increased until the last year in all but the V4 treatment, and hence the temporal rates of species' enrichment varied significantly between treatments ($F_{18,347}$=2.2; P=0.028). Species number increased on average with 1.7 per plot, most notably in pasture treatments (especially in P3; grazing, mowing and hard raking). Raking probably strengthened the trampling effect of grazers, known to create gaps that provide establishment opportunities for the grassland species (Huhta *et al.* 2001).

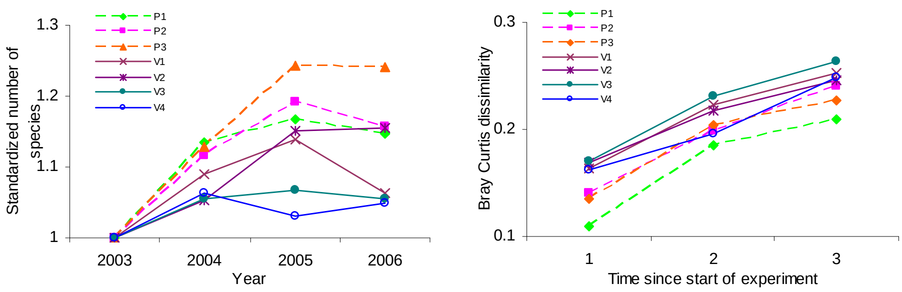


*Figure 2.* a) Plot wise standardized mean species richness per year for all seven treatments and b) mean Bray-Curtis floristic dissimilarity index for each plot between the initial year (2003) and each of the following years (2004-2006). See Materials and Methods for treatment abbreviations.

*Floristic dissimilarity.* The Bray-Curtis dissimilarity index indicated that the vegetation composition became more dissimilar to the initial species composition over the years ($F_{2, 242}$=136.0; P<0.0001), but no significant difference between treatments was found in this respect ($F_{6, 82}$=0.9; P=0.46), see Fig. 2b. Parallel to the species richness, the dissimilarity tended to level off over years. The low precipitation in the 2006 growing season (94 mm in March-August, equalling 65% of normal precipitation, met.no 2008) may have caused loss of many species gained during the experiment. This would increase similarity with the vegetation composition in 2003 (Bartha *et al.* 2003).
*DCA ordination.* The DCA ordination revealed no directional temporal movement of the plots of the different treatments, neither along the management gradient (DCA axis 1; λ=0.39, axis length = 3.48 S.D. units) nor along the moisture/nutrient gradient (DCA axis 2; λ=0.25, axis length =2.90 S.D. units), see Fig. 3. Hence, the vegetation change indicated by analyses of species richness and floristic dissimilarity was not large enough to affect plot positions.

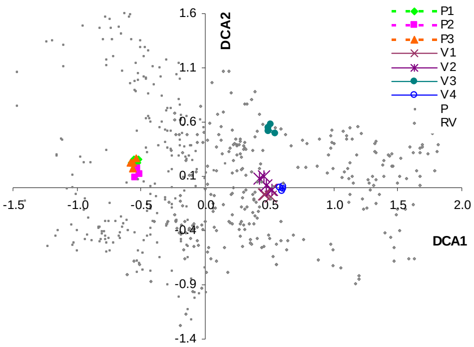


*Figure 3.* DCA ordination of the 492 plots. The mean plot score for the seven treatments in each of the four years are indicated by symbols (see legend), as are pasture (P) and road verge (RV) plots (see Materials and Methods for treatment abbreviations).

The great number of frequently occurring species (49 species were found in >10 plots per year) are probably only slightly affected by the study's relatively gentle treatments, while the species that actually vary in abundance are rarer and impact less on the ordination. Also Hellström et al. (2006) found that grassland vegetation changed slowly in response to restorative mowing, and attributed this result to seed limitation. The dry microclimate typical for the well-drained, steep, south-facing grasslands of our study may also halt vegetation change, as shown by Bennie et al. (2006) for British calcareous grasslands.

## Conclusions pt 10

We show that different methods for assessing vegetation change vary in their sensitivity to temporal and treatment related differences in species composition. Differences observed in species richness and floristic dissimilarity did not affect the mean plot position of the various treatments along the gradients and, hence, the various analyses should be used in concert. We found relatively high resilience to changes in management regime of the dry grassland vegetation in the investigated road verges and pastures. The results of our study should, however, be further tested on a longer time scale. We expect that chance and climatic variability will become less important with time, whereas more distinctive effects of treatments may appear.

## Acknowledgements pt 10

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