SEKCIJA 4: VEGETACIJA
SESSION 4: VEGETATION

4-IL1

Greenhouse gas budget of an Alpine pasture

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Introduction

The need to implement the post Kyoto policies has fostered the development of a large research effort on the net global warming potential resulting from the exchange of greenhouse gases from different plant canopies. The expected results may be used both to assess the relative role of different ecosystems, and to evaluate the possible mitigation scenarios at farm level.
Grasslands extend from boreal regions to the tropics, and cover about 3500 million hectares worldwide; in Europe they represent about 37% of agricultural land, and have a relevant role in forage production and soil protection; moreover, they represent a relevant source of biodiversity, and contribute to the creation of landscapes that have a role in attracting tourists toward mountain areas. Grassland present a wide range of different management systems, that originated from different climatic and edaphic conditions, from the local social structure, from different local productions and different traditions; the management systems, in turn, largely determine their exchange of greenhouse gases. Yet, in comparison to other ecosystems, such as forests, grasslands have received very limited attention up to a few years ago.
Grasslands can often be found in marginal areas, where the vegetative performance is more closely linked to weather and might be substantially modified by the ongoing global change; at the same time, the social systems underlying grassland use and management have been challenged by deep social changes in the last few decades. For all these reasons, the study of grassland gas exchange and management can be extremely interesting. Our study was carried on in the frame of GREENGRASS, an EU project aiming to evaluate the exchanges of greenhouse gases in European managed and semi-natural grasslands and pastures.

Materials and methods

The exchanges of greenhouse gases of an Alpine pasture were monitored throughout the years 2003 and 2004 in a seasonal cow farm ("Malga Arpaco") located at a height of 1669 m a.s.l.; the two growth seasons were characterized by different meteorological conditions, as the first one was very hot and dry, while temperature and rainfall in the second one were closer to the average of the last few decades;. CO2 exchanges were monitored by eddy covariance and chamber measurements; N2O, as well as CH4 exchanges, was evaluated by chamber measurements. At the same time, grazing conditions were observed, and the patterns of soil use were discussed with farmers.
During the measurement period, the meteorological data were recorded by a meteo station.

Results and discussion

As a consequence of the different climatic conditions, the two growth seasons yielded contrasting results.
In 2003, the growth season began earlier, as snow melting took place in the first half of April, and in the first two months the carbon absorption rate was high; nevertheless, in the following months, also in consequence of water stress, the assimilation rate declined; on the contrary, in the following year, in spite of a delayed snow melting, that in turn delayed the onsetting of photosynthesis, assimilation rate was higher in July and August. In both years the hottest hours of the day were characterized by stomatal closure, that limited the photosynthetic activity; yet this phenomenon, very evident in 2003 throughout all summer, in 2004 appeared only in August. In both the years, in spite of some recovery, gas exchanges of September and October played a very minor role in the global

carbon budget, in consequence of low temperatures and short daytime; throughout both winters a slight CO2 emission was monitored. In spite of the differences, in both years the grassland acted as a carbon sink, showing an absorption of 460 g C m-2 y –1 in 2003 and of 387 g Cm-2 y-1 in 2004.

Also the patterns of N2O and CH4 exchanges differed between the two years. Soil displayed some CH4 absorption that was more evident in 2004; in the hottest period of summer 2003 methane absorption was very limited, and soil acted as a source, rather than a sink. N2O emissions were rather scarce, in spite of the presence of grazing animals. Denitrification reached its higher level at the beginning of summer, while nitrification tended to decrease throughout summer.

In spite of the difficult environment, characterized by frequent thunderstorms, the monitoring system did perform well in both the years; Yet, the reduced turbulence at night lead to record a limited number of reliable night data; in this perspective, night respiration measured by chamber techniques can integrate the EC measurements, leading to more precise evaluations.

Higher and more variable soil respiration rates were measured in 2003, in consequence of high temperatures. The daily maxima were reached in the hottest hours. Grazed areas showed higher N2O emissions, and higher soil respiration rates, probably in consequence of a higher microbic activity.

A thorough discussion of the results cannot ignore the management conditions of the experimental site. In fact, the use of Malga Arpaco's pastures has been far from optimum, in consequence of the limited number of animals, and the abandoning of grass mowing. This has led to a reduction in grass quality, largely caused by the presence of weeds of very low palatability. The adoption of fixed calendars for the use of pastures may not be adequate to the conditions that may arise in consequence of the ongoing climatic change: in fact, higher May temperatures may require to anticipate the onset of grazing (with risks due to possible late frosts), while, in summer, grazing on dry soils may lead to soil erosion. At the same time, farmers are facing problems in the management of animals, in consequence of the effects of high summer temperatures on their reproductive physiology and on milk quality.

Conclusions

In the frame of GREENGRASS, the measured data were compared to those obtained in other European grasslands, characterized by higher energy inputs and by a more intensive cultivation. In spite of the extensive use, and of the scarce fertilization, our site showed a high net ecosystem exchange. Most of the monitored grasslands behaved as carbon sinks; yet, adding to the balance the heating power of CH4 and N2O expressed as CO2 equivalents, the net balance results negative for some sites and positive for others. From this point of view, Malga Arpaco resulted anyway a sink; as an average, European grasslands resulted to absorbed 114±67 g CO2 eq m-2 y-1.

No doubts that a wiser farm management could result in an improved grassland productivity. A closer interaction between farmers and tourist operators could open new markets for local dairy products, and foster improvements in farm management.

4-SL1

Functional shifts in plant community composition of calcareous grassland followed by change in management regime

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Introduction

Calcareous grasslands are regarded as valuable habitats due to their diversity of flora and fauna (WallisdeVries et al. 2002). Due to land-use changes in last couple of decades the area of these habitats in Europe dramatically decreased and some measures for their conservation have already been taken in the form of different European and national programmes. Formation of effective management strategies requires deep understanding of vegetation and ecosystem processes. In this study we evaluated the effects of two main threads to the European calcareous grasslands, namely dereliction and eutrophication on the functional composition of plant communities. Plant function was investigated using plant trait and functional type distributions across selected treatments. Species richness and diversity (Shannon index) were also investigated.

Materials and methods

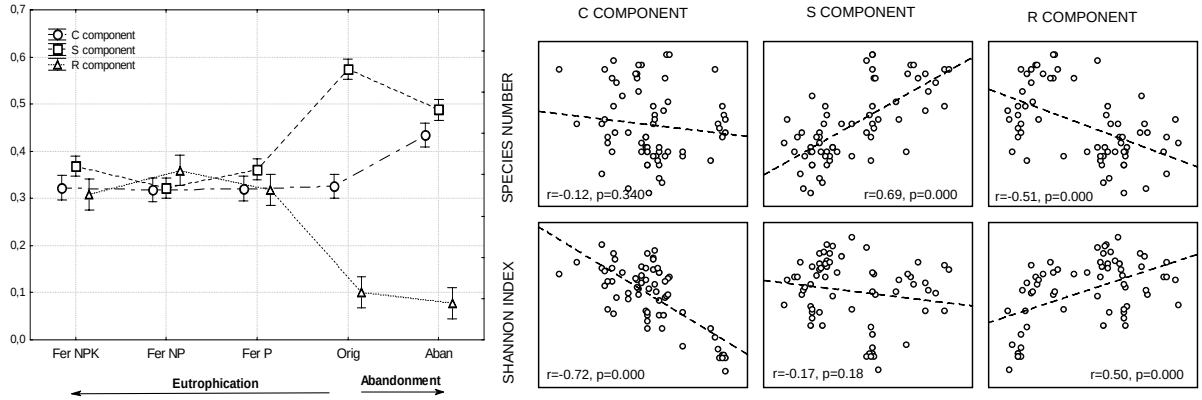
The study was conducted on the mountain Vremščica area (SW Slovenia). The traditionally sheep grazed grassland was subjected to five treatments representing different combinations of fertilization (P, NP and NPK fertilization) and grazing / no grazing regime. Eleven-year effects of these two factors along with other environmental variables (soil properties) on plant species composition and functional signature of vegetation samples were evaluated. Vegetation was sampled in twelve replicates per treatment using Braun-Blanquet method giving sixty samples (3 x 5 m) in total. Some easy measurable plant traits, that had proved to be functionally important in previous studies (see e.g. Landsberg et al. 1999, McIntyre & Lavorel 2001), were selected and their relative frequencies across treatments evaluated. Additionally, species were classified with respect to CSR functional types *sensu* Grime (1977, 2001) to observe shifts in prevailing CSR strategies caused by experimental manipulation. Data was analysed using canonical correspondence analysis (CCA) and general linear modelling.

Results and discussion

Data analysis revealed no difference between P, NP and NPK fertilizaton treatments – whatever the fertilization was, the effects on grassland community were significant and generally larger than effects of grazing. Due to relatively short gradient in environmental factors among vegetation samples rather than complete replacements of plant traits, changes in relative abundance of these traits were observed. Trait composition of original low-intensity grazed vegetation showed importance of stress-tolerance (S component of CSR model), relatively high abundance of small plants, chamaephytes, phalanx strategy and summer green plants. Species richness was the highest in this treatment (median 50 species per sample).

Fertilization (eutrophication) promoted the abundance of therophytes and persistent green, mesophyllous plant species with guerrilla lateral spread. Two ecologically relevant leaf traits showed significant change – specific leaf area increased and leaf dry matter content decreased. Fertilization also caused significant increase in abundance of species expressing ruderality (R component). and decrease in species richness (median 36 species per sample). These results are consistent with findings of other studies (e.g. Rajaniemi 2002, Suding 2005) and support non-random hypotheses of species loss.

Abandonment substantially increased abundance of grasses and suppressed forbs and legumes. Dominance of grasses is also reflected in decrease of Shannon index of diversity. C component of CSR model, showing appearance of competitive exclusion, increased resulting in increased average plant height. Species richness did not differ significantly from the grazed / unfertilized treatment which shows that succession was still very much on the beginning. Wide C:N ratio and frequent drought in summer prevent litter decomposition which causes increase in soil organic matter, lower pH value and occurrence of some acidophyllous plant species.



(A) (B)

Figure 1: (A) Shifts in ratios between components of CSR functional types of original grassland (Orig) due to eutrophication (P, NP and NPK fertilization) and abandonment (Aban). (B) Correlations between CSR components, species richness and Shannon index of diversity.

The results of this study show detrimental effects of fertilizer addition to the diversity and functional composition of the investigated grassland. Low intensity grazing is crucial for preservation of characteristic species and calcareous grassland ecosystem. Additional research is needed to explore the effects of different grazing animals, stocking rates and grazing duration. Critical loads of nutrients, especially nitrogen should also be derived for these habitats in the near future.

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4-SL2

Diversity of noble hardwood forests in Southeastern Europe

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Introduction

Noble hardwood forests have already been thoroughly studied in many parts of Europe. There have been some publications of local nature that deal with noble hardwood trees in the region of Southeastern Europe (Apennine-Balkan province sensu Rivas-Martínez et al. 2001), but we still do not have a synthetic review of these forests in the region. This contribution discusses forests of noble hardwood trees in the region of Apennine-Balkan province, above all their floristic composition, chorology and syntaxonomical affinity. Considering different opinions of their syntaxonomical affinity they were compared to the Southeastern-European beech forests of the alliance *Aremonio-Fagion* and with Central-European forests of noble hardwoods *Tilio-Acerion*.

Materials and methods

A cluster analysis in the SYN-TAX program was carried out when analyzing the syntaxa of noble hardwood forests (2306 relevés from the wider range of the Apennine-Balkan province and Central Europe), resulting in four main clusters. Another two clusters of the syntaxa from the alliance *Aremonio-Fagion* (1621 relevés from the Slovenian national database) were included into comparative synoptic table in order to investigate the diagnostic combination and classification of the studied forests. Average Ellenberg indicator values for relevés of each of six clusters were subjected to PCA (from CANOCO 4.5) to show ecological relationships among these clusters. Diagnostic species of individual clusters were found by calculating the species´fidelity (phi coefficient in the JUICE program) to an individual cluster.

Results

The result of cluster analysis were the following four clusters; 1. the Apennine-Balkan thermoxerophilous group of linden forests, 2. the Apennine-Balkan mesophilous group of maple forests, 3. a group of Central-European thermoxerophilous linden forests and 4. a group of Central-European mesophilous maple forests.

The ordination diagram (Figure 1) demonstrate the transitional character of noble hardwood forests of the Apennine-Balkan province between the alliances *Tilio-Acerion* (Central-European alliance of noble hardwood forests) and *Aremonio-Fagion* (alliance of Illyrian beech forests), as they appear between both alliances on the abscissa. On the ordinate, however, thermoxerophilous and mesophilous forests separate.

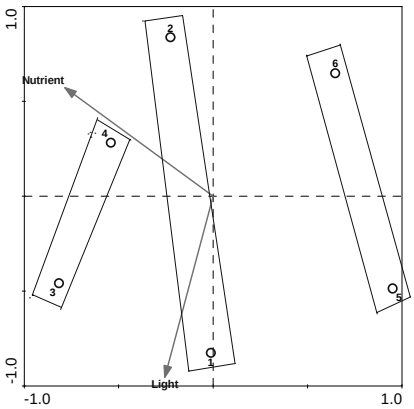

Figure 1: Principal components analysis (PCA) of six relevè clusters, based on average Ellenberg indicator values (nutrients, light) for each cluster. The first four clusters are numbered as in the text above. Cluster 5 represents moderately thermophilous and thermophilous Illyrian beech forests and cluster 6 mesophilous Illyrian beech forests of the alliance *Aremonio-Fagion*.

Discussion

Analysis support the decision on the independent alliance of noble hardwood forests of the Apennine-Balkan region described by Fukarek (1969), alliance *Fraxino-Acerion* Fukarek 1969. On the basis of diagnostic species, which we determined by calculating the species´fidelity, we subdivided the alliance *Fraxino-Acerion* into two suballiances; *Ostryo-Tilienion* (linden forests, cluster 1) and *Fraxino-Acerenion* (maple forests, cluster 2).

Vegetation in the region of the Apennine-Balkan province is mostly chorologically connected. This is because the refugia where the Apennine-Illyrian vegetation survived the unfavourable glaciation period in Teriary were exactly in the region of the Apennines and the Balkan Peninsula (Lang 1994). Forests of the alliance *Fraxino-Acerion*, above all linden forests, stand out regarding the large proportion of endemic species as they are connected by their relic character.

Conclusions

It was determined that noble hardwood forests in the region of the Apennine-Balkan province differ from the forests of the alliance *Tilio-Acerion* and thus represent a unified alliance *Fraxino-Acerion*, characterized geographically, chorologically and paleovegetationally. This contribution establishes the similarity between the vegetation on both sides of the Adriatic Sea and thus confirms certain contemporary phytogeographical findings.

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4-SL3

Wet meadow communities and environmental gradients

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Introduction

Wet meadows have been the object of several studies throughout Europe in the last years, since the threat to the biodiversity of these ecosystems is still increasing and numerous sites have been destroyed. Detailed studies of their vegetation and relation to changes in water regime or management can be made at a restricted number of sites only.
The main objective of this study is to find out which environmental parameters significantly influence the plant species composition of the wet-meadow vegetation and what are the significant differences in site conditions between different associations.

Materials and methods

The relevés were recorded in continental part of Slovenia. The soil samples were collected and following factors were measured according to standard methods: pH, organic carbon, total nitrogen, available phosphorus and potassium, exchangeable cations and texture. Direct gradient analysis (CCA), performed with CANOCO, was used to test their explanation of species data variation. Mean Ellenberg nutrient status values (NV) and moisture values (MV) were added to this analysis. Differences between communities were tested with one-way ANOVA and post-hoc Student-Newman-Keuls test.

Results and discussion

Nine variables (pH, NV, precipitation, MV, Tm, silt, humidity, P_2O_5, clay) that proved to be significant ($p < 0.05$) were used for creation of CCA ordination (Figure 1). The first axis has the strongest correlation with pH and represents acidity gradient. The second axis correlates with NV. The samples were segregated according to communities defined with hierarchical classification: Sa-F – *Sanguisorbo officinalis-Festucetum* with lowest pH; Jc-B – *Junco conglomerati-Betonicetum* with low pH and higher NV; Gp-Ma – *Gentiano pneumonanthes-Molinietum arundinaceae* with low pH, NV, MV and highest silt content; Se-M – *Selino-Molinietum caeruleae* with lowest NV; Pa-M – *Plantagini altissimae-Molinietum caeruleae* with highest NV, MN; Cd-M – *Carici davallianae-Molinietum caeruleae* with highest pH.
Differences in mean pH values are statistically significant between the communities. *Post-hoc* Student-Newman-Keuls test showed differences between most of the groups (Figure 2a). *Post-hoc* test revealed also the differences in means derived from NV between several groups (Figure 2b). This variable does not correlate with acidity gradient, what can also be seen in CCA diagram (Figure 1).

Variance of floristic composition is most affected by pH (15.8% of TVE). Hajek and Hajkova (2004) discovered the same for Czech wet meadows. NV and MV also explained great part of variation (9.5 and 6.2%). Importance of these two factors corresponds to the fact that nutrient availability and water regime are most important in determining the structure of wet meadow vegetation (Grootjans and van Diggelen 1995; De Mars et al. 1996; Zelnik 2005). Almost 45% of explained variation was statistically significant, so selected variables represent a considerable part of possible influencing factors. Most important environmental gradients are acidity, moisture and nutrients, what Wheeler and Proctor (2000) recorded in mires and Hajek and Hajkova (2004) in wet meadows. Statistically significant differences between the communities are best defined with pH, NV, MV.

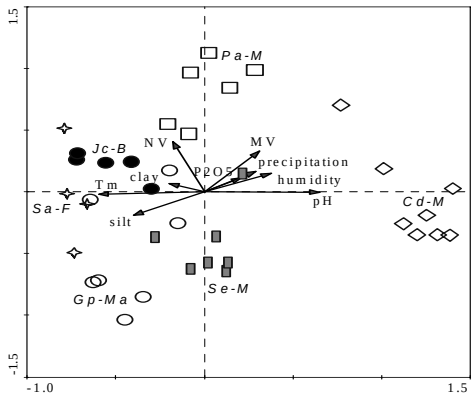

Figure 1. Ordination of samples based on Canonical Correspondence Analysis. Eigenvalues for first two axes are 0.439 and 0.297.

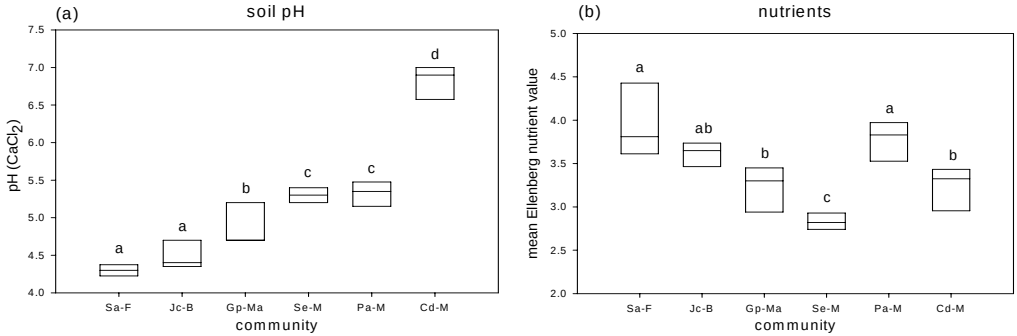

Figure 2. Box plots of soil pH (a) and NV (b) in six plant communities. Significant differences ($p < 0.05$) are marked by letters.

Conclusions

Wet meadow plant communities obtained by the classification occupied a defined position along the acidity and nutrient gradients. Factors like pH, NV and MV enable clear definition of the six studied communities as they show statistically significant differences between them what proves that communities are also ecologically different and their floristic composition is not random.

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4-SL4

Pattern of plant traits in trampled vegetation along climatic gradient in Europe

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Introduction

Trampling is an action of man, animals, vehicles, and like performed vertically on the ground and the same time on vegetation. There are several consequences, the main ones being mechanical damage of tillers, compression of soil reducing aeration and limitation of the content of water in the ground. This action has little or no impact on trampling-resistant species, but their competitors are eliminated. The effect of trampling reflectes on life history of the plants, that adapt to trampling in different ways. As a basis of the research was a group of trampled communities rich in C4 plant species. We took a large data set of communities from all over the Europe (Čarni & Mucina, 1998). Communities of trampled habitats are usually classified within the class of trampled communities *Polygono-Poëtea annuae*. However, we deal with a group of thermophilic trampled communities appearing in the late summer, possesing C4 assimilation pathway, that is advantageous in the conditions of high light intensity, high temperature and low humidity and is classified within the class of weed and ruderal communities *Stellarietea mediae*. In the recent years the research studies have been stressing the importance of plant functional diversity as an important factor in ecosystem functioning. Plant funtional types are a non phylogenetic grouping of species, that have a common functioning on the organisimic level and similar responses to the environment. We suppose that the main pressure on this vegetation all over the Europe is trampling and this should be the most importnat disturbance in establishing of these communities. We tried to find out the other plant trait that enable the divesity within this group of communities?

Materials and methods

A synoptic table from Čarni & Mucina (1998) was used as represents synthesis of trampled vegetation over a broad range of climates in Europe. Therefore we obtained a matrix of 341 taxa and 21 syntaxa. A small indicator frameset was selected as many indicators were not readily available for species in our dataset.

1. Life form (Pignatti 2005),
2. Grime strategy (Grime 1979, determined according to Vela 2002 for Mediterranean species),
3. Choroltypes (Pignatti 2005),
4. Ellenberg values (Pignatti 2005).

Results

Ordination of matrix samples x traits (Fig. 1) shows similar classification as proposed in syntaxonomical scheme by Čarni & Mucina (1998). In the diagram communities indicated with full squares are from Canary Islands and Iberian peninsula, in the area under the Mediterranean climate. This group of communities can be classified within the alliance *Euphorbion prostratae*. The communities indicated with circles can be found in the transitional zone between mediterranean and continental climates, in submediterranean climate, in Italy, Croatia and Slovenia and can be assigned to the *Polycarpo tetraphylli-Eleusinion indicae*. And the group indicated with the crosses in the diagram represents the communities found in atlantic and continental part of Europe classified within the *Eragrostio-Polygonion*. The analysis based on plant functional traits reveal the same pattern as already accepted synsystematic classification that means that the adequate traits have been chosen. As have already been stated, communities dominated by *Heliotropium cirrassavicum* do not belong to this group (number 21 and 22). In these two communities dominate stress tolerant, chamaephytic species.

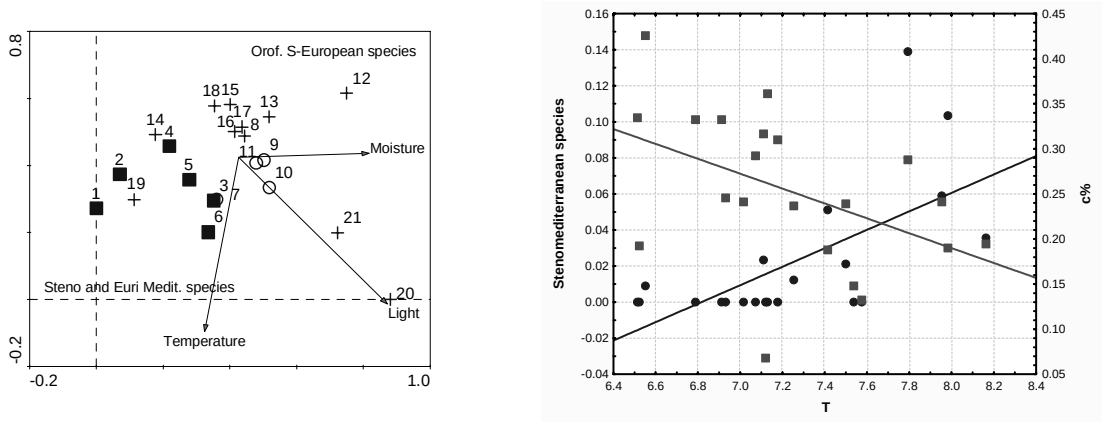

Figure 1 a, b: (a) DCA of matrix samples by traits - samples projected, (b) bivariate correlation plot.

In the diagram (Fig. 1a) plant traits are associated with different sectors of the ordination plane. In can be found out the life history and life span are concentrated in the center of the diagram and they do not have a influence on diversification of this type of communities. It can be seen that the crucial traits are chorotypes, as in the mediterranen region the most imporatnt are stenomediterranean and eurimediterranean species and in atlantic and continental regions, there are montane, alpine and boreal species. If we have a look at the correlation of stenomediterranean and eurimediterranen species and other traits (not shown in this abstract), it can be found out that they correlate significantly positive with temperature and negative with continentality; and alpine and boreal species correlate significantly positive with continentality, hemicriptophytes, competitors and negative with temperature and ratio of C4 plants (Fig. 1b).
According to the passively projected Ellenberg values in the DCA diagram (Fig. 1a), it can be seen that the most important factors of partition are temperature and moisture. We correlated temperature with stenomediterranean species and competitors. It can be found out that mediterranan species disppear in the regions with lower temperature and the number of competitors grows, since in cooler climate the circumstances for survival are better.

Conclusions

It was found out that classification of plant communities made according to plat traits reveals the similar pattern as the classification made according to floristic composition. Since the disturbance is the same in the whole range of distibution of trampled communities, the most important traits are chorotypes, that correlate with the temperature and in a cetrain degree with moisture.

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4-P1

Floristic and ecological differences between managed forest and forest reserves stands of the association *Bazzanio trilobatae-Abietetum albae* Wraber (1953) 1958

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Introduction

Forests, classified in community *Bazzanio trilobatae-Abietetum albae* Wraber (1953) 1958 take only small part in Slovenian forests, but they have high ecological and economic value. Silver fir (*Abies alba* Mill.) is the dominant species in tree layer and usually it is mixed with Norway spruce (*Picea abies* Dietr.). Deciduous trees can be found in the lower tree layer which is often poorly developed.
The *Bazzanio trilobatae-Abietetum albae* thrives in cool and moist sites with very acid soils at altitudes from 380 to 1.200 meters. In addition to a good biological state, this forest community has a protective role. The destruction of the stand would destroy the stand microclimate and the degradation of soil would begin.

Materials and methods

With the intention to investigate ecological and floristic differences between managed and unmanaged forests of the association *Bazzanio trilobatae-Abietetum albae*, six sample plots (25 x 25 m) were established in forest reserves Udin boršt, Zminec, Eržiša – Veliki vrh and Zagoriški hrib (Mlinšek et al. 1980) and six sample plots in managed forests. Within the plots we conducted phytosociological, pedological and light regime surveys.

Vegetation survey was made according to Braun-Blanquet (1964). Statistical methods for treatment of releves also were performed by SYN-TAX 2000 (Podani 2001) and CANOCO (Ter Braak in Šmilauer 1998). Ellenberg values were used for describing and comparing ecological conditions (Ellenberg et al. 1992). Calculations of those values were made in JUICE 6.0 computer program (Tichý 2001).
Pedological samples were sistematical taken in each research plot according to ISO/DIS 10381-4 method (1995).

Results

In the phytosociological table comparison between phytosociological relevés of managed and unmanaged forests do not show significant differences in species composition, but further analysis of Ellenberg values proved significant differences in continentality and moisture between researched forest stands.
Whitney Rank Sum Test showed significant differences in light regime. Statistical significant differences between managed and unmanaged forests exist in amount of direct (DSF), indirect (ISF) and total (TSF) light values.
The statistical analysis of pedilogical data indicate similar pedological circumstances in researched managed forests and forest reserves.

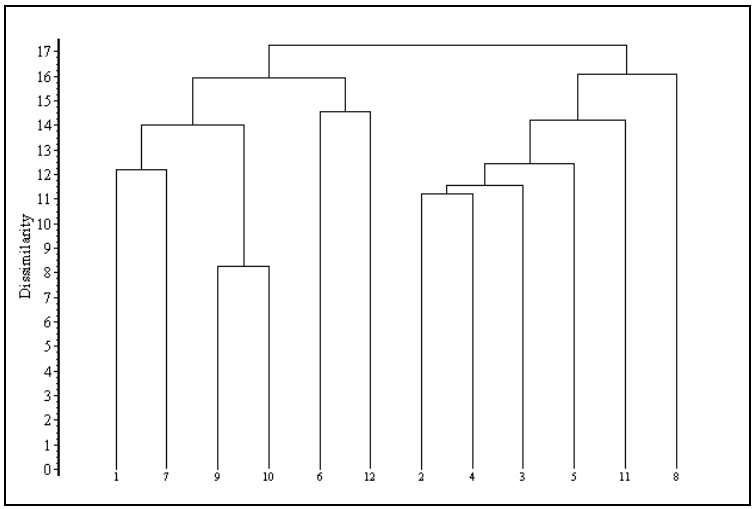

Figure 1: Dendrogram of relevés made in forest reserves (1–6) and managed forests (7–12).

Conclusions

Ascertainment of our research is that floristic structure reflect ecological conditions. Smaller differences in the structure of the vegetation indicate that managing these forests is not as significant as the soil conditions are for the ecosystem changes. Admittedly, our comparison would be more evident if the unmanaged stands for research had been selected in virgin forests. Unfortunately there are no virgin forest plots on such sites in Slovenia.

In the future the occuracy of the results should be tested in a wider European framework.

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4-P2

Posidonia oceanica (L.) Delile as bioindicator of anthropogenic disturbance for environmental quality assessment.

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Introduction

Mediterranean seagrasses are valid bioindicators of anthropogenic disturbance and they can be used to suitably support the environmental quality assessment. In fact benthic biological indicators, such as seagrasses, are the most promising sources of useful information, especially when combined with data on sediment and water column. They respond directly to abiotic and biotic aquatic environment and thus represent sensitive bioindicators of its changes (Boesch & Rosenberg, 1981; Orfanidis et al., 2001). Moreover, population genetics methods using molecular markers are now available, allowing to evaluate the role of genetic diversity for the maintenance and growth of seagrass populations in the face of changing environmental conditions can be evaluated (Reusch, 2001, Fain, 1992).
In this investigation we evaluated several sites, diversely affected by human impact, by the genetic variability of *Posidonia oceanica* (L) Delile and the results were correlated to ecological structure of the meadows.

Material and methods

The plants were sampled in three stations of the natural meadow of S. Marinella (Central Tyrrhenian Sea). According to previous investigations (Micheli et al, 2005), the genetic biodiversity was estimated by RAPD (Random Amplified Polymorphic DNA) markers using PCR (Polymerase Chain Reaction) technique. For biomass analysis all the material was dried (70°C, 48 h) and weighted (DW) to obtain dry weight of shoots, rhizome material and roots. Cluster analysis (UPGMA) of the similarity indices was carried out using NT-SYS software (Rohlf et al., 1993) in order to determine similarities between samples. Fragment sizes of RAPD were estimated from the gel by comparison with a 1Kb ladder marker. The bands were recorded as present (1) or absent (0) and assembled in a data matrix.

Results

In this study we have examined the variation in population dynamics and their status including the physiological features of the plants (tab. 1), then we have analyzed the relationship between genetic diversity and environment quality (fig. 1).

Table 1: Data showing the biomass (g dw m^{-2}) ± STD of the *P. oceanica* plants collected in the meadows of the three stations studied.

Station	Leaves	Roots & Rhizomes	Dead Material
ST 4	1.36±0.606	2.67.0±0.950	0.14±0
ST. 13	1.49±0.703	4.68±2.075	0
ST. 59	1.47±0.456	4.84±1.931	0.045±0.025

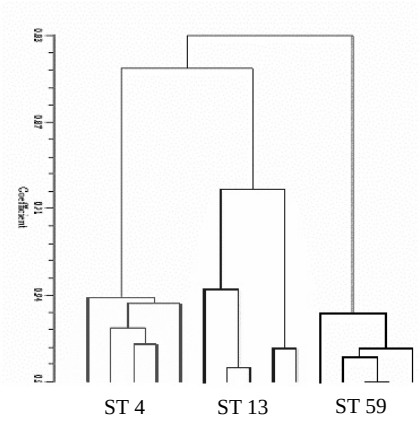

Figure 1: UPGMA phenogram constructed from matrix of RAPD-based genetic distances of three populations of *P. oceanica*..

Discussion

The results enable us to assess the role of environmental stress processes in shaping genetic biodiversity of seagrasses, to identify molecular population-specific RAPD patterns and to relate such patterns to environmental conditions and morphological and physiological features in stress condition

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4-P3

Diversity of plant species in some Ljubljana marsh grasslands under the influence of cutting and fertilizing management

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Introduction

In the last fifty years approximately 2700 km^2 of abandoned Slovene grasslands culminated in forest vegetation. On the menaged grasslands the three cut and two cut (karst and wet grasslands) dominates. The Ljubljana marsh can be described as environmently sensitive. Approximately 75% of the surface area (160 km^2) is covered with semi-natural grasslands of the *Arrhenatherion* type. The second grasslands much smaller in area not included in this study is the *Molinion* type of vegetation. The main reason for our work was to establish management strategies for Ljubljana marsh grassland production with minimal negative effects on the environment. In this study we investigated the effects of cutting and fertilizer treatments on the botanical composition of grass sward, plant diversity and species richness.

Materials and methods

Field trials were established in march 1999 on the semi-natural grassland of the Ljubljana marsh (lat. 45º 58´ N, long 14º 28´ E, alt. 295 m). The trial T1 is based on *Arrhenatherum elatius* grassland. The trail consists of the split-splot design with four replications. The cutting regimes were the main plots, and the four fertilizer treatments as subplots. The cutting regimes were: 2 cuts with a delayed first cut, three cuts and four cuts per year. Fertilizer treatment were 0 (Zero), PK (35 kg P + 133 kg K ha^{-1} y^{-1}); ($N_{(1)}$ PK (50 kg N ha^{-1} cut^{-1} applied to first cut only + 35 kg P and 133 kg K ha^{-1} y^{-1}); $N_{(c)}$ PK (50 kg N ha^{-1} cut^{-1} applied to each of 2, 3 and 4 cuts + 35 kg P and 133 kg K ha^{-1} y^{-1}). The size of sub-plots was 2.5 X 4 m. The soil on the T1 plot was pH neutral (7.2), with low P and K content (ammonium lactate extraction; P = 0.9-2.2 mg, K = 7.7-9.0 mg per 100 g of dry soil). The presented results are from the first cut of fifth trail year (May 11 to June 25, 2003) and consist of portion of botanical groups (and *Equisetum palustre*) in herbage (Table 1) and the plant diversity of grass sward (Table 2).

Results and discussion

The grassland community on the trial consisted of approximately 30 plant species with *E. palustre* and *A. elatius* prevailing. After fertilizer use in first year, the trial exhibited a change in sward species composition. The ratio of botanical groups, measured at the fifth trial year (first cut), showed that the grass sward was less effected by cutting (three $P < 0{,}003$) than by fertilizer application (five $P < 0.001$). On the trial T1 compared to control plots, the proportion of grasses in all fertilized swards increased. This was most evident under the four cut regime (Table. 1). The intensification adopted in the trial, did not negatively affect sward plant diversity (Table 2), which was stable and relative high and highest within 4 cuts. Applying fertilizer decreased diversity in all treatments within 2 cuts and the 200 kg annual rate within 4 cuts. These results are partly in contrast to those in the literature, where negative relationship between fertilizer treatments and plant diversity are reported (Ellenberg, 1952; Nösberger et al., 1994, Zechmeister et al., 2003).

Increasing the frequency of cutting and the use of inorganic fertilizer improved the agronomic value of the grass sward. It also maintained plant diversity in the *Arrhenatherum* grassland on the level of the extensively used sward.

Table 1. The proportion of botanical groups and *Equisetum palustre* (% of fresh matter herbage) in *Arrhenatherum elatius* grassland in year five, first cut, with respect to cutting regime and fertilizer application.

Fertilizer	Cutting regime	grasses	legumes	herbs	*E. palustre*
Zero	2cuts (delayed)	55,8	0.5	43.7	26.4
Zero	3 cuts	75.7	0.6	23.7	14.8
Zero	4 cuts	73.0	0.3	26.7	10.3
PK	2cuts (delayed)	75.5	1.9	22.6	7.6
PK	3 cuts	83.3	3.3	13.4	4.0
PK	4 cuts	82.3	0.5	17.2	2.5
$N_{(1)}$ PK	2cuts (delayed)	85.2	1.9	12.9	6.6
$N_{(1)}$ PK	3 cuts	86.9	0.4	12.7	3.8
$N_{(1)}$ PK	4 cuts	87.5	0.6	11.9	1.4
$N_{(c)}$ PK	2cuts (delayed)	82.3	0.7	17.0	7.5
$N_{(c)}$ PK	3 cuts	86.3	0.7	13.0	3.1
$N_{(c)}$ PK	4 cuts	92.9	0.0	7.1	1.6

Fertilizer treatments were 0 (Zero), PK (35 kg P + 133 kg K ha^{-1} y^{-1}); ($N_{(1)}$ PK (50 kg N ha^{-1} cut^{-1} applied to first cut only + 35 kg P and 133 kg K ha^{-1} y^{-1}); $N_{(c)}$ PK (50 kg N ha^{-1} cut^{-1} applied to each of 2, 3 and 4 cuts + 35 kg P and 133 kg K ha^{-1} y^{-1}).

Table 2. Shannon diversity index and species number in the *Arrhenatherum elatius* grassland in year five, first cut, with respect to cutting regime and fertilizer aplication.

	Shannon diversity index[†]					Species richness of plants investigated[‡]				
	Zero	PK	$N_{(1)}$ PK	$N_{(c)}$ PK	average	Zero	PK	$N_{(1)}$ PK	$N_{(c)}$ PK	average
2 cuts (delayed)	1,92	1.42	1.43	1.52	1.57a[§]	19	15	14	15	16a
3 cuts	2.11	2.06	1.94	1.80	1.98b	22	26	21	20	22b
4 cuts	2.35	2.16	2.18	1.70	2.10b	23	21	23	20	22b
Average	2.13b[§]	1.88a	1.85a	1.67a	1.88	21a	21a	19a	18a	20

[†] $P = 0.006$ for cutting; $P = 0.003$ for fertilizing; no cutting x fertilizing interaction

[‡] $P = 0.001$ for cutting; P = 0.138 for fertilizing; no cutting x fertilizing interaction

[§] Means within a column or row followed by the same letter are not significantly different at $P = 0.05$ Duncan´s multiple range test.

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4-P4

Seasonal vitality of macrophyte species with different life cycles (Lake Velenjsko jezero, Slovenia)

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Introduction

The macrophyte vegetation in the artificial lake Velenjsko jezero has been monitored since 1996. The pH of the lake was around 12 up to 1994, when the lake was remediated. After that macrophytes started to colonize a large proportion of the littoral very quickly. Species appeared in different extend and showed different life cycles (Mazej and Epšek 2005). In the vegetative season 2004 we tried to depict seasonal variability in plant's vitality by measuring dark respiration rates, the photochemical efficiency of PS II and the contents of nutrients.

Materials and methods

Relative abundance of macrophyte species was assessed in a five level description scale (Kohler and Janauer 1995) in one month intervals. At the same time plants (*Potamogeton crispus* L., *Myriophyllum spicatum* L., *Najas marina* All., *Potamogeton filiformis* Pers. and *Potamogeton lucens* L.) were collected. The photochemical efficiency of PS II (F_v/F_m) was measured using a modulated fluorometer (OS-500 fluorometer; OPTI-SCIECES, Tyngsboro, MA, USA) (Schreiber *et al*., 1995). Dark respiration (DR) was measured with Clark-type electrodes (MultiLine P4). Total nitrogen (TN) in plants was determined by standard method ISO 11261:1995. Total phosphorus (TP) in plants was determined following the modified spectrophotometric procedure (PM 4.37).

Results and discussion

There were large seasonal changes in the presence and abundance of the investigated species (Table 1).

Table 1: Relative abundance of different macrophyte species in Lake Velenjsko jezero in the vegetative season 2004.

	Abbrev.	Jun	Jul	Aug	Sep
Myriophyllum spicatum L.	Myr spi	2	2	1	1
Najas marina All.	Naj mar	-	2	4	4
Potamogeton crispus L.	Pot cri	3	1	1	1
Potamogeton filiformis Pers.	Pot fil	3	3	3	2
Potamogeton lucens L.	Pot luc	1	1	2	2

Relative abundance: a five level descriptor scale (1 – very rare, 2 – infrequent, 3 – common, 4 frequent, 5 – abundant, predominant) (Kohler and Janauer 1995).

Young shoots had higher DR (Fig. 1) and F_v/F_m (Fig. 1) and contained much more nutrients than shoots later in the season. This was also seen from the calculated positive correlations between F_v/F_m and DR ($r = 0.39$, $p < 0.05$), between F_v/F_m and plant's nitrogen content ($r = 0.45$, $p < 0.05$), between DR and plant's nitrogen content ($r = 0.61$, $p < 0.05$) and between DR and plant's phosphorus content ($r = 0.66$, $p < 0.05$). High contents of nutrients were detected at the start of the plant's development. In June *P. filiformis* contained 0.37 %DW of TN and 3.0 %DW of TP while *P. lucens* contained 0.38 %DW of TN and 2.9 %DW of TP. *N. marina*, which started its development in the middle of the summer, contained the highest contents of nutrients in August - 0.32 %DW of TN and 3.2 %DW of TP. This

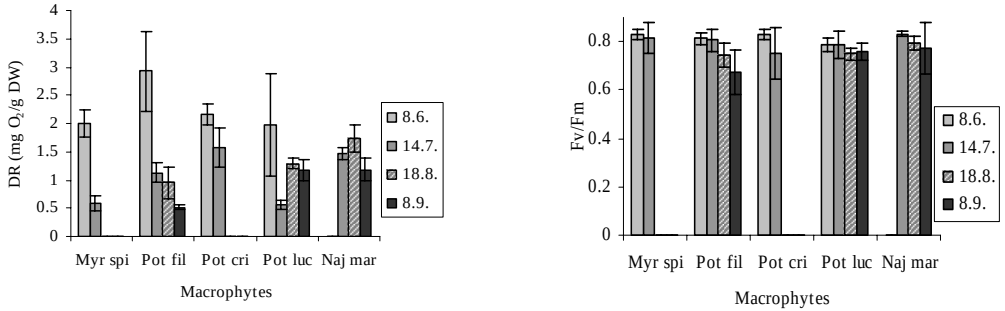

Figure 1 Mean values of dark respiration rate (DR) and photochemical efficiency of PS II (Fv/Fm) measured in the leaves of different macrophyte species throughout the vegetative season 2004. Vertical bars represent the standard deviation (n=6).

phenomenon is known as "luxury" uptake and it was supposed that early uptake of nutrients may benefit the plant later if nutrient concentrations diminish (Garbey *et al*. 2004) and also allowed plant's massive development (Palma-Silva *et al*. 2002). The physiological processes such as respiration and photosynthesis are also affected by temperature. DR was mostly the lowest in the summer conditions at the species (*P. crispus*, *P. filiformis*, *P. lucens* and *M. spicatum*) which started their life cycles in spring, when temperature of lake water was lower (the water temperature was 19 ^{o}C in June). *N. marina*, which prefers higher temperatures, had the highest dark respiration rate on August (the water temperature was 23.9 ^{o}C). Photosynthetic efficiency of PS II at all species slightly decreased through the season. The measurements of photochemical efficiency of PS II do not demonstrate only damage to PS II, but they are also recognised as a powerful way of assessing the effect of various environmental stresses (Ögren and Öquist 1985).

Conclusions

The vitality of the macrophytes varied with respect to the seasonal dynamics of the plants and their plasticity. The physiological processes and the uptaking of nutrients were much intense in the beginning of the plant's development.

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4-P5

Morphological analysis of pubescent oak (*Quercus pubescens* Willd.) in Slovenia

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Introduction

Morphological variability of particular oak species can be result of variety within species, interspecific crossbreeding or reflection of ecological conditions in habitat. Interspecific crossbreeding is very frequent within genus *Quercus* L. because of inexpressive reproductive barriers and adapting of species to habitat conditions. So oak species were a subject of many researches. As most suitable sign for discriminating between species and lower taxa turned out to be morphological signs of leaves and fruits. Research of morphological variability of species *Quercus pubescens* Willd. (pubescent oak) was the main goal of our research. Second goal was to find out how is with species *Quercus virgiliana* (Ten.) Ten. in Slovenia.

Materials and methods

The research was carried out on the trees belonging to eight populations of pubescent oak in Slovenia. Populations Boč and Šmarnogorska Grmada belong to associations of plants with pubescent oak in continental part of Slovenia. While populations Gračišče, Kozana, Petrinje, Podsabotin, Poljane - Razguri and Sveti Kvirik belong to associations of plants with pubescent oak in sub Mediterranean part of Slovenia. Research was planned so that within each population three to five trees were selected and from each we collected short fertile shoots with leaves and when possible also fruits – acorns.
It is important which leaves we collect. In the previous researches (Smole in Batič, 1992; Franjić, 1996; Škvorc, 2003) they found out, that most suitable for morphological analyses are leaves from short fertile shoots growing on the sunny side of the crown. By collecting leaves from short fertile shoots we reduce variability within each individual tree and at the same time leaves from short fertile shoots represents current stadium of species. Selection of trees is also important, because the most suitable are trees (or bushes) growing in the open air or in the outer edge of stand. Those trees can maximally express their phenotype like it is determined by genotype, so ascertained differences between individual trees are consequence of genotype and habitat conditions (Franjić, 1996) and influence on tree from neighbouring trees is excluded. Beside the trees selection is also important time of sampling. Most appropriate is second half of summer and beginning of autumn because sampled leaves for analyses have to be completely developed (Franjić, 1996; Škvorc, 2003). All material for research was collected in the second half of September 2001 (Boč, Gračišče, Petrinje, Poljane – Razguri, Sveti Kvirik, Šmarnogorska Grmada) and 2005 (Kozana, Podsabotin).
Collected shoots with leaves and fruits were first of all herbarised. After drying the leaves (herbarisation) we chose 60 to 100 healthy, undamaged leaves per tree. On each leaf were measured, calculated and assessed 15 parameters which were then used for morphological analysis. Leaf parameters were: lamina length and width (DL and ŠL), petiole length (DP), lamina width to lamina length ratio (ŠL/DL), petiole length to lamina length ratio (DP/DL), number of leaf lobes on left and right side of lamina (KL and KD), number of intercalary veins (IŽ), type of leaf lamina base (LD), type of leaf lamina top (VL), density of leaf pubescence on lower lamina (DSP), on leaf veins (DLŽ), on leaf edge (DLR) and on petiole (DLP) and type of hair (TD). On fruits was measured one parameter: fruit petiole length (DPP) and on one year shoots was assessed density of pubescence (DEP). Statistical methods used for data evaluation were descriptive statistical methods, parametric and nonparametric methods and multivariate statistic methods.
For statistical evaluation of data were used following computer programmes: Excel XP, SPSS for Windows 8.0 and Statistica for Windows 6.0 and 7.0.

Results

The results of analyses confirmed that all chosen trees belong to species pubescent oak, but some individuals indicated possible influence of other species from genus *Quercus*. With nonparametric test and multivariate statistic methods were ascertained

statistically significant differences between individual trees within populations and between populations. With analysis that were done we can not confirm the existence of species *Q. virgiliana* in Slovenia.

Analysis of leaf morphometry data showed significant differences between trees within populations and between populations themselves. It was also ascertained that *Q. virgiliana* (Ten.) Ten. can be treated within species *Q. pubescens*.

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