Effects of land-use change on grassland biodiversity

Dr. Eszter Karolina Ruprecht

Habilitation thesis

Abstract

In my habilitation thesis I present my scientific, professional and academic achievements between 2007 and 2015, after I finished my PhD. The object of my scientific interest was dry grassland (*Festuco-Brometea* communities) in the Transylvanian Plateau, with a special emphasis on continental dry steppe-like grassland dominated by feather grasses (*Stipa* spp.) in the Transylvanian Lowland, and the effects and consequences of land-use change on species diversity and mechanisms behind.

The Transylvanian Plateau in Romania is well known to host large areas of a variety of dry grassland types, still traditionally managed by low-intensity mowing or grazing. This natural heritage is currently facing substantial land-use changes in the form of intensification and abandonment, which threaten their rich biodiversity. Transylvania still hosts High Nature Value grasslands that are biodiversity hotspots at a global scale, and preserving these grasslands should be of a national priority. Continental dry steppe-like grasslands dominated by feather grasses in the Transylvanian Lowland belong to the priority habitat type 62C0 (Ponto-Sarmatic steppes) of the Habitats Directive of the European Union. This conservation interest revealed a serious lack of data regarding the actual state and vegetation dynamics caused by changes in management of these xeric grassland types in the Transylvanian Lowland.

In a first study I wanted to find out what are the consequences of grazing abandonment on the *Stipa lessingiana* dominated steppe-like grasslands, and what is the relative importance of management and environmental factors in causing variation in species composition in the continuously grazed and abandoned grassland stands. Our results pointed out that grasslands formerly grazed, dominated by *S. lessingiana*, in the long-term absence of grazing have been transformed into *Stipa pulcherrima* dominated type. Management, probably by creating bare surfaces and preventing litter accumulation, had the strongest effect on the species composition. Abandoned grassland stands had lower diversity and evenness compared to continuously grazed stands, while at the same time, the relative number of threatened, rare species did not differ between managed and abandoned sites.

The accumulation of biomass and of dead plant remains is a direct consequence of grassland abandonment. Litter can occupy potential microsites for seed germination and seedling establishment, and thus decrease species diversity in the long-term. This effect can be more

accentuated in dry grassland of open structure where species are adapted to excessive light and bare surfaces during the recruitment phase. In collaboration with German scientists, we conducted a field experiment with litter removal alone or in combination with vegetation cutting and studied germination and seedling survival during two years in two abandoned grassland sites. With our experimental treatments we intended to create microsites and to activate the seed bank, with the aim to enhance recruitment of dry grassland species; potentially also those already absent from the established vegetation. Our results show, that while both treatments significantly increased recruitment by enhancing seed germination in the first year of the study, only litter removal combined with vegetation cutting significantly promoted seedling survival during both years. Our experiment demonstrated that even after 40 years of abandonment the applied measures favoured the re-emergence of target species that were very rare or absent from the above-ground vegetation of continental steppe-like grassland. Thus, management prescriptions which comprise removal of dead and even living biomass, such as mowing or grazing, are considered beneficial for this habitat type of high nature conservation priority.

In a series of laboratory and field experiments we studied various chemical, physical and mechanical effects of litter on seed germination and seedling recruitment of dry grassland species. Community composition and ecosystem processes during succession may partly be driven by traits of plant species that attain dominance. Thus, in the first experiment related to litter effects, we addressed the hypothesis that *Stipa pulcherrima*, the dominant grass of abandoned steppe-like grasslands, control seedling recruitment of co-occurring species through chemical effects of its litter. Eight species were selected to experimentally study effects of leaf leachate on the seed germination and seedling recruitment. Leachate affected various stages of seedling recruitment: it significantly reduced seed germination (by 33-94%) and radicle elongation, and it delayed germination of seedlings of all species. Besides other traits and physical or microclimatic effects of accumulating litter, *S. pulcherrima* influences plant community dynamics and may potentially affect ecosystem processes through its secondary compounds.

Isolating physical, chemical and mechanical effects of litter has rarely been achieved experimentally. Thus, in a next study, we tested the effects of different 'litter' types on the germination of dry grassland species, by carrying out a controlled pot experiment using three natural litter types differing in decaying state and composition (*Stipa pulcherrima* fresh leaves, partly decomposed leaves, mixed partly decomposed plant material) and an artificial litter. As a complementary field study seed sowing was conducted in grassland plots with litter removal and plastic litter application. Litter effects were mainly positive or neutral under controlled experimental conditions, and mostly negative in the field. Seed size and environmental

conditions were proved to be the major determinant of litter effects on germination. Significant differences were found in the effect of litter types on germination, much of which could be explained by chemical factors determined by decaying state, since we confirmed the higher concentration of allelopathic compounds in *S. pulcherrima* fresh- than in senesced leaves. As a main conclusion of this study, 'litter' identity and quality matters: litter composition and decay state is influencing its effect on seed germination.

From various potential litter effects on seed germination and seedling recruitment, mechanical effects of litter, as barrier to burial for freshly shed seeds, were the least studied. While there is a huge amount of data about seed mobility within the soil, there is a serious lack about the fate and movements of seeds through other mediums like litter or moss. We analyzed the seed content of litter and underlying soil collected from six dry grassland sites having different disturbance histories, ranging from sites that are currently still grazed to those that have been long abandoned. We related seed content of litter to litter quantity, seed morphology and to the seed content of soil. Grass litter was proved to represent a natural trap for seeds, since we identified significant quantities of seeds of a large number of species within litter samples, and there was a mass effect in the seed trapping by litter– higher litter quantities entrapped more seeds. As a long-term consequence, we expected seed-bank stores to be gradually depleted in abandoned grassland due to the elimination of seeds by litter, but this was not the case. A higher seed production of the above-ground vegetation found in undisturbed sites was very probably compensating for seed losses through litter. Seeds retained by the litter were found to be larger, more rounded and bearing appendages. Especially for those seeds meeting one of these criteria, litter represents a hazardous medium, since the seeds may have failed or delayed germination.
The role of litter as a seed trap is more relevant in grasslands that haven't been disturbed for a long time, where litter seed entrapment can exert a selective pressure on certain species, and by this means drive community assembly in grasslands.

As in many regions of Transylvania sustaining traditional management, grazing and mowing, is not feasible any more, conservation managers as well as farmers are looking for alternative, but cheap solutions to hinder litter accumulation and to arrest succession to shrubland or forest of grassland communities. Fire is not an integral part of terrestrial ecosystems in temperate Europe, nevertheless prescribed burning is proposed to be an alternative to traditional management applied to grasslands. Thus, anthropogenic fire represents a serious challenge to plant species not adapted to this disturbance type, and there is no information on how the recruitment of species responds to fire. The aim of our study was to assess the effect of fire on seed germination of 16 herbaceous grassland and ruderal species belonging to four common families. We performed a controlled pot experiment involving heat treatments and

experimental fire applied to seeds and followed their germination. Seed germination of half of the species was decreased by the passage of fire, and a heat shock of 100 °C for 5 min had an even stronger adverse effect. Seeds of three Fabaceae species were stimulated by heat or fire, while negative effects prevailed among species belonging to other families. Anthropogenic fire in grasslands of temperate Europe might reduce recruitment by seed, particularly in species of the Asteraceae and Poaceae, two very important families with a large representation in temperate grasslands. Our results indicate that prescribed burning should be carefully applied in order not to endanger the local persistence of grassland species whose seedling emergence is negatively affected by fire.

In order to find a proper management scheme to restore abandoned dry grassland, in a final long-term field study we analysed whether restoration measures involving yearly biomass removal over nine years have a beneficial effect on the structure and composition of long-term abandoned European steppe-like grassland; and what is the effect of a single accidental fire event on this grassland community. In two long-term abandoned grassland sites, we experimentally carried out yearly biomass removal by clipping and raking, and by raking alone over a period of nine years. We analyzed the effect of the two planned treatments in both sites and that of an accidental fire in one of the sites on the structure and composition of vegetation. We applied a predominantly functional trait-based analysis, but the dominant species *Stipa pulcherrima* and *Carex humilis* were treated separately. Yearly biomass removal applied for nine years at one site favored subdominant grasses and short-lived forbs over long-lived forbs and the two dominant species, and generated a successional shift to more open grassland. The clipping and raking treatment promoted plot-scale species richness when the grassland species pool was large enough. The number and abundance of red-listed species were not influenced by our treatments. The single accidental fire event at one of the sites negatively affected the two dominant species and promoted one of the subdominant grasses. In addition, burning in combination with abandonment and presence of stoloniferous grass species benefiting from fire decreased species richness. Variation in weather conditions, in particular the series of dry years during our experiment, caused significant changes in vegetation cover and the quantity of litter, and decreased the abundance of *S. pulcherrima* in both sites and that of long-lived forbs in one site. According to our results, biomass removal had a beneficial effect on vegetation structure and composition in long-term abandoned steppe-like grassland. Until further experimental data on the effect of burning on temperate dry grassland are available, traditional management practices should be favored over alternative methods.

At the end of the thesis I present my plan and ideas on my future scientific and academic development.