



**THE ROLE OF THE LAND MANAGEMENT AND THE
ENVIRONMENTAL FACTORS ON THE GRASSLANDS
OF THE NASZÁLY'S EDGES**

THESIS OF PH.D. DISSERTATION

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1. Background and objectives

At present, the grasslands are exposed to more and more threatening factors. They are used as an agricultural area, the landscape is fragmented by creating plots, the smaller spots are isolated from each other, and so the exchange and the variety of the genetic material is prevented. At the same time, on the remaining grasslands, overgrazing and overexploitation could be typical. Concerning industrial activities, mining could be very adverse effect on the surrounding vegetation. Due to the development of transport, an increasing number of road and rail networks are built, by further shaping the landscape. Due to the structural deterioration of grasslands and the decline of diversity of the level of species, motivates sustainable management during land cultivation, and that the protected natural areas should plan to be used according to the recommended technologies (Soons et al. 2005).

Concerning nature and landscape protection researches it is very important to get acquainted with local topographical, soil, and climatic conditions, and to explore the connections of those with each other and the vegetation. The examination of secondary successional processes caused by anthropogenic disturbances is also an increasingly important research topic (Valkó et al. 2012). The protected areas are often unable to provide good living conditions for the species, because due to tourist behaviour even the humans seeking the natural values, are destroying those by trampling on them and throwing wastes away.

On the remaining fragments of grassland high-value protected, relict and endemic species might occur. However, a considerable part of the Hungarian grasslands can only be sustained by human intervention, without it they would be forests. For the preservation of them, grazing, shrub controlling and mowing are necessary. Invasive species can also be suppressed with the latter one.

No final consideration is the fact that conservation of nature may only be in conformity with economic interests, as grazing and mowing provide a valuable feed for live-stock farming. Hay and grass, grazed by animals on grasslands, have different feed values. The extent how it is nutritious for the animals, depends on the ratio of the useful and less useful grass species and on the botanical composition (Barcsák 1986). On the natural grasslands there are a lot of herbs with physiological effect. In the grasslands, rich in herbs, the ratio between the microelement content, the crude fiber and the crude protein is favourable, besides they are rich in taste and flavour (Schmidt 1992).

Around the Naszály, where my research areas are located, in terms of nature conservation high priority is given to the sustainment of the Pannonian steppes, the dry grasslands and scrubland versions, the protection of grassland associations from degradation threatened by invasive species, and the restoration the steppes into grasslands and the sustainment of them with extensive land use.

At the northern foot of Naszály an *Arrhenatherum* hay meadow is located in the valley of “Lósi” stream (Pintér et al. 2010). This grassland provides home for a species-rich community. The relative large distance from settlements played a role in the sustainment of the meadow, but this isn't a wilderness area any more, because of the development of transport and the intensification of tourism. The bed of “Lósi” stream hasn't been built up yet, so the natural water supply is temporarily assured. On the meadow, certain protected plants, especially orchids and carnation species also occur in larger populations, so the ambition to preserve and to protect the natural beauty of the meadow was what sparked my interest to explore the area.

However, at the southern side of the Naszály, next to the grasslands located at the mountain's foot, the mine and agricultural areas are increasing. Therefore, the question is, how can land use be planned, that the remaining values can be seen also by our descendants. The small mosaics of grasslands, used to be utilized as vineyards, are mostly barely accessible and make a challenging task to the researcher. They are also abounded with protected species and cover the landscape with colourful flowers.

Studying the effects of environmental factors and anthropogenic ecosystems is rather complicated due to the complexity of ecosystems, and the results can also be misleading. Therefore, this research topic, despite a number of previous test results maintained its actuality (Bartholy et al. 2012, Besnyői et al. 2012, Bartha et al. 2014). Besides the widespread ecological indicators and the diversity calculations used in the previous studies, emphasis is laid on computer programs, managing greater complexities and are able to take into account a number of variables, while the natural processes and the change in the structure of associations can be better followed. At the evaluation of test data I tried to put greater emphasis on the many-sided, more complex methods such as the ordination analysis. By the use of analysis the correlations can be detected, which could not be previously quantified and displayed in a graphical form (Podani 1997).

By additional landscape history analysis of the examined area during botanical researches, processing contemporary maps with GIS application, data are provided, which have not yet been detected and represented in the

region (Gustavsson et al. 2007). The scientific results, supported by the consequences of past studies contribute to the certification of subjective assumptions in a rational, numerical manner, and so it increases the acceptance of the explored fact. The findings based on many minor elements, localized in and being specific for a region, have both in the short and in the long term at least similar or greater practical importance and use, than the efforts revealing global regularities.

I have set the following objectives:

- *making an analysis of land use history about the surrounding of Naszály*

By analysing land history, I wanted to deduce the past of the grasslands around the Naszály and to follow up the former land use and the changes occurred due to it. We need to be familiar with the past land history, because it affects the activities we can plan in the future in the region. During the work it was also an aim to conduct the analysis with the help of the currently available, modern geoinformatics processing.

- *making floristic analysis of the grasslands around the Naszály*

Focusing on the registration of discoverable plant species the purpose is to examine, which species occur on the grasslands around the Naszály, which protected plant species can be found in them, and how valuable they are based on their structure of species.

- *analysing the vegetation around the Naszály*

By determining the category of the vegetation on the area and analysing the species in the vegetation type we can explore different ecological characteristics. The examination of the vegetation I planned to process the data collected in 3 years to filter the effects of the different years and make them evaluable.

- *examining the management and the effect on the grasslands caused by landscape historical past on the vegetation*

Here I tried to give reply to several questions. Since the area was covered with forests many centuries ago, and on some sampling areas, based on contemporary maps, forests can be seen, therefore, I examined whether the forests have an influence on the species's structure of the grasslands. The question was, which form of management is the most suitable for the conservation of the vegetation and the landscape. Considering the landscape management on the sampling areas, my purpose was to examine which

deviations can be proved in the vegetation of the areas with a land use for many years of mown, unmown and wooded pasture. Hereby the question was, which are the impacts of mowing to the vegetation as a form of land conservation management. In addition, my aim was to explore the structure of an abandoned orchard in the southern area.

- *surveying the role of the environmental factors*

I planned to compare meteorological datas of the sampling areas with the analysis results of vegetation to answer the complex question.

2. Materials and Methods

I characterized the landscape facility of the grasslands at the foot of the Naszály according to Dövényi (2010).

I assigned totally 8 sampling areas at the northern and the southern grasslands of the Naszály, in which there were some variances in the parameters of land use, landscape history or in water management. On the meadow “Gyadai” mown, unmown grasslands, wooded pasture areas and – in addition – at the southern side of the Naszály an abandoned orchard were chosen.

I assigned 2x2 m quadrats for coenological sampling, a total of 80 pieces, so that all subareas comprised 10-10 pieces of them. So I used a stratified random sampling, where the different strates represented the variant facilities. The field data collection was performed in 2013, in 2014 and in 2015. The sampling dates were in spring, in early summer and in autumn. On the field site I assigned the quadrats with Garmin Dakota 20 GPS, and at the following sampling times I looked up the permanent sampling quadrats with the help of GPS. At samplings I noted the time, the GPS recorded the exposure and the elevation.

For the identification of the plant species I used primary the first and the second volumes of the New Hungarian Herbal and I stipulated the plant names according to it (Király G. 2009, Király G. et al. 2011). In addition, however, I could use another herbal as support written by Simon – because of the different explanations and different formulations (Simon T. 1992). For the identification of associations I used the literature named Red book about the plant associations in Hungary and the General National Habitat Classification System (Borhidi et al. 1999; Bölöni J. et al. 2007).

I examined the land structure of the Naszály, it's surroundings and the changes in the past with the help of military, topographical maps and aerial

photos. For examination purposes I assigned an area sized 1600 hectares at the the Naszály and the foot of the mountain. I digitalized the map in QGIS program and so the changes occurred could be followed up and quantified.

I used Flora data base for the assessment of the flora data (Horváth F. et al. 1995). I summarized the data of coenological samplings in an excel table and I also added the data of the flora data base to it. For the sampling areas, in the categories of Zólyomi, the heat-, soil-, moisture- and nitrogen demand were examined. I carried out the examination based on Borhidi's social behavior types (1995) and Simon's nature reserve categories (2000).

I counted the Shannon diversities for all the quadrats of the whole data base and for all the sampling dates. I used Welch test to make the decision whether the differences between the means are significant. I used cluster analysis and ordination analysis calculated by Bray –Curtis function to demonstrate the similarity and dissimilarity of the sampling areas (Podani 1997). The analyses were carried out in the R 3. 02. program.

I elaborated local, site-specific and meteorological data of the examined grasslands. The meteorological data series were available from the database of the National Weather Service. The N. W. S. determined the rainfall and temperature dates of 2013-14 by interpolation on 1-1 points of the northern and the southern grasslands of the Naszály.

3. Results

3.1. The results of the landscape history analysis

During the first military survey of Hungary the extent of forest areas was 72% in the surveyed area unit, while the smaller areas were covered by vineyards (15%) and by arable lands (6%). Grasslands subject to the investigation can only be found on "Gyadai" meadow and along the streams in a narrow segment, amounting to 6% of the area. Based on the second military survey, the ratio of the vineyards at the parts of the mountain's southern foot has been increasing from 15% to 19%. In the valleys of streams small orchards appear as new structural units (1%). In the valley of "Lósi" stream, on the meadow "Gyadai", the area of grasslands is increasing, causing the disappearance of forest parts. The territorial ratio of grasslands is 9%. Based on the third military survey, it can be concluded that at the southern marginal regions of Naszály vineyards and orchards are still planted, and there are forests in the higher mountain regions. Also at that time, the "Gyadai" meadow functioned as grassland.

In the first quarter of the 20th century, the land was used similarly. At the northern foot of the Naszály, on the “Gyadai” meadow, along the streams, grasslands, somewhere trees could be found. There were small orchards alternated with vineyards at the southern foot of the Naszály, and arable lands were cultivated further south. In 1959, the “Gyadai” meadow was scrubby grassland, and some grasslands were ploughed. In the southern foreground of the Naszály, among the old vineyards more and more small orchards were wedged. On the parts of the mountain’ foot, a grassland formerly planted by trees, scrubbies appear, too. On the gentle slope under the limestone mine and “Látó” pike of Naszály, besides grasslands, the area of vineyards and the orchards is considerable.

According to the sources of 1979 the forestry and intensive mining activity on the Naszály continues and the cement factory expands. On the opencast mined areas bare surfaces are formed, and the surroundings of “Vaskapu” is planted with pine trees. The “Gyadai” meadow on the topographic map of 1987 was an arable land in a smaller perpendicular forest grubbing, and along the “Lósi” stream there were wells, grassland with trees, with tree groups and somewhere. On the southern scrub boundary area, at the sharp hairpin bend of the road, the vineyards, the arable lands and the orchards were replaced with an area characterised by trees and bushes. By the end of the 20th century, the southern foreground of the Naszály is significantly fragmented. On the parts, facing from “Sejcei” road to the mine, the cultivation of vine has already been abandoned; instead grasslands with woody areas are growing. In the 1990s, the rate of area covered by vineyards was 0,4%, that of the orchards 3%, the arable lands 5%, and that of the other areas (eg . mining area) 9%, where the vegetation is completely eliminated. On the parts besides the “Sejcei” road and east of the “Sejcei” road where previously grasslands, orchards, vineyards with patches of forest and arable lands were located, instead, forest management and intensive planting of trees can be seen on the land use plan of 2011. In 2011, the ratio of forests was 60% in the surveyed area. The ratio of gardens was 5%, and that of the arable lands was 4%, that of the mining areas was 21%. The valuable areas on the southern foot of the Naszály have been planted with trees, and were utilised for mining, and so they are threatened by elimination. The ratio of the grasslands on semi-natural areas is 6%, and nearly 1% of them is located on a mining area. The “Gyadai” meadow was subjected to local protection.

3.2. Floristic results

I compiled the list of the plant species found on the sampling areas and the regional prevalence data of plant species based on a three-year (2013-15) survey. I reported the spread of the domestic species by treating the works of Király (2009), Simon (1992) and Pintér et al. (2010).

On the sampling areas, 11 protected species were found. From these, in the surveyed land uses, in random distribution, 4 protected species in each of the land uses occurred. However, regarding to the number of individuals, the protected plants most massive occurred on the mowed areas and on the abandoned orchard.

The Slovak Penny-cress is a community importance species according to Annex 3 of Decree No. 275/2004 (X. 8.) of the Government on nature conservation areas of European Community importance (NATURA2000). At the coenological samplings, the Slovak Penny-cress was recorded on three areas of “Gyadai” meadow totally in 4 quadrats.

3.3. The results of vegetation analysis

3.3.1. The results of cluster analysis

On “Gyadai” meadow characterized with a land use of mown, unmown grasslands, and wooded pasture areas – in 2013 can be well separated from the other areas the quadrates of mown area affected by tourism. On separate branches are shown on the dendrogram the quadrates among the mown areas which are located at the entrance of the meadow and were previously forest areas, and the unmown areas closer to Ósagárd except for 2 kvadrats, in which *Bromus erectus* occur with bigger and *Trifolium montanum* with smaller cover. The separation of the unmown areas farther from Ósagárd is less unambiguous. Some of the sampling quadrats of the wooded pasture taken in this year don't separate totally from the mown areas. In 2014 is the separation of the unmown areas closer to Ósagárd conspicuous, and the part of the wooded pasture being forest area previously and the other unmown area totally separated from the other areas. The two mown areas closer to Ósagárd can't be separate from each other. In 2015 the subareas of mown areas and the mown area farther from Ósagárd can be separated from the other areas unambiguously except for some quadrats mentioned above. The quadrates of wooded pasture and the wetter unmown area aren't separated from each other totally.

Based on the joint cluster analysis of 2013-15 among the sampling areas of “Gyadai” meadow the mown area loaded by tourism is markedly

separated. On the cumulative dendrograms of the sampling areas containing the abandoned orchard too – the abandoned orchard highly differs from the other sampling areas in 2013, 2015, but in 2014. The wooded pasture and the wetter unmown area also highly differ from the other sampling areas of “Gyadai” meadow. On the cumulative dendrogram of 2013-15 it is conspicuous that the abandoned orchard, the mown area affected by tourism and the wetter unmown area are separated.

In 2013 the sampling quadrates of the unmown area located closer to Ósagárd are uniform except for 2 quadrats, and the sampling quadrates of the unmown areas farther from Ósagárd are uniform, too. One sampling quadrat differs especially from the other ones of the area, in which *Calamagrostis epigeios* and *Galium boreale* appear with relatively big cover. We can see similar tendencies in 2014 and 2015 to the one in 2013. In two separated quadrats of the unmown area closer to Ósagárd *Bromus erectus* appeared with bigger cover, *Trifolium montanum*, *Arrhenatherum elatius* and *Dactylis glomerata* appeared with smaller cover in 2014, while in 2015 *Bromus erectus* appeared with bigger cover, *Trifolium montanum*, *Arrhenatherum elatius* appeared with smaller cover, than in the other quadrats. The cumulative analysis of unmown areas for the 3 years shows, that the quadrates of different years aren't combined, the quadrates of the two sampling areas separate from each other.

In 2013 the mown area located at the entrance of the meadow, which might be a forest area previously, is sharply separated from the other mown areas. On the subareas, besides the dominance of *Potentilla alba*, the cover of *Bromus erectus* and *Trifolium montanum* are considerable. Those sampling quadrats, presenting a place among mown areas and frequently visited by tourists make a separated group on this subarea, besides *Bromus erectus*, *Festuca rupicola* is dominating. The two mown areas located closer to Ósagárd, aren't separated from each other unambiguously. In 2014 the part affected by tourism and the area located at the entrance of the meadow are separated from the other mown areas. On this latter one, besides the dominance of *Potentilla alba* the cover of *Bromus erectus* and *Trisetum flavescens* are considerable. The two mown areas located closer to Ósagárd, aren't separated unambiguously from each other. In 2015 the mown area at the entrance of the meadow, with the dominance of *Potentilla alba* can also be separated from the other mown areas, and the other mown area frequently visited by tourists with the dominance of *Bromus erectus*. At the mown areas, in the different years, the quadrats of the same sampling areas arranged next to each other, except for those quadrats, which were to be

established in each year on the dendrograms to differ highly from the other quadrats of the sampling area.

In 2013, the quadrates of the wooded pasture are rather heterogeneous. The wooded pasture can be characterized by the dominance of *Alopecurus pratensis*, besides the presence of *Galium verum* and *Poa angustifolia* are also considerable. In 2014, based on the samplings, a forest area previously covered a greater portion of the subarea, may be found. On the former forest area *Alopecurus pratensis* dominates, besides the growing of *Galium verum*, *Trisetum flavescens* and *Arrhenatherum elatius* is considerable. In 2015 the similarity indexes are much smaller than in the previous two years. Thus, in this year, it is not possible to assign the forest border unambiguously. Based on the cumulative dendrogram of wooded pasture the former forest border can be proved in 2013-15.

In 2013 at the abandoned orchard two quadrats highly differ from the other quadrats of the abandoned orchard. In one the covers of *Aster sedifolius* and *Medicago lupulina*, in the other one *Dactylis glomerata* and *Elymus repens* are considerable. In 2014-15, each one quadrate differs from the other ones because of the considerable cover of *Fragaria vesca*. The analysis shows that the sampling quadrats in the different years don't mingle with each other considerably.

3.3.2. The results of the detrended correspondence analysis

The test areas were shown on the DCA-s summarising the subareas on a yearly basis on the one hand, and on a three year basis on the other hand. In 2013. all of the areas of "Gyada" separated from each other. The wooded pasture separates from the others based on *Astragalus cicer*. There are 3 mown areas where *Moenchia mantica* is a dominant species. On the mown area located at the entrance of the meadow the cover of *Potentilla alba* and *Leontodon hispidus* is larger than on the other areas. The species of the unmown area, which dominant in the separation from the other areas, are *Arrhenatherum elatius* and with a rather considerable cover, *Trifolium montanum*. The unmown area farther from Ósagárd represents an area where there are relatively many common species with those in the other areas.

In 2014. the separation of all the areas from each other can be observed. The wooded pasture and the unmown area closer to Ósagárd are best separated from the other areas. The two unmown areas are next to each other, which supports their similarity. The mown area affected by tourism and the mown area at the entrance of the meadow were more similar to each other, than the other mown areas, and the other two mown areas differ from

those two areas differ from each other highly. On the mown area closer to Ösagárd, *Agrostis stolonifera* and *Rhinanthus minor* occur frequently, than on the other mown areas. On the wooded pasture area, *Alopecurus pratensis*, *Pulmonaria mollissima* and *Vicia cracca* appear with larger cover. Species of the unmown area closer to Ösagárd, being dominant in the separation process, are *Trifolium montanum*, *Agrimonia eupatoria*, *Arrhematherum elatius*, *Cruciata laevipes* and *Dactylis glomerata*. The mown area farther from Ösagárd is separated from the other areas by the higher cover of *Trifolium alpestre*, *Carex praecox*, *Trifolium campestre*, *Moenchia mantica* and *Ranunculus acris*.

In 2015, the mown area affected by tourism differed from the other areas most highly. The difference between the wetter unmown area and the wooded pasture is relatively small. The wooded pasture differs from the other areas because of the cover of *Anthriscus sylvestris*, *Euphorbia salicifolia* and *Astragalus cicer*. The typical species of the dryer unmown area are *Clinopodium vulgare*, *Hypericum perforatum* and *Cruciata glabra*. The mown area affected by tourism is separated from the other areas by the appearance of *Centaurea scabiosa subsp. spinulosa* and the higher cover of *Plantago lanceolata*, *Anthoxanthum odoratum* and *Seseli annuum*. The typical plant species of the mown area located at the entrance of the meadow are *Lathyrus latifolius*, *Leontodon hispidus*, *Potentilla alba*, *Primula veris*, *Rhinanthus minor* and *Briza media*. On the combined DCA of “Gyadai” meadow assessed in the different years, the samplings of the same areas arranged into the same direction, except for the mown area at the entrance of the meadow.

Based on the DCA of 2013, summerising all the areas, the abandoned orchard is separated considerable from the other areas. There *Thlaspi perfoliatum* and *Vicia tenuifolia* appear with larger cover, than those on the other areas. In 2014, the abandoned orchard can definitely be marked from the other sampling areas. On these areas *Vicia tenuifolia*, *Salvia nemorosa* and *Thymus glabrescens* appear with typically larger cover than those on the other areas. In 2015, the abandoned orchard are markedly separated from the other areas. On the combined DCA of 2013-15, the typical species of the abandoned orchard are *Aster linosyris*, *Vicia tenuifolia* and *Salvia nemorosa*.

Based on the DCA of the unmown areas, the samplings taken in 2013, an area can be separated, which presents the unmown area closer to Ösagárd and an other presenting the unmown area farther from Ösagárd. Also in 2014-15, the two areas make two independent units.

In 2013, three parts can be separated from each other on the mown areas. An area can be separated containing the quadrates of the mown area located at the entrance of the meadow. The quadrates of the mown area affected by tourism also make an independent group, that contains all of the quadrats of the part. The third part is formulated by the two mown areas at Ósagárd, which two part aren't definitely separated from each other. In 2014-15, four parts can be separated from each other at the mown areas, but this separation isn't unambiguously, because there are some quadrates that are mixed between the parts at a minimum level. Based on the DCA of the wooded pasture sampling taken in 2013, on the featured areas, the structure of species of the sampling quadrates is relatively similar to each other except for 3 quadrates. Previously there was a forest on the major area of the wooded pasture, that can be detected by ordination analysis, including those assessed in 2014-15. Based on the DCA of abandoned orchard area taken in 2013, on the featured area two sampling quadrates seem to be different in terms of structure of species from the other surrounding quadrates. In one quadrate, *Dactylis glomerata* can be found with larger cover and besides *Achillea collina* appears. In the other quadrates, the ratio of *Thymus pannonicus* and *Achillea nobilis* is considerable. In 2014 three sampling quadrates, and in 2015 two sampling quadrates differ considerably in terms of the structure of species from the other surrounding quadrates.

3.4. The diversity analysis of the sampling locations

Based on the findings in 2013, the diversity of the wetter unmown area is rather smaller than those of the other areas. The diversities of mown area affected by tourism and of the abandoned orchard at the southern side are smaller than the diversities of the other mown areas and the wooded pasture.

Based on the assessments in 2014, the diversity of the wetter unmown area is rather smaller than the diversities of the other areas. The diversities of the wooded pasture on the unmown areas are smaller than those of the mown areas, except for the area affected by tourism, which diversity is also smaller than the other mown areas. In this year the diversity of the abandoned orchard located at the southern side isn't smaller than that of the other mown areas.

Based on the assessments in 2015, the diversity of the wetter unmown areas is rather smaller than the diversities of the sampling areas. The mown area at the entrance of the meadow with possible forest area in the past, had the largest diversity.

3.5. The assessment of the sampling areas's vegetation based on the relative coenological indicators of the species

Based on the categories of Zólyomi, on the tested areas according to the data as of 2013-15, the heat demand of most species appropriate to the climate of a broadleaf forest zone. In addition, the plants of the Sub-Mediterranean zone are appearing. The plants of the Mediterranean, the Atlantic evergreen region occur only rarely. On the tested areas with different land use, the same tendency is followed by the distribution of the plants with different heat demand, between the categories. At the abandoned orchard, the number of the plants with the heat demand of sub-Mediterranean broadleaf forests and Mediterranean areas is larger than in the other areas.

On all the sampling areas the plants are dominated, which prefer slightly calcareous soil, secondly are to mention the plants indifferent in terms of the soil demand, thirdly are to mention those which prefer neutral soil pH. On the areas at the southern foot of the mountain can particularly large number of plants be observed with slightly calcareous soil preference.

The area affected by tourism and the other one at the entrance of the meadow differ from each other in terms of humidity preference. On the area affected by tourism, the occurrence is shifted towards the category of dryer humidity demand, while on the mown area, at the entrance of the meadow, this is shifted towards the category of wetter humidity demand. On the mown area closer to Ósagárd, the species having higher humidity preference appear in larger number, and the distribution of species between the categories of humidity preference is more balanced than on the mown areas farther from Ósagárd. At this one, the number of plants is high in the category of "moderately moist". On the wooded pasture and also on the unmown areas, the number of species is few in the category of "dry". Significant difference is found between the mown and unmown areas. On the area of the southern foot of the mountain the number of species with dry humidity preference is especially high. Besides the ones, classified in the category of "moderately dry", is also considerable.

On the surveyed areas the plants were placed in the largest proportion in the category of "species grow in a habitat being rather poorer in nitrogen content". The number of species is also considerable in the category of "species grow in a habitat being poor in nitrogen content" and of "the species with moderately nitrogen demand". On each two unmown areas and

on the wooded pasture the numbers of those belonging to the former categories are lower. In the latter category on the mown areas at the entrance of the meadow and on the one affected by tourism the number of species is lower than the other subareas. On the wooded pasture and on the wetter unmown area the number of species placed in the category of “rather poor in nitrogen content” is lower. Among the species preferring to grow in a habitat with poor nitrogen content, the most were found at the southern area of the Naszály.

On each of the sampling areas, the rates of the subordinate species and the natural disturbance tolerant species are high. 1-4 protected species were found on each mown areas. No protected species appeared on the wetter unmown area. 4 protected species were recorded each on wooded pasture, on the southern abandoned orchard, on the area affected by tourism and on the other mown part. The number of the subordinate species is lower on the unmown area and it is higher on the mown areas. On the unmown areas are lower numbers of natural pioneer species show up than are shown up on the other areas. The most weeds were found on the area of the southern foot of the mountain. On the sampling areas, the rates of generalists and disturbance tolerants are the most considerable. The most natural competitors were found on the mown area closer to Ósagárd. It is interesting that on the mown area affected by tourism, the specialist species and those with narrow ecological tolerance can also find a living space. The number of generalists is lower on the unmown areas than on the mown areas. On the drier unmown areas, some non-native species also grow. The quadrates of the southern areas of the Naszály is characterised by the occurrence of higher number of the native flora's ruderal competitors and of the weed species.

3.6. The results of the evaluation of the meteorological data

Based on the amount of the monthly precipitation, the amount of the rainfall in 2013 was on the sampling points on the average compared to the typical value assessed in the small region, and that measured in 2014, exceeding the previous values at each of the points by more than 80 mm, was considerably higher than the average value characterising the small region. In the year of 2014, the surplus amount of rainfall is considerable during the growing season on both sides of the Naszály, and it was much wetter in the second year. However, the difference of the amount of the rainfall between the northern and southern side wasn't considerable either in 2013 or in 2014. The greatest difference approx. 7 mm between the northern and southern side was assessed in May 2014.

In 2013 the annual average temperature at the sampling points was higher by 0.3 and 0.5 °C and in 2014 was higher by 1,2 and 1,5 °C than the average temperature in the region. Concerning the monthly mean temperatures of the northern and the southern sides of the Naszály, in 2014 mean temperatures were significantly higher from January to March, in September and in December than in 2013. In the months of August, the monthly temperature differences were close to 0.7 °C, and except for the months of November, December, February and March, the northern side of the Naszály was colder than the other side, in both years.

3.7.New scientific results

1. I proved based on land history analysis of the areas around Naszály that the grassland areas showed an increasing trend from the 1700s until the 1990s. Today we can experience a decreasing trend again. In addition, I detected the changes occurred in the meantime due to land use.
2. I compiled a detailed list of species about the grasslands at the foot of the Naszály. I recorded 11 protected species and the Slovak Penny-cress, being a NATURA2000 species with community interest.
3. Based on the datas of vegetation I separated the vegetation of the mown, the unmown and the wooded pasture, and I revealed the traces of the past forest land use, and also the degradation in the vegetation due to the current antropogenic effects.
4. I proved on the sampling areas the higher number of species as an impact of mowing, the higer value of the ecological indicators showing bigger naturalness, and the higher diversities.
5. In the vegetation the values of diversity and the datas of the precipitation are closely connected to each other.
6. I detected that the humidity preferences of the species and the nitrogen demand differ according to the different land uses. In the wetter year the values of diversity are higher than in the other years, and the differencies are outlined more considerably in the wetter period.
7. I proved that the grasslands at the southern foot of Naszály are threatened by changes occurred in land use and by the fragmentation of the area, that I supported with flora data, claster analysis and with detrended correspondence analysis.

4. Conclusions and recommendations

4.1. Territorial, association structural and floristic changes

Based on the maps analysis, which was made using all of the available resources and on the changes presented and illustrated with data, it can be concluded, that the grasslands in the area around the Naszály have considerably changed over the last 230 years. In the late 1700s, they could be found on the “Gyadai” meadow and along the streams, in a narrow segment, amounting to 6% of the area. In the mid-19th century, this ratio increased to 9%, as the narrow segment of the “Gyadai” meadow, presented previously, extended, while grasslands are also growing in the region of the Naszály’s mountaintop. In the 20th century, the northern grasslands have survived almost unchanged. The land use on “Gyadai” meadow has hardly changed in the last more than 200 years, only on a small parts of it spots of arable land appeared in the 1990 -ies. However, the land use in the southern foothill areas completely transformed and became fragmented.

Based on the analyses, the mown, the unmown and the wooded pasture areas are in minor group arrangements, but they form a unit together, however, the area used as an abandoned orchard, separated considerably from them. All of this leads to the conclusion that by land use the composition of the associations is fundamentally and profoundly changed, as previously also shown by other studies. (Czóbel et al. 2005, Gross et al. 2009).

Based on the cluster analysis, the quadrates of the unmown areas are also separated by the dominant species from the other areas.

Based on the classification of the data with cluster analysis, the sampling quadrats of the wooded pasture are mixed, so the similarity of them is confirmed. It is likely that previously a greater proportion of the subarea was covered by forests. On the former forest area the occurrence of *Alopecurus pratensis* is dominant, besides the ratio of *Galium verum*, *Trisetum flavescens*, *Poa angustifolia* and *Arrhenatherum elatius* is considerable.

The quadrats of the abandoned orchard are heterogeneous in all the surveyed years, which may indicate the territorial fragmentation and the anthropogenic presence.

The separation of the unmown areas from the mown areas, based on the composition of the species, supports that mowing with the objective of

nature conservation is important in the controlling of weeds and in the raising of the number of inhabiting attendant species. (Török et al. 2010, Házi et al. 2011, Szentes et al. 2012).

Also the ordination analysis pointed out that the mowed areas are more similar to each other compared to the rest of the areas within the mowed areas, however, there were differences in the composition of species due to different historical land use managements and the impacts by tourism.

The structural changes occurring due to tourism, as well as stated in a number of studies, is also presented in this study (Grabherr 1982, Le et al. 2014). At first, the species don't respond to the changed conditions with disappearance, but they react with the change of dominancy relations, as other studies have already confirmed (Pavlů et al. 2011).

In the grassland which was a forest in the past, *Potentilla alba* dominates (Fehér et al. 2013), that prefers the forest edges, cleared grassland areas, and is a characteristic species of sessile oak woodlands (Borhidi 2003). In addition, this is an unique species of plants, a specialist, having low stress capability of tolerance (Horváth et al. 1995).

The present study also shows as confirmed that due to the mowing large grasses is of minor importance at pasture on Tihany Peninsula and on the Balaton Uplands (Szentes et al. 2007, 2009, 2011, Penksza et al. 2008, 2013). The local mowed areas abound in species. Besides *Festuca valesiaca* with smaller stature, many plants can find a living space there.

Based on the ordination analysis the composition of species of wooded pasture differs considerably from the other sampling areas. On the major part of the wooded pastures forested areas were found, which is demonstrated by the ordination analysis. Saláta et al. also tried to show the different landscape utilization for the past (2011a,2011b).

The diversity of the sampling areas showed higher values in the wetter year than in the other years, and the differencies in this year appeared more considerable.

Among the sampling areas, the diversities of the unmown, wetter area and the wooded pasture were lower than the other areas (Fehér et al. 2015).

Based on the floristic analysis of the sampling areas, we can conclude to the valuable species composition of the grasslands around the Naszály. This is confirmed for example by the most important results of the flora studies, stating that the plant species belonging to NATURA2000 of community importance, the Slovak Penny-cress was found on the "Gyadai"

meadow in three locations, which is in the European terms, also essential based on the exact location of the species.

On the sampling areas 11 protected species were found. In each of the different types of land use 4 protected species were found, however, in one of the unmown areas any of the species were detected.

According to the humidity preference, the data of the mown area affected by tourism and the area at the entrance of the meadow show difference from the other areas, connected with the statement, that water supply affects considerably the productivity of the grasslands, and water has also a primary importance in the structure of plant populations (Barcsák 1989).

The existing protected area network doesn't represent the natural values of the region in an adequate proportion. The survival of the grasslands at the southern foot of the Naszály is threatened by the reduction and fragmentation of the areas, and the current degree of protection does not provide for them proper survival and maintenance of the biodiversity, so the preservation of them is an important nature conservation task. On the southern sampling areas, protected species and species with high nature conservation value are still occurring, eg. Feather grass (*Stipa pennata*), which populations could still be preserved by using protective measures.

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6. Publications in connection with the PhD dissertation

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