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Effects of mowing and removing litter on reproductive shoot modules of some plant species in abandoned meadows of Monte San Giorgio

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Abstract

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Reproductive shoot modules have been counted in a permanent plot experiment on Monte San Giorgio (Southern Switzerland) since 1988. The 8 species presented here, including the dominant grass (*Molinia arundinacea*) and seven locally abundant species, two grasses (*Danthonia alpina*, *Bromus erectus*), a sedge (*Carex flacca*) and four forbs (*Centaurea bracteata*, *Anthericum ramosum*, *Serratula tinctoria*, *Inula hirta*) changed considerably from year to year.

Mowing negatively affected cover and standing crop proportions of *M. arundinacea* and positively influenced the number of reproductive shoot modules of most species. Removing litter did not affect the cover of *M. arundinacea* but mainly increased its number of reproductive shoot modules.

It is concluded that density of reproductive shoots is very sensitive to weather conditions and different treatments.

Key words: Dynamics of species change, fluctuation, management, *Molinia arundinacea*, permanent plot.

Introduction

Since 1955, abandonment on Monte San Giorgio (Ticino, Switzerland) has altered the former meadows and pastures with regard to their species composition. However, more than 35 years of secondary succession and a fire in 1965, both favouring the spreading of *Molinia arundinacea*, have probably not yet resulted in a marked depletion of the flora. Nevertheless, several species (e.g. *Gladiolus imbricatus*, *Scorzonera humilis*) are now very rare and some others are probably extinct (e.g. *Gentianella insubrica*, *Crepis froelichiana*). Management practices are currently discussed to preserve the still most interesting flora and fauna on the mountain.

Successful working in nature conservation requires monitoring programs to test the appropriateness of management practices (Bröring & Wiegleb 1990, Hänggi 1989, Mur-

phy 1990). Experiments on permanent plots were established in 1988 to investigate the effect of mowing and of removing litter on the present vegetation. Cover estimates are widely used for permanent plots studies (Schreiber 1985). However, as they may provide significant results only after a thorough alteration of the vegetation, slow changes can only be detected in the long-term. More accurate quantitative methods to determine successive species change, on the other hand, are very time consuming (Schmidt 1974, Pfadenhauer, Poschlod & Buchwald 1986, Stampfli 1991). Properly counting individual plants is a reliable but difficult method. Counting the number of reproductive shoots is easier. Differences in vitality of herbaceous species may appear in alterations of the number of reproductive shoots (Rabotnov 1974). Krüsi (1981) has shown, that it may yield results of some predictive value in vegetation dynamics of grasslands. Nevertheless it is not yet clear how successive data of reproductive shoot modules can contribute to estimate the future population size of a particular species.

Based on first data of a permanent plot experiment, the hypothesis is tested, that mowing and removing litter will reverse the spreading of *Molinia arundinacea* and positively influence the number of reproductive shoot modules of the other species. The idea of using reproductive shoot modules to predict vegetation dynamic processes will be discussed by comparing short-term trends caused by mowing with the state of species composition in 1950.

Study site

The experimental plots, inclined about 20°, are located on the south west facing slope of Monte San Giorgio, at an elevation about 950 m. On dolomitic rock *Rendzina* soils, varying in depth and rich in clay, mainly determine the species composition of the grassland which represents a plant community unique to Switzerland. Mainly on deep soils species indicating periodical-moist soil conditions occur, above all *Molinia arundinacea* which is very abundant today. Shrubs and trees now partly cover the former meadows and pastures.

Methods

By cursory initial inspection patches of two distinct vegetation types were distinguished, one dominated by *Molinia arundinacea*, the other showing high cover of *Carex humilis*. Within a relatively large area representing the *M. arundinacea* dominated vegetation type, experimental plots were permanently established. Since 1988 three different treatments have been carried out including (Fig. 1):

- (a) no treatment = control (6 × 6 m)
- (b) mowing by scythe and removal of the harvest early in August (6 × 12 m)
- (c) removing litter by rake in spring (6 × 6 m).

Since 1988 yearly records were carried out in May and July, in quadrats of 2.5 × 2.5 m, using different methods:

(1) Standing crop measurements were restricted to experimental treatment 'mowing'. By end of July, before mowing by scythe, a small electric lawnmower was used to cut four strips (9.5 × 100 cm) along the quadrat diagonals at a height of about 3 cm above ground (Fig. 1). *M. arundinacea*, other grasses and forbs were separated and their dry mass measured.

(2) The 'cover' (%) of all the species was estimated in all the quadrats by end of July, before standing crop measurements and mowing were performed. To prevent the vegetation from excessive trampling 'cover' was defined as the visible percentage of a species, thus the sum of all the species' 'cover' values of a quadrat did not exceed 100%.

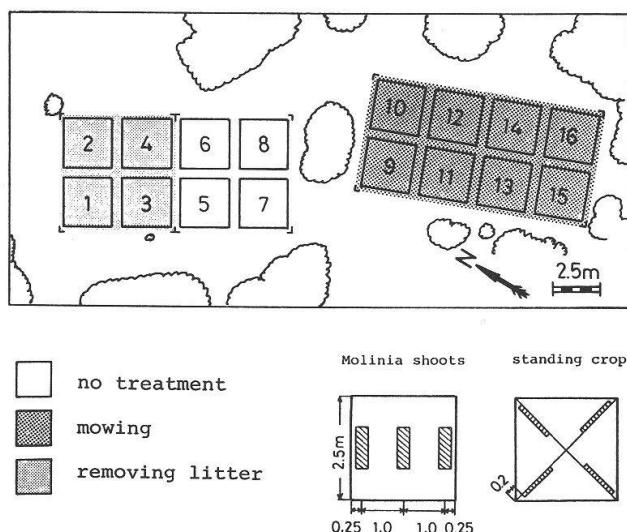


Fig. 1. Experimental design of the *Molinia arundinacea* dominated plots on Monte San Giorgio. No treatment was carried out on quadrats 5–8, mowing was resumed on quadrats 9–16 and litter was removed on quadrats 1–4. *Molinia arundinacea* shoot module density was determined in three subplots of quadrats 1–16. Standing crop samples are taken in four strips along diagonals of quadrats 9–16.

(3) Density of reproductive shoot modules of a manageable selection of species was determined by counting reproductive shoots in all the quadrats at a time of optimal development. In order to get accurate counts, the quadrats had to be subdivided. Reproductive shoot modules of *M. arundinacea* were counted within three regularly spaced subplots per quadrat, assisted by a frame of 33 × 100 cm at a height of 50 cm (Fig. 1). 'Module' is defined as the result of growth from a single apical meristem or cell. With regard to shoot systems this includes a monopodial axes, nodes, internodes, leaves, axillary buds, and in the case of limited growth, a terminal inflorescence (Bornkamm et al. 1991). Reproductive shoot modules, as used here, include an inflorescence (at least potentially).

Species whose reproductive shoots were small in number or did not occur on most quadrats, were omitted, thus only eight of the selected species were examined: *Molinia arundinacea*, *Bromus erectus*, *Danthonia alpina*, *Carex flacca*, *Centaurea bracteata*, *Serratula tinctoria*, *Inula hirta* and *Anthericum ramosum*.

Results

Standing crop measurements yielded a total dry mass value of $254 \text{ g} \cdot \text{m}^{-2} \pm 36 \text{ g} \cdot \text{m}^{-2}$ (mean \pm s.dev.; $n=8$) in 1988 before mowing was resumed. Successive values declined remarkably. *Molinia arundinacea* was generally more affected than the rest of the vegetation (Tab. 1).

Using cover estimation data, afflicted with relatively large error (according to Sykes, Horrill & Mountford 1983), no significant change was recorded during the three year period 1988–1990 for most species, except on the mown quadrats for the dominating *Molinia arundinacea*, *Danthonia alpina* and the sparse *Linum catharticum*. While *M. arundinacea* cover values drastically fell, a rise of *Danthonia alpina* values was observed on mown plots (Fig. 2). The annual *Linum catharticum* was totally absent in 1988 and 1989. It was first recorded in 1990, in all the eight mown quadrats.

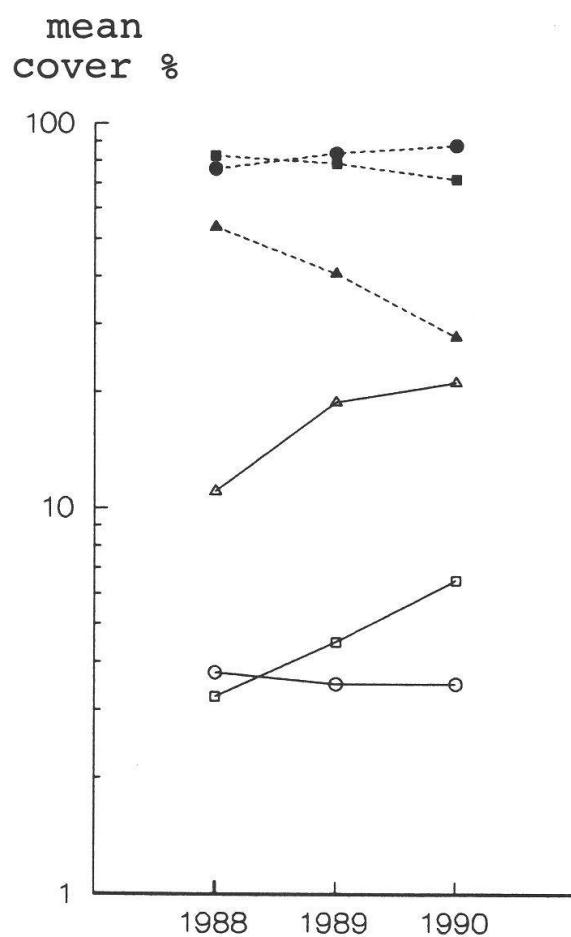


Fig. 2. Change of estimated cover (%) of *Molinia arundinacea* (filled symbols) and *Danthonia alpina* on differently treated sites (means of quadrats), 1988–1990 (logarithmic scales): ○● no treatment, △▲ mowing, □■ removing litter.

Tab. 1. Cover and standing crop of *Molinia arundinacea* before (1988) and after mowing was resumed (mean \pm standard deviation, $n=8$ quadrats).

Year	Cover (%)	Standing crop	
		gm^{-2}	Percentage*
1988	53 ± 19	161 ± 51	62 ± 14
1989	40 ± 15	92 ± 35	59 ± 18
1990	27 ± 13	57 ± 28	47 ± 19

* Total standing crop = 100%

The mean values of reproductive shoot modules per quadrat in three successive years are displayed in Figures 3 a, b with regard to different species and differently treated areas (sites).

Values were subjected to square root transformation to obtain homogeneity of variance before application of analysis of variance to test the effects of treatment, species and

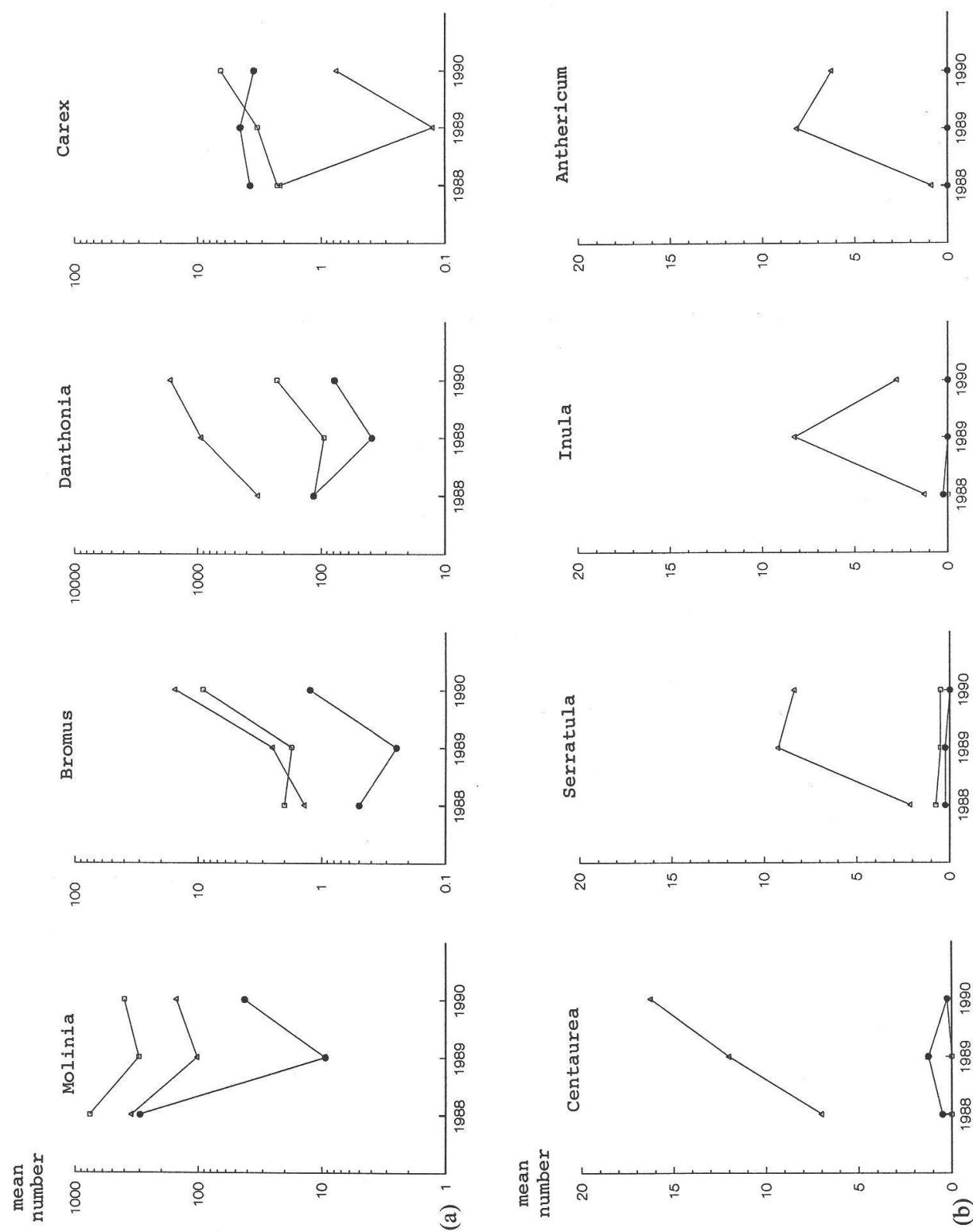


Fig. 3. Change of number of reproductive shoot modules of eight species on differently treated sites (means of quadrats), 1988–1990: ● no treatment, △ mowing, □ removing litter.

(a) *Molinia arundinacea*, *Bromus erectus*, *Danthonia alpina*, *Carex flacca* (logarithmic scale).
 (b) *Centaurea bracteata*, *Serratula tinctoria*, *Inula hirta*, *Anthericum ramosum* (non-logarithmic scale).

Tab. 2. Analysis of variance (after square root transformation) of the number of reproductive shoot modules of eight species from differently treated quadrats (two missing values).

Source of variation	d. f.	1988		1989		1990	
		m. s.	sign.	m. s.	sign.	m. s.	sign
Covariable	1			3490.00	***	6037.85	***
Treatment	2	33.13	***	121.19	***	154.11	***
Control vs. removing litter	(1)	28.37	**	25.88	***	34.77	***
Control vs. mowing	(1)	23.47	**	223.76	***	286.11	***
Species	7	850.89	***	215.52	***	424.35	***
Treatment × species	14	30.94	***	45.18	***	72.78	***
(contr. vs. remov.) × species	(7)	28.41	***	10.17	***	8.77	**
(contr. vs. mowing) × species	(7)	14.46	***	79.60	***	119.19	***
Quadrat	13	3.59		1.12		2.53	
Residual (1988)	89	3.01					
Residual (1989, 1990)	88			1.54		2.70	
Total	125						

** $P < 0.01$; *** $P < 0.001$; other P values > 0.05 .

the treatment × species interaction (Tab. 2). The data of 1988 were treated as covariable in the data analyses of the following years to eliminate effects of initial differences. 'Treatment' effects properly are combined treatment and site effects since quadrats were grouped and not randomized. Significant difference was identified between differently treated sites and different species. In addition the interaction between treatment and species was significant. Significant site differences between quadrats subjected to 'mowing' and the control already existed before different treatments were applied in 1988. Within site heterogeneity was not significant.

Discussion

There is evidence that *Bromus erectus* was the dominant species, when traditional farming was still common practice (Lüdi 1949). At the same time *Molinia arundinacea* was less abundant. Trends in proportion of *M. arundinacea* assessed by cover estimates and standing crop measurements suggest that mowing will reverse the spreading of this dominant grass. With regard to removing litter a reversal of the spreading of *M. arundinacea* cannot be concluded by using data of the short-term period 1988–1990.

Reproductive shoot modules, detected on control quadrats and apparent in *Molinia arundinacea*, *Bromus erectus* and *Danthonia alpina*, considerably fluctuated within the three successive years 1988–1990.

Strong effects of mowing are indicated by distinctly higher variance ratios in 1989 and 1990, effects of removing litter are generally less pronounced. Comparing single species, *Danthonia alpina* reacted most positively to mowing. Except for *Carex flacca* all the abundant species presented in this paper were positively influenced in the first or second year after mowing was resumed. A generally positive reaction of reproductive shoot modules to mowing was also found in the following less abundant species: *Briza media*,

Prunella grandiflora, *Succisa pratensis*, *Leucanthemum heterophyllum*, *Betonica officinalis* and *Globularia punctata* (unpublished data).

Positive effects by removing litter are apparent in *Molinia arundinacea*. This result can be compared to those of Grant et al. (1963) pointing out that flowering tillers of *M. caerulea* are positively influenced by removal of litter as a consequence of increased temperatures within the tussocks (pot experiments). Apart from *M. arundinacea* a positive reaction to removing litter is also likely for *Bromus erectus*, *Danthonia alpina* and for two low-abundance species not presented here, *Peucedanum cervaria* and *Centaurea scabiosa* (unpublished data).

Can reversal of succession by mowing (as suggested by cover and standing crop data of *M. arundinacea*) be predicted by use of a more sensitive method like counting reproductive shoot modules? The assumed positive reaction of *B. erectus* to mowing would be correctly predicted based on changing reproductive shoot module density (see also Krüsi 1981). The same method however would fail in predicting future performance of *M. arundinacea*.

Shoot module density is known to be very plastic (Harper 1977), and its year-to-year fluctuations are therefore much more pronounced compared to fluctuations of cover and biomass data. The factors determining vegetative or reproductive shoots are complex and differ from one species to another. Under field conditions they are generally not well known yet. Extraordinary weather conditions inducing long droughts during the first three years of this study are probably the principal causes of fluctuations.

Although reproductive shoots were found to be very sensitive to different treatments it is not yet clear how species change in grasslands can correctly be predicted by use of data on reproductive shoot modules. Three years of data collection are too short a time to seek for proper trends, even when precise quantitative methods are used. Species preferring more humid conditions like *Serratula tinctoria* may well positively react to mowing in the short-term as they profit from less competition by *M. arundinacea*. Lacking a cover of litter, the soils may become drier in the long-term. Eventually this may negatively influence these species.

Additional features of vigour (e.g. length of reproductive shoot modules) necessarily have to be sampled when trends in population size of plants should be seriously predicted within a relatively short time by investigations of a few years. Further investigations in two complementary ways will help to overcome the actual state of reluctance about the predicting value of reproductive shoot modules in vegetation dynamics:

(1) The first short-term reactions of reproductive shoot modules have to be tested in the long-term by permanent sampling on the experimental plots.

(2) Vegetative and reproductive shoot modules of single species have to be investigated by demographic field studies and supplemented by pot experiments to test the factors influencing the growth of vegetative or reproductive shoot modules.

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