UNIVERSITY OF WEST HUNGARY

PHD THESIS

BOTANICAL STUDIES TO SUPPORT CONSERVATION MANAGEMENT OF GRASSLANDS IN ŐRSÉG NATIONAL PARK

MÁTYÁS SZÉPLIGETI

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Doctoral school: Gyula Roth Doctoral School of Forestry and Wildlife Management Sciences

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Supervisors: Prof. Dr. Dénes Bartha, Dr. Sándor Bartha

1. Introduction, objectives

The main goal of the dissertation is to facilitate the continuous, adaptive development of grassland management of Őrség National Park Directorate. Therefore we classified our research topics into two groups: 1.) gathering knowledge for management plans 2.) continuous monitoring of management activities.Better understanding and support for local traditional farming practices is extremely important in terms of conservation management (MOLNÁR et al. 2009). However, in spite of the long history of studies on meadow management for conservation, there is still no consensus on what their ideal management would be. Thus, we decided to launch a long-term experiment on management, which effectively support evidence-based grassland management strategies for conservation through the better understanding of organizational regularities of grasslands. Mowing is the most common management practice of grasslands in the national park. Therefore the main objective of our field experiment was to evaluate different timing and frequencies of mowing on plant diversity and stands of *Solidago gigantea* – the most common invasive species of grasslands in our region. Besides texture based alpha diversity, it was our goal to study indicators of how various plant species of grasslands live together, since this makes it easier to accurately trace the differences arising from diverse management methods.

The main goals of the dissertation are below:

1. Exploring elements of traditional grassland management of the region and detecting impacts of conservational regulation on them.

2. Studying effects of mowing in different timing and frequencies on species composition, species richness, diversity and internal structure of grasslands.

3. Evaluating the correlation between the presence of *Solidago gigantea* and biodiversity and internal orderliness of hay meadows.

4. Developing an effective method for continuous monitoring of grasslands managed directly by Őrség National Park.

2. Research methods

2.1. Elements and regulation of traditional grassland management

Elements of traditional grassland management were gathered between 2011 and 2013 by directed interviews among elderly (avg. 78 years old) farmers. Then these components were grouped according to their support, prohibition or ignorance by legal provisions. The main questions were focused on the timing and frequency of mowing, location and methods of grazing, manuring and cleaning, and improvement or degradation of grasslands. In 2014 and 2015 consultations were held with farmers, conservation experts and ecologists in order to discover and evaluate the relevant correlations.

2.2. Experimental study of timing and frequency of mowing

2.2.1. Description of the study site and the experimental design

We conducted our study on a mesophyllic hay meadow (*Alopecuro-Arrhenatheretum*) in the valley of Szentgyörgyvölgyi creek on the outskirts of the village of Magyarszombatfa. It is certain that before launching the experiment, the study site was usually mown twice per year by local farmers since the 1940s, but probably for a longer time. Until the 1960s, the second aftergrass was grazed. From the late 1990s grassland management was reduced to irregular mowing only once a year.

The experimental management started in May 2007 on four adjoining, 20m wide strips perpendicular to the stream bed of Szentgyörgyvölgyi-creek according to the following treatment types: mowing once a year in May-June (the most commonly used method in the region), mowing once a year in August-September (often recommended bearing conservation in mind), mowing in both periods (generally considered as traditional landuse), abandonment (landscape-wide tendency, justifiable in some cases for conservation). The differently managed strips were divided into 4-4 20x20 m sampling units by wooden sticks.

The botanical samplings were made in May 2013 and 2014 with two different methods:

1. Using cover estimation sampling, we estimated the coverage of all present vascular plants and the average height of *Solidago gigantea* (in

cm) inside 10 randomly placed 2x2 m quadrat per sampling units (n=160 quadrats).

2. The microcoenological sampling was conducted in the 2nd row from north in every strip on a square shaped transect[user1] with the length of 52 m. We recorded the presence of every vascular plant species along the transect in 1040 pcs of 5x5 cm quadrats. An additional 3 pairs of sampling was conducted as a reference in Szalafő, Nagyrákos and Magyarszombatfa on meadows in good condition which had been mowed twice a year for several decades. Reference sampling units were placed 20 m from their pairs. To analyze the coenological effects of *Solidago gigantea*, 8 5 m long transects (n=100) were selected from all of the 52 m transects on the study area and from two reference transects.

2.2.2. Methods of analysis

Cover estimation sampling

The effects of different mowing methods on vascular plant vegetation were interpreted by number of species and Shannon diversity. Two protected plant species can be found in large numbers on the study site: *Dactylorhiza majalis* and *Ophioglossum vulgatum.* Considering their low coverage rates, we used presence-absence data to evaluate their reactions to management. We used the Pearson correlation to analyze the interrelations of average height and coverage of *Solidago gigantea* and species richness and Shannon diversity. If we found non-linear connections during modelling, we used General Additive Models (GAM); otherwise, we used Generalized Linear Models (GLM) for calculations. To study changes in species composition we applied Redundancy Analysis (RDA) with the involvement of management and quadrat distance from the creek as factors.

Microcoenological sampling

To observe and evaluate the fine-scale pattern of the mesophyllic meadows – altered due to different timing and frequency of mowing and abandonment – we worked with Information statistical Models introduced by Pál Juhász-Nagy (JUHÁSZ-NAGY 1967, 1972ab, 1973, 1980ab, 1993; JUHÁSZ-NAGY & PODANI 1983). From the microcoenological relevés (containing severally 1040 adjoining microquadrats) species richness, species richness distribution was calculated. Then we used species combination diversity (floral diversity) and associatum to express the structural complexity and the degree of spatial organization of grasslands we sampled. The stands were compared with each other in the coenostate-space based on maximum values of floral diversity and associatum. Relevés

were made to investigate correlations between *Solidago gigantea* and different types of management, we calculated first species richness, then (based on frequency values of species) Shannon diversity and evenness (TÓTHMÉRÉSZ 1997). From the 8 short transects we calculated the average and relative standard deviation of variables for each stand. Then the average coenological distances of lineas were determined using the Bray-Curtis and Sørensen Indexes (PODANI 1997). We used linear regression to find the interrelation between frequency values of *Solidago gigantea*, Shannon diversity and evenness of short lineas (SVÁB 1981). Coenological states of differently mowed meadows were compared using one way analysis of variance (SVÁB 1981).

2.3. Landscape-scale testing of the experimental results

To test our results gained from small-sized study sites on a landscape level, we looked for once or twice a year mowed meadows corresponding to currently most widespread and traditional management methods. We also added to the landscape-scale tests some humid cattle pastures. ; However, we were not able to experimentically study the effects of grazing. While collecting data, we estimated vascular plant species coverage in 6 randomly placed 2x2 m quadrats inside a 20x20 m sampling area designated in 6 locations per management types. Then we calculated the Shannon diversity and evaluated results with a one-way analysis of variance.

2.4. Monitoring system for adaptive grassland management in Őrség National Park

2.4.1. **The survey process and the chosen indicators**

Our aim was to provide essential information about the conservation status of each grassland managed by the national park (a total of 1,200 ha) up to 4-5 years. Due to the limited resources, the methodology and data sheets of the surveys were worked out so that they could be done by volunteers.

The test surveys were carried out between 2012 and 2015. The basic units of the survey were single grasslands or groups of grassy areas, which were considered as separate blocks in terms of management. The primary tasks of the surveyors was to identify habitat patches and to draw the habitat map of the units, to take photos of each habitat patch with signs of location and direction. Furthermore, they depicted stands of invasive or protected plant species were found during mapping. After the identification of individual habitat patches, the surveyors specified the dominant (>20%)

and typical (5-20 %) species, listed on the more common (>1%) weeds, the amount of the grass litter, the estimated cover of shrubs and trees, the mass of *Solidago gigantea*, the population size of *Sanguisorba officinalis* and protected plant species observed during the survey. The other endangering factors in our region (boar rooting, overuse, driving through by heavy vehicles, water deficiency) were estimated as a percentage of the affected area. The data sheets asked about the neighbouring habitats as follows: forest/avenue, arable land, similar grassland in a good conservation status, stand of an invasive species. At the end of the form, surveyors assigned a number from Németh-Seregélys's five-grade scale, which synthetically express its conservation value, and summarized their overall impressions in a few sentences

2.4.2. **Data processing and sorting into a database**

Based on these indicators, we got a data set from all of the grasslands are in the trusteeship of Őrség National Park which was updated every four years. Gathered information most effectively aids planning if it is integrated with a GIS database. This system is based on a high-quality habitat map, in which all information recorded in the field can be assigned to the given habitat patches in a table of attributes. We worked out a geographic information system, which includes the conservational status, planned and implemented treatments for each habitat patch, completed with photographic documentation. To express the conservation status of grasslands, a value number was assigned to each of their characteristics. Thereby problems we have to face on managed sites are clearly shown in a table. On this basis, we classified meadows according to typical problems and prioritized them to optimise management resources.

3. Results

3.1. Relationships between traditional grassland management practices and nature conservation regulations

Our investigations verified the prevalence of mowing twice a year in our study region, especially in wet, more productive meadows. Older farmers know the significance of mowing twice a year as it affects richness of species and hay quality. Grazing was not sharply separated from mowing; however, valuable meadows were usually not grazed in the whole vegetation period. The majority of the biomass was removed from the meadows every year; even litter was raked up in springtime. This definitely favoured species richness. Typically a small amount manuring of meadows was done infrequently. The permanently waterlogged areas with sedgy vegetation or *Molinietalia* communities were mown irregularly for cattle bedding. The current conservation and agri-environmental regulations have a direct positive impact only on activities which are essential to maintain grasslands: only one mowing [user2]per year and the prevention of spreading of woody vegetation is required and supported. However, there are only a few expressively prohibited management practices: use of synthetic fertilizers and organic manuring, raking, drainage and irrigation.

We should be able to see and interpret environmentally friendly grassland management not only on individuals parcels but also on farms and landscapes. The maintenance management of valuable grasslands can be only viable if the individual needs of farmers are also taken into account. On some less valuable meadows, manuring, raking and sometimes even drainage should be allowed. Therefore in return, on more valuable grasslands, stricter, sometimes unprofitable conservation rules can be expected.

The following traditional, small-scale farming practices should be more supported and used more frequently by the national park directorate : mowing twice a year (aftermath mowing), grazing after one mowing (aftermath grazing), scattering of hayseed, and continuous change of treatments in space and time (parcel rotation).

3.2. Effects of timing and frequency of mowing: results of the field experiment

3.2.1. Composition, species number and diversity

Mowing a meadow twice, in May and September, resulted in the highest species richness and diversity of plants, whereas both variables were lowest in abandoned plots, and intermediate in once-mown plots either in May or in September. This outcome suggests that the vegetation of the meadows adapted to the management that was most often used through centuries in our study region, i.e. mowing first in May-June and a second time in August-September (BABAI et al. in press). That means that this timing, and frequency is the most appropriate to preserve richness and diversity of mesic grasslands vegetation.

We found different richness and diversity of species between meadows mown in May and September..Species richness was generally higher in plots mown in September than in those mown in May, while diversity showed the opposite pattern.

The effect of management was strongly dependent on soil moisture as indicated by the significant interaction between management type and distance from a stream. Close to the streambed, where the water table was relatively low, twice mown plots harboured significantly higher species diversity than abandoned plots, but they did not differ significantly from once mown plots. Further from the stream however, this difference became significant. These results suggest that mowing twice a year is not essential for maintaining high diversity in drier types of mesic meadows, whereas it becomes more important as moisture increases.

3.2.2. *Solidago gigantea*

Our results highlighted that mowing twice a year is necessary for efficient suppression of invasive *Solidago gigantea*. In plots infested by *Solidago gigantea*, many species were displaced or almost entirely suppressed owing to its shoot height and clonal, rhizomatous growth. Both alpha and beta diversity of meadows we studied showed a decline as a result of increasing coverage of *Solidago gigantea*, and its horizontal structure has become spotted. However, according to our microcoenological investigations on meadows in a good state of conservation and with favourable **environmental** [user3]conditions, a significant micro-scale diversity loss occurs only when the rate of *Solidago gigantea* is above 30%, which means 80% in coverage. Stands of invasive *Solidago* are not able to close everywhere; therefore, many open patches remain for other species to survive, even in abandoned grasslands (KUN et al. 2014). In this

study, we observed a significant association between frequency of *Solidago gigantea* and diversity loss, however the strength of the relationship was weaker than anticipated. This result suggests, that *Solidago gigantea* is not the primary factor responsible for degradation of under-used or otherwise endangered grasslands, but rather occurs as a symptom, and there is a good chance to reverse its negative impacts over a long time. Because mowing once a year became general in our study region, instead of the traditional mowing twice a year (and several meadows were abandoned) greatly contributes to the constant presence and spread of *Solidago gigantea* (SZÉPLIGETI et al. 2015). Hence, a landscape-level increase in the frequency of mowing is required. We emphasize the practical importance of soil water conditions in control of *Solidago gigantea*.On drier plots (independently from timing and frequency of mowing or abandonment) it has lower coverage values, and responds more sensitively to the mechanical treatment.When mowing twice is not feasible, our results suggest that late mowing is more efficient. In plots mown in September stands of *Solidago gigantea* grew thinner, although they remained permanently. These results suggest that it is more effectively suppressed by [user4] mowing during the flowering period when most nutrients are invested in sprouts and florescence. Late mowing weakens polycormons more efficiently. In addition, late mowing favours the spread of native competitor species (eg. *Alopecurus pratensis*) , which are more resistant to the colonisation of goldenrod.

Species of conservation interest

Dactylorhiza majalis showed a preference to twice-mown and September-mown plots. When mowing is done in September, *Dactylorhiza majalis* can successfully disperse its seeds, and there are favourable conditions (reduced shading and competition) during the vernal sprouting. Mowing twice seems to be an appropriate management if there are late mown refuges on a part of the given plant **population**. [user5]It was found only in the wetter, northern plots, what could be explained by their high water demand.

Ophioglossum vulgatum does not seem to be so **sensitive** to soil water content, or to light conditions and competition. Although, it is more frequent on plots mowed at least once a year, we sometimes found it under dense stands of *Solidago gigantea*.

3.3. Landscape-scale testing

The results of landscape-scale testing confirm experiences gained from our experimental site.Typically once-mown sites showed significantly lower numbers of species and Shannon diversity, than twice-mown ones. Similarly, the average cover and height of *Solidago gigantea* was significantly lower on twice-mown meadows than on once-mown ones. Compared with grazing, mowing twice resulted in a significantly higher number of species. The difference in Shannon diversity between data samples was not significant. On grazed sites, the number of species was significantly higher, than in once-mown meadows. The cover of *Solidago gigantea* was negligible on all of grazed sites.

3.4. Conservation status of meadows managed by the Őrség National Park Directorate

According to our results, accumulation of litter is a general problem on the meadows we studied. Besides fallow grasslands and abandoned sites, indicator there are more species of degradation on pastures. The average cover of *Solidago gigantea* is 20% on surveyed grasslands. Serious, over 40% average cover is mainly typical on sites, which were unmanaged for a long time, or on those, which are regenerating after reconstruction, (removal of mature shrubs) . In some locations, however, it is clearly associated with treatment which was not done intensively enough and/or inappropriate timing. Out of further risk factors, boar rooting was recorded on 13% of all examined sites, and overuse was reported from pastures. While driving through the grasslands was an endangering factor only in three cases, 24% of grasslands suffer from a lack of water. Most of the surveyed grasslands are located in an unfavourable environment. Younger shrubs and trees sporadically appear everywhere, but they were a serious risk on only 11% of the sites. More than 50% of the sites had at least a sporadic occurrence of *Sanguisorba officinalis,* known as host plant of *Maculinea teleius* and *Maculinea nausithous* butterfly species..

Based on plus-minus scores given to stands of protected plants and invasive *Solidago gigantea*, we assigned 4 priority level among examined sites, to promote effective use of management resources.

4. Practical utilization of the results

- The information gained from better understanding of traditional grassland management practice can be used both for planning nature conservation management and for developing conservation regulation systems.
- The results of our mowing experiments revealed the importance of timing and frequency of mowing, which provides more conscious planning in grassland conservation.
- The development of a method to control of conservation status of grasslands managed by Őrség National Park enables a combined register and assessment of endangering factors, values, planned and completed treatments on a given site. This system provides a basis for adaptive conservation activities.

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