



GRASSLAND ECOLOGY VIII

Books of Abstracts

International Scientific Conference
Banská Bystrica, Slovakia
19 – 20 March, 2013

Grassland Ecology VIII

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Programme

Tuesday, 19 March 2013

- 8:30 – 9:00 Registration
- 9:00 – 10:00 Official opening and welcome address
- 10:00 – 10:30 **Multifunctional and sustainable management of permanent grasslands in the agricultural system of the Czech Republic**
A. Kohoutek (Czech Republic)
- 10:30 – 11:00 Coffee break
- 11:00 – 11:30 **Actual state and development of soils in Slovakia under grassland ecosystems**
J. Kobza (Slovakia)
- 11:30 – 12:00 **Dynamics of historical land use in relation to grassland area in example of an upland village in Jizera Mts.**
J. Štrobach, V. Pavlů, L. Pavlů, J. Gaisler, J. Mikulka, Š. Supek (Czech Republic)
- 12:00 – 12:30 Discussion
- 12:30 – 13:30 Lunch
- 13:30 – 14:00 **Grazing with suckler cows and its effects on changes in botanical composition and nutritive value of grassland**
J. Golecký, J. Martincová (Slovakia)
- 14:00 – 14:30 **The quality of hay from mountain grassland**
S. Jendrišáková (Slovakia)
- 14:30 – 15:00 **The heavy metal content in selected grass species from mountain meadow**
W. Szewczyk (Poland)
- 15:00 – 15:30 **Use of grass phytomass by anaerobic digestion**
Ilona Gerndtová (Czech Republic)
- 15:30 – 16:00 **Is the grassland dry mater production rising with the increasing concentration of carbon dioxide in the Earth atmosphere? Results of a long-term experiment**
N. Britaňák, M. Michalec, D. Beňová, Ľ. Hanzes, I. Ilavská, Ľ. Jančová, Z. Kováčiková, J. Martincová, Š. Pollák, V. Vargová (Slovakia)
- 16:00 – 16:30 Discussion
- 16:30 – 17:30 Coffee break; Poster sessions
- 18:00 – 22:00 Conference dinner

Wednesday, 20 March 2013

- 9:00 – 9:30 **The effect of fertilization and cutting frequency on species diversity and grassland quality association *Sanguisorba-Festucetum comutata***
A. Nawrath, J. Skládanka, I. Davidová, M. Sochorec, F. Hrabě, J. Edison, A. Mejía (Czech Republic)
- 9:30 – 10:00 **A comparison of proportional losses of plant species in the semi-natural and the temporary grassland as influenced by fertiliser application**
N. Britaňák, Ľ. Hanzes, I. Ilavská (Slovakia)
- 10:00 – 10:15 Discussion
- 10:15 – 10:45 Coffee break
- 10:45 – 11:15 **Ecological restoration of disturbed grassland in the “Malá Fatra National Park”**
J. Novák, S. Javoreková, P. Obtulovič, J. Chlpík, J. Nemeš (Slovakia)
- 11:15 – 11:45 **Sward-height patches under intensive and extensive grazing management in an upland grassland in the Jizera Mountains**
V. Ludvíková, V. Pavlů, L. Pavlů, J. Gaisler, M. Hejzman, Š. Supek (Czech Republic)
- 11:45 – 12:15 Discussion
- 12:15 – 12:30 Conference closing
- 12:30 – 13:30 Lunch

Multifunctional and sustainable management of permanent grasslands in the agricultural system of the Czech Republic

Alois Kohoutek

Výzkumný ústav rostlinné výroby, v.v.i., Praha 6 - Ruzyně, VS Jevíčko, Česká republika

The contribution analyses the structure of voluminous feedstuff and a herd of herbivores for its conversion within the agricultural system of the Czech Republic (CR). In 2010, the agricultural system of the Czech Republic included 5,986 thousand tonnes of dry matter (DM) of voluminous feedstuff for a herd of herbivores at the amount of converted 1,118 livestock units (LU). The consumption of utilizable dry matter by a herd of herbivores is 5,031 thousand tonnes at the consumption of 4.5 t of utilizable DM per LU. The surplus of voluminous feedstuff reached 995 thousand tonnes of DM which represents source of feedstuff for 212 thousand LU for which there was no use. This represents about 1/3 of forage production from permanent grasslands (PG) and an area of about 300 thousand ha of permanent grasslands which were not utilized with an average DM yield of about 3 t ha⁻¹. The key solution of such a long-term unsatisfactory state is an increase of suckler cows numbers by about 100 – 150 thousand heads as more permanent demand for cattle 300 kg can be expected from surrounding countries. Raising the cattle as a major permanent grassland forage consumer has a character of agro-environmental measure. For utilisation of forage from intensively managed PG (4 – 3 cuts) extensive cattle load is sufficient, in case of extensive PG utilisation (2 cuts) intensive cattle load is necessary to provide conversion of produced forage, otherwise its surplus is saturated. For the needs of agrarian policy after 2013, the following load of PG can be recommended: under 0.5 LU ruminants per ha PG, 0.5 – 0.8 LU ruminants per ha PG and over 0.8 ruminants per ha PG.

Grazing with suckler cows and its effects on changes in botanical composition and nutritive value of grassland

Jaroslav Golecký, Jana Martincová, Zuzana Dugátová

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Grazing has been showing its impact on the character of landscape and the biodiversity since the primeval times. The trial was carried out at Sebedín-Bečov site (altitude 420 – 500 m), near the town of Banská Bystrica. Extensive grassland grazing with suckler cows resulted in changed botanical composition of sward. The trial pasture area (9.199 ha; mesophilic grassland) was divided into seven paddocks representing two types of sward. The pasture comprised 35 plant species. At one part of the site (paddocks No. 1, 2 and 3) was dominated by tall grasses, mainly meadow fescue (*Festuca pratensis*), soft brome (*Bromus mollis*) and the sward in the paddocks was much damaged, showing barren soil. At the other part of the pasture site (paddocks No. 4, 5, 6 and 7) the sward was richer in species and the short ones dominated, e.g. crested dog's-tail grass (*Cynosurus cristatus*), perennial ryegrass (*Lolium perenne*), meadow grass (*Poa pratensis*), red fescue (*Festuca rubra*), bent grass (*Agrostis capillaris*), white clover (*Trifolium repens*). In the first year, the mean sward proportion of grasses was 41.5 %, of legumes 17.5 %, of herbs 28.5 % and of bare ground 12.5%, respectively. Over three grazing seasons, the proportion of grasses increased by 7 % and of legumes by 6 %, whereas the proportion of herbs decreased by 4.5 % and that of bare ground by 8.5 %. The herb proportion was dominated by yarrow (*Achillea millefolium*), mainly at the end of season, because animals were refusing it. Changes in the botanical composition have

resulted in 5.9 – 10.2 % increase in the nutrients and energy content in sward, and consequently, the mean daily animal live-weight gains increased by 19.40 to 30.08 %.

Dynamic of historical land use in relation to grassland area in example of an upland village in Jizera Mts.

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The dynamic of land use in relation to grassland management in the last four centuries was studied in the upland village Oldřichov v Hájích (Ullersdorf in German) in Central Europe. It is located in north-eastern part of the Jizera Mountains (Jizerské hory, Góry Izerskie, Isergebirge), Czech Republic. The background for specific study was historical, map of stabile cadastre (1843), and military airplane photos (1938, 2003) chronicle of village (number of animals). The first mention about this village was in an urbarium (urbar in German) in 1381. The inhabitants of this village worked as woodcutters however they kept also some cattle because the tax from grassland was paid. However the first record about the area of agricultural land is in 1651 and number of livestock was written down in 1654 because of list of taxis. The peak of arable land area was during the World War I when was shortage of foodstuff. However it decreased after Velvet revolution in the Czech Republic (1989) when re-structuralization of agricultural production occurred. At these times arable land was converted to grasslands but numbers of ruminants were dramatically reduced. Nowadays we have the same livestock loading as in 1651, but six time larger grassland area. It means that majority of grasslands is managed only because of state subsidies but not because of agricultural production. Remarkable is an enlargement of areas with the same cultivation with consequent loss of mosaic management and land homogenization. This process of historical land use is clearly visible from three selected historical events where the exact data available.

Effects of organised lamb grazing on grassland development

Miroslav Polák, Mariana Jančová

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Over two grazing seasons, effects of rotational paddock grazing with lambs on grassland development and condition of sward. Mean dry mater yield was 1.09 t ha⁻¹ at semi-natural grassland during the research period. Mean live-weight gains were 93 g head⁻¹ at lambs in the 1st grazing season and 100 g head⁻¹ at lambs in the 2nd grazing season. A total sward damage was not observed at the area grazed by the animals. A notable devastation of soil was found at the places with high frequency of animal walks or stays resulting in the soil eutrophication. Consequently, such land spots were overgrown by a range of nitrophilous herbs and grasses.

Influence of farmyard manure on micro and macroelements content of the meadow soil

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This paper presents results of the effect of farmyard manure fertilization and mineral fertilization after three years of use on the content in the soil: phosphorus, potassium, calcium, magnesium, iron, zinc, copper and manganese. Soil from object fertilized of 10 t ha⁻¹ of farmyard manure had the smallest amount of this mineral components, the biggest content was in object receiving twice dose of this fertilizer. Reducing of micro and macroelements content between those objects in the case of iron was - 21%, zinc - 25%, potassium - 29% phosphorus – 35%, magnesium - 36%, manganese - 49%, copper - 61%, and calcium - 64%. The soil fertilized with mineral fertilizers (PKN) had intermediate values between of the smallest and the largest content. In all fertilizer objects soil content of chemical components was higher than the control object except contents of P and K.

Investigation of production and quality parameters at semi-natural grassland under different nutrition

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A field trial was established to study effects of mineral and organic fertilisers on production, quality and botanical composition at permanent grassland over 2006–2009. The fertiliser treatments were (kg.ha⁻¹): 1) control; 2) P₃₀ + K₆₀; 3) N₆₀ + PK; 4) N₁₂₀ + PK; 5) manure 12 t.ha⁻¹; 6) manure 24 t.ha⁻¹. The sward proportion of grasses was increasing with the rising rates of nitrogen fertiliser. At manure application, the proportion of grasses was dominant in the first year, but decreased later and the herb and legume proportions were rising. The highest dry matter yield (4.70 t.ha⁻¹) of herbage (DM) was found in the first harvest year (2006). The highest dry matter yield (5.28 t.ha⁻¹) was recorded at N₁₂₀ + PK fertiliser rate and somewhat lower at the manure application and the fertiliser rate of N₆₀ + PK. The lowest DM yield was found at the control (3.47 t.ha⁻¹).

Heavy metals concentration in grassland ecosystems

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In the contribution we evaluate a concentration of heavy metals in grass ecosystems (in soil and plant biomass). Monitoring was carried out during the years 1997 – 1999 on permanent grassland, in the region of Starohorske vrchy, in three habitats with different altitude (habitat Radvaň, 480 m a.s.l., Panský diel, 1000 m a.s.l., Kráľová studňa, 1300 m a.s.l.). We specified following elements of heavy metals in soil and plant samples (root biomass and above-ground part of vegetation): Cd, Co, Cr, Pb, Zn, Mn, Cu, Fe and Ni (atomic absorption method

metrometry). Based on achieved results, we can state that heavy metals are mostly concentrated in plant roots and in soil. Significantly lower content was determined in biomass of above-ground parts of vegetation. Also was confirmed a significant effect of years and evaluated habitats on the concentration of heavy metals. The concentration of heavy metals is significantly increasing with higher altitude of habitats.

Frequency distribution model of species number in grassland communities

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We developed a model to describe the frequency distributions of species number per unit ground area in grasslands. Plant species that grow ubiquitously throughout a survey site raise the mean number of species per unit area but lower the variance, creating a “mean > variance” relationship in species number per unit area. This relationship was incorporated into the model, which was verified using data obtained in a loess grassland in Shaanxi, China, as well as grasslands in Banská Bystrica, Slovakia.

Actual state and development of soils in Slovakia under grassland ecosystems

Jozef Kobza

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Actual state and development of soil properties in Slovakia according to main threats to soil (contamination, acidification, salinization and sodification, soil organic matter, soil compaction and erosion) under various grassland ecosystems in Slovakia is evaluated in this contribution. The basic soil properties (pH, exchangeable Al, electrical conductivity (ECe), exchangeable sodium percentage (ESP), total content of salts, Cox, HA/FA, N_t, physical properties (bulk density, porosity), as well as basic risk trace elements according to Act 220/2004 Z.z. have been measured and evaluated. The unified chemical and physical procedures were used according to work by Kolektív (2011).

On the basis of obtain results it was determined decrease of available nutrients (P and K), slight increase of soil organic matter with its stabilization, especially during last period. In addition, the processes of soil compaction and erosion are significant, but not such strong opposite arable soils. On the other hand, the content of risk trace elements in soil is practically without significant change also in industrial areas where emission situation has been improved during last 20 years.

Pedodiversity and development of selection agrochemical properties on locality under grassland

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Pedodiversity, detail spatial variability mapping, of direct indicators of acidification (pH v CaCl₂) and compaction (soil bulk density) were realized on key monitoring locality Liesek (Dystric Planosols) test site (17 samples). Samples were collected in 5 m and 10 m distances from centre of locality in eight direction of cardinal points in depth 0 - 10 cm and 35 – 45 cm. Pedodiversity models of soil reaction and soil bulk density (in the depth 0 – 10 cm and 35 – 45 cm) in Surfer 7 were done. On the base of confidence interval and uncertainly rate of value measure methodology intervals of significant changes were determined. Time series of observed parameters (yearly from 2001 to 2012) value were overlap with intervals of significant changes to obtain significant observed parameters changes. The pH value changes were significant in 8 years. Negative changes (decrease of pH valeu) were observed in 5 years. Difference between pH value in 2001 and 2012 year was 0.52, that means shift of pH value to acid area with increased rate of all negative impacts of acidification. The soil bulk density value changes were significant in 6 years in topsoil and in 8 years in subsoil. Negative changes (soil bulk density increase) were observed in three cases in topsoil and in four cases within subsoil.

The possibilities sequestration of carbon in permanent grassland on cambisols

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This article presents the results of measurements of CO₂ production at three sites on the soil type cambisols with two different ways of agricultural soil utilization. The aim is to compare and quantify potential opportunities to preserve soil carbon. Current respiratory activity of the soil profile and soil organic matter was evaluated by field trials measuring CO₂ production method IRGA (infrared gas analyzer) Stability of soil microbial biomass carbon fractions were analyzed rehydration method. For habitats of the most abundant type of soil quality groups 6-9 cambisols we found geographical coordinates using GPS. Summarization of data, we evaluated differences in respiratory activity quantified with potential options for reducing emissions from agricultural activities sequestration carbon in grassland soils, converted to arable land cambisols the repose of 7 ° and above 12 ° degrees.

Respirometric activity and distribution of organic matter in grassland under different management

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Over the growing seasons of 2008 – 2009, a research was carried out at grassland (“Tajov” site; altitude 464 m; central Slovakia). The sward was either without utilisation, or cut and grazed with cows and sheep. The research objective was to study CO₂ production in the grassland soil *in vitro* and *in situ*, as well as vertical structure of organic matter. The so-called reactive CO₂ (R) and basal CO₂ (B) production measured under laboratory conditions was dependent on the content of C_{ox} ($r = 0.54^{++}$; 0.42^+), N_t ($r = 0.51^{++}$; $r = 0.39^+$) and total microbial biomass ($r = 0.49^{++}$; $r = 0.40^+$) in soil, but especially on the stability of soil organic substances specified by the NG : B ratio ($r = - 0.71^{++}$; $r = - 0.74^{++}$). The respiration of sward without removing the above-ground plant parts and litter, i.e. CO₂-T (P), and after their removal, i.e. CO₂-T (OP), measured directly at the research site, was relating to the soil moisture ($r = 0.44^+$; $r = 0.33$), but depended mainly on the soil temperature ($r = 0.55^{++}$; $r = 0.69^{++}$). The total biomass weight was determined and the proportions of living plants, dead plants and root mass were specified. The total mineralization of nitrogen (TMN) was measured. The highest content of plant biomass (approx. 2544 g m⁻¹) was found at the grazed areas, while the content was as much as 28 % lower at the sward utilised by cutting. The proportion of living plants in the total biomass was only 5 to 14 %, but the proportion of roots was very high (63 to 81 %). The highest accumulation of roots was found in the non-utilised and in the grazed grassland. The highest soil C_{ox} and N_t content was also recorded in the non-utilised and in the grazed swards, what may be related to the weak decomposition processes in soil, as confirmed by the low coefficient of mineralization (C-CO₂(R)/C_{ox}).

Returning arable land to grassland by implementing species-rich *Arrhenatherion* and *Mesobromion* communities

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In 2009, within the SALVERE project activities, demonstration sites were established on arable land at Tajov site (altitude 647 m; 48°44'N; 19°02'E) located near Banská Bystrica within the “Starohorské vrchy” mountains. The research aim was to return the non-utilised arable land to grassland by applying the 'green hay' (Method 1) or the 'dry hay' (Method 2) harvested at the grassland donor sites with the *Arrhenatherion* and *Mesobromion* communities. The donor-site sward was cut at its maximum seed ripeness stage and herbage was transferred to the arable land (receptor site) either fresh (as 'green hay') or when dried (as 'dry hay'). During two years (2010 and 2011), the efficiency of new sward establishment and development was investigated at the receptor site. There were not any visible differences in successfulness of the two methods. However, the renovation was more successful at the *Mesobromion* community where the proportion of target species transferred from the donor to the receptor site was 80% in the first harvest year and 64 % in the second harvest year.

The evaluation of soil properties and floristic composition before and after the polder Beša flooding

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In year 2009 in dry polder Beša ended solution of project “Quantification of no-production functions of soil and land in dry polder Beša”. In year 2012 in dry polder Beša started researching of project “Analyse of soil properties and landscape development of non-regularly overflowed areas“. This project builds on the previous one and focuses on the quantification of soil properties changes in the polder Beša after flooding in 2010. In four soil profiles were determined parameters as follows: particle-size composition, bulk density, total porosity, maximum capillary capacity. Ground survey, made in year 2012, confirmed very spatial soil heterogeneity from 2009 year. Overflowing of this area in year 2010 contributed to increasing of soil bulk density and decreasing of total porosity. In year 2012 values of maximum capillary capacity were lower about 1.65 % in comparison with year 2009. Based on the obtained results can be assumed negative changes in soil properties after flooding of the polder Beša area. In year 2012, significant changes of floristic composition in comparison to year 2009 wasn't determined.

Assessment of the persistence of liming on the mountain meadow

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The study was conducted in the 12th year after liming on the mountain meadow. Dose of liming was 2.0 t CaO ha⁻¹. At the beginning of study pH of soil was: pH_{H₂O} = 5.30 and pH_{KCl} = 4.36. The study included three objects located on the limed soil and not limed. They included: object without fertilization, object with potassium and phosphorus fertilizer and receiving beside this 2 components also 100 kg N ha⁻¹. Investigation included: botanical composition of sward, yield of forage, yield of more important macronutrients (N, P, K, Ca, Mg) and soil pH. Residual effect of liming was partly visible in botanical composition of sward, encouraging to development of *Trifolium repens* and *Alchemilla monticola*. Then, in a larger yield of Ca and Mg and in a higher pH of the soil - 0.40 units in KCl at object without fertilization and 0.19 units at object with PKN.

Effect of specific compost application on immobility soil carbon in permanent grasslands

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The main importance of microorganisms in the soil lies in their enzymatic activity in continuous synthesis while affecting the mobility and cycle of many nutrients and especially the main biogenic elements - carbon and nitrogen. The soil microflora ensures residue decomposition of organic matter by mineralization process. The process takes place at several levels of decomposition, intermediates of microbial processes are unstable and act as

minerals, after other oxidation-reduction reactions, which are characterized by increased mobility and transfer to other ecosystem components. Undesirable form of nitrogen is mainly in the form of nitrite with storage capacity and leaching of soil environment. In terms of agricultural utilization based on these features, laboratory experiments proved bacteria-induced decomposition of organic matter mineralization accompanied by the release of nitrogen in ammonium and nitrate form. Process is limited due to aliquots volume of accessible soil carbon and its activities to bind nitrogen.

The impact of grassland management on plant species diversity between 2003 and 2009

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At six sites in the Czech Republic, long-term small plot trials with tall oatgrass stand type *Arrhenatherion* were established on permanent grasslands in 2003, each consisting of 16 treatments in 4 replications. The intensity of utilisation: I₁=(1st cut until May 15th, 4 cuts per year – cuts at 45-day interval), I₂=(1st cut between 16th and 31st May, 3 cuts per year at 60-day interval), I₃=(1st cut between 1st and 15th June, 2 cuts per year at 90-day interval) and I₄=(1st cut between 16th and 30th June, 1 or 2 cuts per year, second cut after 90 days). Four levels of fertilizer application were used: F₀=no fertilisation, FPK=P₃₀K₆₀N₀; FPKN₉₀= P₃₀K₆₀+N₉₀, FPKN₁₈₀=P₃₀K₆₀+N₁₈₀. This paper is aimed at evaluation of botanical composition which changed under different grassland managements. Species diversity increased territorially, in total 163 plant species were identified. Botanical composition was above all influenced by nitrogen fertilization, which supports grass species and reduces legumes and other forbs. Higher grass proportion was found in two-cut regimes (I₃, I₄), too. The diversity of plant species and a more balanced proportion of agrobotanical groups (grasses, legumes, forbs) were found especially in grassland without nitrogen fertilization.

The effect of fertilization and cutting frequency on species diversity and grassland quality association *Sanguisorba–Festucetum comutatae*

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Permanent grasslands are able to perform many functions. These functions are often indispensable. Grasslands are characterized by productive and non-productive functions. These associations are often characterized by high value of diversity, which is then reflected in the quality of biomass. Besides the floristic composition, the quality and yield of forage is determined by the fertilization and the intensity of use. Thanks to thoughtful interventions we can manage the grasslands so that to maintain species diversity and forage quality. The aim of the study was to explore the influence of fertilization N, P, K and cutting frequency on the

species diversity, evenness and grassland quality. The trial plot was located in Kameničky (CHKO Žďárské vrchy). The average yearly temperature is 5,8 °C and the precipitation amount is 758,4 mm per year. Nitrogen application led to a decrease of biodiversity. Non-fertilization stands and stands after the application of P, K showed the highest biodiversity. Three-cut grass stands exhibited a higher diversity than two-cut grass stands did. The evenness was higher in the three-cut grass. The highest grassland quality was reached in the two-cut grass stands after the application nitrogen fertilization.

A comparison of proportional losses of plant species in the semi-natural and the temporary grassland as influenced by fertiliser application

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Changes in botanical composition (species richness) of temporary and semi-natural grasslands under mineral fertiliser application (control; $N_0P_{30}K_{60}$; $N_{90}P_{30}K_{60}$ and $N_{180}P_{30}K_{60}$) were investigated in the Low Tatras mountainous region. A theoretical value for the maximum survival of plant species due to environmental changes (e.i., anthropogenic pressure) was never exceeded. Proportional loss of plant species was the highest at the beginning of the experiment. It later dropped. But the higher proportional loss was detected on temporary grassland than semi-natural one.

Changes of botanical composition at the different exploitation of grassland

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The aim of this study was comparison of the changes in the botanical composition of different utilization of unfertilized grassland in the course of the vegetation season between 2006 and 2009. Four trial treatments were as follows: Treatment 1 - high intensity of utilisation - 4 cuts; Treatment 2 - medium intensity of utilisation - 3 cuts; Treatment 3 - low intensity of utilisation - 2 cuts; Treatment 4 - extensive utilisation - 1 cut. Higher cutting frequency promoted the growth of legumes, as compared to grass species. The percentage proportion of herbs was high and it changed as a result of different cutting frequencies. The highest cutting frequency produced the highest values of both qualitative ($IS_J = 79.31\%$) and quantitative ($IS_{J/G} = 92.60\%$) similarity, respectively.

Impact of long-term fertiliser application on agri-chemical soil properties

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The purpose of this study was to evaluate the impact of rate and proportion of long term fertilization on the agri-chemical soil properties of a grass sward on an alluvial meadow. A field experiment was established in the western part of the Zvolenská kotlina basin at 350 m a.s.l. The experiment consisted of 10 treatments of fertilization: unfertilized grass swards, PK fertilized grass swards and grass swards fertilized 50, 100, 150 and 200 kg N/ha with two nutrient ratios (1 : 0.3 : 0.8 and 1 : 0.15 : 0.4). Grass swards were cut three times while. The soil is loamy fluvisol; the initial soil pH (KCl) = 6.03; the content of available nutrients: P = 6.16 mg kg⁻¹ and K = 96.6 mg kg⁻¹. During 2010 - 2012 decreased the soil pH (KCl) of value 3.92 – 5.48. The greatest decrease of soil pH was in the treatment an N rate of 50 kg with a nutrient ratio of 1 : 0.3 : 0.8. A lower contents accessible to plants of nitrogen, phosphorus and potassium in the soil was found in treatments with a nutrient ratio of 1 : 0.15 : 0.4.

Sward-height patches under intensive and extensive grazing management in an upland grassland in Jizera Mountains

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The patchiness is one of the important features of grazed temperate grasslands, but only a little is known about the structure of sward height patches under different grazing intensity. Therefore the present study examines the effect of continuous intensive and extensive stocking of heifers on the proportions of sward-height patch categories (short <5cm, moderate 5.5-10 cm, tall >10.5 cm) and their plant species composition. A four-year study was performed on species-rich grassland maintained under a long-term grazing experiment in the Jizera Mountains (Jizerské hory), Czech Republic. The main difference between intensive and extensive grazing management of species-rich grassland was seen in the proportions of short and tall sward-height patches, while the proportion of moderate-height patches was similar under both stocking densities. Floristic composition of patches within the same sward height depended upon stocking density. Moderate and tall patches under a given stocking density had similar botanical composition. Vegetation of short patches differed considerably from that of other patches under extensive grazing, whereas under intensive grazing the differences between short, moderate and tall sward-height patches were small. The grazing intensity is the key driver for the proportion as well as for floristic composition of sward-height patches.

Ecological restoration of disturbed grassland in the National Park Malá Fatra

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The aim of the research was the ecological restoration of disturbed secondary grassland dominated by *Rumex obtusifolius* and *Urtica dioica* in the National park Malá Fatra (Strungový príslop, 1 150 m a.s.l.). We studied in years 2004 – 2011 three experimental ruderalized grassland treatments: 1) without management, 2) two mows per vegetation period and 3) seed mixtures of 18 autochthonous species with 2 mows per vegetation period. After 8 years there has been a significant withdrawal of PK nutrients from the soil by aboveground phytomass mowing, C:N ratio in the soil has been changed and conditions for *Rumex obtusifolius* L. and *Urtica dioica* have worsened, which require a high supply of nutrients. The results of the ecological restoration of mountain pasture after overmanuring with cattle excreta show good results with 2 mows. Best results were obtained for variant 3. Contamination of soil (3–times higher in phosphorus and 5–times higher in potassium) taking cuttings and aboveground phytomass (phytoremediation) was removed over a period of research. Significantly increased species diversity has been observed and evaluation of grassland quality with a positive impact on the quality of feed for the animals. Ecological functions of grassland ecosystems and the environment were restored, environmental conditions and the aesthetic qualities of the country were improved, which contributed to sustainable development and landscaping in attractive tourist area.

Adjustment of diversity in weed-infested grassland at a mountain region of Slovakia

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Notable changes in botanical composition of grassland (alliance *Nardo - Agrostion tenuis*) resulted from intensive grazing with big flocks of sheep in the past. The research on changes in biodiversity of poor-quality sward infested with *Deschampsia caespitosa* was carried out at a site within the "Low Tatras National Park". The investigated sward was utilised by cutting during three years. The initial botanical composition comprised 16 species with 32 % dominance of *D. caespitosa* and legume presence nearly zero. Three years later, the proportion of legumes was 12 % and that of *D. caespitosa* markedly decreased. The number of species in sward increased to 25, among them the protected species and those valued as forage. The increased diversity was indicated by the higher Shannon index after three years. As assessed by Gleason index, the similarity between the sward at the beginning and the end of research was 90.58 %. The similarity between the sward quality determined by Jaccard index was lower (57.69 %) after three cutting years. The botanical analyses showed that the proportion of *D. caespitosa* can be reduced by regular cutting to low sward height.

Effects of management intensity on quality and nutritive value of permanent grassland phytomass

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Over 2011 – 2012, a research was performed at permanent grassland (“Suchý vrch” site). The research objective was to study effects of different management intensity on botanical composition of sward as well as on the quality and nutritive value of herbage. The research trial was established by the standard method of long plots and comprised four replicates of five treatments (two treatments with two-cut sward utilization, two treatments with one-cut sward utilization and the control treatment without any management). During the research years, a significant decrease ($r = -0.7268^{++}$) was found in the number of plant species. There were also changes in the percentage proportion of grasses ($r = 0.7286^{++}$) and legumes ($r = -0.8506^{++}$) in sward. The effects of reduced intensity of sward management were manifested as the decrease in the content of crude protein ($r = -0.5621^{++}$) and also in the content of protein digested in the small intestine when nitrogen is limiting (PDIN; $r = -0.5620^{++}$), but the increase was recorded in the content of dry matter ($r = 0.4591^{++}$) and fibre ($r = 0.7087^{++}$). The crude protein content was significantly higher and the fibre content was significantly lower at both of the two-cut treatments and one of the one-cut treatments than at the control treatment.

Impact of land-use and land-cover changes on grasslands environmental functions and services in landscape

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The development in permanent grasslands areas during the period of 224 years was analysed. Three study sites located in various natural conditions of Slovakia were selected, cadastre of Kráľov Brod (KB), mountains cadastres Očová and Dúbravy (OD), Liptovská Tepička (LT). Spatial data derived from historical maps were used in comparison to recent data received by Remote Sensing technology. The results showed that the area of permanent grasslands has undergone significant changes during the 224 years. At KB, permanent grasslands decreased from 52.7 % in 1782 to 0.7 % in 2006 and converted into arable land. At LT, permanent grasslands decreased from 31.8 % in 1782 to 11.7 % in 2006 and converted into forest land. At OD, permanent grasslands decreased from 20.4 % in 1782 to 16.2 % in 2006. The land-use changes contributed also to the changes in environmental functions and services offered by existing ecosystems.

Possibilities of using extensive grassland areas for growing lingonberry (*Vaccinium vitis-idaea* L.)

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A research was carried out with the aim to study a possibility to grow lingonberry (*Vaccinium vitis-idaea* L.) in the flysch-belt region of northern Slovakia. Productivity and adaptability were studied in one lingonberry cultivar (Koralle) at Krivá site (altitude 634 m). In Slovakia, this wild-berry fruit picking is very popular, but planting and growing it is not well-known, though it is quite common abroad. The research data showed that *V. vitis-idaea* could be grown successfully in the northern mountain regions of Slovakia and bring efficient and environment-friendly utilisation of their poor acid soils with low fertility. The investigated *V. vitis-idaea* cultivar Koralle was found to be suitable for growing at commercial plantations. In 2009, the berry yield was 468.g per plant.

Germination of seed treated with iSeed®

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Objective of the study conducted in 2013 at the Forage Research Station in Vatín was to evaluate the influence of the iSeed® treatment on the germination dynamics and total germination of Kentucky bluegrass var. Conni, Perennial ryegrass var. Cassiopeia and White clover var. Pirouette. Treatment had positive effects on germination dynamics and total germination within all varieties. Values of total germination were found significantly higher for treated varieties Cassiopeia and Pirouette by 23.0 % and 17.6 %, respectively, and not significantly higher for treated variety Conni by 19.4%.

Seed treatment and alternative times for grasses sowing

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The aim of the field experiment was to compare the effect of dormant or frost seeding of selected grass species and their seed coating on the plant surviving and development. The seeds of *Lolium perenne* L. var. Kentaur., *Festuca pratensis* L. var. Bíb, *Festulolium* var. Perseus non-coated or coated by the polymer Extender® were sown in Prague in 2004 and 2005 in three dates (December, February-March, April). The plants were significantly higher on average by 15.5-278% when sown in December and by 18-257% when sown in February or March in comparison with the swards sown in April. Number of leaves was higher by 93-528% and by 7-655%; number of tillers was higher by 13-284% and by 21-392% from December and from February/March time of sowing respectively. The effect of seed coating by Extender® was not statistically proved in this experiment.

The influence of drought stress on germinating of selected turfgrass species

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Two laboratory experiments were conducted to evaluate the ability of germination of selected turfgrass species after induced water stress during imbibition. Species used: *Deschampsia caespitosa* /L./ P. Beauv (Kometa), *Lolium perenne* L. (Filip), *Poa pratensis* L. (Harmonie), *Festuca rubra ssp. commutata* (Barborka), *Festuca rubra ssp. trichophylla* (Viktorka), *Festuca rubra ssp. rubra* (Petruna), were imbibed for 1, 2, 3 days under day/light regime 16/8 hours, 15/5 °C, rh 70%. Water stress after this period lasted 3 days (30°C, rh 40%) or 5 days (35°C, rh 40%). The results were evaluated by analysis of variance ANOVA LSD $\alpha = 0.05$ (Statgraphics programme, version XV.). Germination was significantly influenced by the grass species, *L. perenne* germinated most quickly (95%), *P. pratensis* germinated most slowly (68%). The amount of germinated kernels in the 10th day was 1.6 to 1.9 times higher under longer time of imbibition before the stress, later the differences were negligible. The total germination capacity was not influenced by the time of imbibition. More intensive drought stress resulted in a lower amount of germinated kernels (by 4-11%) in particular days of measuring from the 10th day until full germination of the seed.

Dry mater production of the clover crops varieties in dependence by meteorological factors of the East Slovak Lowland

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The production parameters of the clover crops varieties were observed between years 2006 and 2008. Experimental workplace Milhostov is located to the central part of the East Slovak Lowland. The course of the meteorological factors in the individual years had statistically significantly effect the dry matter yield of the clover crops. In treatment, the significantly lowest yields were determined for the bird's-foot clover (*Lotus corniculatus*). The highest yields were determined for tetraploid varieties Amos and Magura. In dry conditions of the East Slovak Lowland lower yields were ascertained for diploid varieties in comparison with tetraploid varieties. Base on our results we can recommend the tetraploid varieties Amos and Magura for these conditions. Less suitable is the using of the diploid varieties of red clover and bird's-foot clover.

Utilization of legumes and grass/legume mixtures on arable land in a mountain region

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Red clover (*Trifolium pratense* L.) and alfalfa (*Medicago sativa* L.) cultivars were grown either as monocultures or as simple mixtures with an inter-generic grass hybrid (x *Festulolium*) in a mountain region of Slovakia. The simple grass/legume mixtures showed better results when grown in a system of perennial forage crops (leys). The mixtures were more efficient and produced more compact swards than the legume monocultures.

Quality changes of *Medicago sativa* and lucerne-grass mixture in sub-mountain area during the vegetation

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We grew lucerne and its mixture with Italian ryegrass (52 % of lucerne, 45 % Italian ryegrass and 3 % other herbs) in a sub-mountain region, at an altitude above sea level 725 m. The objective was to study the influence of the cut delay on nutritive value of food and to compare differences in feeding quality of the monoculture and mixture.

Our results confirmed that proper timing of harvest is decisive from the viewpoint of nutritive value of feed. Delay of cut causes decrease in concentration of crude protein and water-soluble sugars. At the same time there occurs increase in content of whole fibre complex and decrease in digestibility of organic matter, dry matter and crude protein, which becomes evident by decrease in metabolizable energy, net energy and PDI in the produced feed. Growing lucerne in mixture with Italian ryegrass decreases the content of crude protein in feed but thanks to higher concentration of water-soluble sugars there is better precondition for favourable course of fermentation process compared with pure lucerne stand at silage production.

Quality hay from the mountain grasslands

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During 2008 – 2009, the impact of agri-environmental management on xerophytic (XG), mesophilous (MG) and hygrophilous (HG) grasslands in less-favoured areas (LFA) was monitored in the “Poľana Protected Bird Area”. The agricultural farm “PD Bukovina Strelníky” is involved in the Rural Development Plan, Measure: Agri-environment “Conservation of habitats in semi-natural and natural permanent grasslands”. The grassland is utilised by cutting once a year and also by lax grazing with sheep. The nutritive value of herbage was assessed at the time of cutting and grazing. The lowest crude protein content was recorded in XG (99.80 g.kg⁻¹). Hygrophilous grasslands reached an acceptable content of crude protein (111.83 g.kg⁻¹). The fibre content varied in acceptable range in all types of grassland (212.40 g.kg⁻¹ - 2.13 g.kg⁻¹). The content of phosphorus was low in herbage from all the grassland habitats (1.45 g.kg⁻¹ - 2.13 g.kg⁻¹). Mean values of kalium content ranged between 20.53 g.kg⁻¹ in XG and 21.74 g.kg⁻¹ in HG. According to the requirements for evaluation of forage quality (in accordance with the Decree of the Ministry of Agriculture No.39/2/2002-100), the hay made from the sward cut in its optimum ripeness at the evaluated grasslands would be classified as the Category II, but the hay made at cutting later in the growing season is the Category III.

Processing of residual grass material

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Permanent grasslands are an important part of the agricultural landscape. They represent more than twenty percent of agricultural land in the Czech Republic. It is roughly 970 thousand hectares, and a part of this about 800 thousand hectares is used for forage production. The role of permanent grassland lies not only in the production of roughage for ruminants, the focus is now also on a number of non-production functions related to environmental protection maintenance and designing landscapes, but also the need for revitalization of species diversity.

Possibility of alternative energy use of grassland

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In Slovakia, accounted for by permanent grassland 880,000 hectares, of which no more than 350,000 abandoned or unused long. Most of them are located in the mountainous areas. For those areas leads to the onset of succession which is accompanied by the onset-feed less valuable species of grasses and herbs. Mountaintops of Central Slovakia became the dominant tufted hair-grass (*Deschampsia caespitosa* (L.) P. Beauv.) Sites with up to 80% coverage. The relatively high yield of homogeneous vegetation and increased its share of crude fiber predestine for alternative energy use. Technology allows compaction to produce a comfortable and safe fuel in pellet form. We tested a variety of substrates from grasslands to produce pellets and we simulate grassland successional stage in adding sawdust. The best indicators of gross calorific value 18.745 MJ.kg⁻¹ tufted hair-grass.

Fytofuels and their properties

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In consequence of the increasing of the total level and productivity of agricultural production, the land area which is not utilised for food production is enlarged. These areas can be used for the growing of energy crops, among which also belong various kinds of grasses. In cases when the land is set aside by grassing or it is not utilised as a result of the diminishing numbers of beef cattle, the potential of perennial grassland to provide a quantity of grass which can be used for energy purposes is constantly increasing. Wet grass matter is suitable for biogas processing by means of anaerobic fermentation. Overripe and dry mass can be used as a fuel.

Economy of raw materials and energy utilization of permanent grassland biomass

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There are limited possibilities of grassland production usage for feeding in recent years. There are verified options and conditions how to use this production for material and energy purposes. This contribution deals with technology and economy of permanent grassland growing, exploitation grassland biomass for composting and hay utilization for energy purposes. A significant effect on material and energy utilization has the financial support in form of subsidies. By using subsidies the final costs per unit of production could be reduced considerably, particularly positive effect is achieved in regions with the LFA subsidies.

Evaluation of selected indicators affecting the climate change in connection with important areas for biodiversity conservation in some countries of the European Union

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The contribution deals with current issues of climate change and biodiversity. There were evaluated the selected indicators with an impact on climate change and also the proportion of chosen important areas for biodiversity conservation in some EU countries. It is still necessary to look for opportunities and measures to mitigate the impacts of climate change on biodiversity, enhance its adaptation to climate change, resistance and ensure better conservation. Measures and activities related to the mitigation of climate change can also have a positive effect on biodiversity.

The yield and distribution of dry matter to the cuts at *Trifolium pratense*, *Medicago sativa* and their mixtures with *Festulolium* during two consecutive extremely dry years

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The paper presents a research carried out with the objective to compare the total annual dry matter (DM) yield and its distribution to the cuts under the climatic conditions of Banská Bystrica during the growing seasons of 2011 and 2012. The comparison was made between the monocultures of *Trifolium pratense* (cultivars Fresko and Vesna) and *Medicago sativa* (cultivars Kamila and Tereza) and their mixtures with *Festulolium braunii* (cultivar Achilles). There were not any significant differences in the total annual DM yield between the respective monocultures of *Trifolium pratense* cv. Fresko and cv. Vesna, and the mixtures of *Trifolium pratense* with *Festulolium braunii* cv. Achilles. Similarly, *Medicago sativa* cultivars Kamila and Tereza grown as monocultures or as mixtures with *Festulolium braunii* cv. Achilles provided a well-balanced total annual DM yield. However, there was a difference in the DM distribution to the cuts. The significantly highest DM yield was recorded in the monocultures of *Trifolium pratense* cultivars Fresko and Vesna as well as in their mixtures with *Festulolium braunii* cultivar Achilles at the second cut. At the cuts, the difference in DM

yields between the *Medicago sativa* (cvs. Kamila and Tereza) monocultures and their respective mixtures with *Festulolium braunii* cv. Achilles was not significant.

Is the grassland dry matter production rising with the increasing concentration of carbon dioxide in the Earth atmosphere? Results of a long-term experiment

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Carbon dioxide is the most important greenhouse gas and from the beginning of the Industrial Revolution its atmospheric concentration has continually been growing. It is the subject of model and experiments worldwide to find out what happens when its concentration in the atmosphere reaches a certain level. These models and pot and field experiments have dealt with a particular crop or entire plant community to ecosystems. Paper presented here deals with the influence of naturally increasing carbon dioxide in the atmosphere on above-ground dry matter production in a long-term experiment. Increased carbon dioxide concentration positively and significantly has influenced dry matter production over the 36 years. Through the water vapour an increased concentration of carbon dioxide affects indirectly the amount of rainfall. The impact of rainfall has had the same effect (Pearson correlation coefficient) as increasing the concentration of this greenhouse gas in the atmosphere 0.4174 and 0.4108, respectively.

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