Dry Grasslands of Europe:
Grazing and Ecosystem Services



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SPECIAL SECRETARIAT FOR FORESTS
&
HELLENIC RANGE AND PASTURE SOCIETY

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Edited by
Vrahnakis M., Kyriazopoulos A.P., Chouvardas D. and Fotiadis G.

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**Vrahnakis M., A.P. Kyriazopoulos, D. Chouvardas and G. Fotiadis**


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**Preface**

Dry grasslands are herbaceous vegetation types, mostly dominated by grasses (in the sense they botanically belong to the family Gramineae=Poaceae), and graminoids (representatives from the botanical families of Juncaceae, Cyperaceae, etc.), while broadleaved herbs may also contribute to a significant percentage in botanical composition. In Europe they are mostly met (a) in zonal lowland steppes (like in Ukraine, Russia, Kazakhstan, etc.), (b) as alpine (dry) grasslands broadly in European mountain above timberline, (c) as azonal/extrazonal dry grasslands in areas where, due to relief and soil, zonal forests are not grown, and (d) as secondary (semi-natural) grasslands, grown in areas where forest vegetation is not met due to human activities (livestock grazing, mowing, mining) or in areas where arable land is relaxed or abandoned. Secondary dry grasslands is the dominant type in most European countries and recently emphasis is placed from the EU as they generally constitute what is termed as High Nature Value (HNV) grasslands.

Grazing is an integral biological attribute of grassland ecosystems. Through grazing humans intervene in the evolution of grassland vegetation and quite often are able to benefit from the provision of various ecosystem services. Supporting, provisioning, regulating and cultural services In this sense, dry grasslands are of paramount importance for Europe. They sustain economies, from the domestic to the national levels, societies by providing valuable ecosystem services, like adjusting water balance, and nature by, e.g. forming numerous habitat types where exceptional elements of biodiversity flourish. Apart from their importance in terms of the maintenance of biodiversity, several other services and products are provided by grasslands. They play a major role in providing high quality forage for both livestock and wild animals; they support communities of insects with major roles in the ecosystem services of control and pollination, sustain apiculture, and contribute to the prevention of erosion processes, maintenance of the water cycle; they combat the negative impacts from fertilizers and pesticides, as well as their highly significant aesthetic recreational values. Given to their importance, a number of scientific groups are scanning, searching and promoting structural and functional elements of European dry grasslands, in disciplines ranging from the political to the economic and to the ecological. Among them the European Dry Grassland Group (EDGG, www.edgg.org), which is an official group of the International Association for Vegetation Science (IAVS, www.iavs.org), from its inception in October 2008 onwards is placing the development and conservation of European grasslands as first priority.

Present volume is an effort to publicize and promote further the significant values and ecosystem services provided by the European dry grasslands. Controlled livestock grazing appeared to be the major vendor of these values and services. The first part of the volume is dedicated to the impact of grazing on the biotic environment and the role grazing that plays on herbage production and quality, representative species of wild fauna, vegetation structure, spatial distribution, historical changes, and floristic diversity. The impact of grazing on elements of the abiotic environment, like soil and landscape properties, land productivity, and carbon sequestration is the focus of the second part of the volume. The largest part of the volume is the third one dedicated to ecology and management of dry grasslands; among others vegetation and ecological characteristics from dry grasslands of various places of Europe are presented, various impacts of wildfires, mycorrhiza formation, faunal and floristic diversity are investigated, and phytosociological identities and habitat-type statuses are presented. Finally, life quality, landscape historical evolution, infrastructure development, environment-friendly livestock production systems, proposals for sustainable rural development i.e. the tight links of local societies and European dry grasslands is the focus of the last part of the volume.

It is evident from the above contributions that European dry grasslands is a valuable source for the continuum of ecosystem services. However, it is rather a neglected land use/type, although they occupy a significant part of the European continental. Let's counterbalance the lack of the analogous interest from agrarian policy makers with the scientific faith for their paramount importance and drastic actions for their restoration and conservation.

*Michael Vrahnakis*
*TEI of Larissa,*
*Karditsa, Greece*

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# SESSION 1
## Grazing impact on biotic environment

# Relationship between chemical composition and *in vitro* digestibility of rangeland vegetation of northern Greece

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## Abstract

The relationship between chemical composition and *in vitro* digestibility of some rangeland species in northern Greece was examined in the present study. Samples of herbaceous and ligneous browse species were collected during middle of June and early October. Nutritive value of the above species was evaluated based on chemical composition: crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL) and the *in vitro* organic matter digestibility (IVOMD). The herbaceous IVOMD did not significant correlated with any of the cell wall fractions in June. However, a significant negative correlation with NDF and a positive one with CP were found in October. Concerning the browse species IVOMD's, it was negatively related with NDF, ADF, and ADL, both in June and October. It seems that, cell walls content is a reliable predictor for both summer and autumn *in vitro* digestibility for browse species but it is not for herbaceous species.

**Key words:** forage quality, herbage, browse species

## Introduction

The estimation of forage digestibility is probably the most useful tool of the pasture quality (Graham et al., 1997), as it is related to energy content of feed and presents a positive correlation to crude protein. It is known, that rangelands species differ in chemical composition and nutritive value, according to their botanical family and stage of maturity (Marinas et al. 2003, Bell 2003). Therefore, digestibility is mainly predicted by chemical and biological methods for each species separately.

In rangeland ecosystems floristic diversity in relation to the soil characteristics, climate, season, and management (Georgiadis and McNaughton 1990) controls the growth and maturity of each species and consequently affects forage digestibility (Arzani et al. 2006). Thus, the nutritive value of grasses and legumes in mixed pastures may be different from that in monocultures (Vazquez-de-Aldana et al. 2000). Moreover, forbs contribute to animal feed when they are in a mixture with grasses

(Cook and Wayne 1983), while they considered as less favorable feed separately.

The digestibility trials are time- consuming, laborious and require expensive facilities. Thus, the use of chemical composition could be an alternative for the indirect estimation of IVOMD. The aim of this study was to evaluate the nutritive value of herbaceous and ligneous species based on the relationship between their chemical composition and *in vitro* digestibility.

**Materials and methods**

Herbaceous and ligneous species from two different locations in northern Greece were tested in this research. Hand-harvested samples of the herbaceous understory vegetation of a silvopastoral oak system (*Quercus frainetto*) were collected from ten different sites in 2010. The study area was located in Cholomontas, Chalkidiki (40°23'N, 23°28'E) at 800 m a.s.l. The climate of the area is classified as subhumid Mediterranean, with a mean air temperature of 11.1°C and an annual rainfall of 767 mm. Four samples in quadrats (0.50x0.50m) were cut to 2 cm above ground level in each site. The dominant species were representative of different botanical families including grasses, legumes and forbs (*Dactylis glomerata*, *Brachypodium* sp., *Trifolium* sp., *Vicia lathyroides*, *Galium* sp., *Silene* sp. etc) which have different forage characteristics (Van Soest 1994). At the meantime hand-plucked samples (i.e. leaves and twigs <2 mm) of four ligneous browse species (the evergreen shrubs *Arbutus unedo* L., *Arbutus andrachne* L. and the deciduous *Robinia pseudoacacia* var. *monophylla* L., and *Morus alba* L.) from the Aristotle University's farm, Thessaloniki (40° 34′ E, 23°43′ N, at sea level) were collected. The climate of the area is semi-arid, with a mean annual temperature of 16.4°C, and a mean annual precipitation of 374 mm. For each species, foliage from four individual plants was collected. Both herbaceous and ligneous samples were collected at two vegetative stages: at reproductive (middle of June) and at regrowth (early October).

The samples were oven-dried at 60°C for 48 hours, ground through a 1 mm screen and analyzed for N using a Kjeldahl procedure (AOAC, 1990). Crude protein (CP) was then calculated by multiplying the N content by 6.25. Additionally, neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined according to Van Soest *et al.* (1991). *In vitro* organic matter digestibility (IVOMD) of the samples was determined using Tilley and Terry (1963) method as modified by Moore's (Harris, 1970).

The procedures of SPSS 10.0 for Windows statistical software were used for the implementation of Pearson correlation between chemical composition and *in vitro* digestibility (Steel and Torrie,1980).

**Results and Discussion**

There was a significant positive correlation (Tables 1, 2) between IVOMD and CP in herbaceous vegetation both in June and October, although it was weak. This finding is in agreement with results reported by Getachew et al. (2004).

**Table 1.** Correlation coefficients between chemical composition and *in vitro* organic matter digestibility for herbaceous species in June

| | NDF | ADF | ADL | IVOMD |
|---|---|---|---|---|
| CP | -0,265 | -0,736** | 0,187 | 0,439* |
| NDF | 1 | 0,358 | -0,448* | -0,298 |
| ADF | | 1 | -0,417* | 0,377 |
| ADL | | | 1 | -0,230 |

CP:Crude protein, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, ADL: Acid detergent lignin, IVOMD: *In vitro* organic matter digestibility, *Significant at ** $P< 0.01$, * $P<0.05$*

**Table 2.** Correlation coefficients between chemical composition and *in vitro* organic matter digestibility for herbaceous species in October

| | NDF | ADF | ADL | IVOMD |
|---|---|---|---|---|
| CP | -0,884** | -0,342 | 0,219 | 0,386* |
| NDF | 1 | 0,534** | -0,175 | -0,478* |
| ADF | | 1 | 0,392* | -0,273 |
| ADL | | | 1 | -0,168 |

CP:Crude protein, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, ADL: Acid detergent lignin, IVOMD: In vitro organic matter digestibility, Significant at ** $P< 0.01$, * $P<0.05$

Moreover, IVOMD was significantly negative correlated ($P<0.05$) only with NDF (Table 2) in October (r=−0,478), while it was not significantly correlated with any cell walls parameter (NDF, ADF, ADL) in June. Similar negative correlations between NDF and ADF with digestibility have been found by Moreira et al. (2004). On the contrary, Marinas et al. (2003), found strong negative correlation between IVOMD with NDF and ADF in herbage species, but a weak correlation with ADL in consistent with our findings (Tables 1, 2). These findings indicated that it is very difficult to use indirect methods in order to predict IVOMD for herbaceous species. This may be attributed to high variance of chemical composition among species due to different stage of maturity (Aguiar et.al. 2011).

In the ligneous browse species, IVOMD was significantly positive correlated ($P<0.01$) with CP only in June (Tables 3, 4). Similar, Arzani et al. (2006), working with forage species of Zagros Mountain, found a significant positive correlation of IVOMD with CP. Concerning the cell wall components, there was a significant negative strong correlation ($p<0.01$) with IVOMD both in June and October (Tables 3, 4).

**Table 3.** Correlation coefficients between chemical composition and *in vitro* organic matter digestibility for ligneous species in June

| | NDF | ADF | ADL | IVOMD |
|---|---|---|---|---|
| CP | 0,139 | -0,307 | -0,090 | 0,230 |
| NDF | 1 | 0,555 | 0,815** | -0,772* |
| ADF | | 1 | 0,887** | -0,916** |
| ADL | | | 1 | -0,940** |

CP:Crude protein, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, ADL: Acid detergent lignin, IVOMD: In vitro organic matter digestibility, Significant at ** $P< 0.01$, * $P<0.05$

These results are in agreement with those of Ammar et al. (2004), who found a strong negative correlation between IVOMD and both ADF (r=-0,659) and ADL (r=-0,701), in Spanish browse species, collected at different stage of maturity from spring to autumn. In addition, Papachristou (1990) found higher correlation between *in vitro* digestibility and ligneous species compared to grasses and forbs in shrublands in northern Greece.

**Table 4.** Correlation coefficients between chemical composition and *in vitro* organic matter digestibility for ligneous species in October

| | NDF | ADF | ADL | IVOMD |
|---|---|---|---|---|
| CP | 0,076 | -0,617 | -0,163 | 0,370* |
| NDF | 1 | 0,524 | 0,907* | -0,880* |
| ADF | | 1 | 0,818* | -0,849* |
| ADL | | | 1 | -0,965** |

CP:Crude protein, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, ADL: Acid detergent lignin, IVOMD: In vitro organic matter digestibility, Significant at ** $P< 0.01$, * $P<0.05$

Among the cell walls parameters, ADL exhibited the highest correlation with IVODM. The composition and structure of the cell walls may affect digestibility to a greater extent than its content, depending on its degree of lignification (Van Soest, 1994, Ammar et al. 2004), and resulting in higher negative correlations of the in vitro digestibility with ADL than with NDF content.

## Conclusions

The prediction of *in vitro* digestibility of herbaceous species based on the chemical composition parameters had weak correlation with cell walls parameters. However, the correlation with CP was good. On the other hand, indirect estimation of *in vitro* digestibility using cell walls parameters is reliable predictor for browse species both in summer and autumn.

## References

**Aguiar A.D., L.O. Tedeschi, F.M. Rouquette Jr, K. McCuistion, J.A. Ortega-Santos, R. Anderson, D. DeLaney and S. Moore, 2011.** Determination of nutritive value of forages in south Texas using an *in vitro* gas production technique. *Grass and Forage Science*, 66: 526–540.

**Ammar H., S. López, J.S. González and M.J. Ranilla, 2004.** Chemical composition and *in vitro* digestibility of some Spanish browse plant species. *Journal of the Science of Food and Agriculture,* 84(2):197–204.

**AOAC, 1990.** Official Method of Analysis, 15th edn. AOAC, Washington DC, USA, 746 pp.

**Arzani H., M. Basiri, F. Khatibi, and G. Ghorbani, 2006.** Nutritive value of some Zagros Mountain rangeland species. *Small Ruminant Research,* 65:128–135.

**Bell A., 2003.** Pasture assessment and livestock production. Agnote series DPI-428 (1st edition). State of New South Wales.

**Cook C., Wayne, 1983.** "Forbs" need proper ecological recognition, *Rangelands*, 5: 217–220.

**Georgiadis N.J. and S.J. McNaughton, 1990.** Elemental and fibre content of savannah grasses. Variation with soil type, season and species. *Journal of Applied Ecology*, 27: 623-634.

**Getachew G., P.H. Robinson, E.J. Depeters and S.J. Taylor, 2004.** Relationships between chemical composition, dry matter degradation and *in vitro* gas production of several ruminant feeds. *Animal Feed Science and Technology*, 111: 57–71.

**Graham P., A. Bell and C. Langford, 1997.** How pasture characteristics influence sheep production. Agnote series 4-51 (2nd edition). State of New South Wales.

**Harris L.E., 1970.** Nutrition Research Techniques for Domestic and Wild Animals. Vol. 1. L.E. Harris, Logan, UT. pp. 5501-5505.

**Marinas A., R. García-González and M. Fondevila, 2003.** The nutritive value of five pasture species occurring in the summer grazing ranges of the Pyrenees. *Animal Science*, 76:461-469.

**Moreira F.B., I.N. Prado, U. Cecato, F.Y. Wada and I.Y. Mizubuti, 2004.** Forage evaluation, chemical composition, and *in vitro* digestibility of continuously grazed star grass. *Animal Feed Science and Technology*, 113:239–249.

**Papachristou T.G.,1990.** Botanical composition and nutritive value of goat diets on shrublands with different proportions of shrubby and herbaceous species. PhD Thesis. Aristotle University of Thessaloniki, Greece. 145 pp.

**Steel R.G.D. and J.H. Torrie, 1980.** Principles and Procedures of Statistics, 2nd ed. McGraw-Hill, New York, USA, 481 pp.

**Tilley J.A. and R.A. Terry, 1963.** A two-stage technique for the *in vitro* digestion of forage crop. *Journal of British Grassland Society*, 18:104-111.

**Van Soest P.J., 1994.** Nutritional Ecology of the Ruminant. (2nd ed.) C. U. Press, Ithaca, NY.

**Van Soest P.J., J.B. Robertson and B.A. Lewis, 1991.** Methods for dietary fiber, neutral detergent fiber and non-starch polysaccharides in relation to animal nutrition. *Journal of Dairy Science*, 74: 3583-3597.

**Vazquez-de-Aldana B. R., A. Garcia-Ciudad, M. E. Perez-Corona and B. Garcia-Criado, 2000.** Nutritional quality of semi-arid grassland in western Spain over a 10-year period: changes in chemical composition of grasses, legumes and forbs. *Grass and Forage Science*, 55: 209-220.

# Forage chemical composition of a grazed and an ungrazed kermes oak (*Quercus coccifera* L.) shrubland in northern Greece

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## Abstract

Kermes oak shrublands (*Quercus coccifera* L.) are an important source of nutrients for grazing goats during the critical summer period in Greece. This study was carried out to identify the growing plant species in a grazed (GS) and an adjacent ungrazed for 10 years (UGS) kermes oak shrubland at the Municipality of Anthemouda, Chalkidiki, northern Greece, as well as to determine their chemical composition. Two experimental cages 2x2 m were placed in each shrubland in order to identify the herbaceous and woody species and to collect samples. The collected samples were analyzed for ether extracts (EE), crude fibre (CF), crude protein (CP), calcium ($Ca^{2+}$), phosphorus ($P^{5+}$), sodium ($Na^{+}$) and potassium ($K^{+}$) content determination. Mean CF concentration of shrubs was not different ($p<0.05$) between the GS (21.3% DM) and the UGS (19.7% DM). Higher CP content was found in forbs (11.4 % DM) followed by grasses (9.4% DM) and shrubs (7.4% DM) of the GS. On the contrary, higher mineral content (1316.7 mg $Ca^{2+}$/100 g DM, 695.5 mg $P^{5+}$/100 g DM, 1538.6 mg $Na^{+}$/100 g DM, and 953.6 mg $K^{+}$/100 g DM) was observed in the UGS, as only shrub species comprised the vegetation of this shrubland.

**Key words:** Mediterranean shrublands, chemical composition, plant groups

## Introduction

Shrublands occupy extensive areas of the Mediterranean region covering a total surface of 110,854 km$^2$ (Calvo et al. 2011). Generally, their vegetation is composed of both evergreen and deciduous shrubs with an understorey of herbaceous species. Kermes oak (*Q. coccifera* L.) is the dominant vegetation of evergreen sclerophyllous shrublands, covering around 1500 km$^2$ or 50% of the total shrubland area of Greece (Papanastasis 1997). These areas are considered as natural grazing lands, especially for goats, but they also provide fuelwood for the rural communities and a natural habitat for the wildlife, while they protect soil from erosion. Through grazing, goats convert this otherwise unused natural resource into animal products of high biological value. In the heterogeneous forage environment of evergreen shrublands, grazing animals select their diet from various plant species and plant parts, which have obviously different chemical composition. It is known that the chemical composition of forage species common in such environments is widely variable, depending on species, plant parts, phenological stage, environmental conditions as well as previous grazing management (Yiakoulaki 1987, Decandia et al. 2007, Papanastasis et al. 2008).

Information about chemical composition of the dominant plant species in kermes oak shrublands are relatively limited (Yiakoulaki 1987, Yiakoulaki and Nastis 1993, Parkal et al. 2011). Such knowledge will assist in achieving the timely utilization of forage plants, help predict deficiencies of nutrients and suggest supplementation needs.

The objectives of this study were to identify the growing plant species in a grazed (GS) and an adjacent ungrazed for 10 years kermes oak shrubland (UGS) at the district of Chalkidiki peninsula, northern Greece and also to determine their chemical composition.

**Materials and Methods**

The study was conducted at the Municipality of Anthemouda in the district of Chalkidiki peninsula, northern Greece, during the summer of 2009. Two kermes oak (*Quercus coccifera* L.) shrublands -a grazed (GS) and an adjacent ungrazed for over 10 years (UGS)- were selected covering an area of 0.5 ha each. Mean annual precipitation of 2009 was 754 mm while mean annual temperature was 14.21$^{o}$C. Two experimental cages sized 2 x 2 m, fenced with rope, were placed in preselected points in each shrubland and the present herbaceous and woody species were identified. Species nomenclature followed Flora Europea (Tutin et al. 1968-1993). After that the herbaceous and woody vegetation were clipped in situ with hand scissors at 5 cm above the soil surface (Odum 1971). The harvested samples were categorized in three plant groups: grasses, forbs and shrubs. The samples were dried at 60$^{o}$C for 48h, ground to pass a 1-mm screen of a Willey mill and were analyzed for ether extracts (EE) and crude protein (CP) content according to the AOAC methods (AOAC, 1995). Crude fiber was determined by the Bellucci method (Bellucci 1932). Ca, Na, and K concentrations were determined by flame photometry and that of P by spectrophotometeric methods (Khalil & Manan, 1990). Data on plant species were subjected to analysis of variance. The Fisher's Protected Least Significant Difference (LSD) test (Fisher 1966) was used for detecting mean differences ($p \leq 0.05$).

**Results and Discussion**

In the GS were found the following 29 taxa: 3 grasses (*Cynodon dactylon* (L.) Pers., *Vulpia ciliata* Dumort., *Setaria viridis* (L.) P. Beauv.), 20 forbs (*Anthemis cotula* L., *Dianthus diffusus* Sibth. & Sm., *Alyssum heldreichii* Hausskn, *Trifolium lappaceum* L., *Plantago lanceolata* L., *Erysimum graecum* Boiss. & Heldr., *Trifolium angustifolium* L., *Sinapis arvensis* L., *Malva montana* Forssk. sec. C.Chr., *Trifolium repens* L., *Teucrium polium* L., *Trifolium arvense* L., *Centaurea diffusa* Lam., *Erodium moschatum* (L.) L'Hér., *Sedum tenuifolium* (Sm.) Strobl, *Scutellaria columnae* All., *Asparagus acutifolius* L., *Cirsium arvense* (L.) Scop., *Medicago minima* (L.) Bartal., *Carlina vulgaris* L.) and 6 shrubs (*Juniperus oxycedrus* L., *Cistus incanus* L., *Crataegus oxyacantha* L., *Erica arborea* L., *Phillyrea latifolia* L., *Quercus coccifera* L.) On the other hand only 5 taxa (shrub species) were found in the UGS: *Crataegus oxyacantha* L., *Erica arborea* L., *Juniperus oxycedrus* L., *Phillyrea media* L. and *Quercus coccifera* L. Kermes oak was the predominant shrub species in both shrublands (GS and UGS). The absence of herbaceous species in the UGS is in accordance with findings of Metera et al. (2010), who referred that in many areas of Europe, low or no grazing pressure leads to the creation of unexploited areas that are covered by shrubs. In our study the shrubs of the UGS were tall (more than 1.50 m) and dense. Tall and dense kermes oak shrubs are often found in the shrublands of the Mediterranean zone. These shrubs are difficult to be reached or penetrated by grazing animals (Yiakoulaki and Nastis 1998).

No significant differences ($p \leq 0.05$) were observed in the EE content of the shrub species found both in the GS and UGS. Moreover, no significant differences were found among the three plant groups of the GS (Table 1).

Mean crude fibre content of shrubs species in the GS and UGS did not differ ($p<0.05$). However, higher ($p \leq 0.05$) CF values were found for the grasses of GS compared to forbs and shrubs, probably due to the rapid maturation of grasses during the summer.

Mean CP content of the plant groups in this study ranged from 6.4 to 11.4%. The minimum CP value was recorded for the shrubs of UGS, while the maximum for the forbs of GS. Crude protein is an essential dietary nutrient for animals' maintenance, growth and reproduction (Liamadis, 2003). The recommended standards of crude protein for small ruminants (of weight 30 kg) are 8% for maintenance and 10-12% for lactation (NRC 1985). CP content of forbs and grasses approached or exceeded the animals' requirements for maintenance and lactation. However, CP content of shrubs in both shrublands was insufficient to meet even the maintenance requirements.

**Table 1.** Chemical composition of the grazable material in the grazed (GS) and ungrazed shrublands (UGS)

| Season | Plant Group | EE (% DM) | CF (% DM) | CP (% DM) | $Ca^{2+}$/100 g DM | $P^{5+}$/100 g DM | $Na^{+}$/100 g DM | $K^{+}$/100 g DM |
|---|---|---|---|---|---|---|---|---|
| SUMMER | Grazed shrubland (GS) | | | | | | | |
| | Grasses | $1.4^{a}$ | $26.5^{b}$ | $9.3^{a,b}$ | $294.1^{a}$ | $581.5^{a,b}$ | $787.4^{a}$ | $583.1^{a,b}$ |
| | Forbs | $1.9^{a}$ | $20.7^{a}$ | $11.4^{b}$ | $1315.5^{b}$ | $687.9^{a}$ | $856.1^{a}$ | $792.0^{a,c}$ |
| | Shrubs | $1.9^{a}$ | $20.8^{a}$ | $7.4^{a}$ | $559.4^{a}$ | $350.5^{b}$ | $936.9^{a}$ | $463.6^{b}$ |
| | Mean | 1.9 | 21.3 | 10.3 | 1053.4 | 607.1 | 865.7 | 702.4 |
| | S.E. | 0.2 | 0.7 | 0.7 | 160.8 | 54.3 | 54.2 | 46.1 |
| | Ungrazed shrubland (UGS) | | | | | | | |
| | Shrubs (Mean) | $2.1^{a}$ | $19.7^{a}$ | $6.4^{a}$ | $1316.7^{b}$ | $695.5^{a}$ | $1538.6^{b}$ | $953.6^{c}$ |
| | S.E. | 0.6 | 1.0 | 0.7 | 344.4 | 130.2 | 18.8 | 125.9 |

Mean with different letters (a–c) along the same column differ at ($p \leq 0.05$).
$Ca^{2+}$: Calcium; CF: Crude Fibre; CP: Crude Protein; EE: Ether Extracts; $P^{5+}$: Phosphorus; $Na^{+}$: Sodium; $K^{+}$: Potassium; S.E.: Standard Error of Mean

Ca, P, Na and K content of shrubs of the UGS was higher ($p \leq 0.05$) than that of shrubs of the GS (Table 1). Grasses of the GS had the lower Ca value compared to forbs and shrubs. However, significant difference ($p \leq 0.05$) was found only for forbs. Similarly, lower Ca content in grasses compared with forbs and shrubs has been reported by Yiakoulaki and Nastis (1993). On the other hand, forbs tended to maintain greater P and K content than shrubs and grasses. Regarding the Na content of the three plant groups of the GS there were no significant differences ($p \leq 0.05$).

The recommended Ca requirements of goats (30 kg) for maintenance and medium activity are 300mg/100g DM when the consumption is 1 kg of DM per day. Dry matter intake of goats grazing in Mediterranean shrublands has been reported by Yiakoulaki (1992) to be 840 g DM/day.
All plant groups contained sufficient Ca to meet the requirements of goats except grasses. Na, P and K content of all plant groups reached or exceeded the recommended levels for goats (100 mg/100 g DM, 210 mg/100g DM and 500 mg/100g DM, respectively).

## Conclusions

More taxa (29) were found in the GS compared to UGS (5). Specifically, there were found 3 grasses, 20 forbs and 6 shrubs in the GS, while only 5 species (shrubs) in the UGS. As a consequence, the presence of herbaceous species resulted to higher CP in the GS compared to UGS. On the contrary, higher mineral content was observed in the UGS as only shrub species were present in this shrubland. The studied mineral content of all plant groups has approached or exceeded the recommended levels of goats.

## References

**AOAC. 1995.** Association of Official Analytical Chemists. Official methods of analysis. 16$^{th}$ ed. Washington: AOAC International. 1094pp.

**Bellucci C. 1932.** La determinazione della cellulosa nelle farine di frumento e dei sottoprodotti. *Annali di chimica applicata,* 22(1):25-31.

**Calvo L., J. Baeza, E. Marcos, V. Santana and V. P. Papanastasis. 2012.** Post-Fire Management of Shrublands. In: F. Moreira et al. (eds). Post-Fire Management and Restoration of Southern European Forest. Managing Forest Ecosystems 24, Springer Science. pp. 293-319.

**Decandia M., M. Yiakoulaki, G. Pinna, A. Cabiddu and G. Molle. 2008.** Foraging behaviour and intake of goats browsing on Mediterranean shrublands. In: Dairy Goats Feeding and Nutrition (Cannas and Pulina Eds.). CAB International, UK, pp. 161-188.

**Fisher R.A., 1966.** The Design of Experiments, 8$^{th}$ ed. Hafner, New York. 248pp.

**Khalil I.A. and F. Manan. 1990.** Colorimetry and Flame photometry. In: Chemistry One (Bioanalytical chemistry) 2nd edition. Taj printing press, Peshawar, Pakistan. pp. 131-157.

**Liamadis D.G., 2003.** Physiology of Animal Nutrition, Vol. 2. University Studio Press, Thessaloniki, Greece. 612 pp.

**Metera E., T. Sakowski, K. Słoniewski and B. Romanowicz. 2010.** Grazing as a tool to maintain biodiversity of grassland – a review. *Animal Science Papers and Reports*, 28(4):315-334.

**NRC. 1985.** Nutrients Requirements of Sheep, 6$^{th}$ Revised Edition. National Academy Press, Washington, DC. 99pp.

**Odum E.P. 1971.** Fundamentals of Ecology, 3$^{rd}$ ed. W.B. Saunders Co., Philadelphia and London, 544 pp.

**Papanastasis V.P. 1997.** Improvement of kermes oak shrublands for sustainable use by livestock (in Greek with English abstract), In: V.Papanastasis (ed). 1$^{st}$ National Rangelands Congress 'Sustainable Utilization of Rangelands and Pastures', Drama 6-8 November 1996. Hellenic Range and Pasture Society, Publication No 4, pp. 261-270.

**Papanastasis V.P., M.D. Yiakoulaki, M. Decandia, O. Dini-Papanastasi. 2008.** Integrating woody species into livestock feeding in the Mediterranean areas of Europe. *Animal Feed Science and Technology,* 140(1):1-17.

**Parlak A., A. Gökkus, H. Hakyemez and H. Bayetekin. 2011.** Forage yield and quality of kermes oak and herbaceous species throughout a year in Mediterranean zone of western Turkey. *Journal of Food, Agriculture & Environment,* 9(1):510-515.

**Tutin T.G., N.A. Burges, A.O. Chater, J.R. Edmondson, V.H. Heywood, D.M. Moore, D.H. Valentine, S.M. Walters and D.A. Webb. 1968-1993.** *Flora Europaea*, Vol. 1-5. Cambridge University Press.

**Yiakoulaki M.D. 1987.** Nutritive value of range species as determined with laboratory procedures and their contribution to meet animal demands. Scientific Annals of the Department of Forestry and Natural Environment, Vol. A, No 10, Aristotle University of Thessaloniki, Greece, pp. 381-401. (In Greek with summary in English).

**Yiakoulaki M.D. 1992.** Effects of different proportions of shrubby and herbaceous vegetation on intake by goats. Ph.D. Dissertation (in Greek), Aristotle University of Thessaloniki. 115 pp.

**Yiakoulaki M.D. and A.S. Nastis. 1993.** Mineral content of selected forage species common in the mediterranean shrublands”. 7th meeting of the FAO subnetwork on “Mediterranean pastures and fodder crops”. Chania, Crete. REUR Technical Series 28. FAO, Rome. pp. 137-140.

**Yiakoulaki M.D. and A.S. Nastis. 1998.** A modified faecal harness for grazing goats in Mediterranean shrublands. *Journal of Range Management*, 51(5):545-546.

# An assessment of vegetation structure for the rangelands under grazed different seasons in the Eastern Anatolia Region of Turkey

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## Abstract

The aim of the study was to determine the effect of different grazing system and environmental variables on plant species distribution in highlands of eastern Anatolia Region of Turkey. Eight range sites, two of which belong to season-long and the others belong to transhumant grazing system, were selected. The vegetation was sampled using the line intercept method. All data were performed Redundancy analysis (RDA) using CANOCO software, version 4.5. Monte Carlo permutation tests were used to determine the significance of environmental variables. Species distribution was located in separate groups depending on grazing season on ordination diagram. Species distribution produced strong correlations with grazing season and bulk density, pH, $CaCO_3$, Ca, P and Na properties of the soil ($p<0.05$). The results indicated that grazing seasons displayed an important role at distribution of species and also soil properties were important at these rangelands. Hence, it will be better if traditional upland-lowland (transhumant) grazing systems improve with respect to grazing time and stocking intensity for sustainable use of semi arid highland rangelands.

**Keywords:** highland rangelands, ordination analysis, transhumance, species distribution

## Introduction

The rangelands have a significant role in animal husbandry in the Eastern Anatolian Region of Turkey. The rangelands in the region have been grazed for centuries, consequently, rangeland vegetations have been progressively shaped in both an ecological and evolutionary sense by this long history of intensive grazing. The different response of range plant community under similar ecological conditions to grazing can be attributed to timing, duration, intensity and system (Price et al. 2011). Grazing systems, by controlling the frequency and duration of grazing, are a management tool to optimize livestock and plant performance (Heitschmidt and Taylor 1991) and botanical composition (Arevalo et al. 2011).

Although grazing has a key role in shaping plant communities, there are other environmental factors such as climate, soil, altitude and aspect are more important than grazing to understand plant species composition and spatial distribution in rangelands (Vermeire et al. 2008, Arevalo et al. 2011). Therefore, grazing can not be evaluated alone as it is one important element shaping plant community as well as other factors.

Understanding the effect of environmental variables such as herbivory, soil, altitude and aspect on vegetation pattern may contribute to apply these findings in management, development and improvement practices. The objective of this study was to determine the role of different grazing system and environmental variables on distribution of plant species on natural rangelands in semi-arid highlands.

**Materials and Methods**

The study was conducted in 2007 and 2008 at the Kargapazari Mountain in Erzurum, the eastern Anatolia Region of Turkey. Eight range sites, where two different grazing systems, two of them belong to season-long grazing system and the others belong to transhumant grazing system, have been applied traditionally, were selected in the experimental area. The sites can be summarized as follow: (1) Season-long grazed sites; these sites (40$^o$ 18$^I$ N and 41$^o$ 19$^I$ E, altitude of 2350 m and 40$^o$ 16$^I$ N and 41$^o$ 23$^I$ E, altitude of 2200 m) are grazed from the beginning of spring to the end of autumn. (2) Spring and autumn grazed sites; these sites (40$^o$ 23$^I$ N and 41$^o$ 25$^I$ E, altitude of 1950 m and 40$^o$ 25$^I$ N and 41$^o$ 21$^I$ E, altitude of 2000 m) are grazed firstly from the beginning of spring to the middle of June and from the middle of the September to the late of November (lowland part of transhumant). (3) Summer grazed sites; these sites (40$^o$ 21$^I$ N and 41$^o$ 24$^I$ E, altitude of 2150 m and 40$^o$ 26$^I$ N and 41$^o$ 20$^I$ E, altitude of 2450 m) are grazed from the middle of June to the middle of the September (upland, yayla (Turkish), of transhumant) and (4) Winter grazed sites; these sites (40$^o$ 18$^I$ N and 41$^o$ 21$^I$ E, altitude of 1900 m and 40$^o$ 20$^I$ N and 41$^o$ 19$^I$ E, altitude of 2400 m) are grazed initially in the first half part of growing season and closed to grazing until winter and re-opened to grazing at the beginning of the winter and continues up to snow cover on the ground (winter range of transhumant). Winter range sites are located on the south aspect of the mountain, and grazed mainly by sheep flock, whereas the other areas are grazed by sheep and cattle herds.

The study area is characterized with harsh climatic condition with long and extremely cold winter and cool, short and dry summer. The long-term average annual temperature is 5.7$^o$C, average total annual precipitation is 450 mm and it is generally fall from autumn to the late spring. Soil analysis performed according to Soil Survey Laboratory Staff (1992) procedures revealed that the sites soils textures changed loam, clay-loam, or sandy-loam among the sites, organic matter content ranged from 0.9 to 6.7 %, pH ranged from 5.73 to 7.91. The soils of all sites were poor in lime and phosphorus but rich in potassium.

Vegetation survey of range sites were carried out when common plants reached flowering stage in the both years using the line intercept method developed by Canfield (1941). Measurements were performed using 8-line intercept transects (for 10 m interval over a fixed 80 m long transect) based on the basal area in each site.

The relationships between vegetation and environmental variables (soil properties, altitude and grazing system) were analyzed by ordination techniques. Redundancy analysis (RDA) was used to examine the relationships of floristic composition to the measured environmental variables at different sites (Leps and Smilauer 2003). Species data were transformed because the data contained many zeros using the transformation ln (10 x X + 1), where X= species number in species score (ter Braak and Smilauer 2002). Automatical selection was used to determine the variance explained by individual variables. Monte Carlo permutation tests were used to test the significance of each variable. The relationships between plant distribution and environmental factors were performed using the CANOCO 4.5 software (ter Braak and Smilauer, 1998).

**Results**

The relationships between plant species distribution and environmental variables were presented in RDA ordination diagram (Figure 1). The Monte Carlo permutation test indicated that all canonical axes were significant ($p<0.05$). The plant species distribution showed clear differences on the ordination diagrams depending on grazing system application. Season-long grazed sites placed in the right site of ordination diagram and soil P, Na and bulk density significantly affected species distribution on these sites ($p<0.05$). Winter grazed sites were placed on the right side of the ordination diagram and there were not any relation between soil properties and species distribution on these sites (Figure 1). Summer grazed sites were placed on the left side of ordination diagram and there was significantly relation between species distribution and some soil properties such as pH, $CaCO_3$, Ca on these sites ($p<0.05$). COVA, CAST, SCAN and ASLA were common and characteristic species of the rangeland sites under season-long grazing system while FEOV, THMI and KOCR were common in the rangeland sites under winter grazing system. ASMA, SASP and FSP were common plants in the rangeland sites under summer grazing system but annual species such as BRTE and XEAN were common in the rangeland sites under spring-autumn grazing system. In general, undesired species were more common in the rangeland sites under season long grazing system that of the other.

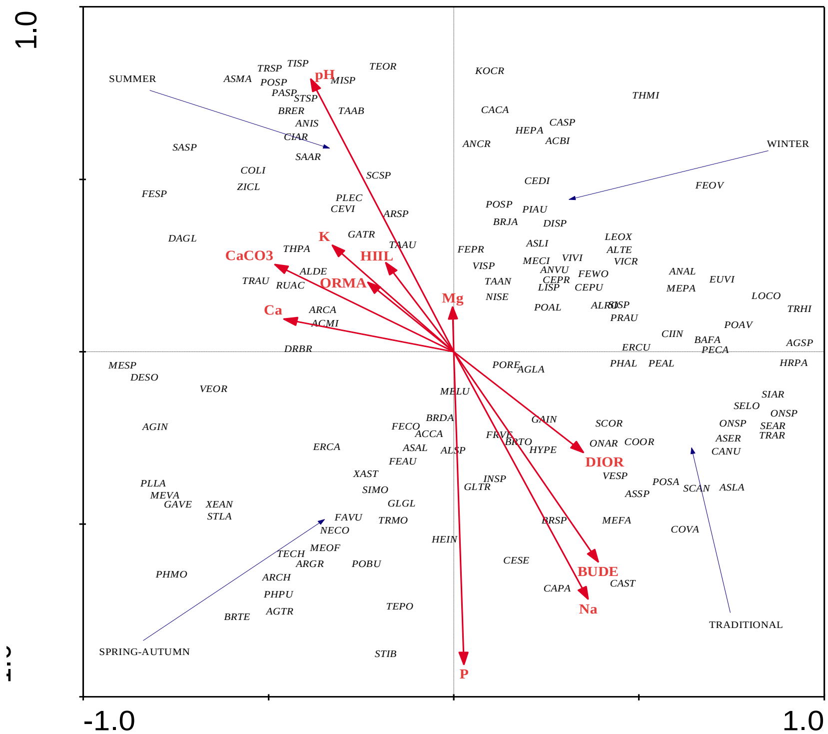


**Figure 1** RDA ordination diagram rangeland vegetation composition with environmental variables.

**Key to abbreviations:** AGCR *Agropyron cristatum*; AGIN *Agropyron intermedium*; AGSP *Agropyron* sp.; AGTR *Agropyron trichophorium*; AGLA *Agrostis lazica*; ALTE *Alopecurus tectilis*; ANIS *Andropogon ischaemum*; BRDA *Bromus danthonia*; BRER *Bromus erectus*; BRJA *Bromus japonicus*; BRSP *Bromus* sp; BRTO *Bromus tomentollus*; BRTE *Bromus tectorum*; CAPA *Catabrollesa parviflora*; DAGL *Dactylis glomerata*; FEOV *Festuca ovina*; FEPR *Festuca prantensis*; FESP *Festuca* sp.; FEWO *Festuca woronowii*; KOCR *Koeleria cristata*; PHAL *Phleum alpinum*; PHMO *Phleum montana*; POAL *Poa alpina*; POBU *Poa bulbosa*; STLA *Stipa lagascea*; ASER *Astragalus ericophalus*; ASLI *Astragalus lineatus*; ASSP *Astragalus* sp.; COOR *Coronilla orientalis*; COVA *Coronilla varia*; LOCO *Lotus cornuculatus*; MEFA *Medicago falcata*; MELU *Medicago lupilina*; MEPA *Medicago papillosa*; MESP *Medicago* sp.; MEVA *Medicago varia*; MEOF *Melilotus officinalis*; ONSP *Onobrychis* sp. TRAR *Trifolium arvense*; TRHI *Trifolium hirtum*; TRMO *Trifolium montanum*; TRSP *Trifolium* sp.; TISP *Trigonella* sp.; VICR *Vicia cracca*; VIVI *Vicia villosa*; ACCA *Acantholimon caryophyllaceum*; ACBI *Achilla biebersteinii*; ACMI *Achilla millefolium*; ALRO *Allium rotundum*; ALDE *Alyssum desertorum*; ALSP *Alysum* sp.; ANAL *Anemone albana*; ANCR *Antemis cretica*; ANVU *Anthllis vulneraria*; ARCA *Arabis caucasica*; ARGR *Arenaria grandiflora*; ARCH *Artemisia chomaemiellifolia*; ARSP *Artemisia spicigera*; ASLA *Asperula laxiflora*; ASMA *Astrantia maxima*; ASAL *Aster alpinus*; BAFA *Bapleurum falcatum*; CAST *Campanula stevenii*; CANU *Carduus nutans*; CASP *Carex* sp.; CACA *Carum carvi*; CESE *Centaurea sessilis*; CEPU *Centaurea pulcherrima*; CEVI *Centaurea virgata*;

CEPR *Cephalaria procera*; CEDI *Cerastium dichotomum*; CIIN *Cichorium intybus*; CIAR *Circium arvense*; COLI *Convolvulus lineatus*; DESO *Descurania sophia*; DISP *Diantus* sp.; DRBR *Draba brunifolia*; ERCU *Erysimum cuspidatum*; ERCA *Eryngium campestre*; EUVİ *Euphorbia virgata*; FAVU *Falcaria vulgaris*; FECO *Ferula communis*; FEAU *Ferulago aucheri*; FRVE *Fragaria vesca*; GAIN *Galium incarnatum*; GAVE *Galium verum*; GATR *Galium tricarnatum*; GLTR *Globularia trichosantha*; GLGL *Glycyrrhiza glabra*; HEPA *Helichyrsum pallasii*; HEPA *Heracleum pastinacifolium*; HEIN *Herniaria incana*; HYPE *Hypericum perfaratum*; INSP *Inula* sp.; LEOX *Leontodon oxylepis*; LISP *Linum* sp.; MECI *Melica ciliata*; MISP *Minuartia* sp; NECO *Nepeta concolor*; NISE *Nigella segetalis*; ONAR *Onosma armenum*; PASP *Papaver* sp.; PECA *Pedicularis caucasica*; *PEAL Petrorhagia alpina;* PHPU *Phlomis pungen*; PIAU *Pimpinella aurea*; PLLA *Plantago lanceolata*; PLEC *Plosella echioides*; POAV *Polygonum aviculare*; POSP *Poligonum* sp; PORE *Potentilla recta*; POSP *Potentilla* sp.; POSA *Poterium sanguisorba*; PRAU *Primula auriculata*; RUAC *Rumex acetosella*; SAAR *Salvia argentea*; SASP *Salvia* sp.; SCAN *Scleranthus annuus*; SCSP *Scobiosa* sp.; SCOR *Scutelleria orientalis*; SEAR *Sempervivum armenum*; SELO *Senecio lorentii*; SIMO *Sideritis montana*; SISP *Silene spergulifolia*; SIAR *Sinapis arvensis*; STSP *Stachys* sp.; STIB *Stachys iberica*; TAAB *Tanacetum abrotanifolium*; TAAU *Tanacetum aucheranum*; TAAN *Taraxacum androssovii*; TECH *Teucrium chamaedrys*; TEOR *Teucrium orientale*; TEPO *Teucrium polium*; THMI *Thalictum minus*; THPA *Thymus parviflorus*; TRAU *Tragopogon aureus*; VESP *Verbascum* sp; VEOR *Veronica orientalis*; XAST *Xanthium strumarium*; XEAN *Xeranthemum annuum*; ZICL *Ziziphora clinopoioides*

## Discussion

The results revealed that grazing system and some soil properties affected spatial distribution of plant species at different scale. Plant species distribution showed distinct differences on ordination diagram depending on grazing system application. Grazing plays a key role in shaping plant distribution together the environmental factors (Li et al. 2009, Price et al. 2011). In addition to the differences in soil properties and the other environmental factors, the differences in grazing time and intensity existing from grazing system may contribute to differences in species distribution among the sites. The increases in undesired plant species abundance in season-long grazed sites most probably stemmed from adverse effect of continuous grazing during the active growing season. As it is well known, uncontrolled continuous grazing has seriously detrimental effect on desired range plants (Price et al. 2011).

Soil nutrients and some physical characteristics have significantly role on species distribution on the rangelands in semi-arid ecosystems (He et al. 2007, Zuo et al. 2012). While Na content and soil bulk density were positively related with CAPA, pH was related with ASMA, TRSP, TISP, POSP, PASP, MISP and STSP. Similar results also reported the other studies conducted on different places on the world (Jafari et al. 2004, Rinella and Hileman 2008, Price et al. 2011).

In addition to investigated environmental variables, the other environmental variables such as altitude, slope, aspect etc. have absolutely considerable effect on plant distribution (Vermeire et al. 2008; He et al.

2007) which is main reason for site selection for special grazing season in animal raiser communities in the region.

In conclusion, according to RDA, uncontrolled season-long grazing system had the most adverse effect on rangeland vegetation than the other system in steppe rangelands in high elevation. The grazing systems providing resting for plants during the growing season showed prominent results with respect to species composition in the rangelands. Hence, it will be better if traditional upland-lowland (transhumant) grazing systems improve with respecting to grazing period and stocking intensity for sustainable use of semi arid highland rangelands.

## References

**Arevalo J.R., L.de Nascimento S. Fernandez-Lugo J. Mata and L. Bermejo. 2011.** Grazing effects on species composition in different vegetation types (La Palma, Canary Islands). *Acta Oecologica,* 37: 230-238.

**Canfield R.H. 1941.** Application of the interception method in sample range vegetation. *Journal of Forestry,* 39: 388-394.

**He M.Z., J.G. Zheng X.R. Li and Y.L.Qian. 2007.** Environmental factor affecting vegetation composition in the Alxa Plateau, China. *Journal of Arid Environment,* 69: 473-489.

**Heitschmidt R.K. and L.T. Taylor. 1991.** Livestock Production. In: R.K. Heitschmidt and J.W. Stuth (eds). Grazing Management: an Ecological Perspective. Timber Press, Corvallis. pp 161-177.

**Jafari M., M.A.Z. Chahouki A. Tavili H. Azarnivand and G.Z. Amiri. 2004.** Effective environmental factors in distribution of vegetation types in Poshtkouh rangelands of Yazd Province (Iran). *Journal of Arid Environment,* 56: 627-641.

**Leps J. and P. Smilauer. 2003.** Multivariate Analysis of Ecological Data Using CANOCO. Cambridge University Press, Cambridge.

**Li C., X. Hao W.D. Willms M. Zhao and G. Han. 2009.** Seasonal response of herbage production and its nutrient and mineral contents to long-term cattle grazing on Rough Fescue grassland. *Agriculture, Ecosystems and Environment,* 132: 32-38.

**Price J.N., R.D.B. Whalley R.D. van Klinken J.A. Duggin and C.L. Gross. 2011.** Periodic rest from grazing provided no control of an invasive perennial forb. *The Rangeland Journal,* 33: 287-298.

**Rinella M.J. and B.J. Hileman. 2009.** Efficacy prescribed grazing depends on timing intensity and frequency. *Journal of Applied Ecology,* 46: 796-803.

**Soil Survey Laboratory Staff. 1992.** Soil Survey Laboratory Methods Manual. USDA-SCS. Soil Survey Investigations Report No: 42, 400 p.

**ter Braak C.J.F. and P. Smilauer. 2002.** CANOCO Reference Manual and CanoDraw for Windows User's Guide: Software for Canonical Community Ordination (Version 4.5) Biometris. Wageningen University and Research Centre, Wageningen.

**Vermeire L.T., R.K. Heitschmidt and M.R. Haferkamp. 2008.** Vegetation response to seven grazing treatments in the Northern Great Plains. *Agriculture, Ecosystems and Environment,* 125: 111-119.

**Zuo X., X. Zhao H. Zhao T. Zhang Y. Li S. Wang W. Li and R. Powers. 2012.** Scale dependent of environmental factors on vegetation pattern and composition in Horqin Sandy Land, Northern China. *Geoderma,* 173,174: 1-9.

# Effects of grazing on vegetation of abandoned arable fields in a sub- humid Mediterranean environment

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## Abstract

Arable land abandonment is a major land use change in the Mediterranean region. Plant colonization and vegetation succession in these areas depend on local climatic conditions, soil quality and, especially, on management practices. Livestock grazing can modify or alter the process of succession by facilitating the colonization of certain species at the expense of others. The aim of this study was to investigate the effects of grazing on vegetation of old fields. The research was conducted in the Taxiarchis village located in the Holomontas mountain of Chalkidiki, northern Greece, with a sub-humid Mediterranean climate. Plant cover and biomass were measured in adjacent moderately to heavily grazed mainly by goats and protected plots of an old field abandoned for 20 years. Species richness and abundance were also recorded and the Shannon –Wiener and equitability diversity indices were calculated. Total plant cover was significantly decreased due to grazing, but herbaceous cover was not significantly affected. Woody species did not appear in the grazed plots, while in the protected ones they covered 12.8% of the ground. Current year's and total herbage biomass was significantly decreased due to grazing. Total biomass (herbage and woody) was dominated by the herbaceous component and differed significantly between the two treatments. Shannon – Weiner index and equitability were significantly higher in the grazed plots, due to the significant increase of species numbers and abundance. The results indicate that moderate to heavy grazing can control woody species invasion and enhance plant species diversity in old fields of sub-humid Mediterranean environments.

**Keywords:** Shannon index, Grazing, Production, Herbaceous species, Woody species.

## Introduction

Arable land abandonment is a major land use change in the Mediterranean region. In Greece, such abandonment is widespread in mountainous areas (Papanastasis 2007). Plant colonization and vegetation succession in these areas depend on local climatic conditions, (Zhang and Dong 2009, Osem et al. 2004), soil quality (Fernandez-Lugo et al. 2009) and especially management practices. Vegetation of abandoned arable fields is closely related to the applied grazing management. Livestock can significantly affect plant species composition (Akiyama and Kawamura 2007) and, consequently, modify or alter the process of succession by facilitating the colonization of certain species at the expense of others. The kind of animal and the degree of grazing pressure are regarded as the two main factors affecting vegetation dynamics (Rook et al. 2004). The aim of this study was to investigate the effects of livestock grazing on vegetation dynamics of old fields.

**Materials and methods**

The research was conducted in the Taxiarchis village located in the Holomontas mountain of Chalkidiki, North Greece. The climate is Mediterranean sub-humid. In an old field abandoned for 20 years, adjacent moderately to heavily grazed mainly by goats and protected plots were established. Plant cover was measured along 5 transects in each plot with the point method (Cook and Stubbendieck 1986). Species richness and abundance were recorded using 30 quadrats (25 x 25 cm each) and the Shannon –Wiener and equitability diversity indices were calculated. Furthermore, herbaceous and woody species biomass was measured in 10 quadrats (1x1m each for the woody species and 50x50cm each for the herbaceous ones) by cutting vegetation with hand-scissors at the ground level.

In the laboratory, herbage and woody biomass was sorted out by hand into current year's and old growth components. Only the current year's growth is reported in this paper. All biomass samples were oven dried at 60º C for 48 h and weighed. Data for cover, biomass and diversity in grazed and protected plots were compared by using a t test. Significant differences for all statistical tests were evaluated at the level of $p \leq 0.05$. All data analyses were conducted using the software package SPSS 11.0.

**Results and discussion**

Total plant cover was significantly decreased by 20% due to grazing, but herbaceous cover was not significantly affected (Table 1). Livestock grazing eliminated woody species presence, indicating its negative effects on secondary succession, as these species dominate in the later successional stages of old fields in Mediterranean environments (Papanastasis 2007). Specifically, woody species did not appear in the grazed plots, while in the protected ones they covered almost 13% of the ground (Table 1).

Total biomass was dominated by the herbaceous component (Table 2). In the grazed plot, current year's herbaceous and total biomass were significantly decreased by 49% and 62%, respectively indicating moderate to heavy grazing pressure . These results confirm previous studies where it was found that the most important effect of grazing is the reduction of aboveground biomass (Bonanomi et al. 2006, Billeter et al. 2007),. The absence of shrubs in the grazed plot should be attributed to the fact that goats were the predominant kind of animal grazing in the study area. Goats have been shown to reduce woody biomass (Celaya et al. 2007) as shrub species can be more sensitive to both consumption and trampling generated by grazing than the herbaceous species in the Mediterranean region (Tzanopoulos et al. 2007).

**Table 1.** Plant cover (%) in grazed and protected plots

| Cover class | Grazed | Ungrazed |
|---|---|---|
| Herbaceous | 74,20a | 79,40a |
| Woody | 0.00b | 12,8a |
| Total | 74,20b | 92,20a |

[1]Means within the same class followed by the same letter are not statistically different at the 0.05 level.

**Table 2.** Current year's e biomass (g DM $m^{-2}$) in grazed and protected plots

| Biomass class | Grazed | Ungrazed |
|---|---|---|
| Herbaceous | 112,04b | 219,14a |
| Woody | 0.00b | 78.32a |
| Total | 112,04b | 297,46a |

[1]Means within the same class followed by the same letter are not statistically different at the 0.05 level.

Species richness, the Shannon – Weiner index and equitability were significantly higher by 52%, 46% and 26%, respectively in the grazed plots than in the ungrazed ones(Table 3). Similar results have been reported by other researchers as well. For example, Noy- Meir et al. (1995) have found higher species diversity in a grazed than in adjacent ungrazed grassland in Israel. Also, Iovi et al. (2003) recorded a higher Shannon - Weiner index of diversity in heavily grazed rangelands than in lightly grazed ones in Greece.It seems that goat grazing can increase species diversity, with potentially more herbaceous species to thrive in the community as shrub dominance decreases (Celaya et al. 2010).

**Table 3.** Species diversity in grazed and protected plots

| Index | Grazed | Ungrazed |
|---|---|---|
| Species richness (no. species/0.25 $cm^2$) | 15,87a | 7,67b |
| Shannon | 2,37a | 1,28b |
| Equitability | 0,86a | 0,64b |

[1]Means within the same row followed by the same letter are not statistically different at the 0.05 level.

## Conclusion

The results indicate that moderate to heavy grazing can control woody species encroachment and enhance plant species diversity in old fields of sub-humid Mediterranean environments.

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## References

**Akiyama T., K. Kawamura. 2007.** Grassland degradation in China: methods of monitoring, management and restoration. *Grassland Science*, 53:1–17.

**Billeter R., M. Peintinger, M. Diemer. 2007.** Restoration of montane fen meadows by mowing remains possible after 4–35 years of abandonment. *Botanica Helvetica*, 117:1–13.

**Bonanomi G., S. Caporaso, M. Allegrezza. 2006.** Short-term effects of nitrogen enrichment, litter removal and cutting on a Mediterranean grassland. *Acta Oecologica,* 30:419–425.

**Celaya R., A. Martınez, K. Osoro. 2007.** Vegetation dynamics in Cantabrian heathlands associated with improved pasture areas under single or mixed grazing by sheep and goats. *Small Ruminant Research,* 72: 162–177.

**Celaya R., B.M. Jauregui, R.R. Garcıa, R. Benavides, U. Garcıa, K. Osoro. 2010.** Changes in heathland vegetation under goat grazing: effects of breed and stocking rate. *Applied Vegetation Science,* 13:125–134.

**Cook C. W. and J. Stubbendieck. 1986.** Range Research: Basic Problems and Techniques. Society of Range Management, Denver, Colorado, USA. 317 pp.

**Fernandez-Lugo S., L. de Nascimento, M. Mellado, L.A. Bermejo, J.R. Arévalo. 2009.** Vegetation change and chemical soil composition after four years of goat grazing exclusion in a Canary Islands pasture. *Agriculture, Ecosystems and Environment,* 132: 276-282.

**Gibson R.S., A. Hewitt, G. Sparling, O.J.H. Bosch. 2001**. Vegetation change and soil quality in central. Otago Tussock grasslands, New Zealand. *Rangeland Journal,* 22:190–204

**Iovi K., M.S. Vrahnakis and V.P. Papanastasis. 2003.** Plant diversity of subalpine rangelands in the Grammos mountain of Greece. In: P.D. Platis and T.G. Papachristou (eds).

Range science and development of mountainous regions. Proceedings of the 3rd Panhellenic Rangeland Congress. pp. 463-468. (In Greek with English Abstract)

**Noy-Meir I. 1995.** Interactive effects of fire and grazing on structure and diversity of Mediterranean grasslands. *Journal of Vegetation Science,* 6:701-710.

**Osem Y., A. Perevolotsky, J. Kigel. 2004.** Site productivity and plant size explain the response of annual species to grazing exclusion in a Mediterranean semi-arid rangeland. *Journal of Ecology,* 92:297- 309.

**Papanastasis V. P. 2007.** Land abandonment and old field dynamics in Greece. In: V. A. Cramer and R. J. Hobbs (eds). Old fields: dynamics and restoration of abandoned farmland. pp. 225-246, Islandpress, Washington.

**Pettit N.E., R.H. Froend, P.G. Ladd. 1995.** Grazing in remnant woodland vegetation: changes in species composition and life form groups. *Journal of Vegetation Science,* 6:121–130.

**Rook, A.J., B. Dumont, J. Isselstein, K. Osoro, M.F. Wallis DeVries, G.Parente, J. Mills. 2004.** Matching type of grazing animal to desired biodiversity outcomes –a review. *Biological Conservation,* 119: 137–150.

**Tzanopoulos J., J. Mitchley, J.D. Pantis. 2007.** Vegetation dynamics in abandoned crop fields on a Mediterranean island: development of succession model and estimation of disturbance thresholds. *Agriculture, Ecosystems and Environment,* 120:370 -376.

**Zhang J., Y. Dong. 2009.** Effects of grazing intensity, soil variables, and topography on vegetation diversity in the subalpine meadows of the Zhongtiao Mountains, China. *The Rangeland Journal,* 31: 353-360.

# Rangeland use by the European hare (*Lepus europaeus*) in relation to short- and long- term non- grazing

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## Abstract

Protection from grazing results in biomass accumulation and lower forage quality, which in the long-run adversely affects lower-seral wildlife species' use. The effects of short-term (i.e. two years) and long-term (more than 15 years) protection from grazing by livestock, on the use of grasslands by the European hare (*Lepus europaeus*) were investigated in a typical Mediterranean grazing land, using the pellet count method. Hares used the grazed sites with a sparse herb layer more intensively than the short- and long- term ungrazed ones where a denser and higher plant structure occurs. The most striking effect was that even the two year protection from grazing was sufficient enough to reduce the hare's grazing intensity to a level similar with that of sites ungrazed for more than 15 years. These findings confirm that vegetation characteristics play a prevailing role on the use of space by the hare. Furthermore, these findings guide new strategies both on hare conservation and multiple rangeland management, since grazing by small ruminants may function as an agent to create suitable habitats for the hare.

**Keywords:** livestock-wildlife interactions, herbivory, animal behaviour, rangeland management, wildlife management.

## Introduction

Livestock grazing affects the composition, structure and the secondary succession of vegetation, which is often beneficial for wild herbivores predominating in earlier stages of succession (Karmiris and Nastis 2007, Kuijper and Bakker 2008). This could be justified by decreasing forage quality, as the plants grow taller and mature in ungrazed sites earlier than in grazed ones (Davidson 1993). However, in addition to forage quality effects, grazing reduces the vegetation sward height, which may be advantageous for small- and medium- sized herbivores, such as the European hare (*Lepus europaeus* – hereafter hare), as it is easier to locate visually approaching predators (Karmiris and Nastis 2007, 2009, Bakker et al. 2009). Therefore, livestock grazing can be used as a valuable 'tool' to manipulate small- and medium- sized herbivores' habitats (Holechek et al. 2001, Karmiris and Nastis 2009).

The hare prefers the grazed and partially disturbed habitats, such as grassland, scrubland, clearings in scrub and forest stands and farmland (Tapper 1987). It is documented that hare seems to prefer the moderately grazed pastures (about 40% of the annual production grazed) with a sparse herb layer over lightly grazed ones (about 20%), and avoid the ungrazed habitat patches (Karmiris and Nastis 2007). Despite its importance, little is known about the effects of the ceasing of grazing on hare's use of space.

The aim of this study was to investigate the impact of grazed, short-term (i.e. two years) and long-term (i.e. more than 15 years) exclusion of grazing by livestock on the potential use by the hare. Our hypothesis was that there was no significant difference in the use by the hare of short-term ungrazed sites in relation to the long-term and the grazed ones. Given that, the hare avoids the ungrazed sites (Karmiris and Nastis 2007) and uses the microhabitats covered by short and sparce herb layer (Karmiris et al. 2010), we predicted that the hypothesis tested should be false at least for the latter comparison. However, significant differences between short- and long- term ceasing of grazing depend primarily on the plasticity of the hare's behaviour by responding to changes in the biotope and making shifts in its feeding areas in a relatively short space of time.

**Material and Methods**

The study was conducted in a 100 ha rangeland (360-520 m altitude), located north of the city of Thessaloniki, in central Macedonia, Greece, covered approximately 70% by shrubs and 30% by herbaceous species. There was no farmland in the study area. The soil was shallow, of low productivity and partially degraded. The climate is semiarid (average annual precipitation 416 mm), with cold winters and hot dry summers.

This area is a mosaic of kermes oak (*Quercus coccifera*) shrubland sites intermingled with scattered grassland sites (0.3 and 3 ha). Other shrub species, such as Jerusalem thorn (*Paliurus spina cristi*), dog rose (*Rosa canina*), hawthorn (*Crataegus monogyna*) and phryganic plants, such as pink rockrose (*Cistus incanus*) and asparagus (*Asparagus acutifolius*) also coexisted in the study area. The main herbaceous species in the study area were brush grass (*Chrysopogon gryllus*), yellow bluestem (*Dichanthium ischaemum*), sheep's fescue (*Festuca valesiaca*), Bermuda grass (*Cynodon dactylon*), drooping brome (*Bromus tectorum*), ovate goatgrass (*Aegilops ovata*), cocksfoot (*Dactylis glomerata*), star clover (*Trifolium stellatum*), hairy medick (*Medicago polymorpha*), haresfoot clover (*Trifolium arvense*) and hop trefoil (*Trifolium campestre*). The main wild mammal species in the study area were brown hare, fox (*Vulpes vulpes*), beech marten (*Martes foina*), weasel (*Mustela nivalis*) and badger (*Meles meles*).

The whole study area was grazed by sheep and goats in common for several decades, following a traditional continuous grazing system. In order to protect this area from development and to maintain its conservation and aesthetic role, several protection measures have been applied, such as hunting ban and limitations on grazing. Recently, about one third of the total area was protected and grazing herds moved to other areas. As a result, there are sites which have not been grazed for more than 15 years, others which have been ungrazed for the last 2 years and those which have been moderately grazed by sheep and goats (ratio 1:4). Hereafter, these 3 categories of sites (i.e. grazed, short- and long-term ungrazed) are considered as treatments. Hares were using the grasslands at night as feeding places while during the day they usually rested in shelters under shrubs. This is a typical behaviour of the hare (Hutchins & Harris, 1995; Holley, 2001, Karmiris 2012). The evaluation of the spatial distribution of the hare was based on pellet counting, which is considered as an appropriate estimate of the abundance and the feeding intensity of hare (Langbein et al. 1999). Fifty permanent fecal-pellet count plots (0.5 m radius) were randomly established on each treatment. Faecal pellets were counted and subsequently removed from each plot.

Pellet count data were subjected to ANOVA using the S.P.S.S. statistical package (version 13.0). Treatments were fixed factors. Homogeneity of variances was checked using Levene's test (Petrie and Watson 1999). A log(x+1) transformation of the original data was used in order to homogenise the variance between treatments (Steel and Torrie 1980). Mean differences were evaluated with Tukey's HSD at $P < 0.05$.

**Results and Discussion**

The feeding intensity (as estimated by the number of pellets per $m^2$) of hares in the grazed sites was significantly higher ($F = 9.7$, d. f. = 2, $P < 0.001$) than both the short-term and the long-term ungrazed sites (Figure 1). However, non-significant differences were detected between short- and long- term ungrazed sites ($P = 0.980$).

Based on previous studies from northern Europe, the hare might be disturbed by the presence of farm animals (Barnes et al. 1983, Tapper and Barnes 1986), one might expect the opposite outcome, i.e. the grazed sites should be used less than the ungrazed ones. If the overriding factor shaping spatial distribution of the hare was the decreasing forage quality as the plants grow taller and mature in ungrazed sites (Rhodes and Sharrow 1990), then the observed differentiation between the grazed and ungrazed sites should not be apparent in spring when the growing plants are usually short and more nutritious, a hypothesis however that has been rejected (Karmiris and Nastis 2007). Under this perspective, the more intensive use of grazed sites by the hare in relation to the ungrazed ones, which was observed in this and in previous studies (Karmiris and Nastis 2007, 2009), should probably be the outcome mainly of the modified structure of vegetation mainly by the domestic herbivores. It seems that the hare is seeking for feeding areas covered by short and sparse plant communities (Karmiris et al. 2010). Hence, the effects of plant structure seem to be more important than disturbance by livestock for the hare and under proper grazing management strategy the co-development of livestock and game in the same time-space is feasible.

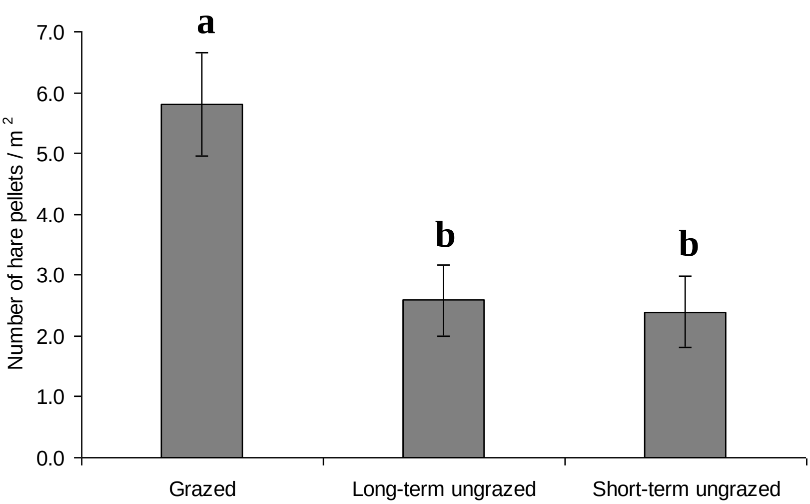


**Figure 1.** Mean number of hare pellets (± SE) deposited in grazed, short-term (2 years) and long-term (> 15 years) ungrazed sites. Different letters indicate significant differences at $P < 0.001$.

The most profound outcome of this study was the non-significant differences between the use of short- and long- term ungrazed sites ($P$ = 0.980). Within a time interval of two years since the protection from grazing the use of short-term ungrazed sites were very low and similar with that of the long-term ones. This raises the hare’s ability to make shifts in the use of space according to changes in the vegetation characteristics in a relatively short space of time. From these findings can be concluded that livestock grazing can be used as a ‘tool’ for the creation of suitable habitats for the hare and to influence its movements and the use of space.

## Conclusions

Grazed rangeland sites, under moderate levels of grazing intensity, were used more intensively by the hare as feeding places than the short- and the long- term grazing exclusion treatments. Just two years of exclusion seems to be sufficient to suppress the feeding intensity of the hare to a similar level with that of sites ungrazed for more than 15 years. Reduction in aboveground biomass can be used as a means for the management of wildlife species, such as the hare, which is inhibited by tall and dense vegetation. Thus, livestock grazing can be used as a 'tool' to create suitable habitats for hares. The Mediterranean rangeland management strategy should be focused to a more holistic approach integrating livestock and hare needs.

## Acknowledgements

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## References

**Bakker, E. S., Olff, H. & Gleichman, J. M. 2009**: Contrasting effects of large herbivore grazing on smaller herbivores. *Basic and Applied Ecology*, 10:141-150.

**Barnes R.F.W., S.C. Tapper and J. Williams. 1983.** Use of pastures by brown hares. *Journal of Applied Ecology*, 20:179-185.

**Davidson D.W. 1993.** The effects of herbivory and granivory on terrestrial plant succession. *Oikos*, 68:23-35.

**Holechek J.L., R.D. Pieper and C.H. Herbel. 2001.** Range management principles and practices. Prentice-Hall, Upper Saddle River, New Jersey. 587 pp.

**Karmiris I. 2012.** Movements and use of dens by radiotracked captive-reared European hares (*Lepus europaeus*). *Scientific annals of the department of Forestry and Management of the Environmental and Natural Resources*. (in press).

**Karmiris I. and A. Nastis. 2007.** Intensity of livestock grazing in relation to habitat use of brown hares (*Lepus europaeus*). *Journal of Zoology*, 272:193-197.

**Karmiris I. and A. Nastis. 2009.** Small ruminants as manipulators of brown hare (*Lepus europaeus*) habitat in kermes oak rangelands. *Options Méditerranéennes*, 85:171-176.

**Karmiris I., I. Pappas, Z. Koukoura and M. Kitsos. 2010.** Plant cover influences on the use of microhabitats by the European hare (*Lepus europaeus*) in recently burned rangelands. In: A. Sidiropoulou, K. Mantzanas and I. Ispikoudiss (eds). Range Science and Life Quality. Proceedings of the 7$^{th}$ Panhellenic Rangeland Congress. pp. 217-222. (In Greek with English Abstract).

**Kuijper D.P.J. and J.P. Bakker. 2008.** Unpreffered plants affect patch choice and spatial distribution of European brown hares. *Acta Oecologica*, 34:339-344.

**Langbein J., M.R. Hutchings, S. Harris, C. Stoate, S.C. Tapper and S. Wray. 1999.** Techniques for assessing the abundance of brown hares *Lepus europaeus*. *Mammal Review*, 29:93-116.

**Petrie A. and P. Watson. 1999.** Statistics for veterinary and animal science. Blackwell Science Ltd. London. 243 pp.

**Rhodes B.D. and S.H. Sharrow. 1990.** Effects of grazing by sheep on the quantity and quality of forage available to big game in Oregon's coast range. *Journal of Range Management*, 43:235-237.

**Steel R.G.D. and J.H. Torrie. 1980.** Principles and procedures of statistics: A biometrical approach. 2nd edition. McGraw-Hill, USA. 633 pp.

**Tapper S.C. and R.F.W. Barnes. 1986.** Influence of farming practice on the ecology of the brown hare (*Lepus europaeus*). *Journal of Applied Ecology*, 23:39-52.

**Tapper S. 1987.** The brown hare. Shire Natural History, No. 20. 24 pp.

# Grazing effects on floristic diversity of a juniper-oak rangeland

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## Abstract

The aim of the present study was to investigate the effects of grazing intensity on plant cover and floristic diversity of a juniper - oak rangeland ecosystem in the Mediterranean region. The research was conducted in an area, which is grazed mainly by goats, at Megalo Dereio in Evros region, northeastern Greece. Three experimental plots were selected in a rangeland dominated by *Juniperus oxycedrus* with the spontaneous presence of *Quercus frainetto*: 1) a lightly grazed plot, 2) a moderately grazed plot and 3) a heavily grazed plot. An area of 25 $m^2$ in each plot was fenced in autumn 2008, in order to be protected from grazing. The plant cover, the species composition and the herbage production were measured in June 2010 and ecological diversity indices as well as the forage utilization percent were determined. The plant cover was significantly reduced by heavy grazing. The floristic diversity was not affected by the different grazing intensities. There was however, a significant reduction of it where protection from grazing was applied.

**Keywords:** Overgrazing - Plant cover - Silvopastoral system - Species composition.

## Introduction

Biodiversity plays an essential role to all levels of the ecosystem service hierarchy: as a regulator of supporting ecosystem processes, as a service and as a good that is subject to valuation (Mace et al. 2012). Consequently, one of the main challenges for rangeland managers is to identify effective grazing management strategies in order to maintain biodiversity and enhance multiple rangeland ecosystem services.

It is well substantiated that grazing pressure is an important determinant of plant diversity in rangeland ecosystems (Dorrough et al. 2007, Yayneshet et al. 2009). Grazing effects, in natural plant communities, include changes to vegetation structure and composition as certain species are favoured by grazing so that their numbers and cover will increase, while others are disadvantaged and will reduce in number and cover (Belsky

1992). Furthermore, livestock grazing is considered essential in maintaining species diversity, as in many Mediterranean ecosystems it has been decreased when grazing was removed (Noy- Meir et al. 1989).

On the other hand, livestock grazing is considered as the most important factor of soil erosion and consequently desertification in the Mediterranean region (Papanastasis 1998). Defoliation of vegetation by the grazing animals results in reduced plant cover which is essential for combating soil erosion. The degree of plant cover reduction is seriously affected by grazing intensity (Papanastasis and Noitsakis 1992).

The aim of this paper was to evaluate the effect of different grazing intensity by small ruminants on plant cover and floristic diversity of a juniper - oak rangeland ecosystem in the Mediterranean region.

**Materials and methods**

The study was conducted in the area of Megalo Dereio which is located in Evros prefecture, northeast Greece at 380 m a.s.l. The climate of the area is classified as sub-Mediterranean, with a mean air temperature of 13.7° C and an annual rainfall of 560 mm. The study area extends in the thermophilous deciduous oak zone i.e. Quercion frainetto subzone sensu, Dafis (1973) and Horvat et al. (1974) and is dominated by *Juniperus oxycedrus* with the spontaneous presence of *Quercus frainetto.* The area is grazed mainly by goats. Three experimental areas of similar vegetation but with different grazing intensity were selected: i) a lightly grazed, ii) a moderately grazed and iii) a heavily grazed. An area of 25 $m^2$ in each plot was fenced in the autumn of 2008, in order to be protected from grazing. A similarly-sized area was assigned next to the fenced plot for comparison. The sampling of herbaceous vegetation (the number of species, frequency of occurrence and herbage yield) was carried out in four 0.5 m x 0.5 m quadrats in every grazed and protected plot in June 2010. The difference of fenced and open plots yield was used to calculate forage utilization percent. It was calculated to be 20% in the lightly grazed plot, 50% in moderately grazed plot and 70% in the heavily grazed one. Four transect lines of 20 m long were established in every grazed plot. The plant cover was measured by using the line-point method (Cook and Stubbendieck 1986) in June 2010. Contacts were obtained every 20 cm.

The nomenclature of the recorded taxa follows Strid and Tan (1997, 2002) and Tutin et al. (1968-1980; 1993). Floristic diversity was determined by the number of species (N), the Shannon-Wiener diversity index (H’), the Simpson diversity index (D) and the Berger-Parker dominance index (d). The formulae of the indices are given below (Henderson 2003):

$$H' = -\sum_{i=1}^{S} p_i \ln p_i \qquad D = 1 - \sum_{i}^{S_{obs}} p_i^{\,2} \qquad d = \frac{N_{\max}}{N_T}$$

where S is the maximum recorded number of taxa, pi is the proportional abundance of the i-th taxa, $N_{max}$ is the number of records of the dominant taxon and $N_T$ is the total number of records.

General linear models procedure (SPSS 18 for Windows) was used for ANOVA. The LSD at the 0.05 probability level was used to detect the differences among means (Steel and Torrie 1980).

**Results and Discussion**

Species richness and floristic diversity, as described by the diversity indices and by Berger-Parker dominance index, were significantly higher when grazing was applied (Table 1). Floristic diversity tends to be higher in the heavily grazed plot compared to both moderately and lightly grazed ones, but this increase did not produce significant results with the exception of the Berger-Parker dominance index. No significant interactions between the grazing intensity and the grazing protection treatments were recorded (Table 1).

**Table 1**. Floristic diversity indices of the different grazing treatments.

| | **L G** | | **M G** | | **H G** | | | **Significance** | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **G** | **P** | **G** | **P** | **G** | **P** | **LSD** | **PT** | **GI** | **PTxGI** |
| N | 5.75 | 3.00 | 8.25 | 4.00 | 7.75 | 6.33 | 1.78 | * | ns | ns |
| H’ | 1.39 | 0.78 | 1.24 | 0.98 | 1.68 | 1.29 | 0.32 | * | ns | ns |
| D | 4.68 | 2.05 | 3.63 | 2.30 | 5.20 | 3.20 | 0.93 | * | ns | ns |
| d | 0.40 | 0.70 | 0.51 | 0.62 | 0.35 | 0.46 | 0.09 | * | * | ns |

LG, Lightly Grazed; MG, Moderately Grazed; HG, Heavily Grazed; G, Grazed plot; P, Protected plot; PT, Protection from grazing treatment; GI, Grazing Intensity; LSD, Least significant difference

*P≤0.05; ns, non significant

Many authors have found that grazing abandonment leads to a decrease in plant species richness (Poschlod et al. 2005, Guretzky et al. 2007). Cessation of livestock grazing modifies both the disturbance regime and interactions among plant species (Marc et al. 2003). Thus, the reduction of floristic diversity found in the present study could be related to dominance of woody species such as *Juniperus oxycedrus* subsp. *oxycedrus* and *Cistus incanus* subsp. *creticus* in the protected plots (Kyriazopoulos et al. 2010).

The plant cover decreased progressively as grazing intensity increased. Its lowest value was recorded in the heavily grazed plot (Figure 1). Similar results have been reported by Kyriazopoulos et al. (2010) in an open coppice oak forest located close to the study area. Livestock consume the aerial parts of vegetation and involve mechanical actions such as trampling (Crawley 1997). Thus, light grazing would have a profound effect on vegetation recovery. This drastic reduction of plant cover may increase the risk of soil erosion. Moreover, bare soil was limited in the lightly grazed plot compared to the moderate and heavily grazed plots (Figure 1). Apparently, these results confirm that grazing causes a reduction in vegetative cover (Pluhar et al. 1987, Hill et al. 1992).

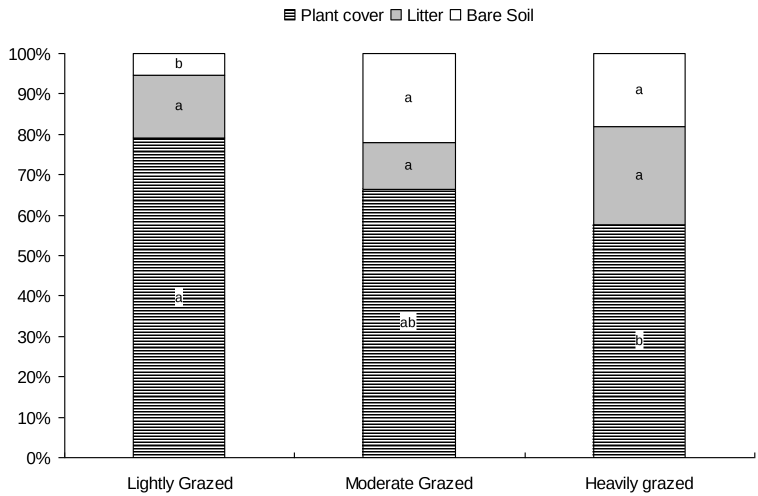


**Figure 1.** Cover (%) in the different grazing intensities. Means within each group followed by the same letter are not significantly different (P≤0.05).

## Conclusions

Protection from grazing reduced floristic diversity. Heavy grazing slightly increased floristic diversity in comparison to light and moderate grazing. However, it resulted in a drastic reduction of plant cover, which may increase the risk of soil erosion. Thus, moderate grazing could be considered as the most appropriate grazing intensity as it slightly decreased plant cover and can enhance floristic diversity.

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## References

**Belsky A.J. 1992.** Effects of grazing, competition, disturbance and fire on species competition and diversity in grassland communities. *Journal of Vegetation Science*, 3:187-200.

**Cook C.W. and J. Stubbendieck J. 1986.** Range Research: Basic Problems and Techniques. Soc. Range Manage. Denver, Colorado. 317 pp.

**Crawley M.J. 1997.** Plant-herbivore dynamics. In: M.J Crawley (ed). Plant Ecology. Blackwell Science, Oxford. pp. 401–474.

**Dafis S. 1973.** Classification of the forest vegetation of Greece. *Scientific Annals of the Department of Forestry and Natural Environment*, 115(2):75-91 (In Greek).

**Dorrough J., J. Ash, S. Bruce, and S. McIntyre. 2007.** From plant neighborhood to landscape scales: how grazing modifies native and exotic plant species richness in grassland. *Plant Ecology*, 191:185–198.

**Guretzky J.A., K.J. Moore, C.L. Burras and E.C. Brummer. 2007.** Plant species richness in relation to pasture position, management, and scale. *Agriculture, Ecosystems & Environment*, 122:387-391.

**Henderson P.A. 2003.** Practical Methods in Ecology. Blackwell Science Ltd., Oxford, UK. 300 pp.

**Hill M.O., D.F. Evans and S.A. Bell. 1992.** Long term effects of excluding sheep from hill pastures in North Wales. *Journal of Ecology*, 80:1–13.

**Horvat I., V. Glavac and H. Ellenberg. 1974.** Vegetation Südosteuropas. Gustav Fischer Verlag. Stuttgart. 768 pp.

**Kyriazopoulos A.P., E.M. Abraham, Z.M. Parissi, G. Korakis and Z. Abas. 2010.** Floristic diversity of an open coppice oak forest as affected by grazing. *Options Méditerranéennes,* 92:247-250.

**Mace G M., K. Norris and A. H. Fitter. 2012.** Biodiversity and ecosystem services: a multilayered relationship. *Trends in Ecology and Evolution*, 27(1):19-26.

**Marc T., P.V. Jean, O. Annie, C.G. Jean and C.L. Jean. 2003.** Vegetation dynamics and plant species interactions under grazed and ungrazed conditions in a western European salt marsh. *Acta Oecologia*, 24:103–111.

**Noy-Meir I., M. Gutman and Y. Kaplan. 1989.** Responses of mediterranean grassland plants to grazing and protection. *Journal of Ecology*, 77:290-310.

**Papanastasis V.P. 1998.** Grazing intensity as an index of degradation in semi-natural ecosystems: the case of Psilorites mountain in Crete. In G. Enne (Ed). Indicators for Assessing Desertification in the Mediterranean. Universita di Sassari, Sassari. pp. 146-158.

**Papanastasis V.P. and B.I. Noitsakis. 1992.** Rangelands Ecology. Giahoudis- Giapoulis publications, Thessaloniki. 244 pp. (In Greek).

**Pluhar J.J., R.W. Knight and R.K. Heitschmidt. 1987.** Infiltration rates and sediment production as influenced by grazing systems in the Texas rolling plains. *Journal of Range Management*, 40:240-244.

**Poschlod P., J.P. Bakker and S. Kahmen. 2005.** Changing land use and its impact on biodiversity. *Basic and Applied Ecology*, 6:93–98.

**Steel R.G.D. and J.H. Torrie. 1980.** Principles and Procedures of Statistics. 2nd edition.

McGraw-Hill, New York. 481 pp.

**Strid A. and K. Tan (eds). 1997, 2002.** Flora Hellenica Vol. 1-2. Patra, 547 + 511 pp.

**Tutin T.G., N.A. Burges, A.O. Chater, J.R. Edmonson, V.H. Heywood, D.M. Moore, D.H. Valentine, S.M. Walters and D.A. Webb (eds). 1993.** Flora Europea I. 2nd edition. Cambridge, 581 pp.

**Tutin T.G., V.H. Heywood, N.A. Burges, D.M. Moore, D.H. Valentine, S.M. Walters and D.A. Webb (eds). 1968, 1972, 1976, 1980.** Flora Europaea II - V. Cambridge, 469 + 385 + 505 + 452 pp.

**Yayneshet T., L.O. Eik and S.R. Moe. 2009.** The effects of exclosures in restoring degraded semi-arid vegetation in communal grazing lands in northern Ethiopia. *Journal of Arid Environments*, 73(4–5):542–549.

# The short-term impacts of cessation of grazing on plants and land snails in grasslands in the west of Ireland.

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## Abstract

The Burren in western Ireland is famous for its biodiversity. It is well accepted that the high biodiversity of the region is linked strongly to its agricultural traditions. However, there are significant changes happening in the landscape including a major expansion of hazel scrub into grazing land. This is due, at least in part, to changes which have occurred in farming in recent decades. To provide some evidence-based insight into this issue, this study investigated the effects that the complete cessation of grazing in Burren grasslands would have on biodiversity – with the focus on vascular plant and land snail communities. Large changes were recorded from within fenced grassland exclosures (with more mixed pictures emerging for scrub and woodland). A significant decrease was seen in both species richness and diversity for the plants in the grasslands, along with a significant increase in the amount of litter present. In the case of the snails, however, abundance increased significantly inside the fenced plots, while there was only a very small change in the controls. Shifts in community structure were also evident. It is likely that the molluscs benefitted from the higher vegetation and denser litter, providing them with food, shelter and moisture.

**Keywords:** Mollusc, Burren, Land-use change, Exclosures, Diversity

## Introduction

The Burren in the west of Ireland is famous for its flora and fauna and its impressive biodiversity and landscape (O'Connell and Korff, 2001; Viney, 2003). All of this is indebted in no small way to the agricultural traditions of the area (Dunford, 2002). Many of the best known habitats, including limestone pavements and species-rich grasslands, are now considered to be under threat from encroaching hazel scrub (The Heritage Council, 2006). The scrub also interferes with farming practices by blocking pathways used by stock and taking over grazing land. There is no single reason for the increased rate of scrub encroachment, but one of the main contributing factors is changes in farming practices. The use of less-hardy animal breeds, the decrease in the practice of out-wintering animals, farmers often working off-farm and the changeover from beef cattle to suckler cows has resulted in a general decrease in the grazing pressure on some of the most valuable Burren habitats (Dunford, 2002; Williams *et al.*, 2009). With these changes in mind, the current study was devised in order to investigate the effects that might be wrought on biodiversity should grazing cease altogether. The focus was on vascular plant and land snail communities.

**Materials and Methods**

A network of twelve fenced exclosures (each 20x20m) was set up across the Burren region in 2006. The fences prevent access by large grazers (mainly cattle and goats) and were placed in three types of habitat: rough grassland, areas with low or scattered hazel scrub, and hazel woodland. Beside each fenced area is an unfenced control plot of similar size. Plants and snails have been monitored since the set-up in these paired fenced and control plots. Plant data were collected from five fixed 2x2m quadrats within each plot, and molluscs were sampled using 25x25cm quadrats placed adjacent to these (vegetation was removed, dried and the molluscs picked from the samples and identified to species level).

To investigate if the cessation of grazing had an effect on plant species richness or diversity, general linear ANOVA models were constructed. These tested for differences in changes in numbers of plant species and diversity between 2006 and 2008. Diversity was measured using 'Simpson's Diversity Index'. The factors used in the model were 'habitat' (fixed), 'site' (nested within habitat; random) and 'treatment' (i.e. fenced/unfenced; fixed). The effect of 'year' was accounted for in the analysis by using 'change in species number' as the response variable. Tukey Simultaneous Tests were used for post-hoc analysis. Before computations, data were tested for normality and homogeneity of variances, and transformed where necessary. Analyses were carried out in Minitab 13.3.

To elucidate the effect of cessation of grazing on mollusc community structure NMS (non-metric multidimensional scaling) was used. This is a form of indirect gradient analysis, and is a robust ordination technique, well suited to extracting patterns from community data which are often non-normal and 'zero-heavy' (McCune and Grace, 2002; Perrin *et al.*, 2006). All data were screened using outlier analysis, and the distance measure used was Quantitative Sørensen (Bray-Curtis). All analyses were carried out using PC-ORD 5. Only a subset of the analyses is presented here – i.e. the fenced grassland plot data only.

**Results and Discussion**

A significant interaction ($p<0.001$) between 'habitat' and 'treatment' was found in the test for differences in species number between 2006 and 2008, meaning that the effect of the treatment between years changed depending on the habitat (Figure 1). Post-hoc analysis revealed that the changes in species numbers inside the fenced plot in grasslands were significantly different to the changes in the grassland controls (p=0.0001), but that this was not the case for either woodlands or scrub. For changes in diversity, results again indicated a significant interaction between habitat and treatment, with post-hoc analysis showing that there was a highly significant difference (p<0.0001) between the change in diversity seen in the woodland fenced and control plots (diversity increased more within the fenced plots) (Figure 2). There was a more moderate, but still statistically significant (p=0.0291), difference between the changes seen in the fenced and control plots in the grassland sites (diversity decreased inside the fences but remained almost unchanged in the controls). No significant differences were found for the scrub plots. These findings, though perhaps surprising clear-cut for a short-term study, are not without precedent. Other studies based in grasslands, such as those of Gibson (1997), Hansson and Fogelfors (2000), Moles et al. (2005), Enyedi et al. (2008) and Deenihan et al. (2009), have all found lower species richness and/or diversity in ungrazed grasslands, when compared to grazed sites.

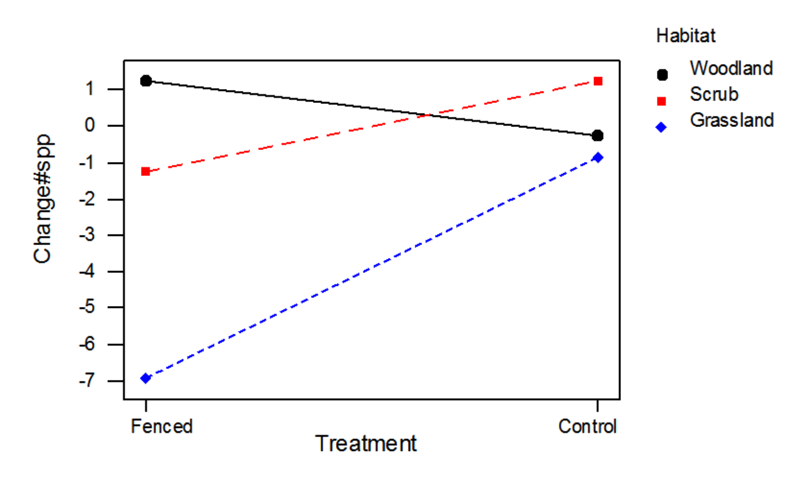


**Figure 1.** Interaction plot showing effects of treatment on the mean change in number of species between 2006 and 2008 in each of the three habitat types.

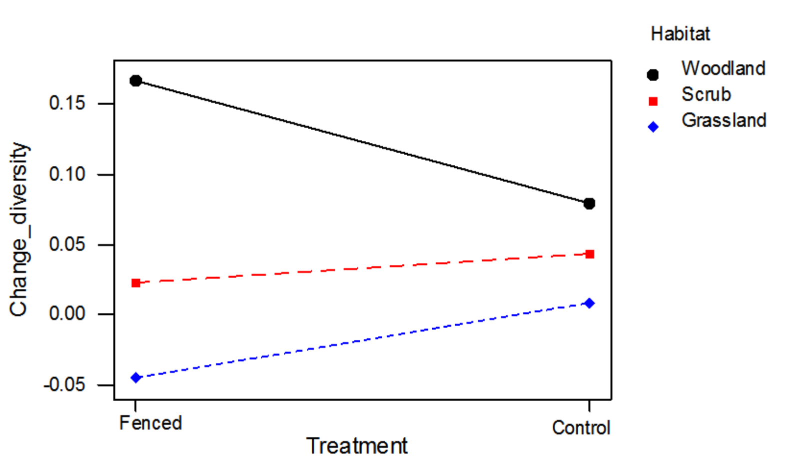


**Figure 2.** Interaction plot showing effects of treatment on the mean change in Simpson's Diversity Index between 2006 and 2008 in each of the three habitat types.

With respect to the land snails, while there was no change in the total number of species recorded (25 each year), the mean number of individuals collected per quadrat inside the fenced plots (across all species and all habitats) increased by almost 50% between the first and second sampling periods – from an average of 14.1 ±2.3 snails to an average of 20.9 ±5.4. There was only a very small change in the corresponding control plot numbers (a decrease of 3%, from 12.1 ±2.6 to 11.8 ±2.5). The largest and most consistent changes were seen in the grassland sites (more detailed data available on request).

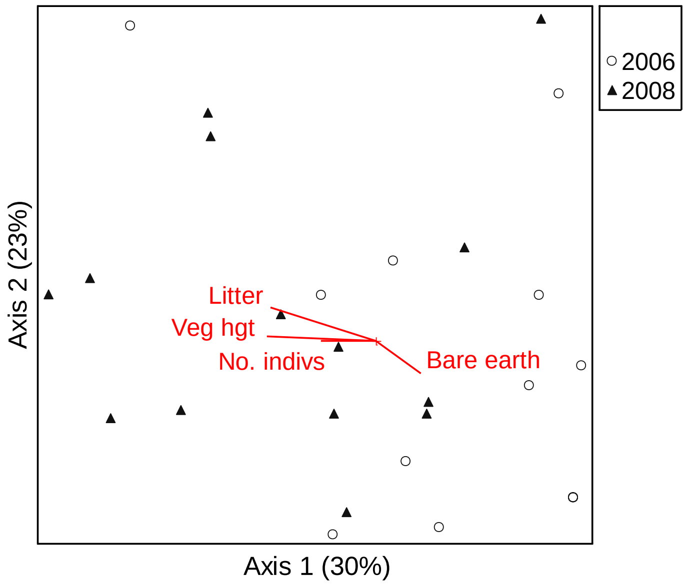


**Figure 3.** NMS ordination of mollusc data from fenced grassland plots. Each point corresponds to a quadrat. Figures in brackets on axis labels are the percentage of the variation in the distance matrix which is explained by this axis. The most influential variables are overlaid.

Multivariate analysis of the fenced grassland plot data showed a definite shift in the species composition of the mollusc communities over the two-year period, with quadrats sampled in 2006 tending to separate from those sampled in 2008 (Figure 3). (Analyses not presented here confirm that no such trend is evident from the control plots.) The main factors associated with this shift were found to be cover of litter and vegetation height, both of which increased substantially in the absence of grazing.

The findings presented here suggest that the snail populations overall benefitted from the longer vegetation and denser litter which resulted from the exclusion of grazers from grassland plots, and these findings concur with those of Boyd (1960) and Labaune and Magnin (2002). Ausden et al. (2005), in a study of fens, also found that the exclusion of cattle caused an increase in the number of molluscs. Further, on the re-introduction of cattle grazing, they recorded a reduction in litter, and a reduction in mollusc densities. It is likely that the build-up of litter provides extra food, shelter and moisture for snails, and thus conditions improve (at least for certain species). It should be noted that no such trends were seen in this study in scrub or woodland habitats.

## Conclusions

The significant decrease in both species richness and diversity in vascular plants recorded from within the grassland fenced plots points to the crucial role that grazers play in maintaining grassland plant communities. However, the numbers of individual snails recorded increased dramatically within fenced grassland exclosures over the study period. These contrasting findings highlight the importance of assessing a suite of taxa when investigating the effects of changes in management practices on biodiversity.

The exclosures set up during this study provide a valuable tool for monitoring long-term vegetation and landscape change in the Burren into future decades. It is hoped that this work will be continued into the longer term. In particular, it will be of interest to investigate the longer-term effects on rarer snail species and on those requiring open habitats.

## References

**Ausden, M., Hall, M., Pearson, P. & Strudwick, T. 2005.** The effects of cattle grazing on tall-herb fen vegetation and molluscs. *Biological Conservation* 122: 137-326.

**Boyd, J. M. 1960.** Studies of the differences between the fauna of grazed and ungrazed grassland in Tiree, Argyll. *Proceedings of the Zoological Society of London* 135(1): 33-54.

**Deenihan, A., Donlan, J., Breen, J. & Moles, R. 2009.** Mid-term impacts of excluding large grazing animals on a Burren grass/scrubland patch. *Biology and Environment: Proceedings of the Royal Irish Academy* 109B(2): 107-113.

**Dunford, B. 2002.** *Farming and the Burren.* Teagasc, Ireland.

**Enyedi, M. Z., Ruprecht, E. & Deak, M. 2008.** Long-term effects of the abandonment of grazing on steppe-like grasslands. *Applied Vegetation Science* 11: 55-62.

**Gibson, C. W. D. 1997.** The effects of horse and cattle grazing on English species-rich grasslands. Report No. 210, English Nature, Peterborough, UK.

**Hansson, M. & Fogelfors, H. K. 2000.** Management of a semi-natural grassland; results from a 15-year-old experiment in southern Sweden. *Journal of Vegetation Science* 11(1): 31-38.

**Labaune, C. & Magnin, F. 2002.** Pastoral management vs. land abandonment in Mediterranean uplands: impact on land snail communities. *Global Ecology and Biogeography* 11: 237-245.

**McCune, B. & Grace, J. B. 2002.** *Analysis of Ecological Communities.* MjM Software Design, Oregon, USA.

**Moles, R., Breen, J. & O'Regan, B. 2005.** A pilot scale long-term experimental study of the effects of grazing and gap creation on Burren grassland dynamics: implications for conservation. *Biology and Environment: Proceedings of the Royal Irish Academy* 105: 15-32.

**O'Connell, J. W. & Korff, A. (Eds) 2001.** *The Book of the Burren (2nd Edition).* Tír Eolas, Kinvara, Co. Galway, Ireland.

**Perrin, P. M., Martin, J. R., Barron, S. J. & Roche, J. R. 2006.** A cluster analysis appoach to classifying Irish native woodlands. *Biology and Environment: Proceedings of the Royal Irish Academy* 106B(3): 261-275.

**The Heritage Council. 2006.** Assessment of Landscape Change and Effects on Archaeology and an Assessment of Habitat Survey in the Burren, Co. Clare. Report to The Heritage Council, Kilkenny, Ireland.

**Viney, M. 2003.** *Ireland.* Smithsonian Institution, USA/Blackstaff Press Limited, Belfast, Northern Ireland.

**Williams, B., Parr, S., Moran, J., Dunford, B. & Ó Conchúir, R. 2009.** The Burren - farming for the future of the fertile rock. *British Wildlife* 21(1): 1-9.

# Late Holocene changes in the high-altitude vegetation of mountainous areas of north-central Greece and the role of grazing.

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## Abstract

Palynological studies have been carried out in the Lailias, Belles, Voras and Pieria (Flambouro) mountains which are located in north- central Greece. The four mountainous sites share some common geological and vegetation features. All sites have crystalline bedrocks and the high altitude forest vegetation is dominated by beech and/or pine forests though there are differences among these areas regarding the extent of these forest types, their location in relation to the coring sites etc. A distinct subalpine zone is present in all sites except Lailias and is dominated by *Juniperus communis* ssp. *nana*, ericaceous dwarf shrubs and extended grasslands. A comparative palynological study of the changes in the high-altitude vegetation of the four sites is attempted covering the Late Holocene. Pollen types related with human induced disturbance (e.g. forest clearings, animal husbandry) are compared up against pollen types of major forest vegetation units. Signs of local grazing pressure can be traced in various time periods in the diagrams of Beles, Lailias and Pieria. Though traceable in the Voras diagram, grazing pressure seems to have no major impact on the forest vegetation.

**Key words**: pollen analysis, vegetation, Greece, Voras, Lailias, Beles, Pieria

## Introduction

Human impact on the natural vegetation of eastern Mediterranean has a long history of several thousand years (Bottema and Woldring 1990). Human impact manifested itself in the form of forest clearings, cultivation of land but quite often as animal husbandry.

Pollen analysis and reconstruction of past vegetation have been performed in several mountainous regions in northern Greece. In all sites signs of human impact have been traced and in many cases are well documented by historical or archaeological data (e.g. Gerasimidis et al. 2003, Athanasiadis et al. 2003).

This study compares the different vegetation histories of the Late Holocene in the mountainous regions of Pieria (Flambouro), Voras, Beles and Lailias (Figure 1) located in north-central Greece giving emphasis to grazing activity. Information on the sites of coring (coordinates, altitude, local and regional vegetation) can be found in previously published works

(Gerasimidis 2000, Athanasiadis et al. 2003, Gerasimidis et al. 2009, Gerasimidis and Panajiotidis 2010). All sites share same geological features having crystalline bedrock and their dominant forest types are beech and or pine, though there are differences among these areas regarding the extent of these forest types their location in relation to the coring sites etc. With the exception of Lailias, there is a clear subalpine zone in all sites where grasslands and dwarf juniper (*Juniperus communis* ssp. *nana*) and ericaceous shrubs dominate the vegetation.

**Materials and Methods**

Standard procedures were used for the preparation and counting of pollen grains (Faegri and Iversen 1989). Pollen diagrams were created using Tilia and TGView 2.0.2 software (Grimm 2004). Radiocarbon dates were calibrated with the help of CALIB 6.0 (Stuiver and Reimer 1993). Sum of pollen types (AP + NAP), upon which pollen percentage (PP) values were calculated, includes major forest tree species, subalpine species and pollen types indicators of grazing or forest clearings in local (Asteraceae, Cichoriaceae, Caryophyllaceae, Rubiaceae,) or regional scale (*Plantago*, *Artemisia*, Chenopodiaceae, *Rumex*) mountainous regions with a crystalline bedrock (Mazier et al. 2006). Clustering and zonation of the diagrams was based on the same, as above, assemblage of pollen types.

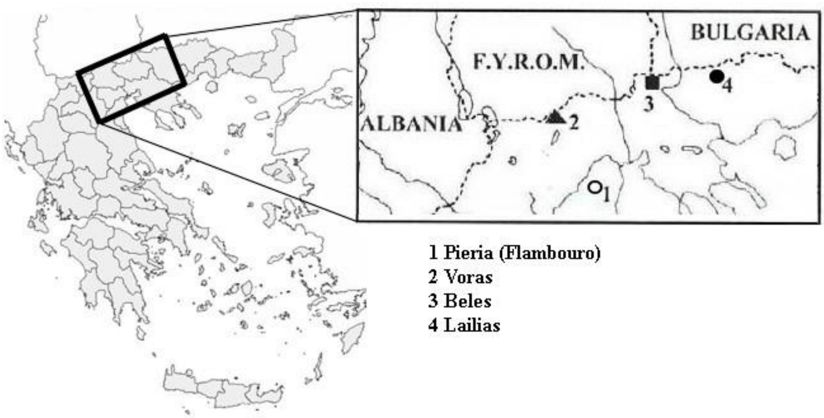


**Figure 1.** Map showing the locations of the coring sites in north-central Greece.

**Results- Discussion**

The composite diagram (Figure 2) comprises the Beles (BE), Voras (VR), Lailias (LA) and Pieria (Flambouro, FL) pollen diagrams. The original diagrams of Voras and Lailias cover a larger time period but in this study we take into consideration their late Holocene period for which there is a good time resolution between consecutive samples (around 100 years per 10 cm) for most part of the diagrams. In this respect Beles diagram has the best time resolution, with a time 'window' between samples of ca. 30 years per 10 cm.

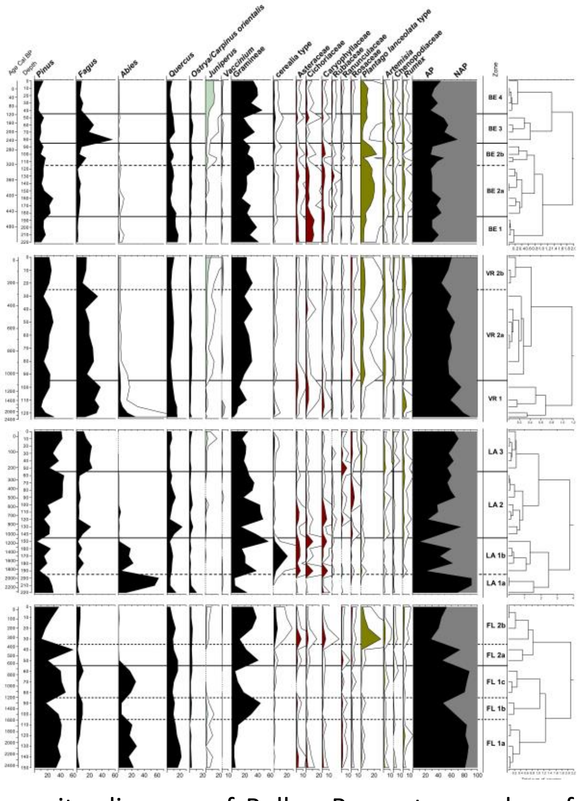

**Figure 2.** Composite diagram of Pollen Percentage values for the four cores analyzed. Beles (BE) , Voras (VE), Lailias (LA) and Pieria (Flambouro, FL).

In the Beles Mountains grazing pressure appears for the first time at the base of the diagram in a period that coincides with the start of the Turkish occupation (Athanasiadis et al. 2003). The large PP values of *Plantago lanceolata* type together with those of Asteraceae, Cichoriaceae, Caryophyllaceae, Rubiaceae, indicate the strong grazing pressure around the coring site (BE 2a-b). In the boundary of subzones BE 2a- BE 2b clear impact on forest vegetation is implied by the alternating high values of grazing pollen indicators with low values of forest pollen types and vice versa. This pattern is also seen among the same indicators and pollen of *Juniperus* (BE 2a-b, BE3, BE4). A possible explanation is that usually juniper shrubs were burned, as they are not edible by domesticated animals, to provide fields for grazing (Prof. V. Papanastasis pers. comm.).

In Voras Mountains all pollen indicators of grazing show in general low values with the exception of *Plantago lanceolata* type. The constant present of the latter as well as of Chenopodiaceae and *Rumex* (subzones VR 2a-b) indicate grazing pressure in the region which is mainly taking place in the subalpine zone. This is supported by the fact that there are no tremendous changes in forest cover as indicated by the comparison of the AP/NAP curve of Voras with those of the other diagrams.

In Lailias mount the pattern of alternating magnitude in PP values between indicators of grazing and major forest types is again detected in the upper and lower boundaries of subzone LA1b as well as in part of zone LA2. In the same subzone the abundant presence of cerealia type indicates also cultivation of land. Interestingly, PP values of *Plantago lanceolata* type are very low and the curve is fragmented.

In Pieria (Flambouro) diagram a first short event of fir decline (FL1b) indicates forest clearings and logging as no pollen indicators of grazing are significantly present. After the second and as it appears permanent decline of fir (Fl2a-b) around the coring site, a major shift in the values of grazing indicators, coinciding with the establishment of the Katafygi village (Gerasimidis et al. 2008), is observed (base of Fl2b).

It is important to notice that in the sites with a distinct subalpine zone (Pieria, Voras, Beles) the decline of grazing pressure in the recent decades has led to a rise in PP values of juniper marking a qualitative change in the composition of the vegetation.

Clear indications of human impact were found on the forest vegetation of most north-central Greece Mountains, examined in this study. Most of the pollen indicators proposed in the published literature are found to be good ‘tools’ in evaluating the spatial dimension and intensity of human activity manifested mainly as animal husbandry.

## References

**Athanasiadis N., A. Gerasimidis, S. Panajiotidis. 2003.** A palynological study in the Beles mountains, Northern Greece. In S. Tonkov (ed). Aspects of Palynology and palaeoecology. pp 185-197.

**Bottema, S. and H. Woldring. 1990.** Anthropogenic indicators in the pollen record of the Eastern Mediterranean. In: S. Bottema, G. Entjes-Nieborg, W. van Zeist (eds.). Man's role in the shaping of the Eastern Mediterranean landscape. Balkema, Rotterdam, 231 -264

**Gerasimidis A. 2000.** Palynological evidence for human influence on the vegetation of mountain regions in northern Greece: The case of Lailias, Serres. In P. Halstead and C. Frederick 'Landsacape and Land Use in Ancient Greece. pp 28-37.

**Gerasimidis A., N. Athanasiadis, S. Panajiotidis. 2003.** Pastoral activity in mount Paiko during the last three millennia, evidence by palynological and historical data. In P. Platis and T. Papachristou (eds). Livadoponia kai oreini anaptixi. Proceedings of the 3rd Panhellenic Rangeland Congress. pp. 175-185. (In Greek with English Abstract).

**Gerasimidis A., S. Panajiotidis, N. Athanasiadis. 2008.** Five decades of rapid forest spread in the Pieria Mountains (N. Greece) reconstructed by means of high-resolution pollen analysis and aerial photographs, *Veg. Hist Archaeobot* 17(6) 639-652.

**Gerasimidis A., N. Athanasiadis, S. Panajiotidis. 2009.** 8. Mount Voras (north-west Greece)-CONTRIBUTIONS TO THE EUROPEAN POLLEN DATABASE. *Grana* 48: 316- 318

**Gerasimidis A. and S. Panajiotidis. 2010.** 9. Flambouro, Pieria Mountains (northern Greece)-CONTRIBUTIONS TO THE EUROPEAN POLLEN DATABASE. *Grana* 49: 76- 78

**Grimm E. 2004.** Tilia and TGView 2.0.2. Illinois state museum, research and collections center, Springfield

**Faegri K., J. Iversen. 1989.** Textbook of pollen analysis, 4th edn. Wiley, Chichester

**Stuiver M., and P. J. Reimer. 1993.** Extended 14C database and revised CALIB radiocarbon calibration program, *Radiocarbon* 35:215-230.

# Plant diversity of grazed and reforested Mediterranean rangelands

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## Abstract

Rangelands cover a large area in the Mediterranean region but are largely degraded due to their improper grazing management. The aim of this study was to investigate the effect of various management practices applied for restoration of degraded Mediterranean rangelands on plant diversity. The research was conducted in rangelands of Lagadas county, in North Greece, dominated by evergreen shrublands. The management practices studied were: moderate grazing, overgrazing, control (banning of grazing), partial and full reforestation with pines (*Pinus pinaster*). Three transects were established on each management practice. Plant cover was recorded along each transect using the line-point method and species composition was calculated. Additionally, species presence /absence was measured using 10 quadrats per transect. The recorded species were classified into five *a priori* groups (trees, shrubs, grasses, legumes, forbs). Furthermore, three plant diversity indices (Shannon-Wiener, evenness and species richness) were calculated for each transect. The five management practices had high plant cover, with the exception of the overgrazed one. The composition of the vegetation however differed in terms of the dominant plant group in each practice. As far as plant diversity is concerned, the moderately grazed practice had the highest values followed by the control while the full reforestation had the lowest. It is concluded that the various management practices for restoration of degraded Mediterranean rangelands affect differently plant species composition and diversity. However moderate grazing can contribute to restoration of plant diversity without resorting to other management practices such as pine plantations.

**Key words:** Shannon-Wiener index, evenness, species richness, grazing, reforestation

## Introduction

Rangelands cover a large area in the Mediterranean region and constitute a dominant land use type (Le Houerou 1981). They have a long history of grazing by livestock that has resulted in high biological diversity (Papanastasis et al. 1998). Most of these areas, however, are degraded due to the improper grazing use, especially overgrazing, which affects the structure and function of the ecosystem. For this reason, several management interventions are implemented for their restoration including appropriate grazing management (Papanastasis 2009). In Greece, restoration practices involve regulation of grazing to the grazing capacity of rangelands, total banning of grazing and partial or full pine plantation followed by banning of grazing for at least ten years after tree seedling establishment. The aim of this study was to investigate the effects of these management practices on plant diversity of Mediterranean rangelands.

**Material and Methods**

The research was carried out in Lagadas county, North Greece, on rangelands dominated by evergreen shrublands. It involved five management practices that were applied, over the last 30 years: moderate grazing, overgrazing, no grazing (abandoned rangeland - control), partial and full reforestation with pines (*Pinus pinaster*). On each management practice, three transects (50 m long each) were established. Plant cover was recorded along each transect using the line-point method (Cook and Stubbendieck 1986). Species overlapping in each point were also recorded (multiple contacts) and species composition was calculated. The recorded species were classified into five *a priori* groups: trees, shrubs, grasses, legumes, forbs and their contribution in each transect was calculated. Furthermore, the Shannon-Wiener diversity index and evenness (Magurran 2004) were calculated for each transect. Additionally, species presence/ absence was measured using 10 equally distributed quadrats (50 x 50 cm each) systematically (every 5 m) placed along each transect. Species richness was estimated as the mean number of species recorded in the ten quadrats of each transect. All data were analysed using one way ANOVA. Duncan multiple range test was applied to detect the differences among the means at 0.05 level of significance. Plant cover and *a priori* group contribution data were previously transformed using arcsine transformation (Sokal and Rohlf 1995). All analyses were carried out using the software package PASW Statistics 18.0 (SPSSInc. 2009).

**Results and Discussion**

High plant cover, ranging from 93.3% (full reforestation) to 98.0% (moderate grazing) (Table 1) was recorded for all the management practices except the overgrazed one, which had the lowest plant cover (56.67%). On the contrary, the overgrazed practice had the highest cover of rock and bare soil (39.4%). High rock and bare soil and low vegetation cover in freely grazed areas have been also reported by Alrababah et al. (2007). Litter had a mean cover of 3.5% in all practices and did not differ significantly among them.

Full and partial reforestation had the highest tree cover. Shrubs covered a large area in the overgrazed rangeland, but they were absent from the canopy cover of the full reforestation. All other practices had an intermediate shrub cover reaching a mean of 13%. Herbaceous cover was maximum in the moderate grazing and minimum in the partial reforestation. A reduction in herbaceous species cover with the simultaneous increase of woody plant (trees and shrubs) cover is also reported by Karakosta et al. (2010).

**Table 1.** Mean plant cover (%) of the five management practices

| Management practice | Trees | Shrubs | Herbaceous species | Litter | Rock | Bare soil |
|---|---|---|---|---|---|---|
| Moderate | 0.00c[1] | 16.67b | 81.33a | 1.67a | 0.00 | 0.33b |
| Overgrazing | 0.00c | 38.33a | 18.33bc | 4.00a | 12.3 | 27.00 |
| Control area | 63.33b | 12.00b | 21.67b | 2.67a | 0.00 | 0.33b |
| Partial | 86.00a | 10.33b | 1.33d | 2.34a | 0.00 | 0.00b |
| Full | 85.67a | 0.00c | 7.67cd | 6.66a | 0.00 | 0.00b |

[1] Different letters in the same column indicate significant differences among the five practices ($p \leq 0.05$)

The contribution of the five *a priori* groups in each management practice is shown in table 2. Grasses had the highest representation in the moderately grazed practice, while it did not differ significantly among the other practices. Grasses have been found to be also reduced with increasing grazing intensity by other researchers (e.g. Noy-Meir et al. 1989, Hadar et al. 1999, Sternberg et al. 2000), as well as in the case of grassland and shrubland afforestation (Chirino et al. 2006). Legumes contributed more in the two grazing and the control practices, while they were almost absent in the full reforestation practice. The effect of grazing on legumes has been found to vary by Hadar et al. (1999), while no significant effect of grazing intensity on legumes was found by Sternberg et al. (2000) and Papanastasis et al. (2002). Forbs representation was significantly greater in the control area than in the two reforestation practices, while their contribution did not significantly differ between the control and the two grazing practices.

The overgrazed practice had the highest shrub representation, as in the case of plant cover, followed by partial reforestation (Table 2). On the contrary, shrub contribution was almost absent in the full reforestation practice. As far as trees are concerned, they were proportionally more in the full reforestation, followed by the partial reforestation. The control area had significantly less trees than the two former practices, while the two grazing practices did not have any trees. These results indicate that the reforestation practices had greater vertical plant stratification due to the presence of the tree stratum, than the grazing practices. Similar results have been reported by Chirino et al. (2006). It should be noted that partial reforestation had a better vertical stratification than full reforestation where the shrub stratum was actually absent. The fact that the control area had a vertical vegetation structure, suggests that suspension of grazing can also contribute to the restoration of grazing lands (Papanastasis 2009).

**Table 2.** Mean contribution (%) of the various *a-priori* groups to the five management practices

| Management practice | Grasses | Legumes | Forbs | Shrubs | Trees |
|---|---|---|---|---|---|
| Moderate | 61.93a[1] | 15.82a | 10.53a | 11.72c | 0.00d |
| Overgrazing | 15.78b | 9.61ab | 9.88ab | 64.72a | 0.00d |
| Control area | 19.60b | 14.60a | 12.49a | 18.43c | 34.87c |
| Partial | 9.28b | 2.52bc | 3.61c | 32.20b | 52.40b |
| Full | 18.08b | 0.31c | 6.58bc | 0.56d | 74.47a |

[1] Different letters in the same column indicate significant differences among the five practices ($p \leq 0.05$)

Shannon-Wiener diversity index was highest in the control and the moderate grazing practices and lowest in the full reforestation. Species richness had the maximum value in moderate grazing, followed by the control area and the minimum in the full reforestation, showing a similar trend with the Shannon index. On the other hand, evenness did not significantly differ between the management practices, except full reforestation where it was significantly lower. In general, moderate grazing had the highest plant diversity followed by the control area and full reforestation the lowest. Higher diversity values have been also found in grazed as compared to ungrazed areas by other researchers (e.g. Noy-Meir 1995, Castro et al. 2010). Noy-Meir (1998) reports that several studies in Mediterranean grasslands confirm that species diversity increases at intermediate grazing intensity and decreases at high intensity. As far as reforestation is concerned, a negative impact of afforestation on plant diversity has been also reported by Chirino et al. (2006) and Alrababah et al. (2007).

**Table 3.** Mean values of Shannon-Wiener diversity index, evenness and species richness of the five management practices

| Management practice | Shannon-Wiener (H) | Evenness (J) | Species richness (no. species/ 0.25m$^2$) |
|---|---|---|---|
| Moderate grazing | 2.29ab[1] | 0.70a | 11.30a |
| Overgrazing | 1.66c | 0.68a | 5.47c |
| Control area | 2.42a | 0.69a | 7.77b |
| Partial reforestation | 1.93bc | 0.64a | 3.43cd |
| Full reforestation | 1.08d | 0.42b | 2.93d |

[1] Different letters in the same column indicate significant differences among the five practices ($p \leq 0.05$)

## Conclusions

1. Management practices to restore degraded Mediterranean rangelands affect differently plant structure and diversity.
2. Moderate grazing results in higher plant diversity than no grazing (control) and, especially, overgrazing while full reforestation with pines ends up with the lowest values.
3. Appropriate grazing management can contribute to restoration of degraded rangelands without having to resort to reforestation with pines.

## Acknowledgements

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## References

**Alrababah M.A., M.A. Alhamad, A. Suwaileh and M. Al-Gharaibeh. 2007.** Biodiversity of semi-arid Mediterranean grasslands: Impact of grazing and afforestation. *Applied Vegetation Science 10*:257-264.

**Castro H., V. Lehsten, S. Lavorel and H. Freitas. 2010.** Functional response traits in relation to land use change in the Montado. *Agriculture, Ecosystems & Environment 137*:183-191.

**Chirino E., A. Bonet, J. Bellot and J. R. Sanchez. 2006.** Effects of 30-year-old Aleppo pine plantations on runoff, soil erosion, and plant diversity in a semi-arid landscape in south eastern Spain. *CATENA 65*:19-29.

**Cook C.W. and J. Stubbendieck. 1986.** Range Research: Basic Problems and Techniques. Society of Range Management, Denver, Colorado, USA. 317 pp.

**Hadar L., I. Noy-Meir and A. Perevolotsky. 1999.** The effect of shrub clearing and grazing on the composition of a Mediterranean plant community: functional groups versus species. *Journal of Vegetation Science 10*:673-682.

**Karakosta C., M. Papadimitriou, K. Mantzanas and V. P. Papanastasis. 2010.** Diachronic change in plant cover and diversity in abandoned arable fields at the University Forest of Taxiarhis in Chalkidiki, northern Greece. In: A. Sidiropoulou, K. Mantzanas and I. Ispikoudis (eds). Range Science and Life Quality. Proceedings of the 7th Panhellenic Rangeland Congress. pp. 173 – 178. (In Greek with English Abstract).

**Le Houerou H. N. 1981.** Impact of man and his animals on Mediterranean vegetation. In: F. di Castri, D. W. Goodall and R. L. Specht (eds). Mediterranean type Shrublands. Elsevier Sci. Co., New York. pp. 479-521.

**Magurran A. E. 2004.** Measuring biological diversity. Blackwell Science Ltd, Oxford. 256 pp.

**Noy-Meir I. 1995.** Interactive effects of fire and grazing on structure and diversity of Mediterranean grasslands. *Journal of Vegetation Science 6*:701-710.

**Noy-Meir I. 1998.** Effects of grazing on Mediterranean grasslands: the community level. In: V.P. Papanastasis and D. Peter (eds). Ecological basis of livestock grazing in Mediterranean ecosystems. European Commission, EUR 18308 Luxembourg. pp. 27-39

**Noy-Meir I., M. Gutman and Y. Kaplan. 1989.** Responses of Mediterranean grassland plants to grazing and protection. *Journal of Ecology 77*:290-310.

**Papanastasis V. P. 2009.** Restoration of Degraded Grazing Lands through Grazing Management: Can It Work? *Restoration Ecology 17*:441-445.

**Papanastasis V. P., G. Enne, M. Dubost, N. Seligman, P. Talamucci and L. Liacos. 1998.** Conclusions and recommendations. In: V. P. Papanastasis and D. Peter (eds). Ecological basis of livestock grazing in Mediterranean ecosystems. European Commission, EUR 18308 Luxembourg. pp. 343-344

**Papanastasis V. P., S. Kyriakakis and G. Kazakis. 2002.** Plant diversity in relation to overgrazing and burning in mountain mediterranean ecosystems. J*ournal of Mediterranean Ecology 3*:53-64.

**Sokal R. R. and F. J. Rohlf. 1995.** Biometry. The principles and practice of statistics in biological research, 3rd edition. W.H. Freeman and Company USA. 887 pp.

**SPSSInc. 2009.** PASW Statistics 18.0. PASW Statistics Base 18.0 for Windows User's Guide. SPSS Inc., Chicago IL.

**Sternberg M., M. Gutman, A. Perevolotsky, E.D. Ungar and J. Kigel. 2000.** Vegetation response to grazing management in a Mediterranean herbaceous community: a functional group approach. *Journal of Applied Ecology 37*:224-237.

# The effect of different combination of livestock grazing on herbage production in permanent dry grasslands

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## Abstract

Rangelands are multifunctional natural non-arable land, covered by different types of vegetation, including herbaceous and woody plants. Dry grasslands occupy areas that have relatively dry and nutrient-poor soils and they are mainly used for livestock grazing. Grazing is recognized as an important ecological factor in grassland ecosystems, which has affected the structure, the composition and the characteristics of vegetation. The aim of this paper was to study the effect of different combination of livestock grazing on the production in two dry grasslands. The study area was located near the lakes Zazari and Chimaditida, in Florina region, western Macedonia, Greece. The grasslands in Zazari were used by small ruminants and cattle of the nearby village, while the grasslands in Chimaditida were used mainly by sheep and very few goats. The herbage production in both grasslands was measured in 2008. It was found significantly lower in the grasslands of Zazari than in the grasslands of Chimaditida. The grazing by different kind of animals has created a different plant structure and composition in the grasslands.

**Key words**: rangeland, livestock, small ruminant, cattle, composition

## Introduction

Rangelands in the Mediterranean region occupy 52% of its total area (Le Houerou 1981), while in Greece, they cover 40% of the total area (NSSG 1997). They are natural ecosystems covered by herbaceous or woody vegetation, produce forage for both livestock and wild herbivores, and provide various goods and services (Bugalho and Abreu 2008). Natural rangelands are marginal lands used primarily as pastures by sheep, goats and cattle and are found mainly in arid, semiarid and sub-humid areas (Papanastasis 2008).

Grasslands are one of the four types of rangelands covered by herbaceous plants (grasses and broadleaf forbs) (Papanastasis and Noitsakis 1992, Papachristou 2000, Papanastasis 2000). Moreover, grasslands are often characterized by abundance of species, which contribute to the variability of floristic composition and production (Maranon 1985). Dry grasslands comprise a variety of grassland habitats that all have relatively dry and nutrient-poor soils (DMEFNA 2008) but are rich in plant and animal species and frequently used either as meadows or as pastures (Bolliger et al. 2010). Livestock grazing on dry grasslands enhance habitat diversity, altering plant species with different habitat requirements to thrive (DMEFNA 2008). The aim of this study was to estimate the effect of different combination of livestock grazing on herbage production of two dry grasslands.

**Methods and materials**

The research was conducted in Florina region, in western Macedonia, Greece in 2008. The altitude of the area is 600 m. The climate is classified as Csb (mild Mediterranean climate in sites with altitude more than 500 m, mild winter, and dry summer) under the Koeppen climate classification. The average annual precipitation was 516 mm. The maximum temperatures was in July (29.2 °C) and minimum in January (-1.9 °C). The area has been characterized as a Natura 2000 site and is considered as an important biotope of the Corine Biotopes Project.

Two experimental areas based on different kind of grazing animals were selected: 1) dry grasslands in the region close to Lake Zazari, which was grazed by small ruminants and cattle of the nearby village (Limnochori) and 2) dry grasslands close to Lake Chimaditida, which were mainly grazed by sheep and very few goats (Table 1).

**Table 1.** Number of grazing animals in the two dry grasslands during the trial

| Area /Animals | Sheep | Goat | Cattle |
|---|---|---|---|
| Zazari | 1561 | 460 | 190 |
| Chimaditida | 1006 | 69 | 0 |

(Source: Directorate of Rural Development of Southeastern Florina).

In both dry grasslands the dominant species of the vegetation were recorded. The dominant herbaceous species for the Zazari's grasslands were the cool season ($C_3$) grasses *Festuca ovina* group and *Agrostis* sp. and the warm season grasses ($C_4$) *Dichanthium ischaemum, Chrysopogon gryllus*, followed by legumes such as *Lotus corniculatus*,*Trifolium angustifolium,* and *T. campestre* in a smaller percentage. In Chimaditida's grasslands, the dominant species were mainly broadleaved perennial forbs such as *Marrubium* sp., *Carlina* sp. and *Carduus* sp. In the same grasslands, were scattered perennial grasses such as *Phleum* sp. and annual grasses *Avena* sp. and *Dasypyrum villosum* in a small percentage and annual legumes such as *Trifolium hirtum, T. strictum* and *T. angustifolium*.

Three experimental plots were established in each of the two grasslands. At the end of the growing season the herbage biomass remained after grazing was harvested using four (4) 0.5x0.5 m quadrats. The samples were oven-dried at 60°C for 48 h, and weighed. The herbage production was subjected to one way- analysis of variance (ANOVA) using the SPSS program. Differences among means were determined by the LSD test at $P<0.05$ level of significance (Steel and Torrie 1980).

**Results - Discussion**

Herbage production of Chimaditida's grasslands was significantly higher than the one of Zazari's grasslands (Figure 1). This is probably due to the fact that Chimaditida's grasslands were grazed mainly by sheep (Table 1) resulting in the increment of unpalatable species for sheep, such as broadleaved spiny forbs *Carlina* sp., and *Carduus* sp. These species have higher biomass compared to grasses and legumes. It is known that sheep preferred grasses, followed by legumes and then by broadleaved species and after continuous grazing, species composition was significantly altered with an increment of broadleaved species (Pillai et al. 1985). In addition, selective grazer as sheep provides competitive advantages to unpalatable plants, increasing their robustness and their number (Mueggler 1972), resulting in the increase of unpalatable species for sheep, such as broadleaved spiny forbs.

Herbage production of Zazari's grasslands was low, probably because it was grazed by a combination of small ruminants and cattle (Table 1). Cattle and sheep have a complementary feeding behaviour (Putfarken et al. 2008), as they consume the available feed resources in different way depending on their diet preference (Rook et al. 2004). It is known, that grazing could either increase or decrease species richness and diversity in herbaceous plant communities, depending mainly on foraging behaviour of the herbivores in relation to the dominant plant species (Zhang 1998).

The use of the two dry grasslands by different combination of livestock has led to different species composition as it seems from the dominant species. Mixed grazing may have affected the vegetation differently from that of single-species grazing, as herbivore species differ in diet preferences, terrain use and their potential to impact vegetation growth (Walker 1994, Bakker 1998, Rook et al. 2004).

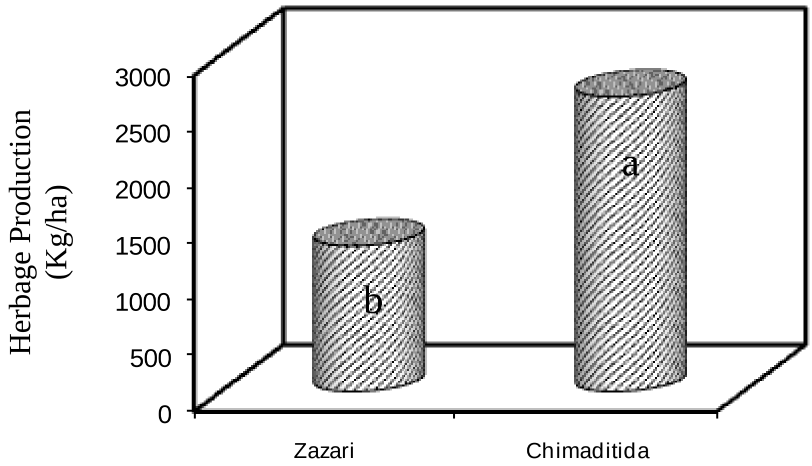


**Figure 1.** Herbage production kg/ha of the two grasslands. Means indicated by the same letter are not significantly different (P≤0.05).

## Conclusions

In Zazari, the rational use of livestock with different types of animals has resulted in the presence of desirable species, while in Chimaditida sheep grazing has led to the dominance of undesirable species. Therefore, a proper grazing management with mixed grazing animals is necessary for the proper utilization of the rangelands by the farmers.

## References

**Bakker J.P., 1998.** The impact of grazing on plant communities. In: M.F. Wallis DeVries, J.P. Bakker and S.E. van Wieren (eds). Grazing and Conservation Management. Conservation Biology Series 11. Kluwer. Dordrecht. pp. 137–184.

**Bolliger J., F. T. C. Edwards JR., S. Eggenberg, S. Ismail, I. Seidl and F. Kienast, 2010.** Balancing Forest-Regeneration Probabilities and Maintenance Costs in Dry Grasslands of High Conservation Priority. *Conservation Biology*, 25: 567–576.

**Bugalho M.N. and J.M. Abreu, 2008.** The multifunctional role of grasslands In: C. Porqueddu and M.M. Tavares de Sousa (Eds). Sustainable Mediterranean Grasslands and Their Multifunctions. *Option Méditerraneénes*, 79: 25-30.

**Danish Ministry of the Environment Forest and Nature Agency, 2008.** Restoration of dry grasslands in Denmark. Life Nature and Natura 2000.

**Le Houerou H. N., 1981.** Impact of man and his animals on Mediterranean vegetation. In: F. di Castri *et al.* (eds). Ecosystems of the World 11, Mediterranean-type Shrublands. Elsevier Scientific Publishing Company. Amsterdam. pp. 479-521.

**Marañón T., 1985.** Diversidad florística y heterogeneidad ambiental en una dehesa de Sierra Morena. *Anales de Edafología y Agrobiología* 44: 1183-1197 (in Spanish).

**Mueggler W.F., 1972.** Influence of competition on the response of blue-bunch wheat grass to clipping. *Journal of Range Management.* 25: 88 -92.

**National Statistical Service of Greece (NSSG), 1997.** Census data

**Papachristou T. G., 2000.** Forage resources of Greece and their relation to grazing animals. In: F. Guessous, N. Rihani and A. Ilham (eds). Livestock Production and Climatic Uncertainty in the Mediterranean. International Symposium, Agadir, Morocco. October 22-24 1998. EAAP publication No. 94. Wageningen Pers. pp. 283-290.

**Papanastasis V.P. and V. Noitsakis, 1992.** Rangelands Ecology. Giahoudi-Giapouli Press Thessaloniki, Greece. (in Greek). pp.101-166

**Papanastasis V.P., 2000.** Role of the grasslands in the production of animal products. *Livestock production today*. 15:38-39.

**Papanastasis V.P., 2008.** Grazing Land and pastoral landscapes. In Lucinda (Land care in Desertifiaction affected areas. On line: http://geografia.fcsh.unl.pt/lucinda/booklets/C5_ Booklet_Final_GR.pdf

**Pillai K.K., S. Thiagarajan and C. Samuel, 1985.** Weed control by sheep grazing under plantation tree crop. In: S. Sivarajasingam, R.I. Hutagalung, and Kassim Hamid. (eds). Proceedings of 9th Annual Conference, Malaysian Society of Animal Production. Serdang, Malaysia. pp. 43-52.

**Putfarken D., J. Dengler, S. Lehmann and W. Härdtle, 2008.** Site use of grazing cattle and sheep in a large-scaled pasture landscape: a GPS/GIS assessment. *Applied Animal Behaviour Science* 111: 54-67.

**Rook A.J., B. Dumont, J. Isselstein, K. Osoro, M.F. WallisDeVries, G. Parente and J. Mills, 2004.** Matching type of livestock to desired biodiversity outcomes in pastures-a review. *Biological Conservation*. 119: 137-150.

**Steel R.G.D. and J.H. Torrie, 1980.** Principles and Procedures of Statistics. 2$^{nd}$ edition. McGraw-Hill. New York. 481 pp.

**Walker J.W., 1994.** Multispecies grazing: the ecological advantage. *Sheep Research Journal* Special Issue pp.52–64.

**Zhang W., 1998.** Changes in species diversity and canopy cover in steppe vegetation in Inner Mongolia under protection from grazing. *Biodiveristy and Conservation*. 7: 1365-1381.

# The spatial distribution of rangeland vegetation depending on distance to settlement in highland rangelands of Turkey

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## Abstract

The aim of this study was to assess the effects of distance from settlements on spatial pattern of rangeland vegetation in semi-arid highlands of Bayburt and Erzurum provinces, Eastern Anatolia Region, in Turkey. The vegetation was sampled using the line intercept method, and environmental variable data were collected from both locations. All data were proceeded to ordination analysis using CANOCO, in order to test relations between species composition and environmental variables. There were strong correlation between species composition and environmental variables. The results indicate that distance from permanent settlement and environmental variables are important factors affecting spatial distribution of species. As getting further from permanent settlement the environmental conditions becomes more favorable and species composition improves with respect to desirable status.

**Key words:** floristic composition, vegetation, distribution

## Introduction

Terrain of the Eastern Anatolia (Turkey) is unsuitable for arable crop production due to geomorphologic feature and climatic conditions, hence rangelands dominate and cover about 50% of total area giving to livestock husbandry an important role for the regional agriculture. The species richness of rangeland vegetation in the region is pleasing but is threatened from both unfavourable climatic conditions and human activities (Erkovan et al. 2011). Spatial changes of the rangeland vegetation are affected by various factors such as climate, soil and grazing distribution (Holechek et al. 2004). Physical and chemical properties of the soil affect the floristic composition of rangelands vegetation (Rietkerk et al. 2000, Duckworth et al. 2000). In general, the degradation in soil triggers the changing in vegetation toward to unfavourable condition (Critchley et al. 2002).

Intensity and spatial distribution of grazing significantly affect floristic composition of the rangeland vegetation. Overgrazing reduce plant species and increase trampling which contributing in the degradation of the soil (Koc et al. 2008). Settlements cause seriously heterogeneity on spatial distribution of grazing in rural communities. Yunusbaev et al. (2003)

reported that grazing pressure increased as getting closer to the settlements or corral in Dagistan Republic of Russian Federation. Similar results have also reported for Turkey by Erkovan et al. (2003).

Factors such as soil, climate, aspect, the location of gathering places and herbivory may be the ultimate determinants of grazing and vegetation patterns. Spatial autocorrelation analysis is a commonly used method to measure spatial heterogeneity (Chang et al. 2006).

The aim of this study was to determine the effect of distance from settlements and environmental variables on spatial distribution of rangeland.

**Materials and Methods**

The study was conducted in Bayburt and Erzurum provinces in the eastern Anatolia region of Turkey during 2000 and 2001. Three rangeland sites in both of the locations which were close to settlement (5 km) (Site I), middle distance to settlement (20 km) (Site II), and far away to permanent settlement (30 km) (Site III) were selected to determine the effect of grazing on spatial distribution of rangeland vegetation. Seasonal suitable grazing system was applied in Erzurum province and transhumant grazing system in Bayburt province. Grazing firstly starts around the permanent settlement and then goes further areas in advanced season. In general, the rangelands around the permanent settlement suffer from early and late season grazing pressure compared to other sites.

Cold steppe climate prevail in the study areas which are characterized by long and extremely cold winter and cool, short and dry summer. As a consequence actively plant growth occurs in between a restricted period. Long term annual total precipitation in Bayburt and Erzurum province are 421.4 mm and 435.6 mm, respectively. The mean annual temperature is 6.9 $^{0}$C in Bayburt, and 5.7 $^{0}$C in Erzurum. Soil texture, organic matter, pH, lime, phosphorus, potassium and salt from soil samples taken from every site at the depth of 0-30 cm were analysed considering standard procedures described by A.O.A.C. (1999). The soils texture of site I, site II and site III in Bayburt province was loamy, sandy-loamy and sandy-loamy-clay, and it was loamy in site I and clay-loamy in site II and III in Erzurum province.

Floristic composition of range sites was determined by using the line intercept method developed by Canfield (1941). Eight subsamples each of 10 m in different part of sites were measured to represent an 80 m long transect and basal area was considered in the measurement.

Canonical Correspondence Analysis (CCA) was used to determine the relationships between vegetation and environmental variables using

CANOCO, version 4.5 for windows (Leps and Smilauer 2003). Due to many zeros species data were transformed using the transformation ln (10 x X + 1), where X= species number in species score (ter Braak and Smilauer 2002). Automatically selection was used to determine the variance explained by individual variables. Monte Carlo permutation tests used to test the significance of each variable.

**Results and Discussion**

Ordination analysis showed that spatial distribution of samples were significantly affected by distance from settlements in both location, but site I of Bayburt and site II of Erzurum became more similar compared to the other sites (Fig. 1). The relationships between species and environmental variables were presented in CCA ordination diagrams (Figure 2). The sites are clearly separated along axes but site I of Bayburt and Site II of Erzurum overlapped on same axes. The CCA revealed some gradients such as the relationship between floristic composition and environmental variables which are shown in the CCA for Bayburt and Erzurum (Fig. 2). The cumulative percentage variance of the species and species-environmental relationship were high for Bayburt and Erzurum sites. There was considerably cumulative percent variance of species-environment relations, which were 16.6, 29.6, 39.5 and 47.0 for Bayburt and 25.1, 36.7, 45.6 and 53.8 for Erzurum.

Slope, distance from the settlement, altitude and phosphorus, potassium, organic matter, clay and sand content of soil were significantly correlated to species distribution in Bayburt ($p<0.05$) (Fig. 2) whereas all environmental variables (slope, distance, altitude and phosphorus, potassium, organic matter, clay, sand, silt, lime and salt content of soil) were significantly correlated to species distribution in Erzurum ($p<0.01$) (Fig. 2).

The results of this study revealed that the distance from the permanent settlements plays an important role to the determination of floristic composition, which mainly originated from differences of spatial distribution of grazing intensity and season. The most affected areas from grazing are those around the permanent settlements because the domestic animals are grazing freely around them during early and late season (Koc et al. 2008). Kellner and Bosc (1992) have found that vegetation pattern of semi-arid rangelands were formed through grazing of herbivores. Overgrazing has caused decrease of the palatable perennial plants and destruction of the native rangelands (Belsky 1992, Metzger et al. 2005).

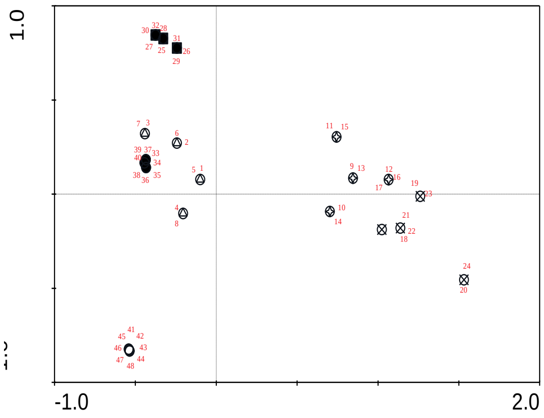


**Figure 1** Ordination showing that samples varied according to distance to settlement and locations. Non-filled triangles within non-filled circle represent close to settlement at Bayburt (site I); star within non-filled circle represent middle distance to settlement at Bayburt (site II); x-mark non-filled circle represent long distance to settlement at Bayburt (site III); filled square represent close to settlement at Erzurum (site I); filled circle represent middle distance to settlement at Erzurum (site II); and non-filled circle represent long distance to settlement at Erzurum (site III)

The ordination analysis showed that soil properties had significant effect on species pattern. Vegetation and soils are dynamic systems and the condition of one affects the other. The spatial heterogeneity of overgrazing pressure, determined by the distance from the permanent settlements, causes heterogeneity in spatial distribution of soil and vegetation properties because heavy grazing and unsuitable season affect more severe around the permanent settlement or corral (Yunusbaev et al. 2003, Koc et al. 2008, Arevalo et al. 2011). Duckworth et al. (2000) have found that, apart from settlements, environmental factors such as altitude, topography also significantly affect species composition and soil properties. In the experimental areas, permanent settlement or corral used in summer are located in high elevation areas in both sites hence the differences in species composition and soil properties between sites can not be solely attributed to grazing distribution.

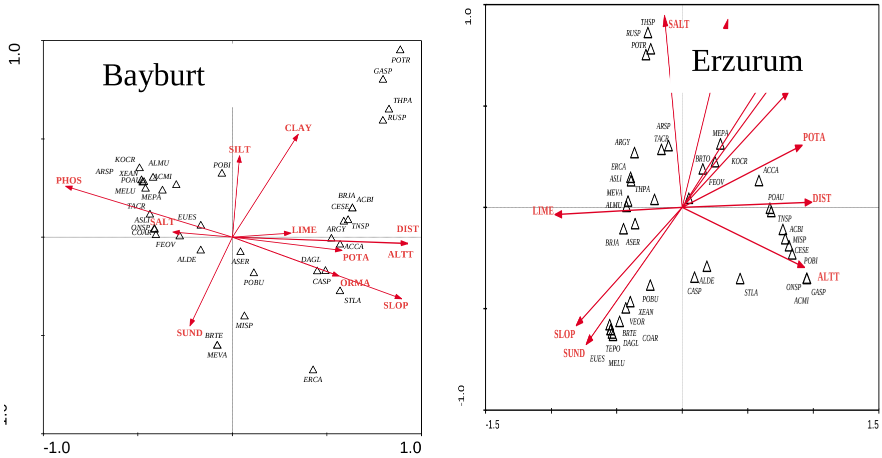


**Figure 2** CCA ordination diagram of rangeland vegetation species with environmental variables. Key to abbreviations: (AGIN *Agropyron intermedium,* BRJA *Bromus japonicus,* BRTE *Bromus tectorum,* BRTO *Bromus tomentellus,* DAGL *Dactylis glomerata,* FEOV *Festuca ovina,* KOCR *Koeleria cristata,* POBU *Poa bulbosa,* POTR *Poa trivialis,* STLA *Stipa lagascae,* ASLI *Astragalus lineatus,* ASER *Astragalus eriocephalus,* MELU *Medicago lupiluna,* MEPA *Medicago papillosa,* MEVA *Medicago varia,* ONSP *Onobrychis* sp., ACCA *Acantholimon caryophyllaceum,* ACBI *Achillea biebersteinii,* ACMI *Achillea millefolium,* ALDE *Alyssum desertorum,* ALMU *Alyssum murale,* ARGY *Arenaria gypsophiloides,* ARSP *Artemisia spisigera,* CASP *Campanula* sp., CESE *Centaurea sessilis,* COAR *Convolvulus arvensis,* ERCA *Eryngium campestre,* EUES *Euphorbia esula,* GASP *Galium* sp., MISP *Minuartia* sp., POAU *Polygonum aviculare,* POBI *Potentilla bifurca,* RUSP *Rumex* sp., TNSP *Tanacetum* sp., TACR *Taraxacum crepidiforme,* TEPO *Teucrium polium,* THSP *Thesium* sp., THPA *Thymus parviflorus,* VEOR *Veronica orientalis,* XEAN *Xeranthemum annuum,* pH, ORMA organic matter, LIME, SALT, PHOS phosphorus, POTA potassium, SUND, SILT, CLAY, ALTT altitude, DIST distance, SLOP slope)

In conclusion, the rangelands around the permanent settlements suffer from heavy grazing pressure and this affects adversely rangeland vegetation. Severity of overgrazing pressure and, as a consequence, the degradation of vegetation in the vicinity of permanent settlement and middle points is higher than that of the rangelands away from the permanent settlement. However seriously soil and vegetation degradation are also seen on the areas away from the permanent settlements because neither early season nor late season grazing pressure prevail. Therefore, it is essential to develop sustainable range management strategies for areas experiencing transhumance or seasonal suitable grazing management schemes.

## References

**A.O.A.C. 1999.** Official Methods of Analysis, 16$^{th}$ ed. Association of Offical Analytical Chemists, Washington, DC.

**Arevalo J.R., L.de Nascimento S. Fernandez-Lugo J. Mata and L. Bermejo. 2011.** Grazing effects on species composition in different vegetation types (La Palma, Canary Islands). *Acta Oecologica,* 37: 230-238.

**Belsky A.J. 1992.** Effects of grazing, competition, disturbance and fire on species composition and diversity in grassland communities. *Journal of Vegetation Science,* 3: 187-200.

**Canfield R.H. 1941.** Application of the interception method in sample range vegetation. *Journal of Forestry,* 39: 388-394.

**Chang C.R., P.F. Leen M.L. Bai and T.T. Lin. 2006.** Identifying the scale thresholds for field-data extrapolation via spatial analysis of landscape gradients. *Ecosystems* 9: 200–214.

**Critchley C.N.R., B.J. Chambers J.A. Fowbert A. Bhogal S.C. Rose and R.A. Sanderson. 2002.** Plant species richness, functional type and soil properties of grasslands and allied vegetation in English Environmentally Sensitive Areas. *Grass and Forage Science,* 57: 82-92.

**Duckworth J.C., R.G.H. Bunce and A.J.C. Malloch. 2000.** Vegetation-environment relationships in Atlantic European calcareous grasslands. *Journal of Vegetation Science,* 11: 15-22.

**Erkovan H.I. A. Koc Y. Serin. 2003.** Some vegetation properties of Bayburt (Turkey) province rangeland. In: A. Kirilov, N. Todorov and I. Katerov (eds). Grassland Sciences in Europe. Optimal Forage System for Animal Production and the Environment. pp. 617-620.

**Erkovan H.I., A. Koc E.L. Aksakal T. Oztas and M.Ozgul. 2011.** The effect of exclosure and different grazing systems on rangeland vegetation. 9th Crop Science Congress. (impress). (In Turkish with English Abstract).

**Holechek J.L., R.D. Pieper and C.H. Herbel. 2004.** Range Management: Principles and Practices. Prenticahall, New Jersey. 607 pp.

**Kellner K. and O.J. Bosc. 1992.** Influence of patch formation in determining the stocking rate for southern African grasslands. *Journal of Arid Environments,* 22: 99-105.

**Koc A., H.I. Erkovan and Y.Serin. 2008.** Changes in vegetation and soil properties under semi-nomadic animal raising areas in highlands of Turkey. *Current World Environment*, 3: 15-20.

**Leps J. and P. Smilauer. 2003.** Multivariate Analysis of Ecological Data Using CANOCO. Cambridge University Press, Cambridge.

**Metzger K.L., M.B. Coughenour R.M. Reich and R.B. Boone. 2005.** Effects of seasonal grazing on plant species diversity and vegetation structure in a semi-arid ecosystem. *Journal of Arid Environments,* 61: 147-160.

**Rietkerk M., P. Ketner J. Burger B. Hoorens and H. Olff. 2000.** Multiscale soil and vegetation pathchiness along a gradient of herbivore impact in a semi-arid grazing system in West Africa. *Plant Ecology,* 148: 207-224.

**Ter Braak C.J.F. and P. Smilauer. 2002.** CANOCO Reference Manual and CanoDraw for Windows User's Guide: Software for Canonical Community Ordination (Version 4.5) Microcomputer Power Ithaca, USA. 500 pp.

**Yunusbaev U.B., L.B. Musina L.B. and Ya T. Suyundukov. 2003.** Dynamics of steppe vegetation under the effect of grazing by different farm animals. *Russian Journal of Ecology,* 34: 43-46.

# SESSION 2

## Grazing impact on abiotic environment

# Characteristics of grazed and restored Mediterranean landscapes of Northern Greece

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## Abstract

Rangelands are a dominant land use type in the Mediterranean basin countries occupying more than 50% of the Mediterranean zone and forming pastoral landscapes of various types. These landscapes usually include severely degraded lands due to overgrazing. The most common restoration actions for such lands are grazing management regulation and pine reforestation. In the Lagadas county of northern Greece five (5) different grazed and restored landscapes were identified: a moderately grazed shrubland, an overgrazed shrubland, an abandoned shrubland, a rangeland partially reforested with pines and a rangeland fully reforested with pines. All these landscapes were evaluated for two main characteristics, namely the landscape structure and value. Landscape structure was evaluated with the use of landscape metrics (size, edge and shape metrics), while landscape value was based on analysis of specific qualitative criteria. Results showed that the moderately grazed shrubland and the overgrazed shrubland sustained the most fragmented - heterogenic and geometric structure compared with the other landscapes. For the landscape value, the moderately grazed and the abandoned rangeland sustained high-valued landscapes that require retension while the partially and fully reforested rangelands as well as the overgrazed ones sustained low-valued landscapes that need modification. It was concluded that moderate grazing had the best influence on the structure and value of Mediterranean pastoral landscapes.

**Key words:** Pastoral landscapes, landscape metrics, landscape value analysis.

## Introduction

Rangelands are a dominant land use in the Mediterranean basin countries, occupying more than 50% of the Mediterranean zone (Le Houerou 1981). These rangelands are part of Mediterranean landscapes that have been shaped during the human history mainly by pastoral activities (Papanastasis and Chouvardas 2005). In northern Greece, three types of pastoral landscapes can be found, namely grasslands, shrublands and forest ranges (<40 tree canopy cover). One of the main threats of the Mediterranean pastoral landscape is land degradation due to overgrazing. The most common restoration actions against land degradation are regulation of grazing management, reforestation followed by prohibition of livestock grazing (Papanastasis 2009) and suspension of grazing without reforestation . The aim of this study was to evaluate two main landscape characteristics, namely landscape structure and value, of grazed and restored rangelands, in order to investigate the role of the different restoration practices on the formation and value of pastoral landscapes.

**Materials and methods**

Five different pastoral landscapes were chosen, located within the Lagadas county in central Macedonia of northern Greece. These landscapes were: a moderately grazed shrubland, an overgrazed shrubland, an abandoned shrubland, a rangeland partially reforested with pines and a rangeland fully reforested with pines. The area covered by each type was 12.14, 10.61, 3.69, 7.08 and 28.04 ha respectively. All these landscapes are related to restoration actions taken against land degradation in the study area.

The first step in the process of analyzing landscape characteristics (landscape structure) was to create tree / shrub cover maps for each landscape, based on Google Earth remote sensing images (access year 2011). In order to update or confirm the results, these maps were corrected in ArcGIS v9.3 using Greek orthophotos of 2008 (source: Ktimatologio S.A.) The program Patch Analyst v 3.1 (Elkie et al. 1999) was used to quantify tree / shrub structure for the five landscapes. The digital tree / shrub cover maps were the main source for the structural analyses. Four indices were included in the study: number of patches (NP) and mean patch size (MPS) as an overall measure of landscape fragmentation and heterogeneity, edge density (ED) as a measure of the amount of ecotones (Farina 2000), and mean shape index (MSI) as a measure of landscape geometry (tree-shrub shape irregularity). The mathematical formulas of the chosen indices are included in the Patch Analyst and Arc Fragstats user manuals (McGarigal and Marks 1995, Elkie et al. 1999).

For the landscape value analysis, 20 landscape criteria were applied (Penning-Rowsell 1981, Ispikoudis et. al. 2001): scale, enclosure, variety, harmony, movement, texture, colouring, rarity, security, stimulus, impression, type of view, fragility, naturalness, typicalness, size, importance, authenticity, symbolic and potential values. These criteria were used by six independent experts who visited the five landscapes and graded each one based on a scale from value 1 to 4. The average of the total scores obtained by each expert resulted in the total grade of each landscape. Based on the final grades (total landscape grades from 20 to 80), three management classes were set up , namely modification (20-50), retention (51-65) or preservation (66-80) (Bacon 1979, Ispikoudis et. al. 2001).

**Results and Discussion**

The analysis of the data for the five digital maps showed that 36.83 ha or 59.83% of the whole area was covered by shrubs or threes. The moderately grazed and the overgrazed landscapes were below average with 23.06% and 43.17% of shrub cover, respectively. On the contrary, the abandoned as well as the partially and fully reforested landscapes had much higher tree / shrub cover, namely 71.27%, 96.05% and 71.40% respectively. The relatively lower tree / shrub cover of the fully reforested in comparison to the partially reforested landscape was attributed to the fact that the pine plantation of the former landscape was younger (about 10 years) and suffered more damages from natural hazards such as strong winds and diseases than the latter landscape. The graphical representation of tree / shrub cover of the five landscapes is shown in figure 1.

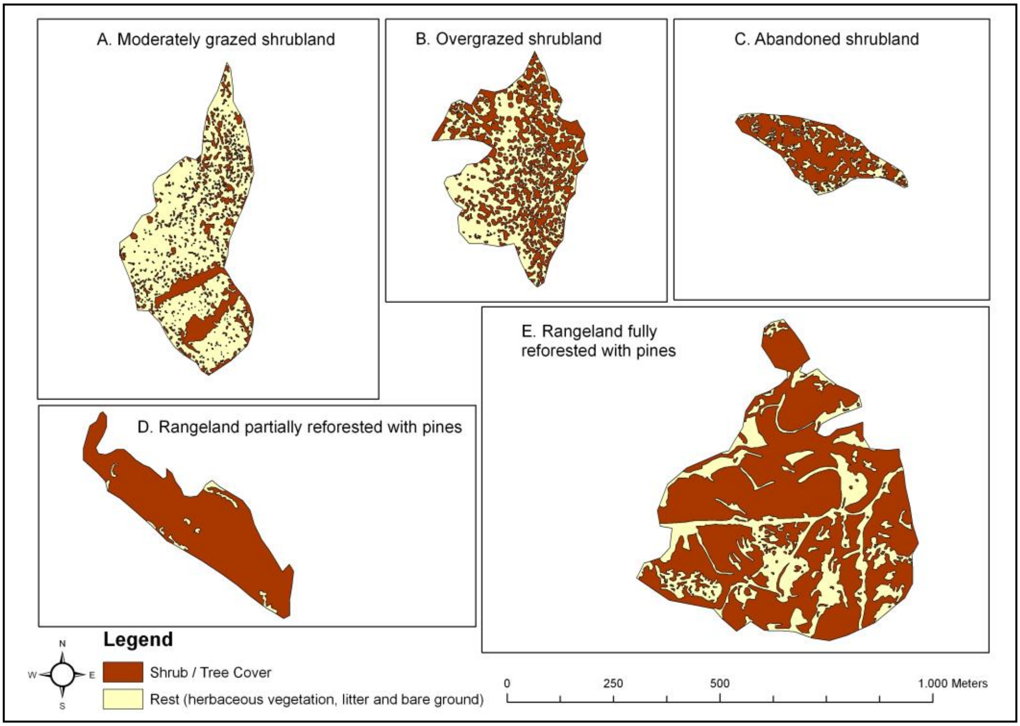


**Figure 1.** Shrub / Tree cover maps of five Mediterranean pastoral landscapes

The calculation of landscape metrics for the five landscapes revealed that the moderately grazed and overgrazed landscapes had the most fragmented - heterogenic cover structure (NumP and MPS) (Table 1). On the contrary, the partially reforested and the abandoned landscapes were the most homogenous because their tree / shrub cover structure was arranged to only a few relatively large patches (NumP). The fully reforested landscape had an average amount of fragmentation probably due to the openings that were created from the pine tree damages. The two grazed landscapes presented the most geometrical structure of shrubs (MSI, Table 1), which displayed a more irregular shape of tree / shrub cover, indicating the geometric effect that grazing activity has on landscapes. Finally, based on the edge metric (ED), it is clear that the overgrazed, the abandoned and the moderately grazed landscapes created a significant amount of edges between the tree / shrub cover and the other cover types (herbs, litter and bare ground) compared to the other two reforested landscapes.

**Table 1.** Landscape metric values for the tree / shrub class of the five grazed and restored Mediterranean landscapes

| | Landscape | NumP[1] | MPS[2] (Ha) | ED[3] (m/Ha) | MSI[4] |
|---|---|---|---|---|---|
| 1 | Moderately grazed shrubland | 431 | 0,0065 | 1143,92 | 1,3757 |
| 2 | Overgrazed shrubland | 189 | 0,0242 | 1526,38 | 1,5577 |
| 3 | Abandoned shrubland | 7 | 0,3758 | 1365,14 | 2,6444 |
| 4 | A rangeland partially reforested with pines | 1 | 6,7967 | 329,90 | 2,5289 |
| 5 | A rangeland fully reforested with pines | 56 | 0,3575 | 587,82 | 1,6907 |

[1] Number of Patches, [2]Mean Patch Size, [3]Edge Density, [4]Mean Shape Index

The results of the landscape value analysis can be seen in table 2. From this table it is apparent that the moderately grazed and the abandoned landscapes received higher grades (value) than the others suggesting their need for retention (visually attractive). On the contrary, the partially and fully reforested landscapes, as well as the overgrazed one received lower grades suggesting their need for modification (visually less attractive).

Based on the final outcome on landscape structure and value, it seems that the action of moderately grazing results in landscapes with the most positive characteristics.

**Table 2.** Value analysis of the five grazed and restored Mediterranean landscapes

| | Moderately grazed shrublands | Overgrazed shrublands | Abandoned shrublands | Rangeland partially reforested with pines | Rangeland fully reforested with pines |
|---|---|---|---|---|---|
| Grades | 61 | 44 | 52 | 49 | 38 |

## Conclusions

Restoration actions taken against land degradation seem to have a direct effect on landscapes characteristics (structure and value). The moderately grazed landscape is the most fragmented - heterogenic, geometrically shaped and with the highest landscape value. Also, the abandoned landscape was the most irregularly shaped and with high landscape value. On the contrary, the overgrazed landscape had the lowest landscape value but the largest amount of edges. The partially reforested landscape was less fragmented, more irregularly shaped and with a higher value than the fully reforested one. In general, moderately grazing seems to have a positive impact on landscape structure and value.

## Acknowledgements

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## References

**Bacon W.R. 1979.** The visual management system of the Forest Service, USDA. In: G.H. Elsner, and R.C. Smardon, technical coordinators. Proceedings of our national landscape: a conference on applied techniques for analysis and management of the visual resource. Gen. Tech. Rep. PSW-GTR-35. U.S. Department of Agriculture. pp. 660-665.

**Elkie P., R. Rempel and A. Carr 1999.** Patch Analyst User's Manual. A Tool for Quantifying Landscape Structure. NWST Technical Manual TM-002, Ontario, Canada. Pages 23.

**Farina A. 2000.** Landscape Ecology in Action. Kluwel Academic Publishers. The Netherlands. Pages 235.

**Ispikoudis I., D. Chouvardas and P. Kourakly. 2001.** Landscape rehabilitation planning for touristic development of an abandoned marble quarry. Proceedings of the 9nd conference of Hellenic Forestry Society on: Environmental Conservation and Restoration of Disturbed Areas. pp. 638-645. (In Greek with English Abstract).

**Le Houerou H.N. 1981.** Impact of man and his animals on Mediterranean vegetation. In: F. di Castri, D.W. Goodall and R.L. Specht (eds). Ecosystem of the world 11. Mediterranean - type shrublands. Elsevier Scientific, New York. pp. 479–521.

**McGarigal K. and B. Marks. 1995.** FRAGSTATS: spatial pattern analysis program for quantifying landscape structure. Gen Tech. Rep. PNW-GTR-351. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 122pp.

**Papanastasis V.P. 2009.** Restoration of degraded grazing lands through grazing management: Can it work? *Restoration Ecology,* 17: 441-445.

**Papanastasis V.P. and D. Chouvardas. 2005.** Application of the state-and-transition approach to conservation management of a grazed Mediterranean landscape in Greece. *Israel Journal of Plant Science,* 53:191–202.

**Penning-Rowsell E.C. 1981.** Assessing the validity of landscape evaluations. *Landscape Research,* 6(2):22-24.

# Investigation on Soil and Vegetation Characteristics in relation to Distance from Critical Areas in the Central Alborz's Grasslands (Iran)

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## Abstract

The continuous heavy livestock grazing may cause excessive destruction of rangeland ecosystems. Thus, monitoring of qualitative and quantitative changes on the soil and vegetation characteristics is essential in these sites in order to to improve rangeland management practices. The objective of this study was to investigate the effects of high livestock density on vegetation cover and soil properties in central Alborz's grasslands in Iran. Grazing gradient method (systematic changes in vegetation cover with distance from stock ponds and around villages as two of critical areas) has been used to determine the characteristics of soil and vegetation.. Factors such as vegetation cover, litter, plant diversity, bare soil, rock and gravel were measured. The results showed that vegetation cover was significantly correlated with distance from the village but not with the distance from the watering pointss. Litter and plant diversity was significantly correlated with the distance from critical points noticeably so that these factors had higher values at longer distances. Although, the grit was not significantly correlated with any critical area, it increased at longer distances from villages. Regarding that, in order to improve ranges condition (with emphasis on critical areas) proper management should be practiced including change of grazing pattern and bed ground livestock in Iran's grasslands.

**Keywords**: Critical Areas, Grazing Gradient, Iran's Grasslands

## Introduction

Non- uniform and continuous livestock grazing in rangelands is one of the problems that range managers have always faced. This is due to various factors including distance from water resources, topography, vegetation diversity, disproportion of livestock with range, pests and climate (Holechek et al, 1995). Evidently, the highergrazing pressure,the more degradation usually occur in these critical areas (Badripour, 1997). Changes in vegetation due to distance from critical areas is called Grazing Gradient (Bastin et al, 1993). Regarding that, continuous grazing and daily traffic of livestock caused excessive destruction of these areas (critical area) more than in other rangeland sites. Hence, frequent monitoring of quantitative and qualitative changes on the soil and vegetation is essential in these areasIn order to improve rangeland management practices. The aim of this study was to estimate the effects of high livestock density on vegetation cover and soil properties of critical areas and on their surroundings in central Alborz's grasslands in Iran.

**Material & Methods**

This study was conducted in central part of Alborz called Polour in Mazandaran province (85 km northeast of Tehran). This site is at an altitude of 1800 to 2600m asl. Climate is cool- dry with average annual precipitation of 204 mm. The dominant species include Dactylis glomerata L, Bromus tomentellus Boiss, Festuca ovina L, *Thinopyrum intermedium* (Host) Barkworth & D.R. Dewey, Stipa barbat Desf and number of invaders such as Sophora alopecuroides (L) Bong ex Boiss, Cousinia commutate Bung, Euphorbia aucheri Boiss. Critical areas determined in two places, around the village and stock pond. Data were collected by using 100m transect and 1m² quadrates. Condition of biophysics indicators including vegetation cover, litter, plant diversity, rock and garavel and bare soil was determined into each quadrat. Regression analysis and Pearson correlation were used in order to study the correlation between the distance of critical area in grazing gradient and the measured vegetation and soil characteristics at SPSS 17.0 software.

**Results & Discussion**

The results showed that the condition of soil cover was reduced around the village because of high stocking rate and continuous livestock grazing. Thus, with increasing distance from village, vegetation cover, plant diversity and litter increased, while palatable and desirable species that were replaced increased in number and cover. Although, vegetation cover, density and bare soil were not correlated with distance from stock pond, desirable species and litter were. This result is probably related to the large number of stock pond in the area. Rock and gravel were not affected by the distance in the critical areas. Bastin et al (1993); Pichup and Chewing (1994) and Badripour (1997) produced similar results.

**Table 1.** The relationship of study factors with distance from critical areas

| Critical Areas | Vegetation | Bare Soil | Rocks & Gravels | Litter | Plant Diversity | Correlation |
|---|---|---|---|---|---|---|
| Around village | <0.01** | <0.01** | <0.05* | <0.01** | <0.01** | P |
| | 0.095 | 0.097 | 0.075 | 0.096 | 0.097 | R |
| Stock pond | >0.05 | >0.05 | >0.05 | <0.01** | <0.01** | P |
| | 0.065 | 0.042 | 0.047 | 0.099 | 0.096 | R |

Note: ** is significant in 99% level and * is significant in 95% level

## Conclusion

Condition of vegetation and soil around villages was very poor in comparison to areas around stock ponds due to overgrazing and overstocking. The model of grazing gradient is simple- regular around villages and it is simple- combination around stock ponds. This means that vegetation increases gradually with distance from critical areas and the destruction intensity is limited. However, around stock ponds, vegetation, and especially desirable species decreased to a certain distance from stock ponds and then increases. This type of grazing gradient remains in times of annual dryness and wetness that causes increase of shrubs and unpalatable species near to the stock ponds. Regarding that, in order to improve ranges condition (with emphasis on critical areas) proper management should be practiced including changes of livestock traffic, grazing pattern and bed ground livestock in Iran's grasslands.

## Reference


**Badripour, H., 1997.** The effect of distance from stock pond on characteristic and condition of vegetation, MSc thesis of range management in faculty of natural resources, Tehran University

**Bastin, G.N. and Chewings, V.H., 1997.** Assessing desertification in arid Australia using satellite data. In Proceedings of CERES International Symposium on the role of remote sensing for the environmental issues in arid and semi-arid regions, Japan Chiba University, 81-88.

**Bastin, G.N., Pickup, G., Chewing, V. H. and Pearce, G., 1993.** Land degradation assessment in central Australia using a grazing gradient method, *Journal of Rangeland*, 15(2): 190-216.

**Holechek, J. L., Pieper, R. D., Herbel, C. H., 1995.** Range management, Principal and practices, 5th Edition, Prentice- Hall Publisher. Upper Saddle River, NJ. Pp, 607.

**Pickup, G. and Chewing, V.H., 1994.** A grazing gradient approach to land degradation assessment in arid areas from remotely sensed data, *International Journal of Remote Sensing*. 15(3): 597-617.

# Soil properties along grazing gradients in an open canopy oak forest

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## Abstract

There is a great interest in understanding how management practices of silvopastoral systems affect the long-term sustainability of oak ecosystems and mainly their influence on nutrient cycling. The aim of this study was to examine the effects of relative grazing intensity on soil properties in an open canopy oak forest dominated by *Quercus frainetto*. The research was conducted in the area of Pentalofos, which is located in Evros region, northeastern Greece and is grazed mainly by goats. The distance (meters) from a goat corral was used to represent relative grazing intensity. In June 2011, soil samples were collected within each of three quadrats along transects running perpendicular to three replicates. The transects were placed at 50, 150, 300, 600 and 1200 m from the goat corral. Soil pH, phosphorous (P) and nitrogen (N) concentrations were measured. Heavy grazing reduced soil organic matter while it increased total nitrogen. Grazing intensity did not affect available P and soil pH.

**Keywords:** Grazing intensity – Nitrogen - Organic matter - Silvopastoral system

## Introduction

It is well substantiated that Mediterranean forests maintain an extensive area with significant social benefits and services. These forests are rich in plant species and are of great ecological and economic interest. Most of them have relatively open canopy because they have suffered from mismanagement during the last decades (Ainalis et al. 2009). Oak forests are the dominant forest type in Greece occupying 1,471,839 ha (Ministry of Agriculture 1992). Deciduous oak forests, especially the open coppice, have been affected more than other forest types by livestock grazing as silvopastoralism is well adapted to the Mediterranean environment (Papanastasis et al., 2009). Thus, there is evidence that coexistence of livestock and forest production can be achieved under certain conditions.

Grazing animals primarily affect soil properties by direct impacts through trampling and lunging and indirectly by altering plant community structure (Beukes and Cowling 2003). Soil chemical characteristics as well as soil moisture are the most important soil properties that may be altered by livestock grazing (Al-Seekh et al. 2009). Grazing can cause altering to the natural chemical processes of the soil, while it could cause soil erosion (Azarnivand et al. 2010).

Numerous studies have shown that overgrazing causes dramatic changes in plant community, leads to reduction in canopy cover and productivity and causes heavy destruction in soil structure and compaction, fact that leads to decrease in soil organic C and N contents (Shi et al. 2010).

It has been reported by Zhou et al (2010) that high grazing intensity increases soil compaction and soil density, reduces soil aggregate stability and fertility. Some of these effects are acting in combination and it is believed that they resulted in an increase of topsoil erosion (Zhou et al. 2010). Sustainable management of grazing lands is of great importance. Sustainable grazing management increases herbage production and ameliorates litter accumulation. Therefore, it results in reduction of soil erosion and evaporation, it increases permeability and water holding capacity of the soil and it also adjust soil surface temperature (Fakhimi et al. 2011). Consequently, one of the main objectives of silvopastoral management is to identify which grazing intensity optimizes the soil properties.

The main objective of the present study was to examine the effects of relative grazing intensity on some soil properties in an open canopy oak forest dominated by *Quercus frainetto*.

**Materials and methods**

The research was conducted in the area of Pentalofos, which is located in Evros region, NE Greece. The oak forest of Pentalofos occupies a total area of 10199.56 ha. It is mainly used for firewood and livestock grazing by the local population. The common oak species are *Quercus frainetto, Quercus petraea*, *Quercus pubescens* and *Quercus cerris*. The spread of oak covers almost the entire area of the forest. Other common woody species are *Carpinus orientalis, Fraxinus ornus*, *Juniperus oxycedrus*, *Cornus mas*, *Tilia tomentosa*, *Phyllirea latifolia* and *Acer monspessulanum*. The climate of the area is classified as sub-Mediterranean, with cold, moist winters and warm, dry summers. The average maximum temperature is 30.5 ˚C in July and the average minimum temperature is -7.0 ˚C in January. The annual precipitation is 539.5 mm. The study area is grazed by goats.

A grazing gradient approach (Andrew 1988) was used. The distance (in meters) from a goat corral was used to represent relative grazing intensity, according to previous studies where this approach was applied (Sasaki et al. 2012). In June 2011, soil samples were selected within each of three quadrats along transects of 20 m long running perpendicular to three replicates. A 10 cm diameter ring was used for the collection of soil samples at a depth of 0-10 cm. The transects were placed at 50, 150, 300, 600 and 1200 m from the goat corral. These distances are stand for very heavy, heavy, moderate, light and very light grazing respectively. Soil samples were air dried and sieved through 2 mm mesh screens. Soil organic matter was determined by means of wet oxidation (Nelson and Sommers 1982). Total N was determined by the Kjeldahl method (Stevenson 1982). Available P was extracted with 0.5N $NaHCO_3$ at pH 8.5 and was measured spectophotometrically by a modified phospomolybdenum blue method (Alifragis 2010). Soil pH was determined by using a glass electrode.

The obtained data were analysed with SPSS 17 for Windows. One-way ANOVA was used to analyse the effect of grazing intensity on the soil properties. The LSD at the 0.05 probability level was used to detect the differences among means (Steel and Torrie 1980).

**Results and Discussion**

Significant lower organic matter content was obtained at the distances close to the goat corral indicating that organic matter decreased gradually as grazing intensity increased (Table 1). This decrease can be attributed to a significant reduction in litter due to intensive grazing that reduces vegetation cover and consequently it leads to litter being blown away by wind or washed away by heavy rainfalls (Liu et al. 1997). Similar results have been reported by Xie and Witting (2004).

Soil organic matter provide nutrient for plant growth and it was the most cited as one of the most effective predictor of soil quality (Al-Seekh et al. 2009). Fakhimi et al. (2011) reported that increased soil organic matter is strongly related to higher biomass production. Zhao et al. (2007) found that the increase of the degree of soil compaction by trampling will possibly increase the risk of soil degradation and erosion. Trampling breaks up soil aggregates, exposing organic matter to decomposition and loss through erosion (USDA 2001). However, it is has to be noticed that moderate and light grazing did not affect significantly soil organic matter.

On the contrary, total nitrogen was significantly higher at the closest distance to the goat corral (Table 1). This result implies that heavy grazing results in an increase of total soil nitrogen. The higher amount of nitrogen in soil under heavy grazing is probably caused by animal excrement and urine (Tamartash et al. 2007). This result is in agreement with this that has reported by Liu et al. (2011).

**Table 1.** Soil properties at the different distances from the goat corral

| Distance (m) | Organic matter (%) | | N (%) | P (mg*100g$^{-1}$) | pH |
|---|---|---|---|---|---|
| 50 | 0.511 | c* | 0.143 a | 2.063 | 6.206 |
| 150 | 0.704 | bc | 0.109 b | 2.203 | 6.268 |
| 300 | 0.874 | ab | 0.065 c | 2.435 | 6.207 |
| 600 | 1.070 | a | 0.068 c | 2.229 | 6.468 |
| 1200 | 1.126 | a | 0.091 bc | 2.149 | 6.429 |
| *Significance* | 0.005 | | 0.005 | NS | NS |

*Means in the same column followed by the same letter are not significantly different (P≤0.05)

Grazing intensity did not significantly affect available P and soil pH (Table 1). Milchunas and Lauenroth (1993) analysed a set of worldwide data from 236 sites and found no relationship between grazing and soil phosphorus and pH. Controversially, while Xie and Witting (2004) reported a significant reduction of available P under heavy grazing in a steppe rangeland, Dahlgren et al. (1997) found higher available P in an oak woodland under grazing. Probably, available P in soil is related to grazing and also to vegetation type.

## Conclusions

Heavy grazing reduced soil organic matter while it increased total nitrogen. Grazing intensity did not affect available P and soil pH. Moderate grazing had a minimal effect upon the analyzed soil properties. Thus, extensive moderate grazing can be a viable way of managing ecosystem sustainability (Arevalo et al. 2011).

## References

**Ainalis A.B., P.D. Platis and I.M. Meliadis. 2009.** Grazing effects on the sustainability of an oak coppice forest. *Forest Ecology and Management*, 259: 428-432.

**Al-Seekh S.H., A.G. Mohammad and Y.A. Amro. 2009.** Effect of Grazing on Soil Properties at Southern Part of West Bank Rangeland. *Hebron University Research Journal*, 1: 35-53.

**Alifragis D. 2010.** Description, sampling, laboratory analyses of forest soils and plant tissues. Aivazis Press, Thessaloniki, Greece 181pp (in Greek).

**Andrew M.H. 1988.** Grazing impact in relation to livestock watering points. *Trends in Ecology and Evolution*, 3: 336–339.

**Arévalo J.R., L. Nascimento, S. Fernández-Lugo, J. Mata and L. Bermejo L. 2011.** Grazing effects on species composition in different vegetation types (La Palma, Canary Islands). *Acta Oecologica*, 37: 230-238.

**Azarnivand H., A. Farajollahi, E. Bandak and H. Pouzesh. 2010.** Assessment of the Effects of Overgrazing on the Soil Physical Characteristic and Vegetation Cover Changes in Rangelands of Hosainabad in Kurdistan Province, Iran. *Journal of Rangeland Science,* 2: 95-102.

**Beukes P.C. and R.M. Cowling. 2003.** Non-selective grazing impacts on soil-properties of the Nama Karoo. *Journal of Range Management*, 56: 547-552.

**Dahlgren R.A., M.J. Singer and X. Huang. 1997.** Oak tree and grazing impacts on soil properties and nutrients in a California oak woodland. *Biogeochemistry*, 39: 45–64.

**Fakhimi E., M. Mesdaghi, G.A. Dianati Tilaki and M. Tavan. 2011.** Relationships among forage and litter production in three grazing intensities in Nodooshan Rangeland (Yazd, Iran). *Journal of Rangeland Science*, 3: 217-223.

**Liu T., Z. Nan and F. Hou. 2011.** Grazing intensity effects on soil nitrogen mineralization in semi-arid grassland on the Loess Plateau of northern China. *Nutrient Cycling in Agroecosystems*, 91: 67–75

**Liu Y., T. Wang and G. Chen. 1997.** The effect of animal grazing on the soil in grassland. Steppe Ecosystem Research. Science Press, Beijing.

**Milchaunas D.G. and W.K. Lauenroth. 1993.** Quantitative effects of grazing on vegetation and soils over a global range of environments. *Ecological Monographs*, 63, 327–366.

**Ministry of Agriculture. 1992.** Results of the First Forest Survey. General Secretariat of Forests and Natural Environment, 134 pp. (in Greek).

**Nelson D.W. and L.E. Sommers. 1982.** Total carbon, organic carbon and organic matter. In: Page AL (ed), Methods of soil analysis, Part 2. American Society of Agronomy and Soil Science Society of America, Madison, Wisconsin, pp 539-577

**Papanastasis V.P., K. Mantzanas, O. Dini-Papanastasi and I. Ispikoudis. 2009.** Traditional Agroforestry Systems and Their Evolution in Greece. In: Rigueiro-Rodríguez A., McAdam J. and Mosquera-Losada M.R. (eds.), Agroforestry in Europe: Current Status and Future Prospects. *Advantages in Agroforestry*, 6:89-109.

**Sasaki T., T. Ohkuro, U. Jamsran and K. Takeuchi. 2012.** Changes in the herbage nutritive value and yield associated with threshold responses of vegetation to grazing in Mongolian rangelands. *Grass and Forage Science*, 67: 446–455.

**Shi F., H. Chen, Y. Wu and N. Wu. 2010.** Effects of livestock exclusion on vegetation and soil properties under two topographic habitats in an alpine meadow on the eastern Qinghat – Tibetan Plateau. *Polish Journal of Ecology*, 58: 125-133.

**Steel R.G.D. and J.H. Torrie. 1980.** Principles and Procedures of Statistics. 2nd edition. McGraw-Hill, New York. 481 pp.

**Stevenson F.J. 1982.** Nitrogen-organic forms. In: Page AL (ed), Methods of soil analysis, Part 2. American Society of Agronomy and Soil Science Society of America, Madison, Wisconsin, pp 625-641.

**Tamartash R., H. Jalilvand and M.R. Tatian. 2007.** Effects of grazing on chemical soil properties and vegetation cover (Case study: Kojour Rangelands, Noushahr, Islamic Republic of Iran). *Pakistan Journal of Biological Sciences*, 24: 4391-4398.

**United States Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS). 2001.** Rangeland Soil Quality – Organic matter. Rangeland Sheet 6. (http://soils.usda.gov/SQI/management/files/RSQIS6.pdf)

**Xie Y. and R. Wittig. 2004.** The impact of grazing intensity on soil characteristics of Stipa grandis and Stipa bungeana steppe in northern China (autonomous region of Ningxia). *Acta Oecologica*, 25:197-204.

**Zhao Y., S. Peth, J. Krummelbeina, R. Horn, Z. Wang, M. Steffensd, C. Hoffmanne and X. Peng. 2007.** Spatial variability of soil properties affected by grazing intensity in Inner Mongolia grassland. *Ecological Modeling*, 205: 241-254.

**Zhou Z.C., Z.T. Gan, Z.P. Shangguan and Z.B. Dong. 2010.** Effects of grazing on soil physical properties and soil erodibility in semiarid grassland of the Northern Loess Plateau (China). *Catena*, 82: 87-91.

# Differences in plant communities and soil properties in grazed versus mown lands around Xilinhot, Inner Mongolia

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## Abstract

A *Carex duriuscula-Stipa krglovii* community and a *Serratula centauroides-Stipa grandis* community were classified, based on Braun-Blanquet methodology, in grazed versus mown areas, respectively. In the 0~10cm soil layer, soil compaction and water content were significantly different in the grazed and mown sites; at 11~30cm, soil temperature was significantly higher at grazed sites than at mown sites. The species dominating on grazed sites were more closely related to compacted soil, higher soil temperature and lower water content, whereas the species dominating on mown sites were more closely related to the opposite environmental conditions.

**Keywords:** grazing, mowing, plant community, soil property, Inner Mongolia

## Introduction

Grassland is a major terrestrial ecological system (Xu *et al*. 2008), and the grassland around Xilinhot is a very important part of Inner Mongolia (northern People's Republic of China) (Li *et al*. 2008). It is also the critical resource that supports livestock and performs the important function of stabilizing the soil. Moderate grazing is a major management form in temperate grasslands (Bullock *et al*. 2001), and mowing for animal fodder is another main use of grassland (Wang *et al*. 2007). The main uses of the grassland around Xilinhot are also grazing and mowing. Much research has attempted to assess, separately, the effects of grazing, mowing and enclosures on the grassland communities. There has been less research, however, comparing the effects of grazing and mowing on the grassland communities and on soil properties.

In order to find the most rational use of grassland at a place, it is necessary to compare the effects of grazing and cutting systems. Therefore, the objects of this study are: (1) to compare the differences in plant species composition under grazing and mowing regimes; (2) to compare the soil properties under grazing and mowing; and (3) to identify relationships between species composition and soil properties.

**Material and methods**

The study area is located around Xilinhot city (43°02′～44°52′N, 115°13′～117°03′E), which is located in the central part of the Xilingol grassland, the typical steppe of Inner Mongolia. Xilinhot has a semi-arid temperate continental climate (Lu *et al*., 2004), with long, cold winters and short, cool summers. The mean annual temperature is -1.4, and average annual precipitation is 250-350mm, falling mainly from June to August. The mean annual evaporation is 1746 mm, which is six times the annual precipitation. The average elevation is about 988m.

The study was conducted at three sites (Maodeng, Huitengliang and Bayannaoer) around Xilinhot city, all of which have both grazing land and mowing land adjacently. At Maodeng and Huitengliang the lands were mown from the 1970's but at Bayannaoer only from 2005. A vegetation survey was performed in the summers of 2009 and 2010. At each site, 20 relevés were recorded by the Braun-Blanquet phytosociology method (Braun-Blanquet 1964, Fujiwara 1997). 10 relevés represent grazing land and 10 relevés represent mown land. On the three plots at each site where the vegetation survey was done, we also took soil samples in three layers (0~10cm, 11~20cm and 21~30cm). The soil properties recorded were pH, water content (WC), electrical conductivity (EC), compaction and temperature.

The plant communities were also classified by Braun-Blanquet methodology. Using SPSS 11.5 we conducted t-tests on independent samples to analyze threshold levels for the effects of grazing and mowing on plant height, plant cover, species richness and soil properties. A redundancy analysis (RDA) in CANOCO for Windows 4.5 (Jongman *et al.* 1995) was used to analyze relationships between species composition and soil properties.

**Result**

Species composition and plant communities

In this study 77 vascular plant species were identified, of which 42 were found in grazing lands and 65 in mown lands. Two communities were classified by Braun-Blanquet methodology, namely a *Carex duriuscula-Stipa krglovii* community and a *Serratula centauroides-Stipa grandis* community.

The *Carex duriuscula-Stipa krglovii* community occurs mainly in grazing areas of the three sites. The mean plant height of this community is 9.5cm, its mean plant cover is 30%, and the mean number of species present (species richness) is 12 (Table 1). This community can be divided further into three sub-types: a typical sub-type at Huitengliang, a *Convolvulus ammannii* sub-type at Bayannaoer, and a *Chloris virgata* sub-type at Maodeng. The typical sub-type is shortest in stature and has the lowest average plant cover and fewest species; the *Convolvulus ammannii* sub-type is the tallest and has the highest average plant height and number of species (Table 1).

**Table 1. Plant height, cover and species richness at three sites in Xilinhot**

| location | usage | height | cover | richness |
|---|---|---|---|---|
| | | cm | % | |
| Maodeng | Grazing | 9.4±4.2a | 31.0±5.2a | 10.3±2.0 |
| | Mowing | 77.0±23.6b | 55.5±7.2b | 11.5±2.5 |
| Huitengliang | Grazing | 9.2±1.0a | 28.0±2.6a | 9.0±1.1a |
| | Mowing | 40.8±4.3b | 61.0±6.1b | 29.6±1.5b |
| Bayannaoer | Grazing | 9.8±1.5a | 30.0±4.1a | 15.9±1.7 |
| | Mowing | 22.0±3.2b | 46.0±6.1b | 14.7±2.6 |
| All | Grazing | 9.5±2.6a | 29.7±4.1a | 11.7±3.4a |
| | Mowing | 46.6±26.8b | 54.2±8.9b | 18.6±8.3b |

Within columns,means±S.D. with the different letters are significantly different ($p<0.001$).n=10

The *Serratula centauroides-Stipa grandis* community occurs mainly on mown areas of the three sites. The mean plant height of this community is 46.6cm, its mean plant cover is 54%, and the mean number of species is 19 (Table 1). This community can be divided into two sub-types a *Chenopodium aristatum* sub-type occurring at Maodeng and an *Agropyron cristatum* sub-type occurring at Huitengliang and Bayannaoer. The *Chenopodium aristatum* sub-type is taller but has fewer species. The *Agropyron cristatum* sub-type can be divided further into two sub-units, a *Poa attenuata* sub-unit occurring at Huitengliang and an *Artemisia scoparia* sub-unit occurring at Bayannaoer.

The mean plant height at the three sites was significantly higher on mown land than on grazed land, as was the mean plant cover. The mean number of species was significantly higher on mown land only at Huitengliang, and there was not a statistically significant difference between grazed and mown land at the other two sites (Table 1).

Soil properties. The result of soil properties are given in Table 2. Significant differences for soil compaction ($p$=0.006) and soil water content ($p$=0.040) were detected in the 0~10cm layer between grazed and mown land. Significantly different soil temperature was also detected in the 11~30cm layer. Soil electrical conductivity was higher on grazed land in each layer at all three sites, but it was not significantly different. Soil pH was statistically and numerically similar at all three sites.

**Table 2. Soil properities of three layers at three sites in Xilinhot**

| | usage | Compaction | Temp. | WC | EC | pH |
|---|---|---|---|---|---|---|
| | | mm | ℃ | % | ms /m | |
| 0-10cm | Grazing | 26.3±2.0a | 28.2±1.4 | 10.1±3.3a | 4.3±1.9 | 8.1±0.5 |
| | Mowing | 21.9±3.6b | 27.2±1.2 | 13.2±2.5b | 3.3±1.9 | 7.9±0.3 |
| 11-20cm | Grazing | 26.8±2.8 | 25.1±1.3a | 11.9±4.5 | 4.8±3.1 | 8.3±0.4 |
| | Mowing | 24.6±5.3 | 22.9±1.4b | 13.9±4.0 | 4.0±2.8 | 8.1±0.3 |
| 21-30cm | Grazing | 27.3±2.1 | 24.3±1.5a | 12.4±5.8 | 7.9±6.6 | 8.5±0.4 |
| | Mowing | 28.6±3.9 | 22.3±1.3b | 10.8±3.4 | 4.0±3.0 | 8.2±0.4 |

Within columns,means±S.D. with the different letters are significantly different ($p<0.05$),n=3

Ordination. The ordination (Fig.1) shows a clear relationship between species composition and soil properties in the 0~10cm layer. The main species on grazing sites at Maodeng were likely to appear in high pH and high electrical conductivity. The other species dominant on grazing sites were likely to appear in compacted soil and higher soil temperature and lower water content. The species dominant on mown sites were likely to appear under the opposite environmental conditions.

## Conclusion

In this study different land uses differentiated two communities, both of which could be subdivided into sub-types at different sites. The main species in the sub-types on grazed land were annual plants, whereas under mowing they were perennial plants. Grazing has a much heavier effect on plant height and cover than mowing.

The soil in the 0~10cm layer was significantly compacted and soil water content in it was significantly lower on grazed sites than on mown sites. At 11~30cm soil temperature was significantly higher under grazing than under mowing.

The species dominating on grazed sites were more closely related to compacted soil, higher soil temperature and lower water content, whereas the main species on mown sites were more closely related with the opposite environmental conditions.

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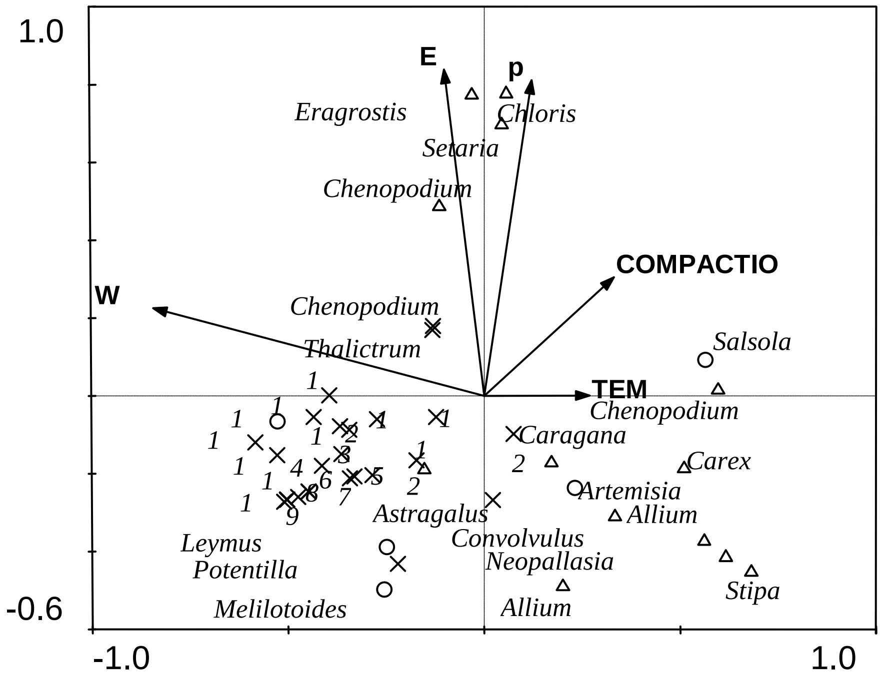


**Fig.1 Results of RDA Ordination for species composition versus soil properties of the 0~10cm layer of three sites of Xilinhot City.** Δ represents species favored by grazing, × represents species favored by mowing and ○ represents common species. 1 *Koelrria cristata*, 2 *Saposhnikovia divaricata*, 3 *Potentilla longifolia*, 4 *Adenophora stenanthina*, 5 *Cymbaria dahulica*, 6 *Galium verum*, 7 *Spiraea aquilegifolia*, 8 *Dontostemon integrifolius*, 9 *Allium senescens*, 10 *poa attenuate*, 11 *Carex korshinskyi*, *Achnatherum sibiricum*, *Scorzonera austriaca*, *Buplurum scorzonerifolium*, *Agropyron cristatum*, *Schizonepeta multifida*, *Potentilla tanacetifolia*, *Artemisia oxycephala*, 12 *Allium condensatum*, 13 *Stipa grandis*, 14 *Cleistogenes squarrosa*, 15 *Thalictrum petaloideum*, 16 *Serratula centauroides*, 17 *Artemisia scoparia*, 18 *Asparagus dauricus*, 19 *Allium anisopodium*, 20 *Lepidium apetalum*, 21 *Heteropapus altaicus*.

## References

**Braun-Blanquet, J. 1964.** Pflanzensoziologie, Grundzüge der Vegetationskunde, 3rd edition. Springer-Verlag, Berlin. 631pp.

**Bullock, J.M., Franklin, J., Stevenson, M.J., Silvertown, J., Coulson, S.J., Gregory, S.J. and Tofts, R. 2001.** A plant trait analysis of responses to grazing in a long-term experiment. *J. Appl. Ecol*, 38: 253-267.

**Fujiwara K. 1997.** Methodology of vegetation analysis and mapping based on phytosociology and vegetation science. Bull. Inst. Environ. Sci. Technol., Yokohama Natn. Univ., 23(1): 13-46.

**Jongman R. H. G., ter Braak, C. J. F. and van Tongeren, O. F. R. 1995.** Data analysis in community and landscape ecology. Cambridge University Press, Cambridge. 292pp.

**Li Z.H., Bao Y.J., Wang H.M., Xu T., Cheng Y. and Gao J.X. 2008.** Analysis on degeneration status and the driving force of Xilinguole Steppe. *Ecology and Environment*, 17(6): 2312-1318. (In Chinese, with English Abstract).

**Lu J.F., You L.Y., Chen H., Zhou J.X and Lu Z.C. 2004.** Assessment of ecological security and adjustment of land use in Xilinhaote City of Inner Mongolia. *Resources Science*, 26(2): 1-7. (In Chinese with English Abstract).

**Wang Z.H., Baoyin T.G.T., Bao Q.H. and Zhong Y.K. 2007.** Dynamic changes of plant biodiversity in *Leymus chinensis* community clipped every other year. *Chinese Journal of Ecology*, 26(12): 2008-2012. (In Chinese with English Abstract).

**Xu Z.Q., Li W.H., Xu Q., Min Q.W., Wang Y.S. and He X.S. 2008.** Effect of grazing-prohibition on species biodiversity of typical steppe in Xilinguole. *Chinese Journal of Ecology*, 27(8): 1307-1312. (In Chinese with English Abstract).

# Productivity of grazed and restored Mediterranean rangelands of Lagadas County in northern Greece

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## Abstract

Livestock grazing is an old practice in the Mediterranean Basin, while continuous overgrazing increases the risk to land degradation. Several management actions are applied in the Mediterranean rangelands in order to reduce this risk. Five such actions were evaluated in Lagadas County (Northern Greece), for their impact on primary standing productivity. They involved overgrazed, moderately grazed and control areas, as well as partially and fully reforested areas with rangeland pines. Measurements included soil characteristics and plant biomass. Samples were taken from areas where each action was implemented in order to estimate soil texture and organic matter content. For plant biomass (herbs and shrubs), three transects of 50m each were established in each of the five actions and 10 quadrats were taken in each transect. The double sampling technique of visual weight estimation calibrated by harvesting was applied. For the tree biomass, two representative plots, (0.1 ha each), were selected in the three actions that had trees, i.e. the control area, and the partial and full reforestation areas. Allometric equations related to the diameter at breast height, the average tree height and the form factor were applied for the tree biomass estimation. The results showed that actions promoting grazing tended to result in shallower soil and less organic matter content than the other. Shrub biomass was highest in the overgrazed area, while herbaceous biomass was highest in the moderately grazed area. The reforestation actions resulted in the highest pine biomass, while the highest oak biomass was recorded in the control area.

**Keywords:** management actions, soil characteristics, plant biomass, plant height

## Introduction

Rangelands are the largest type of land use in Greece covering 40% of the whole country, approximately; they include four main vegetation types: grasslands, shrublands, forest ranges and phrygana (Papanastasis 1999). Mediterranean rangelands can provide a large variety of goods and services such as wood products, fruits for human consumption, improvement of soil fertility, erosion control, water conservation, forage and habitat to wildlife, land reclamation, landscaping and amenities (Le Houerou 1993). Over the last decades, there is a gradual degradation of rangelands for animal production due to over-utilization or abandonment of grazing. Various management practices have been introduced to reverse this degradation such as reforestation with pines, application of grazing with appropriate stocking rates and abandonment (Papanastasis 2009). The aim of the present study was to investigate the soil dynamics and plant biomass production of different management actions applied to restore degraded Mediterranean rangelands.

**Materials and methods**

The study area is located in Lagadas County, northern Greece. Climate is semi-arid to sub-humid Mediterranean, with cold winters, resulting in at least 3 months-long hot and dry summer period. Soils are acid and have been derived from metamorphic rocks. For prevention of land degradation the applied restoration management resulted into five (5) l types that will be called actions (i) a moderately grazed area, dominated by *Quercus coccifera*, *Pyrus amygdaliformis* and *Q. pubescens* (stocking rate 1 sheep equivalent / ha/ year), (ii) an overgrazed shrubland dominated by *Q. coccifera, Cistus incanus* and *Q. pubescens* (3 sheep equivalents / ha/ year), (iii) an abandoned rangeland (control) dominated by *Q. pubescens* and *Q. coccifera*, (iv) a partially reforested rangeland with pines (*Pinus pinaster*) 30 years old (other woody species were *Q. pubescens* and *Q. coccifera*), where trees were planted at the openings of oak species and (v) a fully reforested rangeland with pines (*P. pinaster*) 20 years old, where the area were totally cleaned from vegetation. The last three types were not grazed by domestic animals over the last 30 years.

Measurements taken in these actions included soil characteristics and plant biomass (herbaceous plants, shrubs and trees). For the soil texture, soil samples were taken from a depth of 0-5 cm. In addition, soil samples were taken from the various soil horizons after appropriate diggings in order to measure soil organic matter. All soil samples were air dried and sieved through 2 mm mesh screens. Particle size distribution of mineral soil was determined according to Bouyocos (1962) and soil organic matter was determined by means of wet oxidation (Nelson and Sommers 1982). Herbaceous and shrubby biomass was measured along a 50 m transect in three (3) replications per action. Specifically, 10 quadrats were systematically (every 5 m) taken in each transect. The size of the quadrat was 1x1 m for shrubs within which a 0.50x0.50 m quadrat was randomly placed for the herbaceous plants. The double sampling technique of visual weight estimation calibrated by harvesting was applied for measuring the biomass (Tadmor et al. 1975). Specifically, in two (2) quadrats the biomass was harvested, oven dried and weighed, while the standing biomass, framed by the rest eight (8) quadrats, was visually estimated.

For the tree biomass, two (2) representative plots, 30x30 m each, were selected in the three (3) actions that had trees, namely the control area, the partial and full reforestation. In each of these plots, the diameter at the breast height (DBH) of all the trees was measured (with more than 5 cm DBH). Also, the height of the average tree and its form factor was estimated in order to calculate the wood stock. Then the following allometric relations were used in order to estimate the total tree biomass:

(a) For the oak trees (Jenkins et al. 2003): Y=Exp(B0+B1*lnD)

Y: Above ground dry biomass (Kg)

B0, B1: Parameters

D: Diameter at breast height (cm)

(b) For the pine trees (Roussou et al. 2008): ln(BDW) = (12.196-(31.377/DBH))

BDW: Above ground biomass (without stem) (gr)

DBH: Diameter at breast height (cm)

The results were statistically analysed using the program SPSS 17.

**Results and discussion**

**Soil characteristics**

The soil in most areas were relatively shallow (Table 1), indigenous, developed on weathered gneiss. It has sandy-clay to sandy texture, rich in pebbles. Regarding the concentration of organic matter (OM) there were statistical significant differences between the five actions. Specifically, the highest concentration of OM was found under the control and the partially reforested actions and the lowest in overgrazed one, while moderate grazing and full reforestation resulted in intermediate values. The lack of management and the diversity of plant species and forms under control and partial reforestation actions (combination of herbages, shrubs and coniferous and broadleaved trees) resulted in the accumulation of plant residues on the ground and the gradual decomposition supplies the soil with OM. The intermediate values of OM measured under the moderately grazing can be attributed to rich herbaceous vegetation, which is known to renew each year a large proportion of the small rooting system. Actually it is rhizomull; a type of mull formed mainly in areas with herbaceous vegetation (grasses) (Papamichos 1985).

The low OM in the overgrazed type was almost expected, as the high intensity of grazing negatively affects it, due to the consumption of a significant part of the vegetation (Papamichos 1985).

**Table 1.** Soil depth and organic matter

| Actions | Soil depth (m) | Organic matter (%) |
|---|---|---|
| Moderately grazing | 0.21 | 2.39 ab[1] |
| Overgrazing | 0.25 | 1.95 b |
| Control | 0.37 | 2.92 a |
| Partial reforestation | 0.29 | 2.74 a |
| Full reforestation | 0.35 | 2.25 ab |

[1] Different letters in the same column indicate significant differences among the five actions ($p \leq 0.05$).

**Plant biomass**

Partial reforestation and overgrazing resulted in significantly higher shrub biomass than the moderate grazing and control actions, while shrubs were absent from full reforestation (Table 2).

**Table 2.** Above ground dry biomass (t/ha) produced under the five (5) management actions

| | Moderate grazing | Overgrazing | Control | Partial reforestation | Full reforestation |
|---|---|---|---|---|---|
| Shrubs | 4.09 b[1] | 17.46 a | 5.04 b | 16.88 a | 0.00 b |
| Herbs | 4.49 a | 0.48 bc | 0.73 b | 0.14 c | 0.55 b |

[1] Different letters in the same row indicate significant differences of biomass produced after the implementation of the five (5) management actions ($p \leq 0.05$).

Under overgrazing and partial reforestation the shrub layer was mainly consisted of *Quercus coccifera*, while in the moderately grazed area *Pyrus amygdaliformis* was also present. The cover of *Q. pubescens* at the control area was higher than that of *Q. coccifera* shrubs. Regarding herbaceous biomass, moderate grazing resulted in the highest shrub cover, while the control and full reforested area had intermediate values and overgrazied and partially reforested area the lowest ones. The higher shrub biomass in the overgrazed than in the moderately grazed area should be attributed to the higher nutritive value of herbaceous species compared to the shrub *Q. coccifera* (Yiakoulaki 1997), which eventually led to the increase of the latter at the expense of herbaceous species. As far as the decreased presence of herbaceous biomass in the fully reforested action concerns, this may be explained by the increased shading of the pine canopy (Mantzanas and Papanastasis 2011).

The partially reforested action resulted in the highest amount of tree biomass, probably because it included both pines (planted) and deciduous oaks (indigenous). The control area had only oaks (indigenous) and the fully reforested only pines (planted) (Table 3).

**Table 3.** Tree biomass (t/ha) produced under three (3) management actions.

| | Control | Partial reforestation | Full reforestation |
|---|---|---|---|
| Pines | – | 61.08 | 63.18 |
| Oaks | 50.37 | 36.33 | – |

## Conclusions

1. Livestock grazing, especially overgrazing tends to reduce soil depth and soil organic matter content, while no grazing as well as the establishment of pine plantation have an opposite effect.
2. Overgrazing results in the reduction of herbaceous biomass in favour of evergreen shrubs such as *Quercus coccifera*, thus decreasing their grazing value; the same effect is caused by suspension of grazing or pine introduction.
3. Banning of grazing can lead to recovery of indigenous forest vegetation and biomass, thus suggesting that there is no need to plant pines, if the objective of their establishment is ecosystem restoration.

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## References

**Bouyoucos G.J., 1962.** Hydrometer method improved for making particle size analysis of soil. *Agronomy Journal*, 54:464-465.

**Le Houerou H.N., 1993.** Environmental aspects of fodder trees and shrubs plantation in the Mediterranean basin. In: V. Papanastasis (ed.). Fodder Trees and Shrubs in the Mediterranean Production Systems: Objectives and Expected Results of the EC Research Contract. pp. 11-34. Agrimed Research Programme, Commission of the European Communities, EUR 14459 EN.

**Mantzanas K. and V.P. Papanastasis, 2011.** Relation between thinning and understory plant cover and biomass in a brutia pine plantation in northern Greece. In E. Rigolot (ed.) Book of Abstracts, Medpine 4th International Conference in Mediterranean Pines, Avignon-France

**Nelson D.W. and L.E. Sommers, 1982.** Total carbon, organic carbon and organic matter. In: Methods of Soil Analysis, Part 2, A.L. Page (ed.), American Society of Agronomy and Soil Science Society of America, Madison, Wisconsin, USA, pp. 539-577.

**Papamichos N.T., 1985.** Forest Soils-Formation, Characteristics, Behavior. Aristotle University of Thessaloniki, Publication Office. 384 p.

**Papanastasis V.P., 2009.** Restoration of degraded grazing lands through grazing management: Can it work? *Restoration Ecology*, 17:441-445.

**Papanastasis V.P., 1999.** Grasslands and woody plants in Europe with special reference to Greece. In: V.P. Papanastasis, J. Frame and A.S. Nastis (eds.) Grasslands and Woody Plants in Europe. pp. 15-24. Grassland Science in Europe. Volume 4.

**Tadmor N.H., A. Briechet, I. Noy-Meier, R.W. Benzamin and A. Eyal, 1975.** An evaluation of the Calibrated Weight-Estimate Method for Measuring Production in Annual Vegetation. *Journal of Range Management*, 28(1): 65-69.

**Yiakoulaki M.D., 1997.** Nutritive value of forage species and shrubland utilization by goats. In V.P. Papanastasis (ed.) Sustained utilization of rangelands and pastures. Proceedings of the 1st Panhellenic Rangeland Congress. pp 257-262.

# Grazing intensity affects soil carbon sequestration in an altitudinal gradient

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## Abstract

Grassland management affects soil carbon content and many management practices have been proposed to sequester carbon. One of them livestock grazing has the potential to modify soil carbon content as it affects the soil – plant system, altering the C cycle. The objective of this study was to evaluate the effects of grazing intensity on soil organic carbon in grasslands along an altitudinal gradient in the Mediterranean region. Three grasslands were selected at three different altitude ranges between (800 – 1000 m, 1000 – 1200 m and 1200 – 1500 m) at Central Greece that were under grazing conditions for a long time with different grazing species. Forage production, utilization rate, species richness and soil parameters were measured at each grassland. Species diversity and forage production increased respectively by 25.8% and 56.5% along altitude gradient while forage utilization rate decreased by 53.5%. The results also showed that soil organic carbon increased as grazing intensity decreased at elevated altitudes. These results revealed that moderate grazing intensity could enhance soil carbon accumulation at higher altitudes, contributing to climate change mitigation.

**Keywords:** climate change, moderate grazing, grasslands, soil organic carbon.

## Introduction

Land use may be an important factor mitigating climate change, as it may have an impact on soil organic matter (SOM) storage (Lal 2009). Grasslands are an important land use type in Europe, covering more than a third of the European area, have basic role in animal feeding, provide important regulating ecosystem services, support biodiversity and store carbon in soil. Grazing is one of the most significant factors that could change the soil C stock in grassland ecosystems (Cui et al. 2005), which influences organic matter input and associated soil properties (Steffens et al. 2009, Wiesmeier et al. 2009). Soil organic matter (SOM) is the main reservoir of soil organic carbon (SOC) and soil organic nitrogen (SON) in rangelands and determines soil fertility, water retention, and soil structure (Lal 2004). The amount of organic matter stored in soils is controlled by natural site-specific factors such as climate, topography, land cover and human-induced factors associated with land use (Pineiro et al. 2010). The objective of the present study was to investigate the effects of grazing intensity on soil carbon sequestration along an altitudinal gradient.

## Materials and Methods

The research was conducted at Othrys Mountain in central Greece in 2005. Three grasslands were selected at altitude ranges between (800 – 1000 m, 1000 – 1200 m and 1200 – 1500 m), which were subjected to grazing for a long period. In each grassland three experimental areas 50x50m were randomly selected. Fenced experimental plots were established in each zone, in order to protect vegetation from grazing. Forage samples were measured in ten 1.5x1.5m plots while species richness and abundance in 0.5x0.5m. From these data Shannon- Weiner (H′) was calculated according to the formula: $H' = -\sum_{i=1}^{S} Pi \cdot \ln Pi$ ,

where H′= Shannon- Weiner index and

Pi is the proportion of the individuals

Soil samples were collected at 20cm depth, were the majority of herbaceous plant root occur and soil properties were determined using common soil analysis methods. In the laboratory, soil total nitrogen and soil organic matter concentration were measured by the $K_2Cr_2O_7$ method using the modified Kjeldahl wet digestion procedure of Miller and Keeney (1982). One-way ANOVA was used to compare means in three grasslands. Further differences were evaluated with the LSD posthoc test, at a level of significance of 0.05. The SPSS 15.0 statistical software was used (Kinnear and Gray 2008).

## Results and Discussion

Forage production in ungrazed plots was significantly ($P< 0.05$) higher at grasslands above 1200 m, but forage utilisation rate was lower compared to other grasslands, indicating moderate grazing conditions at higher altitudes (Table 1). Furthermore, species diversity index increased by 25.8% along altitude gradient. According to Derner and Schuman (2007), Gao et al. (2007) and Hafner et al. (2012) intermediate levels of grazing can be beneficial to the environment, enhancing nutrient cycling, promoting species diversity and increasing carbon sequestration. In contrast, the increased forage utilisation rate and low productivity in two grasslands at lower altitudes exhibit heavy grazing pressure which could affect soil carbon storage. Recent studies in grasslands ecosystems have been reported that high grazing intensity reduced soil organic carbon concentration compared to low intensity (Han et al. 2008, Klumpp et al.

2009, Martinsen et al. 2011, Sun et al. 2011). Heavy grazing also induces soil compaction which may decrease soil moisture and net primary production (NPP) (Savadogo et al. 2007).

**Table 1.** Forage production (gr/$m^2$) in grazed and ungrazed areas, utilization rate and diversity index in the selected grasslands.

| Altitude | 800- 1000 m | 1000 – 1200 m | 1200 - 1500 m |
|---|---|---|---|
| Ungrazed plots | 48.5a | 43.1a | 112b |
| Grazed plots | 10.5a | 11.8a | 52.1b |
| Forage utilisation rate (%) | 78.3a | 73.2a | 53.5b |
| Shannon – Weiner (H') | 2.44a | 2.72a | 3.07b |

Letters in the same row indicate differences at 0.05 significant level using LSD posthoc test

**Table 2.** Mean soil attributes from three grasslands

| Altitude | 800- 1000 m | 1000 – 1200 m | 1200 - 1500 m |
|---|---|---|---|
| Moisture (%) | 17.1a | 18.9a | 23.5b |
| Organic matter (%) | 31.0a | 22.6a | 46.1b |
| Total nitrogen (%) | 2.7a | 1.8a | 5.4b |
| C:N | 11.5a | 12.6a | 8.5b |
| Soil texture | SCL | SC | S |

Letters in the same line indicate differences at 0.05 significant level using LSD posthoc test (S: Sandy, SC: Sandy-Clay, SCL: Sandy –Clay-Loam)

An overview of selected soil chemical and physical data in three grasslands were presented in Table 2. Grasslands at 1200 – 1500 m altitude range had significant (*P<0.05*) higher soil moisture, nitrogen and organic matter content than grasslands at lower altitudes. The former had lower value of C:N index and sandy soil texture, indicating favourable conditions for organic matter microbial decomposition and nutrient cycling (Drewnik 2006). The latter had high SOM C:N ratios, which was frequently increased under heavy grazing conditions, suggesting potential N limitations for SOM formation under overgrazing (Pineiro et al. 2010).

## Conclusions

Livestock grazing has significant effects on C storage in grasslands ecosystems and moderate grazing intensity could enhance soil carbon accumulation at higher altitudes.

## References

**Cui X., Y. Wang, H. Niu, J.Wu, S. Wang, E. Schnug, J. Rogasik, J. Fleckenstein and Y. Tang, 2005.** Effect of long-term grazing on soil organic carbon content in semiarid steppes in Inner Mongolia. *Ecological Research,* 20:519–527.

**Derner J.D. and G.E. Schuman, 2007.** Carbon sequestration and rangelands: a synthesis of land management and precipitation effects. *Journal of Soil and Water Conservation,* 62:77-85.

**Drewnik M., 2006.** The effect of environmental conditions on the decomposition rate of cellulose in mountain soils. *Geoderma*, 132:116-130.

**Gao Y.H., P.Luo, N. Wu, H. Chen and G.X. Wang, 2007.** Grazing intensity impacts on carbon sequestration in an Alpine Meadow on the Eastern Tibetan Plateau. *Research Journal of Agriculture and Biological Science,* 3(6): 642-647.

**Hafner S., S. Unteregelsbacher, E. Seeber, B. Lena, X. Xu, X. Li, G. Guggenberger, G. Miehe and Y. Kuzyakov, 2012.** Effect of grazing on carbon stocks and assimilate partitioning in a Tibetan montane pasture revealed by $^{13}CO_2$ pulse labeling. *Global Change Biology,*18: 528-538.

**Han G., X. Hao, M. Zhao, M. Wang, B.H. Ellert, W. Willms and M. Wang, 2008.** Effect of grazing intensity on carbon and nitrogen in soil and vegetation in a meadow steppe in Inner Mongolia. *Agriculture, Ecosystems and Environment*, 125: 21–32.

**Kinnear P.R. and C.D. Gray, 2008.** SPSS 15 made simple. Psychology Press. Hove.

**Klumpp K., S. Fontaine, E. Attard, X. Le Roux, G. Gleixner and J-F. Soussana, 2009.** Grazing triggers soil carbon loss by altering plant roots and their control on soil microbial community. *Journal of Ecology*, 97:876–885.

**Lal R., 2004.** Soil carbon sequestration impacts on global climate change and food security. *Science* 304:1623-1627.

**Lal R., 2009.** Challenges and opportunities in soil organic matter research. *European Journal of Soil Science* 60:159-168.

**Martinsen V., J. Mulder, G. Austrheim and A. Mysterud, 2011.** Carbon storage in low-alpine grassland soils: effects of different grazing intensities of sheep.*European Journal of Soil Science* 62:822-833.

**Miller R.H and D.R. Keeney, 1982.** Methods of soil analysis. Part 2: chemical and microbiological properties, 2nd edn. American Society of Agronomy, Soil Science Society of America, Madison. 228 pp.

**Pineiro G., J.M. Paruelo, M.Oesterheld and E.G. Jobbagy, 2010.** Pathways of grazing effects on soil organic carbon and nitrogen. *Rangeland Ecology & Management*, 63:109–119.

**Savadogo P., L. Sawadogo and D. Tiveau, 2007.** Effects of grazing intensity and prescribed fire on soil physical and hydrological properties and pasture yield in the savanna woodlands of Burkina Faso. *Agriculture, Ecosystems & Environment* 118:80-92.

**Steffens M., A. Kolbl and I. Kögel-Knabner, 2009.** Alteration of soil organic matter pools and aggregation in semi-arid steppe topsoils as driven by organic matter input. *European Journal of Soil Science,* 60:198-212.

**Sun D.S., K. Wesche, D.D. Chen, S.H. Zhang, G.L. Wu, G.Z. Du and N.B. Comerford. 2011.** Grazing depresses soil carbon storage through changing plant biomass and composition in a Tibetan alpine meadow. *Plant, Soil and Environment*, 57(6):271–278.

**Wiesmeier M., M. Steffens, A. Kölbl and I. Kögel-Knabner, 2009.** Degradation and small-scale spatial homogenization of topsoils in intensively grazed steppes of Northern China. *Soil and Tillage Research,* 104:299-310.

# SESSION 3

## Ecology & Management of Dry Grasslands

# Impact of wildfires on plant cover and biomass in shrublands of Lagadas County in northern Greece

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## Abstract

Large forested areas are destroyed by wildfires in Greece every year. A significant part of these areas is composed of shrublands dominated by kermes oak (*Quercus coccifera*). The present study was carried out in kermes oak shrublands covered by various shrub densities and located at Lagadas County of the Thessaloniki prefecture. In 2007, an area of an 563 hectares extension was burned. In three cover degrees (10-40% - open, 41-70% - medium and 71-100% - dense) and two burning treatments with three replications plant cover and above ground biomass (herbaceous and woody) were measured at the end of the second growing season since the wildfire. Herbaceous plant cover was highest in the open and woody plant cover was highest in the dense shrubland. Vegetation (herbaceous and woody) recovered very fast and no significant differences were observed two years after the wildfire. Regarding the above ground biomass, herbaceous was increased considerably in burned areas due to the reduction of woody plants. Total biomass however was statistically similar in burned and unburned areas.

**Key words:** Unburned area, burned area, cover type, cover, biomass

## Introduction

Shrublands dominated by kermes oak (*Quercus coccifera*) cover large areas in several Mediterranean countries. They are important grazing areas for goats significantly contributing to animal production since they are mainly used during the autumn and winter months (Papanastasis et al. 2008). In Greece, there is a gradual degradation of kermes oak shrublands over the last decades due to underutilization, or, even, abandonment of grazing resulting in fuel accumulation and in a great fire danger. Wildfires have become a considerable threat to these degraded shrublands. Although several studies have been carried out on the effects of wildfires on kermes oak shrublands (e.g. Papanastasis 1988, Papachristou et al. 1997), there is a lack of knowledge on how shrubland density is related to post-fire restoration of these ecosystems. In this paper, the impact of wildfires on plant cover and biomass was investigated so that the post-fire grazing management of kermes oak shrublands is properly organized.

**Materials and methods**

The research was conducted in kermes oak shrublands of Lagadas County of Thessaloniki prefecture. In August 2007, an area amounting to about 563 ha and covered by various shrub densities was burned by a wildfire (Figure 1). Measurements were taken two growing seasons later, specifically in May and June 2009. The study area is located at 450- 550 m a.s.l. and has soils derived from metamorphic rocks and climate semi-arid Mediterranean.

The experimental design involved three shrub cover classes (10-40% open, 41-70% medium and 71-100% dense) and two types of fire history (burned and unburned) with three replications. In each treatment combination, three transects of 25 m each were taken where plant cover and above ground biomass were measured. For plant cover, the point-line method was applied (Cook and Stubbendieck 1986). For biomass, five random quadrats of 1 $m^2$ were cut at the ground level in each transect, the herbaceous and woody vegetation was separated and transferred to the Laboratory. Before oven drying and weighing, the woody material was hand separated into current year's and old growth.

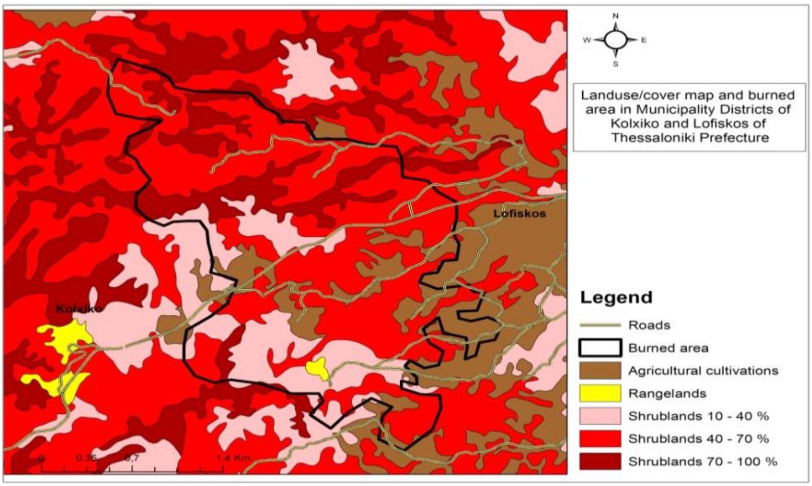


**Figure 1.** Study area with the three shrub classes.

**Results and discussion**

Dense shrublands had significantly lower herbaceous and higher woody cover than the other two classes while no significant differences were observed between open and medium cover classes (Table 1). Litter and bare ground did not present any significant differences in the three shrub cover classes.

| **Table 1.** Mean plant cover (%) in the three shrub cover classes | | | |
|---|---|---|---|
| | Shrub cover | | |
| Category | Open | Medium | Dense |
| Herbaceous | 54.67 a[1] | 58.33 a | 42.33 b |
| Woody | 24.83 b | 26.17 b | 39.83 a |
| Litter | 10.00 a | 8.00 a | 5.33 a |
| Bare ground | 18.00 a | 8.00 a | 15.83 a |

[1] Means in the same line followed by the same letters are not significant different at the 0.05 level of significance.

As far as fire history is concerned, no statistical differences were found between the burned and unburned treatments (Table 2). This can be attributed to rapid recovery of the vegetation (herbaceous and woody) in the burned area two years after the wildfire. A rapid increase of kermes oak cover was also observed in the first two years after a wildfire in southern France (Trabaud 1977) as well as in Greece (Papanastasis 1988).

| **Table 2.** Mean plant cover (%) in the sites with different fire history | | |
|---|---|---|
| | Fire history | |
| Category | Burned | Unburned |
| Herbaceous | 55.22 a[1] | 48.33 a |
| Woody | 26.00 a | 34.56 a |
| Litter | 7.11 a | 8.44 a |
| Bare ground | 14.56 a | 13.33 a |

[11] Means in the same line followed by the same letters are not significant different at the 0.05 level of significance.

For biomass, medium class shrubland had significantly higher herbaceous biomass than the open and dense ones (Table 3). The lower biomass of the herbaceous plants in light class shrubland should be attributed to the intensive grazing that was applied the first two years after the fire due to its higher attractiveness to the animals compared with the other two classes. In contrast, the dense class had significantly higher current year's growth than the other two treatments, while the old growth was statistically the same in all the cover classes. The total biomass (herbaceous and woody), finally, was significantly increased from light to dense shrubland.

| **Table 3**. Mean above ground biomass (kg/0.1ha) in the three shrub cover classes | | | |
|---|---|---|---|
| | Shrub cover | | |
| Biomass category | Open | Medium | Dense |
| Herbaceous | 88.40 b | 235,04 a[1] | 120,60 b |
| Current's year growth | 8,90 b | 8,80 b | 26,00 a |
| Old growth | 37,80 a | 71,40 a | 134,63 a |
| Total woody | 44,60 a | 80,20 a | 160,60 a |
| Total biomass | 135,00 b | 281,20 ab | 315,30 a |

[1] Means in the same line followed by the same letters are not significant different at the 0.05 level of significance.

Regarding fire history, herbaceous biomass was significantly higher in the burned treatment than the unburned while the woody biomass (especially the old growth) was significantly decreased (Table 4). The increased herbaceous biomass in the burned area was balanced by the reduction of woody biomass, resulting in no differences for the total biomass two years after the fire between the two treatments. Papanastasis (1988) also found that herbaceous vegetation recovered two years after the fire and significantly contributed to the total production of a burned kermes oak shrubland.

| **Table 4.** Mean above ground biomass (kg/0.1ha) in the two burning treatments | | |
|---|---|---|
| | Burning treatments | |
| Biomass category | Burned | Unburned |
| Herbaceous | 202.6 a[1] | 93.4 b |
| Current's year growth | 8.2 a | 20.9 a |
| Old growth | 6.7 b | 155.8 a |
| Total woody | 15.0 a | 176.7 a |
| Total biomass | 217.6 a | 270.1 a |

[1] Means in the same line followed by the same letters are not significant different at the 0.05 level of significance.

## Conclusions

1. Woody plant cover increased from the open to dense kermes oak shrublands two years after the wildfire while the herbaceous plant cover decreased. The intense resprouting of kermes oak in the burned area resulted in a similar cover of woody plants with the unburned area.

2. Herbaceous biomass was affected by the grazing management applied after the wildfire more than woody biomass and was highest in the middle cover class of shrublands.

3. Burned shrublands had significantly higher herbaceous biomass than the unburned ones two years after the wildfire thus explaining why shepherds often set wildfires in these areas.

## References

**Cook C.W. and J. Stubbendieck. 1986.** Range Research: Basic Problems and Techniques. Society of Range Management, Denver, Colorado, USA. 317 pp.

**Papanastasis, V.P. 1978.** Early succession after fire in maquis-type shrublands of Chalkidiki, Greece. *To Dassos*, 30 (79-80): 19-26.

**Papanastasis, V.P. 1988.** Evolution of vegetation after a wildfire in a burned kermes oak shrubland seeded with range grasses. *Scientific Annals of the Department of Forestry and natural Environment*, Vol. LA (No 15):255-270.

**Papanastasis, V.P., M.D. Yiakoulaki, M. Decandia, O. Dini- Papanastasi. 2008.** Integrating woody species into livestock feeding in the Mediterranean areas of Europe. *Animal Feed Science and Technology*, 140: 1-17.

**Papachristou, T.G 1997.** Foraging behaviour of goats and sheep on Mediteranean kermes oak shrublands. *Small Ruminant Research*, 12: 35-44.

**Trabaud, L. 1977.** Comparison between the effect of prescibed fires and wildfires on the global quantitative evolution of the kermes oak ( Quercus coccifera L.) garriques. P. 271-282. In: Symp. Env. Coseq. Fire and Fuel Management in Mediterranean Ecosystems (H.A. Mooney and E.C. Conrad, coors). USDA, For. Serv. Gen. Techn. Rep. WO-3.

# Assessing the conservation status of habitat 6210(*) Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia) in Italy

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## Abstract.

One of the main goals of the protection and management of Natura 2000 habitat types is the assessment of their conservation status. While some countries have already tested procedures to assess conservation status, many others, including Italy, still lack standard measures at the national level. The aim of our study was to address this lack of a national standard in Italy for habitat 6210(*) by adapting procedures used in other member states to the Italian context. The dry grasslands of habitat 6210(*), determined by human activities, display very high species richness but are, at the same time, seriously threatened by current climatic trends and land-use changes. Although the conservation of this habitat is a priority, there is no policy regarding the conservation of such grasslands. On the basis of the parameters included in the Habitats Directive, we selected the indicators most suited to the assessment of conservation status. These indicators were inferred from floristic and vegetation data collected in 2010 and 2011. As structure parameters, we selected non-graminoid *vs* graminoid cover and shrub cover; as floristic and vegetation parameters, we selected the occurrence and abundance of characteristic and abundant species, of species of conservation or biogeographic interest, and of weeds or invasive species. We identified three types of indicators, which represent a tool for conservation strategies aimed at grasslands included in habitat 6210(*).

**Key words:** grasslands, Natura 2000, monitoring, management, indicators

## Introduction

The evaluation of the habitat's conservation status has been defined by the Habitats Directive (92/43/EEC, hereafter HD). Some EU member states have already proposed and tested procedures to assess the conservation status of their habitats (e.g. Austria, France, UK, Spain), while many others, including Italy, lack standardized measures that can be used on a national scale. This paper presents part of a PhD project[1] that was designed to assess the conservation status of habitat 6210(*) and that addresses the need for a standardized and validated approach (de Bello et al. 2010). For

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[1] This project is part of the activities carried out under an agreement between the Region of Molise and Italian Botanical Society (SBI) for Management Plans of 10 Natura 2000 sites in Molise.

this purpose, we adapted procedures and indicators already being used in other member states to Italy (JNCC 2004, Yera Posa & Martorell 2009, Bundesamt für Naturschutz 2011).

Secondary succession grasslands are considered as important habitat type owing to their high species diversity. However, this habitat is currently being threatened by climatic factors and changes in land use (Gibson 2009). Although the conservation of this habitat is a priority for the scientific community (EDGG 2011, Fundatia ADEPT 2011, EGF 2011), no standardized measures exist for this purpose. Such measures should be aimed at grasslands that can sustain themselves and require minimal management. Indeed, it is more difficult to preserve grasslands that have begun to evolve into more advanced stages of vegetation (JNCC 2004). Dry grasslands referred to habitat 6210(*) Semi-natural dry grasslands and scrubland facies on calcareous substrates (*Festuco-Brometalia*) are determined by human activities. The management practices that affect biodiversity in grasslands are above all livestock grazing and mowing (de Bello et al. 2007). The main aspects of these practices are the intensity of the activities (Bakker et al. 2006), their timing, their seasonality (Díaz et al. 2007) and local environmental conditions (Klimek et al. 2007). Another important factor, about which little is known, is the type and size of the grazing animals (e.g. sheep, goats, cattle, horses) (Bakker et al. 2006, Díaz et al. 2007). Indeed, Italy has witnessed changes in the type of grazing animals, particularly from sheep to cattle, fact that have led to changes in biodiversity, like in southern Italy (Fascetti *in verbis*).

After the II World War, land use in European rural areas changed considerably, with grasslands being affected most (Falcucci et al. 2007, de Bello et al. 2010). Moreover, the cessation of traditional management, due to both rural abandonment and agricultural intensification, determined the loss and fragmentation of habitats, which is considered to be one of the main causes of the decrease in biodiversity (de Bello et al. 2007).

**Materials and methods**

The study area (Fig. 1) comprises ten Natura 2000 sites in the Molise region (central Italy). We focused on semi-natural grasslands, which represent one of the most common habitats in this region. More than 16% of the area is covered by habitat 6210(*) (EEA 2011).

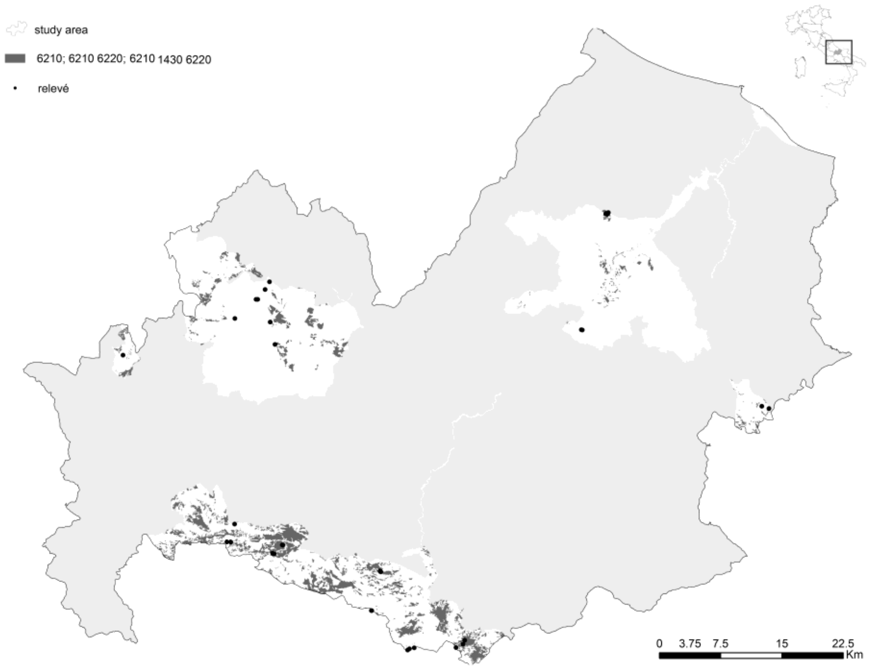


**Figure. 1** The study area

The parameters suggested by the HD to assess conservation status (EC 2007) can be used in various ways, depending on the purposes of the monitoring being conducted and the most accessible type of information. We selected indicators that could easily be collected during the field work. We also assessed human-induced threats according to the IUCN (2011) nomenclature. In order to test the conservation indicators in 2010 and 2011, we performed a floristic and vegetation survey by means of 37 phytosociological relevés, which we used to identify the habitat. We also identified the threats for each site.

**Results and Discussion**

The surveyed grasslands, which we recognized as *Phleo ambigui-Bromion erecti* Biondi & Blasi ex Biondi et al. 1995, seem to be poorer in species than in the reference community, probably owing to the marly-arenaceous substrate that may reduce floristic diversity, as Biondi et al. (1985) also suggested. Below, we present the selected parameters, the information yielded by them and the methodology used to assess them.

We identified three types of indicators: (i) structure indicators; (ii) floristic and vegetation indicators; (iii) threats to the habitat posed by human activities. As structure parameters, we selected the relative cover of non-graminoids *vs* graminoids per relevé, which is a useful indicator of the naturalness of the grasslands (JNCC 2004, Pueyo et al. 2006, de Bello et al. 2010). We also selected shrub cover per relevé, which sheds light on the evolution of the vegetation stages (JNCC 2004). As floristic and vegetation parameters, "characteristic species composition" of the grasslands, assessed by the presence and cover of characteristic and abundant species (Braun-Blanquet 1931), was compared with that of a reference community, which is one of the most important floristic indicator methods available (de Bello et al. 2010); the presence and cover of weeds or invasive species indicates the fragility of the community or the presence of disturbance; lastly, the presence and cover of species of conservation or biogeographic interest and their population dynamics is indicative of the peculiarity of the site (JNCC 2004).

In the surveyed area, non-graminoid species are more abundant in the highlands, particularly in the Matese mountains, where sheep grazing is still practised, whereas graminoid species are more common in the lowlands, which are managed above all by mowing and cattle or horse grazing. The spread of *Brachypodium rupestre* (Host) Roem. & Schult. may reduce species richness, as observed by Catorci et al. (2011). Eleven relevés contained orchid species, which help to identify the conservation priority of the habitat (*Aceras anthropophorum*, *Anacamptis pyramidalis*, *Ophrys apifera*, *O. lutea*, *O. fuciflora*, *Orchis morio*, *O. pauciflora*, *O. sambucina*, *O. tridentata*, *Serapias vomeracea*); we also recorded three of the 35 species of conservation or biogeographic interest (*Himantoglossum adriaticum*, *Hypericum hircinum*, *Stipa austroitalica*).

As regards the threats, the main causes of biodiversity loss in the grasslands are land use changes, which could be assessed by diachronic remote sensing data. In particular, the abandonment and changes in the type of pastures, as assessed by the cover of clonal or spiny species of no pastoral interest, point to deviation from the reference community (Catorci et al. 2011). Indeed, abandoned pastures (i.e. those dominated by tall species) usually host a lower number of plant species (de Bello et al. 2010). The threat parameter data have not been analyzed yet.

**Conclusions**

We identified three types of indicators, which represent a tool for conservation strategies aimed at grasslands included in habitat 6210(*): (a)

Structure indicators: (i) non-graminoid *vs* graminoid cover ratio and (ii) shrub cover per relevé; (b) Floristic and vegetation indicators: (i) “characteristic species composition”, (ii) presence and cover of weeds or invasive species and (iii) presence and cover of species of conservation or biogeographic interest and their population dynamics. We are also planning to test the conservation status of the grasslands according to the following threats indicators: (i) changes in land use, as detected by means of diachronic remote sensing data and (ii) cover of clonal or spiny species of no pastoral interest.

## References


**Bakker E.S., M.E. Ritchie, H. Olff, H. Milchunas and J.M. Knops. 2006.** Herbivore impact on grassland plant diversity depends on habitat productivity and herbivore size. *Ecology Letters*, 9:780-788.

**Biondi E., S. Ballelli and D. Principi. 1985.** Sur les pelouses seches des substrats marneux- arenaces de l'Apennin septentrional (Italie). *Doc. Phytosoc*. N.S., 9:351-357.

**Braun-Blanquet J. 1931.** Plant sociology. McGraw-Hill book company, New York. 472 pp.

**BfN 2011.** <http://www.bfn.de/fileadmin/MDB/documents/030306_bewertungssgruen.pdf> (Accessed 12 October 2011)

**Catorci A., G. Ottaviani, S. Ballelli and S. Cesaretti. 2011.** Functional differentiation of Central Apennine grasslands under mowing and grazing disturbance regimes. *Polish Journal of Ecology*, 59(1):115-128.

**de Bello F., J. Lepš and M.T. Sebastià. 2007.** Grazing effects on the species-area relationship: variation along a climatic gradient in NE Spain. *Journal of Vegetation Science*, 18:25-34.

**de Bello F., S. Lavorel, P. Gerhold, Ü. Reier and M. Pärtel. 2010.** A biodiversity monitoring framework for practical conservation of grasslands and shrublands. *Biological Conservation*, 143: 9–17.

**Díaz S., S. Lavorel, S. McIntyre, V. Falczuk, F. Casanoves, D.G. Milchunas, C. Skarpe, G. Rusch, M. Sternberg, I. Noy-Meir, J. Landsberg, W. Zhang, H. Clark and B.D. Campbell. 2007.** Plant trait responses to grazing - a global synthesis. *Global Change Biology*, 13:313-341.

**European Environmental Agency, 2011.** <http://www.eea.europa.eu/data-and-maps/data/natura> (Accessed 12 October 2011)

**European Commission. 2007.** Interpretation Manual of European Union Habitats. European Commission DG Environment. Nature and biodiversity.

**European Dry Grassland Group, 2011.** <http://www.edgg.org/> (Accessed 16 December 2011)

**European Grassland Federation, 2011.**< http://www.europeangrassland.org/ > (Accessed 16 December 2011)

**Fundatia ADEPT, 2011.** http://www.fundatiaadept.org/?content=HNV_Grasslands_Conference> (Accessed 16 December 2011)

**Falcucci A., L. Maiorano and L. Boitani. 2007.** Changes in land-use/land-cover patterns in Italy and their implications for biodiversity conservation. *Landscape Ecology*, 22:617-631.

**Gibson D.J. 2009.** Grasses and grassland ecology. Oxford University Press, New York. 322 pp.

**IUCN, 2011.** <http://www.iucnredlist.org/technical-documents/classification-schemes/threats-classification-scheme-ver3> (Accessed 15 October 2011)

**JNCC. 2004.** Common Standards Monitoring Guidance for Lowland Grassland Habitats. JNCC, Peterborough, United Kingdom.

**Klimek S., A.R.G. Kemmermann, M. Hofmann and J. Isselstein. 2007.** Plant species richness and composition in managed grasslands: the relative importance of field management and environmental factors. *Biological Conservation*, 134:559-570.

**Pueyo Y., C.L. Alados and C. Ferrer-Benimeli. 2006.** Is the analysis of plant community structure better than common species-diversity indices for assessing the effects of livestock grazing on a Mediterranean arid ecosystem? *Journal of Arid Environments*, 64:698-712.

**Yera Posa J. and J. Ascaso Martorell. 2009.** 6210 Pastos vivaces mesofíticos y mesoxerofíticos sobre sustratos calcáreos de *Festuco-Brometea*. In: AA.VV. Bases ecológicas preliminares para la conservación de los tipos de hábitat de interés comunitario en España. Ministerio de Medio Ambiente, y Medio Rural y Marino.

# Phytosociological research of the *Erica* heathlands and evergreen broadleaved shrublands at the north side of Mount Cholomon

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## Abstract

Mediterranean *Erica* heathlands and evergreen broadleaved shrublands consist considerably degraded communities primarily due to overgrazing and repetitive fires. A phytosociological analysis of these communities was carried out at the north side of Mount Cholomon (Chalkidiki, N. Greece) using the Braun-Blanquet method. The classification of the vegetation units was achieved through Twinspan analysis on 80 relevés and resulted in one community and one association. The evergreen broadleaved shrublands are assigned to the Quercetea (-alia) ilicis, as *Arbutus unedo-Erica arborea* community, and the *Erica manipuliflora* heathlands to the Cisto-Micromerietea julianae, as Ericetum verticillatae association. The floristic composition of the research area consist of 176 taxa comprising high number of taxa belonging to the classes Thero-Brachypodietea and Festuco-Brometea that confirm the intense degradation.

**Key words**. Syntaxonomy, vegetation, *Erica manipuliflora,* Chalkidiki

## Introduction

Heathlands and evergreen broadleaved shrublands in the Mediterranean area are highly degraded primarily due to overgrazing and repetitive fires. Phytosociological research in Greece in this type of ecosystems is very limited (Oberdorfer 1954, Krause et al. 1963, Knapp 1965, Horvat et al. 1974, Raus 1979, Bergmeier 1990, Konstantinidis 1990, Athanasiadis et al. 1998, Stamou 2004, Theodoropoulos et al. 2011).

The research area is situated at the north side of mount Cholomon in Chalkidiki (Northern Greece). Geologically, the area belongs to the Vertiscos Range of the Serbomacedonian massif (Mountrakis 1985), and the substrate consists of igneous acid rocks (granites, granodiorites, monzonites) (I.G.M.E. - Institute of Geology and Mineral Exploration 1983).

The climate of the area is classified as the “Csa climatic type” according to Köppen’s classification, representing Mediterranean climate with “very hot and dry summers and mild winters” (Theodoropoulos 1991; source of data: Meteorological Station of Arnea).

The vegetation of the area is mostly consisted of Mediterranean type ecosystems and the results of the longlasting and intense anthropogenic influence (overgrazing, fires) are obvious everywhere in the study area.

The aim of this study is to: (1) classify the heathlands and evergreen broadleaved shrublands at the north side of the mount Cholomon, and (2) describe their floristic composition, as well as the environmental factors related to the defined vegetation units.

**Materials and Methods**

Data from 80 sample plots were recorded in May and June of 2008 using the Braun-Blanquet approach (Braun-Blanquet 1964). Selected sites for sampling were homogenous in species composition and environmental conditions. Plot size was 100 $m^2$ according to Chytrý & Otýpková (2003). Physiographic data i.e. elevation, exposure, slope, macro- and microrelief were recorded for each sample plot as well as shrub and herb ground cover. Two classification layers of the plants have been chosen: (a) the herbaceous layer (H), which includes all herbaceous species and woody species up to 0.50 m; (b) the shrub layer (S), which includes all woody species from 0.50 m up to 5 m.

Vascular plants were identified using Flora Europaea 1-5 (Tutin et al. 1968-1980, 1993), and Flora Hellenica 1 & 2 (Strid and Tan 1997, 2002). Furthermore, selected taxonomic literature was used (Zohary and Heller 1984, Scholz 1986). The nomenclature of taxa follows Euro+Med (2006-2011), Flora Hellenica 1, 2 (Strid and Tan 1997, 2002), Med-Checklist 1, 3, 4 (Greuter et al. 1984-1989) and Flora Europaea 1-5 (Tutin et al. 1968 -1980, 1993).

The relevés were stored in the TURBOVEG database (Hennekens and Schaminée 2001). For cover-abundance values the seven-degree Braun-Blanquet scale was used. Vegetation data were processed using JUICE 6.5 software (Tichý 2002). Two-way indicator species analysis (Twinspan) (Hill 1979) was applied, as a classification technique. In addition hand sorting was considered necessary to achieve the final phytosociological table.

The syntaxonomy was conducted on the basis of Knapp (1965), Horvat et al. (1974), Raus (1979), Bergmeier (1990), Athanasiadis et al. (1998), Stamou (2004), Mucina et al. (2009), Theodoropoulos et al. (2011). The nomenclature of vegetation units follows Weber et al. (2000).

## Results

Phytosociologically, one community and one association as well as inferior vegetation units were distinguished (Table 1). The syntaxonomy, the structure and the synecology of the distinguished phytosociological units are discussed.

The plant list contains 176 taxa; the floristic composition of the *Erica manipuliflora* heathlands consists of 118 taxa and the evergreen broadleaved shrublands of 141 taxa.

*Syntaxonomic synopsis*

CLASS: Quercetea ilicis Br.-Bl. ex A. de Bolòs y Vayreda 1950
ORDER: Quercetalia ilicis Br.-Bl. ex Molinier 1934
ALLIANCE: Erico-Quercion ilicis S. Brullo et al. 1977
COMMUNITY: *Arbutus unedo-Erica arborea* community
VARIANT: with *Satureja vulgaris-Rubus canescens*
CLASS: Cisto-Micromerietea julianae Oberd. 1954
ORDER: Poterietalia spinosi Eig 1939
ALLIANCE: Hyperico olympici-Cistion cretici (Oberd. 1954) R. Jahn et Bergmeier in
Mucina et al. 2009
ASSOCIATION: Ericetum verticillatae (= manipuliflorae) Oberd. 1954
VARIANT: with *Psilurus incurvus-Trifolium campestre*

### ***Arbutus unedo-Erica arborea*** **community (Quercetea ilicis)**

The community is characterized by a shrub layer with a cover degree of 50-90% in which *Arbutus unedo, Erica arborea, Juniperus oxycedrus* subsp. *oxycedrus and Erica manipuliflora* participate mainly, while other species as *Quercus pubescens, Phillyrea latifolia* and *Arbutus andrachne* participate at a lower degree (Table 1: I & II). The maximum height of shrubs in the plots is 1-5 m and the average height of the 10 highest shrubs per plot is 0.8-3.3 m.

The herb layer is rich in species (13-41 per plot) with a cover degree of (50)65-95%. Apart from the above mentioned woody taxa, the following were also identified in the particular structure: *Genista carinalis*, *Dorycnium graecum*, *Teucrium chamaedrys*, *Leontodon hispidus*, *Stipa bromoides*, *Luzula campestris*, *Scabiosa triniifolia*, *Cytisus triflorus*, *Hypericum montbretii*, *Carex flacca* subsp. *serrulata*, *Ferulago sylvatica*, *Thesium divaricatum*, *Brachypodium pinnatum* subsp. *pinnatum*, *Physospermum* *cornubiense, Aira elegantissima, Scleranthus perennis* subsp. *dichotomus, Chrysopogon gryllus, Thesium humile, Muscari neglectum, Trifolium arvense, Vulpia myuros, Pilosella piloselloides, Teesdalia coronopifolia, Thymus sibthorpii* and others. A significant number of herbs are diagnostic of classes Thero-Brachypodietea and Festuco-Brometea.

The *Arbutus unedo-Erica arborea* community occurs at an altitude of 386-665 m a.s.l. (386-400: 12.1%, 401-500: 54.5%, 501-600: 18.2%, 601-665: 15.2%), at various exposures (NW and NE: 69,7%, E: 18,2%, W: 9,1% and SSE: 3%), at slopes of inclination 1-50% (1-30%: 67%, 31-50%: 33%), and on acid soils which developed on granite (type Arneas). The 87.9% of the plots found in the lower or middle part of the slope and with varying microrelief.

In the *Arbutus unedo-Erica arborea* community, the variant with *Satureja vulgaris-Rubus canescens* was distinguished (Table 1: I). The variant is differentiated by a group of 14 differential species. The shrub layer cover is 65-85%, while this of the herb layer is 70-95%. The maximum height of shrubs of the variant is 1.6-5 m and the average height of the 10 highest shrubs per plot is 1.1-3.3 m. Number of taxa per plot is 24-41. The variant was found at the altitude of 386-472 m a.s.l., with northern exposures, mainly at the lower or middle part of even or concave slopes and at inclination of 4-42%. Physiographic factors of the variant reveal better soil-water conditions and suggest that the variant occurs in the best ecological locations, occupied by the community.

***Ericetum verticillatae (Cisto-Micromerietea julianae)***

The structure of the Ericetum verticillatae association is characterized by the high presence and constancy of *Erica manipuliflora* (Table 1: III & IV). The cover of the shrub layer is (15)30-70%. Except from *Erica manipuliflora, Quercus coccifera*, *Arbutus unedo*, *Anthyllis hermanniae*, *Cistus salviifolius*, *Cistus creticus* participate with lower cover and presence values. The maximum height of shrubs is 0.7-3.2 m and the average height of the 10 highest shrubs per plot is 0.6-1.4 m.

The herb layer is very dense covering 60-85% of the surface with 10-41 taxa per plot. Species of the genus *Cistus* and characteristic taxa of the classes Thero-Brachypodietea and Festuco-Brometea were identified characterized by high presence and cover.

The association is found at an altitude of 372-585 m a.s.l., mainly between 400-500 m (74.5%). There is no special preference for the exposure, and the inclinations vary from 4% to 34% (1-30%: 85.1%, 31-34%:

14.9%). The soils are acid developing on granite (Noidou 2003). The 87.2% of the plots were found in the lower or middle part of the slope and with varying microrelief.

In the Ericetum verticillatae association, the variant with *Psilurus incurvus-Trifolium campestre* was distinguished (Table 1: IV). The variant is differentiated by a group of 23 species. Cover of shrub layer reaches 15-65%, while the herbs layer the 60-85%. The maximum height of shrubs at the plots of the variant is 0.7-2.5 m and the average height of the 10 highest shrubs per plot is 0.6-1.1 m. Number of taxa per plot varies from 16 to 41. The variant was found at the altitude of 372-525 m a.s.l., mainly at the lower part of slopes and at inclinations of 4-32%. Physiographic factors of the variant reveal that it occurs in the most degraded locations of the research area.

## Conclusions

The evergreen broadleaved shrublands are assigned to the Quercetea (-alia) ilicis, as *Arbutus unedo-Erica arborea* community, and the *Erica manipuliflora* heathlands to the Cisto-Micromerietea julianae, as Ericetum verticillatae association.

High presence and cover of species of the classes Thero-Brachypodietea and Festuco-Brometea confirm the intense degradation of the vegetation.

The floristic composition of the *Erica manipuliflora* heathlands (118 taxa) and the evergreen broadleaved shrublands (141 taxa) of the research area consist of 176 taxa.

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## References

**Athanasiadis N., K. Theodoropoulos, A. Gerasimidis, E. Eleftheriadou, I. Tsiripidis and G. Korakis. 1998.** Vegetation units of the zone of evergreen broadleaved in Agion Oros (Holy Mount) - Special publication within the research programme “Report of Agion Oros (Holy Mount), Nature and Environment - Thessaloniki Cultural Capital of Europe 1997''. 87 pp.

**Bergmeier E. 1990.** Wälder und Gebüsche des Niederen Olymp (Káto Olimbos, NO-Thessalien). Ein Beitrag zur systematischen und orographischen Vegetationsgliederung Griechenlands. *Phytocoenologia* 18: 161-342.

**Braun-Blanquet J. 1964.** Pflanzensoziologie - Grundzüge der Vegetationskunde, 3 Auflage. Springer Verlang, Wien, New York. 865 pp.

**Chytrý M. and Z. Otýpková. 2003.** Plot sizes used for phytosociological sampling of European vegetation. *J. Veg. Sci*. 14: 563-570.

**Euro+Med. 2006-2011.** Euro+Med PlantBase - the information resource for Euro-Mediterranean plant diversity. Published on the Internet http://ww2.bgbm.org/EuroPlusMed/ (15/11/2011).

**Greuter W., H.M. Burdet and G. Long. 1984, 1986, 1989.** Med-checklist. A critical inventory of vascular plants of the circum-mediterranean countries, vol. 1, 3, 4. Conservatoire et Jardin Botaniques, de la Ville de Genève, Genève.

**Hennekens S. and J.H.J. Schaminée. 2001.** TURBOVEG, a comprehensive database management system for vegetation data. *J. Veg. Sci*. 12: 589-591.

**Hill M.O. 1979.** TWINSPAN- a FORTRAN program for arranging multivariate data in an ordered two way table by classification of the individuals and the attributes. Ecology and Systematics, Cornell Univ. Ithaca, USA.

**Horvat I., V. Clavač and H. Ellenberg. 1974.** Vegetation Südosteuropas. Gustav Fischer Verlag, Stuttgart.

**I.G.M.E. - Institute of Geology and Mineral Exploration (ed.) 1983.** Geological map of Greece 1:500.000, 2nd edition, Athens.

**Knapp R. 1965.** Die Vegetation von Kephallinia, Griechenland. Geobotanische Untersuchung eines mediterranen Gebietes und einige ihrer Anwendungs -Möglichkeiten in Wirtschaft und Landesplanung. Verlag Otto Koeltz, Königstein.

**Konstantinidis P. 1990.** The effect of physiography on the plant communities in forest of *Pinus halepensis*, of Sithonia Peninsula Halkidiki, N. Greece. PhD Thesis. Sci. Ann. Depart. Forest. and Nat. Environm. Thessaloniki 22(5): 145 pp.

**Krause W., W. Ludwig and F. Seidel. 1963.** Zur Kenntnis der Flora und Vegetation auf Serpentinstandorten des Balkans. 6. Vegetationsstudien in der Umgebung von Mantoudi (Euboea). *Bot. Jahrb. Syst*. 82: 337-403.

**Mountrakis D. 1985.** Geology of Greece. University Studio Press, Thessaloniki. 207 pp.

**Mucina L., J. Dengler, E. Bergmeier, A. Carni, P. Dimopoulos, R. Jahn and V. Matevski. 2009.** New and validated high-rank syntaxa from Europe. *LAZAROA* 30: 267-276.

**Noidou M. 2003.** Soil conditions of Erica heathlands. Msc Thesis. Thessaloniki. 56 pp.

**Oberdorfer E. 1954.** Nordägäische Kraut- and Zwergstrauchfluren im Vergleich mit den entsprechenden Vegetationseinheiten des westlichen Mittelmeergebietes. *Vegetatio* 5: 88-96.

**Raus Th. 1979.** Die Vegetation Ostthessaliens (Griecheland). II. Quercetea ilicis und Cisto-Micromerietea. *Bot. Jahrb. Syst*. 101: 17-82.

**Scholz H. 1986.** The Genus *Poa* (Gramineae) in Greece: Annotated check-list and key to the species. *Willdenowia* 15: 393-400.

**Stamou A. 2004.** Phytosociological research of Telethrio - Lixada - Gialtra (Evia, Greece). Msc Thesis. Thessaloniki. 73 pp.

**Strid A. and K. Tan. 1997.** Flora Hellenica, vol. 1. Koeltz Scientific Books, Königstein. 547 pp.

**Strid A. and K. Tan. 2002.** Flora Hellenica, vol. 2. A.R.G. Gartner Verlag. K.G. Ruggell. 511 pp.

**Theodoropoulos K. 1991.** Bestimmung und Klassifizierung der pflanzensoziologischen Vegetationseinheiten im Universitätswald Taxiarchis Chalkidiki. PhD Thesis. Sci. Ann. Depart. Forest. and Nat. Environm. Thessaloniki 22(18): 200 pp.

**Theodoropoulos K., C. Adamidou. E. Eleftheriadou and K. Mitsara. 2011.** Phytosociological research of *Erica manipuliflora* heaths of Xanthi (NE Greece). *Geotechnical Scientific Issues* 21(2): 5-15.

**Tichý L. 2002.** JUICE, Software for vegetation classification. *J. Veg. Sci.* 13: 451-453.

**Tutin T.G., N.A. Burges, A.O. Chater, J.R. Edmonson, V.H. Heywood, D.M. Moore, D.H. Valentine, S.M. Walters and D.A. Webb. 1993.** Flora Europaea, vol. 1. 2nd ed., Cambridge University Press, Cambridge. 629 pp.

**Tutin T.G., V.H. Heywood, N.A. Burges, D.M. Moore, D.H. Valentine, S.M. Walters and D.A. Webb. 1968, 1972, 1976, 1980.** Flora Europaea, vol. 2-5. Cambridge University Press, Cambridge.

**Weber H., E. Moravec and J.P. Theurillat. 2000.** International Code of Phytosociological Nomenclature. 3rd ed. *J. Veg. Sci*. 11: 739-768.

**Zohary M. and D. Heller. 1984.** The Genus *Trifolium*. Israel Academy of Science and Humanities, Jerusalem. 606 pp.

# Spatio-temporal analysis of sheep and goats grazing in different forage resources of Northern Greece

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## Abstract

Grazing animal moving patterns are largely affected by the shepherd himself but also related with the grazing season as well as the kind of livestock species and the available forage resources. In this paper, the spatial distribution of representative flocks of sheep and goats were recorded in different grazing areas of Askos village in Northern Greece in order to study the total time spent for the activities of feeding, moving, ruminating and standing in different forage resources during the day as well as the time they devoted for the activity of feeding during the year. It was found that sheep and goats used to a different extend the grazing areas, depending on season, and vegetation type. More specifically, during the spring period, both animal kinds spent more time (sheep 255 min/day and goats 298 min/day) in rangelands (mainly shrublands and grasslands) than in agricultural land (mainly temporal pastures and fallow land; 108 min/day for sheep and 123 min/day for goats). During summer, goats used more agricultural land (mainly cereal stubble and fallow land) than rangelands (325 min/day and 255 min/day, respectively), while sheep did the opposite (270 min/day and 398 min/day, respectively). Rangelands were mainly used during the winter period, when weather conditions allowed animals to graze (2475 min/day for sheep and 3025 min/day for goats). It seems that animals spent more time searching for feed in rangelands and this was more pronounced during spring for goats and in summer for sheep. Agricultural land and rangelands supplemented each other in providing forage throughout the year, while animal activities were diversified according to animal kind and season.

**Key words***:* small ruminant grazing activities, rangelands, Greece

## Introduction

The production system of sheep and goats in northern Greece is based traditionally on grazing of communal rangelands, which can provide forage to animals for only 6-7 months during the year (Yiakoulaki et al. 2003). Agricultural land (e.g. fallow land and temporary pastures during spring as well as cereal stubble after harvesting in summer) are used alternatively by farmers to fill the feed gap in the remaining months of the year.

Rangeland and agricultural land use depends to a great extent on grazing animal moving patterns, which are largely affected by the shepherd himself, but also related with the grazing season as well as the kind of livestock species and forage availability. Sheep and goat flocks following specific grazing circuits from sheds to these diversified forage resources come across an extremely heterogeneous environment which dictates their behaviour, especially their feeding, moving and standing activities (Evangelou et al. 2008).

In this paper, the spatial distribution of representative flocks of sheep and goats were recorded in communal mediterranean rangelands as well as agricultural land, in order to study the total time spent for grazing in different forage resources during the day as well as the time they devoted to the various activities during the year.

**Material and methods**

The research was conducted in the Askos village of the Lagadas County, located northeast to the city of Thessaloniki, Northern Greece, during spring and summer of 2007 and winter of 2008. The study area has a total surface of 7,871 ha. Mean annual precipitation is 556 mm and mean air minimum temperature is 3 $^{0}$C, indicating a semi arid mediterranean climate. Topography varies with the flat areas occupied by arable lands and the hills and mountains covered by natural vegetation. The latter is dominated by evergreen shrublands mainly composed of kermes oak (*Quercus coccifera* L.) interspersed by openings with herbaceous species (Hugues et al. 2008). The available resources were classified as rangelands (grasslands, shrublands and forest ranges) and agricultural land (temporary pastures, fallow land and cereal stubbles after harvesting). The experimental animals were raised for milk and meat purposes. They were moved by shepherds to grazing areas during the largest part of the day while at night they were sheltered in sheds.

Animal activities of four representative sheep and goats flocks (two flocks from each animal kind) were recorded in different seasons of the year. A focal sampling technique (Altman, 1974) was applied in six adult female animals (three sheep and goats of each flock) which have randomly selected. These animals were marked with large numbers on their sides for identification. The animals were followed continuously with a sampling period of 10 minutes, by three observers for two consecutive days in each studied period. The recorded activities were:

- feeding time (the time that animals spent for grazing and browsing),
- moving time (the time that animals spent for moving from one site to another site),
- standing time (the time that animals stopped all their activities and stood inactive),

- ruminating time and
- laying time (the time animals devoted for laying or rest)

During the experimental periods, the daily track of the flocks was recorded with the use of a handheld GPS. This route was exported into ArcGIS and segments of 10 minutes as sampling units were cut. Each segment was overlayed with a detailed land use map, which was created from IKONOS image (acquisition date November 2007) and from field records.

Animal activities of each flock were grouped according to the season, animal kind and forage resource. The average time devoted from sheep and goats to the different forage resources were subjected to Univariate Analysis of Variance (General Linear Model) with SPSS and, when needed, LSD test was applied for multiple comparisons (SPSS Inc. 2001).

**Results and discussion**

Taking into account the time spent (Table 1) for feeding in relation to other activities (moving, standing, and ruminating), it was found that both kind of animals spent for this activity less time in rangelands in comparison to agricultural land ($P \leq 0.05$) during spring and summer. Sheep spent more time for feeding than goats during spring, while in summer the opposite ($P \leq 0.05$) happened. During winter, animals were found to graze only in rangelands, while there was no significant difference ($P \leq 0.05$) in feeding time between animal kinds. Goats were found to spend more time for moving than sheep during spring and summer ($P \leq 0.05$). Only in summer, feeding, moving and standing showed interaction between animal kind and resources with significant differences ($P \leq 0.05$). Sheep were not found laying, while goats devoted only a very small part of their total time (less than 2%). For this reason, this activity was not considered in further analyses.

Grazing animals used to a different extend the grazing areas, depending on season, resource type and animal kind. Converting the percentage of time of Table 1 in minutes per day it comes out that during the spring season, both animal kinds spent more time (255 min/day and 298 min/day for sheep and goats, respectively) in rangelands than in agricultural land (108 min/day for sheep and 123 min/day for goats). During summer, goats used more agricultural land than rangelands (325 min/day and 255 min/day, respectively). On the contrary, sheep used more the rangelands compared to stubble fields (270 min/day and 398 min/day, respectively). Rangelands were mainly used during the winter period, when weather conditions allowed animal to graze. The corresponding time was 248 min/day for sheep and 303 min/day for goats. Animals also spent more time during the day for feeding, moving and standing, in comparison to ruminating and laying.

**Table 1.** Percentage of time (%) devoted to animal activities by sheep and goats on different resources during spring, summer and winter

| Season | Animal Activities | Animal kind | | Forage resource | |
|---|---|---|---|---|---|
| | | Sheep | Goats | Rangelands | Agricultural land |
| Spring | Feeding | 61.9a[1] | 40.6b | 38.9b[1] | 63.6a |
| | Moving | 19.4b | 38.0a | 32.1a | 25.3b |
| | Ruminating | 1.8a | 4.9a | 3.2a | 3.6a |
| | Standing | 16.9a | 14.3a | 25.2a | 6.1b |
| Summer | Feeding | 31.4b | 40.1a | 18.1b | 53.4a |
| | Moving | 24.6b | 34.9a | 21.6b | 38.0a |
| | Ruminating | 0.2b | 2.0a | 1.3a | 0.9a |
| | Standing | 43.8a | 22.8b | 58.9a | 7.7b |
| Winter | Feeding | 57.8a[2] | 52.2a | - | - |
| | Moving | 34.7a | 33.5a | - | - |
| | Ruminating | 0.2b | 3.7a | - | - |
| | Standing | 7.4a | 9.6a | - | - |

[1]Means of animal kind or forage resource within the same row followed by a common letter were not significantly different (*P≤ 0.05*). [2]Means of animal kind within the same row followed by a common letter were not significantly different (*P≤ 0.05*)

Percentage of time devoted to animal activities by sheep and goats on different type of resources (grasslands, shrublands and forest ranges as well as fallow, stubble fields and temporary pastures) is presented in Table 2. Specifically, animals spent more time (*P≤ 0.05*) for moving in cereal stubble fields during summer compared to fallow land and temporary pastures.

Furthermore, in agricultural land, sheep spent significantly more time (*P≤ 0.05*) for feeding than goats, while goats spent more time for moving and ruminating. Finally, moving activity in both resources was found to interact between animal kind and resource type (*P≤ 0.05*).

**Table 2.** Percentage of time (%) devoted to animal activities by sheep and goats on different type of resources

| Resource | Animal activities | Animal kind: Sheep | Animal kind: Goats | Resource type: Grasslands | Resource type: Shrublands | Resource type: Forest ranges |
|---|---|---|---|---|---|---|
| Rangelands | Feeding | 33.4a[1] | 35.0a | 32.8a | 37.6a | 30.2a |
| | Moving | 31.9a | 40.7a | 34.9a | 34.0a | 43.7a |
| | Ruminating | 1.5a | 2.8a | 2.3a | 1.4a | 3.4a |
| | Standing | 33.3a | 20.5a | 29.5a | 26.5a | 22.3a |
| | | Sheep | Goats | Fallows | Cereals | Temporary pastures |
| Agricultural land | Feeding | 66.6a | 49.8b | 61.8a | 52.3a | 60.5a |
| | Moving | 28.8b | 35.9a | 29.9b | 38.9a | 28.1b |
| | Ruminating | 0.0b | 3.5a | 0.9a | 1.2a | 3.3a |
| | Standing | 4.6a | 9.9a | 6.6a | 7.6a | 7.6a |

[1]Means of animal kind or resource type within the same row followed by a common letter were not significantly different (*P≤ 0.05*)

## Conclusions

Animals spent more time searching for feed in rangelands than in agricultural land and this was more pronounced during spring for goats and in summer for sheep. Agricultural land and rangelands supplemented each other in providing forage throughout the year, while animal activities were diversified according to animal kind and season.

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## References

**Altman J. 1974.** Observational study of behavior: Sampling methods. *Behaviour* 49, 227-267.

**Evangelou Ch., M.D. Yiakoulaki and V.P. Papanastasis. 2008.** Evaluation of sheep and goats breeding system and the subsidies paid in Askos village community of Lagadas county, Prefecture of Thessaloniki. In: K. Mantzanas and V.P. Papanastasis (eds). Range science and

Protected Areas. Proceeding of the 6th Panhellenic Rangeland Congress in Leonidio Arcadia Peloponnesus. pp 179-185. (In Greek with English summary).

**Hugues L., Ch. Evangelou, M. Stellmes, J. Hill, V.P. Papanastasis, G. Tsiourlis, A. Roeder and E.F. Lambin. 2008.** Land degradation and economic conditions of agricultural households in a marginal region of northern Greece. *Global and Planetary Change* 64: 198–209.

**SPSS Inc. 2001.** SPSS Base 11.0 for Windows User's Guide. SPSS Inc., Chicago IL.

**Yiakoulaki M.D., M.P. Zarovali, I. Ispikoudis and V.P. Papanastasis. 2003.** Evaluation of small ruminants’ production systems in the area of Lagadas County, Greece. In: P. Platis and T. Papachristou (eds). Range Science and Development of Mountainous Regions. Proceeding of the the 3rd Panhellenic Rangeland Congress in Karpenisi Greece, pp. 395-402. (In Greek with English summary).

# Orchid species distribution in rangelands of Epirus, Greece

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## Abstract

The orchid family (*Orchidaceae* L.) is one of the richest plant families in the world, including at least 24,000 species and subspecies. In Greece the number exceeds 200 taxa, while the endemics are 50 or more. These numbers often change, as new species are described or others considered until recently as endemics in Greece, are recorded in neighbouring countries. This research carried out at various rangeland types of Epirus region. A total of 58 species and subspecies were identified. The majority of taxa belong to the genera *Ophrys* and *Orchis*. The results revealed that the highest number of taxa (37) exists in forest openings and silvopastoral systems especially of oak trees, followed by 25 taxa in grasslands and 22 taxa in open shrublands (evergreen broadleaved species). The lower orchid richness, 17 taxa, was found in the phryganic ecosystems. As a conclusion, rangeland ecosystems of Epirus are significantly rich in orchids and their conservation, especially in oak silvopastoral systems, seems to be of particular importance for the maintenance of orchid diversity.

**Key words:** Epirus, orchids, rangeland types, oak silvopastoral systems.

## Introduction

The various rangeland types in Greece, namely grasslands, phryganic ecosystems, shurblands, and silvopastoral systems including forest openings, are rich in herbaceous plant species and orchids (Papanastasis and Noitsakis 1992). The orchid family (*Orchidaceae* L.) is one of the richest plant families in the world, including at least 24,000 species and subspecies (Chase and Fay 2009). According to Delforge (2006), in Greece the number exceeds 200 taxa, while the endemics are 50 or more. These numbers often change, as new species are described or others considered until recently as endemics in Greece, are recorded in neighbouring countries (Antonopoulos 2009). The research referring to the orchids in Epirus is limited and few data are available mainly from general floristic studies of orchids in Greece (Antonopoulos 2009, Petrou et al. 2011).

The aim of the study is to record the orchid flora in different rangeland types of Epirus and to estimate their orchid species richness, accessing in that way their importance as possible orchid habitat.

**Materials and methods**

Epirus occupies the northwestern part of Greece (Fig.1). It is one of the most mountainous regions, with intense and complex geomorphology, extending from the Ionian Sea to the ridges of the mountain range of Pindos. These features, combined with abundance of water resources, create a variety of habitats of particular importance.

The study area was extended all over the area of Epirus, including the high mountains as well as the Ionian coast (Fig.1). Each site, where one or more orchid taxa were recorded, defines a specific collecting locality. At each collecting locality, the following data were recorded: the site, the geographical coordinates, the altitude and the type of rangeland. The data were sampled during the years 2009-2011 with excursions mostly in spring and summer.


**Fig 1.** Map of Greece with the study area**.**

The identification of the orchid species and subspecies based mainly on photography and was made according to Buttler (1991), Baumann et al. (2006), Delforge (2006). The nomenclature is largely followed Delforge (2006), Kreutz (2004) and Kretzschmar et al. (2007).

**Results and Discussion**

A total of 58 species and subspecies were identified (Table 1).

**Table 1.** List of orchid species in different rangeland types in Epirus.

| | Species/Subspecies | Altitude (m) | Grass-lands | Phry-ganic | Shrub-lands | Silvopa-storal |
|---|---|---|---|---|---|---|
| 1 | *Anacamptis coriophora* (L.) R.M. Bateman, Pridgeon & Chase | 300-400 | ✓ | | | |
| 2 | *Anacamptis coriophora* (L.) R.M. Bateman, Pridgeon & Chase subsp. *fragrans* (Pollini) R.M. Bateman, Pridgeon & Chase | 200-300 | ✓ | | | ✓ |
| 3 | *Anacamptis laxiflora* (Lamarck) R.M. Bateman, Pridgeon & Chase | 0-1000 | ✓ | ✓ | ✓ | |
| 4 | *Anacamptis morio* (L.) R.M. Bateman, Pridgeon & Chase | 250-1350 | ✓ | ✓ | ✓ | ✓ |
| 5 | *Anacamptis papillionacea* (L.) R.M. Bateman, Pridgeon & Chase | 200-900 | ✓ | | ✓ | |
| 6 | *Anacamptis picta* (Loiseleur) R.M.Bateman | 400-900 | ✓ | | | |
| 7 | *Anacamptis pyramidalis* (L.) Richard | 400-900 | ✓ | ✓ | ✓ | |
| 8 | *Cephalanthera longifolia* (L.) Fritsch | 700-1250 | | | | ✓ |
| 9 | *Cephalanthera rubra* (L.) Richard | 250-1300 | | | | ✓ |
| 10 | *Dactylorhiza incarnata* (L.) Soó | 1350 | ✓ | | | |
| 11 | *Dactylorhiza kalopissii* E.Nelson | 1250-1350 | ✓ | | | ✓ |
| 12 | *Dactylorhiza saccifera* (Brongniart) Soó | 750-1300 | ✓ | | | ✓ |
| 13 | *Dactylorhiza sambucina* (L.) Soó | 900-1500 | ✓ | ✓ | ✓ | ✓ |
| 14 | *Dactylorhiza smolikana* B.&E.Willing | 1350 | ✓ | | | |
| 15 | *Epipactis atrorubens* ( Hoffm. ) Besser subsp. *spiridonovii* (J.Devillers-Terschuren & P.Devillers) Kreutz | 1400 | | | | ✓ |
| 16 | *Epipactis atrorubens* ( Hoffm. ) Besser subsp. *subglausa* (Robatsch) Kreutz | 950-1200 | | | | ✓ |

| | | | | | | |
|---|---|---|---|---|---|---|
| 17 | *Epipactis helleborine* (L.) Crantz | 900-1300 | | | | ✓ |
| 18 | *Epipactis leptochila* ( Godfery ) Godfery subsp. *neglecta* Kümpel | 1350 | | | | ✓ |
| 19 | *Epipactis microphylla* (Ehrhardt) Swartz | 1100 | | | | ✓ |
| 20 | *Epipactis palustris* (L.) Crantz | 1300 | | | | ✓ |
| 21 | *Epipactis placentina* Bongiorni & P.Grünanger ?(*) | 1300 | | | | ✓ |
| 22 | *Gymnadenia conopsea* (L.) R.Brown | 1100-1400 | | | | ✓ |
| 23 | *Himantoglossum caprinum* (F.A.M. von Bieberstein) Sprengel | 250-1300 | | | | ✓ |
| 24 | *Himantoglossum robertianum* (Loiseleur) Delforge | 150-900 | | ✓ | ✓ | ✓ |
| 25 | *Limodorum abortivum* (L.) Swartz | 700-1400 | | | | ✓ |
| 26 | *Neotinea lactea* (Poiret) R.M.Bateman, Pridgeon & Chase | 200 | | ✓ | | |
| 27 | *Neotinea maculata* (Desfontaines) Stearn | 900 | | | | ✓ |
| 28 | *Neotinea tridentata* (Scopoli) R.M.Bateman, Pridgeon &Chase | 750-900 | ✓ | ✓ | | |
| 29 | *Neottia nidus-avis* (L.) Richard | 450-1000 | | | | ✓ |
| 30 | *Neottia ovata* (L.) Bluff & Fingerhuth | 400-1400 | ✓ | | | ✓ |
| 31 | *Ophrys apifera* Hudson | 400-750 | ✓ | ✓ | ✓ | |
| 32 | *Ophrys epirotica* (Renz) J.Devillers-Terschuren & P.Devillers | 250-1000 | ✓ | ✓ | ✓ | ✓ |
| 33 | *Ophrys grammica* (B.&E.Willing) J.Devillers-Terschuren & P.Devillers | 400 | | | ✓ | |
| 34 | *Ophrys helenae* Renz | 200-900 | ✓ | ✓ | ✓ | ✓ |
| 35 | *Ophrys herae* Hirth & Spaeth | 400-500 | | ✓ | | |
| 36 | *Ophrys hystera* C.A.J. Kreutz & R.Peter | 900 | | | ✓ | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 37 | *Ophrys leucophthalma* J.Devillers-Terschuren & P.Devillers | 500 | ✓ | | | |
| 38 | *Ophrys mammosa* Desfontaines | 500-900 | ✓ | | ✓ | ✓ |
| 39 | *Ophrys oestifera* Steven in M.-Bieberstein | 250-900 | ✓ | | ✓ | ✓ |
| 40 | *Ophrys oestifera* M.Bieb. subsp. *bicornis* (Sadler ex Nendt.) Kreutz | 600 | | | ✓ | |
| 41 | *Ophrys phryganae* J.Devillers-Terschuren & P.Devillers | 350-600 | | ✓ | ✓ | ✓ |
| 42 | *Ophrys reinholdii* Spruner ex Fleischm. | 50-100 | | ✓ | | |
| 43 | *Ophrys sicula* Tineo | 200-600 | ✓ | ✓ | | |
| 44 | *Ophrys spruneri* Nyman | 50-100 | | ✓ | | |
| 45 | *Ophrys zeusii* M.Hirth | 300 | | | | ✓ |
| 46 | *Orchis italica* Poiret | 250-450 | ✓ | ✓ | | ✓ |
| 47 | *Orchis mascula* (L.) L. | 900-1400 | ✓ | | ✓ | ✓ |
| 48 | *Orchis mascula* (L.) L. subsp. *pinetorum* (Boissier & Kotschy) E.G. Camus, Bergon & A.Camus | 900-1350 | | | | ✓ |
| 49 | *Orchis pauciflora* Tenore | 900-1250 | ✓ | | ✓ | ✓ |
| 50 | *Orchis provincialis* Balb. ex Lam. & DC. | 250-1000 | | | ✓ | ✓ |
| 51 | *Orchis purpurea* Hudson | 500-1000 | | | ✓ | ✓ |
| 52 | *Orchis quantripunctata* Cyrillo ex Ten. | 600-1250 | | ✓ | ✓ | ✓ |
| 53 | *Orchis simia* Lamarck | 400-1000 | | | ✓ | |
| 54 | *Orchis spitzelii* Sauter ex W.D.J.Koch | 900-1000 | | | | ✓ |
| 55 | *Platanthera chlorantha* (Custer) Reichenbach | 250-900 | | | | ✓ |
| 56 | *Serapias bergonii* E.G.Camus | 0-50 | ✓ | | | |
| 5 | *Serapias vomeracea* (Burm.f.) | 800 | | | | ✓ |

| | | | | |
|---|---|---|---|---|
| 7 | Briq. | | | |
| 58 | *Spiranthes spiralis* (L.) Chevallier | 100-1000 | ✓ | |

*(*) Reported for the first time in Greece, needs further research*

The majority of taxa belong to the genera *Ophrys* (15 taxa) and *Orchis* (9 taxa). The results revealed that the highest number of taxa (37) exists in forest openings and silvopastoral systems especially of oak trees, followed by 25 taxa in grasslands and 22 taxa in open shrublands, mainly of evergreen broadleaved species. The lower orchid richness, 17 taxa, was found in phryganic ecosystems. Regarding the silvopastoral types according the tree species, oaks had the higher number of orchid taxa followed by coniferous and other broadleaved species (Table 2).

**Table 2.** Number of orchid taxa in different silvopastoral types in region of Epirus.

| Silvopastoral types according to tree species | Number of orchid taxa |
|---|---|
| Oak | 25 |
| Pines | 20 |
| Firs | 15 |
| Other broadleaved species | 3 |

## Conclusions

1. Rangeland ecosystems of Epirus are significantly rich in orchids with 58 recorded taxa.
2. Silvopastoral systems play a major role in orchid diversity. Depending on that, their conservation seems to be of particular importance for the maintenance of orchid diversity (Tsiftsis et al. 2005, Tsiftsis et al. 2008, Tsiftsis 2009).

## References

**Antonopoulos Z. 2009.** The Bee Orchids of Greece. Mediterraneo Editions, Rethymno. 320 pp.

**Baumann H., S. Künkele and R. Lorenz. 2006.** Die Orchideen Europas mit angrenzenden Gebieten. Ulmer Verlag, Stuttgart. 333 pp.

**Butler K.P. 1991.** Field guide to the orchids of Britain and Europe. English edition, The Crowood Press, Swindon. 288 pp.

**Chase M.W. and M.F. Fay. 2009.** Orchid biology: from Linnaeus via Darwin to the 21st century. *Annals of Botany*, 104:359–364.

**Delforge P. 2006.** Orchids of Europe, North Africa and the Middle East. English Edition, A and C Black Publishers, London. 640 pp.

**Kretzschmar H., W. Eccarius and H. Dietrich. 2007.** The Orchid Genera *Anacamptis*, *Orchis, Neotinea*. EchinoMedia Verlag. 544 pp.

**Kreutz C.A.J. 2004.** Kompendium der Europäischen Orchideen. Kreutz Publishers, Landgraaf. 239 pp.

**Papanastasis V.P. and V.I. Noitsakis. 1992.** Rangeland Ecology. Giahoudi-Giapouli Editions, Thessaloniki. 256 pp.

**Petrou N., M. Petrou and M. Giannakoulias. 2011.** Orchids of Greece, Koan Publiching House, Athens. 320 pp.

**Tsiftsis S., V. Karagiannakidou and I. Tsiripidis. 2005.** Orchid species richness in the mountains and the habitat types of east Macedonia (NE Greece). Proceedings of the 10th Panhellenic Scientific Conference of the Hellenic Botanical Society, Ioannina. pp. 1-9.

**Tsiftsis, S., I. Tsiripidis, V. Karagiannakidou and D. Alifragis. 2008.** Niche analysis and conservation of the orchids of east Macedonia (NE Greece). *Acta Oecologia* 33:27-35.

**Tsiftsis S. 2009.** The Orchids (Orchidaceae) of E. Macedonia: Distribution, Ecology and High Conservation Value Areas. Ph D Thesis, Aristotle University of Thessaloniki. 270 pp. (in Greek with English Summary)

# Distribution of Leguminosae taxa in habitat types of northern Greece

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## Abstract

The plant family of Leguminosae includes many taxa of high economical and ecological value. The present paper aims at the investigation of Leguminosae taxa distribution in habitat types of northern Greece. Published data from floristic and vegetation works, as well as, unpublished field data were used to explore their habitat preferences. Results revealed that Leguminosae taxa found in salt meadows and dunes are few; most of them occur in (sub-) continental forests and grasslands: a) a group including taxa growing at lowland grasslands (e.g. *Trifolium cherleri*), b) another group comprised of taxa occurring at higher altitudes and mainly at subalpine grasslands (e.g. *Anthyllis montana* ssp. *jacquinii, Onobrychis montana* ssp. *scabrica*), c) a third group representing taxa found mainly in thermophilous scrubs (e.g. *Calicotome villosa*, *Anthyllis hermanniae*), d) a fourth group concerning taxa occurring in azonal forests (e.g. *Gleditsia triacanthos*, *Robinia pseudoacacia*), and e) a fifth group of taxa found in submediterranean and subcontinental forests (e.g. *Vicia grandiflora*, *Trifolium alpestre, Lathyrus vernus,*). Some species have a broad niche breadth, such as *Trifolium fragiferum, T. campestre* and *Lotus corniculatus*, occurring in a high variety of habitats.

**Key words:** legumes, natural ecosystems, Macedonia, Thrace.

## Introduction

Leguminosae include some of the most valuable species of the plant kingdom due to their high ecological and economic value. Their ecological value lies mainly in their ability to bind nitrogen from the atmosphere and thus improving soil fertility, contributing decisively to the productivity of natural ecosystems. Their economic value lies to their extensive usage as food for both humans and animals (as hay or forage material) due to their high protein content (Papanastasis et al. 1999, White et al. 2002). This is the reason that many countries (eg. New Zealand, Australia, Argentina) have introduced non-native legume species to use them as animal feed (Real et al. 2008). In addition, legumes are also used in pharmacology, in beekeeping, dye industry etc. (Ricciarelli et al. 2000, Merou et al. 2007). Northern Greece has a high diversity of habitats including ammophilous plant communities and maquis at the lower altitudes up to beech and spruce forests on the high mountains (Dafis et al. 2001). These habitats host many species of the legume family (Strid & Tan 1991, Merou et al. 2007).

The aim of this study is to investigate the legume taxa distribution in habitat types in the area of northern Greece.

## Materials and Methods

The study area comprises northern Greece and covers, specifically, Macedonia and Thrace. In this area, many habitat types and species of high conservation value occur, a fact that is evident from the high number of sites dedicated to conservation of biodiversity (e.g. NATURA 2000 sites, Ramsar sites; Dafis et al. 2001). The main vegetation types found in the area are coastal, wetland, grassland (natural and semi-natural), shrubland, deciduous broadleaved forests, sub-continental broadleaved deciduous forests and coniferous forests. In the lowlands, natural vegetation is scarce, replaced mainly by rural and urban lands.

Data used in the analyses come from published and unpublished relevés concerning the study area. A database was created including, approximately, 3700 relevés of different authors and from different localities (reference list of data sources are available from the authors upon request). Additionally, 1123 unpublished relevés were included in the data base. Relevés data were imported in Juice 7.0 (Tichý 2001) software. Taxa with absolute constancy equal or lower to four were omitted before the analyses to reduce noise. Relevés were classified by means of TWINSPAN analysis (Hill 1979). Three pseudospecies cut-levels, namely 0, 5 and 25, were used. In the analyzed data, 127 legume taxa occurred. The relative constancy of these species in the distinguished vegetation units was used to determine their fidelity to certain vegetation types, applying the algorithm of Tsiripidis et al. (2009).

Nomenclature of taxa follows Strid & Tan (1997, 2002), Greuter et al. (1984-1989), Strid (1986), Strid & Tan (1991) and Tutin et al. (1968-1993).

## Results and Discussion

TWINSPAN analysis distinguished at the second level of divisions the coastal vegetation (170 relevés), the inland aquatic vegetation (130 relevés) (these two former vegetation types host few Leguminosae taxa; e.g. *Trifolium tomentosum*), the synanthropic vegetation (58 relevés), where 12 Leguminosae taxa are found (mainly of genus *Vicia*), and the sub-continental forests and grasslands. Higher levels of divisions were applied in the latter vegetation group (see Table 1), where most of the Leguminosae taxa occur. These divisions revealed the existence of several generalists legumes (e.g. *Trifolium nigrescens, Medicago rigidula, Trifolium tenuifolium*), occurring in many vegetation types, albeit their preference to the thermophilous deciduous broadleaved forests. Most of these species are not diagnostic of forest vegetation classes (Braun-Blanquet (1964) hierarchical classification), but of vegetation types without tree cover (see Mucina 1997). These species have entered in the thermophilous deciduous broadleaved forests because of the forest structure (e.g. coppice forests) as well as their degradation due to intense logging or grazing (Theodoropoulos 1991, Fotiadis 2004).

**Table 1.** Relative constancy of Leguminosae taxa in the vegetation units of northern Greece. Dark grey color indicate a positive fidelity of taxa to certain vegetation groups and light grey color indicate a negative fidelity vs. the former vegetation groups and a positive one vs. the rest groups. (1: coastal vegetation, 2: inland aquatic vegetation, 3: synanthropic vegetation, 4: lowland meadows, 5: subalpine grasslands, 6: shrublands of low canopy and degraded, and shrub like oak forests, 7: thermophilous shrublands of evergreen and deciduous broadleaved species, 8: azonal forests, 9: thermophilous, sub-Mediterranean deciduous broadleaved forests, 10: sub-continental broadleaved deciduous forests)

| Groups | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| *Lotus preslii* | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Medicago marina* | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Trifolium tomentosum* | 91.7 | 0 | 0 | 0 | 0 | 8.33 | 0 | 0 | 0 | 0 |
| *Lotus glaber* | 66.7 | 25 | 0 | 0 | 0 | 0 | 0 | 8.33 | 0 | 0 |
| *Melilotus albus* | 52 | 20 | 0 | 0 | 0 | 0 | 0 | 24 | 4 | 0 |
| *Ononis spinosa* | 44.4 | 22.2 | 0 | 0 | 0 | 8.36 | 25 | 0 | 0 | 0 |
| *Lathyrus annuus* | 0 | 0 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Trigonella foenum-graecum* | 0 | 0 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Vicia hybrida* | 0 | 0 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Vicia narbonensis* | 0 | 0 | 97.3 | 0 | 0 | 0 | 0 | 0 | 2.7 | 0 |
| *Vicia peregrina* | 0 | 0 | 97.3 | 0 | 0 | 2.7 | 0 | 0 | 0 | 0 |
| *Vicia lutea* | 0 | 0 | 96 | 0 | 0 | 0 | 0 | 0 | 4 | 0 |
| *Lathyrus cicera* | 0 | 0 | 91.2 | 0 | 0 | 0 | 2.94 | 0 | 5.88 | 0 |
| *Vicia pannonica* | 0 | 0 | 88.9 | 0 | 0 | 0 | 0 | 0 | 11.1 | 0 |
| *Melilotus indicus* | 28.6 | 0 | 64.3 | 0 | 0 | 0 | 0 | 7.14 | 0 | 0 |
| *Coronilla scorpioides* | 0 | 0 | 56 | 0 | 24 | 4 | 4 | 0 | 12 | 0 |
| *Lotus pedunculatus* | 0 | 33.3 | 0 | 66.7 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Trifolium cherleri* | 0 | 0 | 0 | 100 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Trifolium strictum* | 0 | 0 | 0 | 100 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lotus angustissimus* | 0 | 0 | 0 | 92.3 | 0 | 0 | 7.69 | 0 | 0 | 0 |
| *Trifolium purpureum* | 14.3 | 0 | 0 | 71.4 | 0 | 14.3 | 0 | 0 | 0 | 0 |
| *Medicago monspeliaca* | 0 | 0 | 0 | 37.5 | 0 | 25 | 0 | 25 | 12.5 | 0 |
| *Hippocrepis ciliata* | 0 | 0 | 0 | 57.1 | 0 | 14.3 | 28.6 | 0 | 0 | 0 |
| *Onobrychis caput-galli* | 0 | 0 | 0 | 38.5 | 0 | 0 | 15.4 | 0 | 30.8 | 15.4 |
| *Trifolium tenuifolium* | 0 | 0 | 0 | 43.8 | 0 | 0 | 18.8 | 0 | 37.5 | 0 |
| *Trifolium scabrum* | 0 | 0 | 0 | 56.7 | 0 | 0 | 16.7 | 0 | 26.7 | 0 |
| *Medicago minima* | 0 | 0 | 0 | 38.4 | 6.85 | 4.11 | 17.8 | 1.37 | 31.5 | 0 |
| *Genista lydia* | 0 | 0 | 0 | 21.6 | 37.8 | 0 | 0 | 0 | 8.11 | 32.4 |
| *Anthyllis aurea* | 0 | 0 | 0 | 0 | 100 | 0 | 0 | 0 | 0 | 0 |
| *Anthyllis montana* ssp. *jacquinii* | 0 | 0 | 0 | 0 | 100 | 0 | 0 | 0 | 0 | 0 |
| *Onobrychis montana* ssp. *scardica* | 0 | 0 | 0 | 0 | 100 | 0 | 0 | 0 | 0 | 0 |
| *Astragalus angustifolius* | 0 | 0 | 0 | 0 | 93.3 | 0 | 0 | 0 | 6.67 | 0 |
| *Hippocrepis comosa* | 0 | 0 | 0 | 0 | 92.9 | 0 | 0 | 0 | 7.14 | 0 |
| *Genista depressa* | 0 | 0 | 0 | 0 | 84.6 | 0 | 0 | 0 | 0 | 15.4 |
| *Chamaecytisus polytrichus* | 0 | 0 | 0 | 0 | 83.3 | 0 | 0 | 0 | 0 | 16.7 |
| *Anthyllis vulneraria* | 0 | 0 | 0 | 18.2 | 72.7 | 3.03 | 0 | 0 | 6.06 | 0 |
| *Trifolium heldreichianum* | 0 | 0 | 0 | 0 | 71.1 | 0 | 0 | 0 | 20 | 8.89 |
| *Trifolium fragiferum* | 25.7 | 11.4 | 0 | 0 | 0 | 60 | 0 | 0 | 0 | 2.86 |
| *Onobrychis gracilis* | 0 | 0 | 0 | 0 | 0 | 57.9 | 31.6 | 0 | 10.5 | 0 |
| *Pisum sativum* ssp. *sativum* | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | 0 | 0 |
| *Calicotome villosa* | 0 | 0 | 0 | 0 | 0 | 0 | 96.2 | 0 | 3.77 | 0 |
| *Cercis siliquastrum* | 0 | 0 | 0 | 0 | 0 | 0 | 88.2 | 0 | 11.8 | 0 |
| *Cytisus villosus* | 0 | 0 | 0 | 0 | 0 | 0 | 83.3 | 0 | 16.7 | 0 |
| *Trifolium grandiflorum* | 0 | 0 | 0 | 0 | 0 | 0 | 80 | 0 | 20 | 0 |
| *Spartium junceum* | 0 | 0 | 0 | 0 | 0 | 0 | 78.9 | 0 | 21.1 | 0 |
| *Anthyllis hermanniae* | 12.1 | 0 | 0 | 8.62 | 0 | 3.45 | 60.3 | 0 | 15.5 | 0 |
| *Lupinus angustifolius* | 0 | 0 | 0 | 0 | 0 | 0 | 66.7 | 0 | 33.3 | 0 |
| *Gleditsia triacanthos* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | 0 |
| *Amorpha fruticosa* | 0 | 7.14 | 0 | 0 | 0 | 0 | 0 | 92.9 | 0 | 0 |
| *Robinia pseudoacacia* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 92 | 8 | 0 |
| *Melilotus officinalis* | 14.3 | 0 | 0 | 0 | 0 | 28.6 | 7.14 | 35.7 | 14.3 | 0 |
| *Medicago polymorpha* | 0 | 0 | 31.1 | 0 | 0 | 2.22 | 2.22 | 17.8 | 46.7 | 0 |
| *Vicia sativa* | 0 | 0 | 49.4 | 0 | 0 | 0 | 2.33 | 30.2 | 60.5 | 6.98 |
| *Trifolium nigrescens* | 5 | 5 | 0 | 35 | 0 | 25 | 0 | 7.5 | 22.5 | 0 |
| *Trifolium campestre* | 0 | 0 | 0.96 | 26.3 | 2.87 | 16.7 | 8.13 | 0.96 | 40.7 | 3.35 |
| *Astragalus onobrychis* | 0 | 0 | 0 | 36 | 0 | 20 | 4 | 4 | 36 | 0 |
| *Trifolium angustifolium* | 0 | 0 | 0 | 25.5 | 0 | 22.4 | 10.2 | 0 | 41.8 | 0 |
| *Medicago rigidula* | 0 | 0 | 0 | 23.1 | 7.69 | 7.69 | 23.1 | 0 | 38.5 | 0 |
| *Melilotus neapolitanus* | 0 | 0 | 0 | 0 | 0 | 20 | 40 | 20 | 20 | 0 |
| *Medicago falcata* | 0 | 0 | 25 | 2.27 | 2.27 | 27.3 | 6.82 | 0 | 36.4 | 0 |
| *Trifolium hirtum* | 0 | 0 | 0 | 0 | 0 | 35.8 | 1.49 | 0 | 62.7 | 0 |
| *Trifolium stellatum* | 0 | 0 | 0 | 0 | 0 | 27.8 | 27.8 | 0 | 44.4 | 0 |
| *Medicago arabica* | 0 | 0 | 13.5 | 0 | 0 | 21.2 | 0 | 32.7 | 32.7 | 0 |
| *Hippocrepis emerus* ssp. *emeroides* | 0 | 0 | 0 | 0 | 10.8 | 0 | 28.8 | 6.31 | 51.4 | 2.7 |
| *Bituminaria bituminosa* | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 0 | 50 | 0 |
| *Astragalus monspessulanus* | 0 | 0 | 0 | 0 | 9.09 | 3.03 | 33.3 | 0 | 54.5 | 0 |
| *Trifolium patens* | 0 | 4.76 | 9.52 | 0 | 0 | 0 | 23.8 | 23.8 | 38.1 | 0 |
| *Trifolium physodes* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 |
| *Trifolium leucanthum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 |
| *Medicago sativa* | 0 | 7.14 | 0 | 0 | 0 | 0 | 0 | 0 | 92.9 | 0 |
| *Lathyrus sphaericus* | 0 | 0 | 0 | 0 | 0 | 3.37 | 2.25 | 2.25 | 92.1 | 0 |
| *Lathyrus digitatus* | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 0 | 90 | 0 |
| *Lens nigricans* | 0 | 0 | 0 | 0 | 11.1 | 0 | 0 | 0 | 88.9 | 0 |
| *Trifolium striatum* | 0 | 0 | 0 | 0 | 0 | 12.5 | 0 | 0 | 87.5 | 0 |
| *Lathyrus inconspicuus* | 0 | 0 | 0 | 0 | 12.5 | 0 | 0 | 0 | 87.5 | 0 |
| *Vicia tenuifolia* | 0 | 0 | 0 | 0 | 2.5 | 0.83 | 5 | 0 | 84.2 | 7.5 |
| *Trifolium aureum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 83.3 | 16.7 |
| *Lathyrus nissolia* | 0 | 0 | 0 | 0 | 0 | 15.5 | 1.72 | 0 | 82.8 | 0 |
| *Trifolium sebastianii* | 0 | 0 | 0 | 0 | 0 | 0 | 20 | 0 | 80 | 0 |
| *Vicia grandiflora* | 0 | 0 | 0 | 0.9 | 0 | 4.48 | 2.69 | 10.3 | 79.4 | 2.24 |
| *Dorycnium pentaphyllum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13.8 | 79.3 | 6.9 |
| *Vicia hirsuta* | 0 | 0 | 0 | 0.4 | 0 | 2.39 | 3.59 | 4.78 | 78.9 | 9.96 |
| *Trifolium subterraneum* | 0 | 0 | 0 | 1.79 | 0 | 10.7 | 1.79 | 7.14 | 78.6 | 0 |
| *Vicia tetrasperma* | 0 | 0 | 0 | 0 | 0 | 1.53 | 0 | 0.76 | 77.9 | 19.8 |
| *Trifolium ochroleucon* | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0.8 | 76.8 | 18.4 |
| *Chamaecytisus triflorus* aggr. | 0 | 0 | 0 | 0 | 2.16 | 0 | 3.88 | 0 | 76.7 | 17.2 |
| *Vicia cassubica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2.5 | 75 | 22.5 |
| *Cytisus procumbens* | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 75 | 0 |
| *Trifolium alpestre* | 0 | 0 | 0 | 0 | 6.49 | 1.62 | 1.35 | 0.27 | 74.3 | 15.9 |
| *Dorycnium herbaceum* | 0 | 0 | 0 | 10.2 | 6.12 | 6.12 | 3.06 | 0 | 73.5 | 1.02 |
| *Colutea arborescens* ssp. *arboresce* | 7.14 | 0 | 0 | 0 | 0 | 0 | 0 | 7.14 | 71.4 | 14.3 |
| *Lathyrus aphaca* | 0 | 0 | 19 | 0 | 0 | 0 | 1.59 | 7.94 | 71.4 | 0 |
| *Vicia villosa* | 0 | 0.66 | 25.2 | 0 | 0 | 4.46 | 6.25 | 17.9 | 69.6 | 1.79 |
| *Adenocarpus complicatus* | 0 | 0 | 0 | 15.4 | 0 | 0 | 15.4 | 0 | 69.2 | 0 |
| *Medicago lupulina* | 0 | 2 | 0 | 0 | 0 | 4.08 | 4.08 | 4.08 | 67.3 | 20.4 |
| *Chamaecytisus supinus* | 0 | 0 | 0 | 0 | 1.89 | 3.77 | 7.55 | 3.77 | 66 | 17 |
| *Genista tinctoria* | 0 | 0 | 0 | 0 | 4.92 | 0 | 18 | 0 | 65.6 | 11.5 |
| *Vicia lathyroides* | 0 | 0 | 0 | 2.56 | 0 | 19.2 | 7.69 | 5.13 | 65.4 | 0 |
| *Medicago orbicularis* | 0 | 0 | 25 | 0 | 0 | 12.5 | 0 | 0 | 62.5 | 0 |
| *Ornithopus compressus* | 0 | 0 | 0 | 11 | 0 | 19.5 | 6.1 | 1.22 | 62.2 | 0 |
| *Trifolium glomeratum* | 0 | 4.76 | 0 | 19 | 0 | 4.76 | 9.52 | 0 | 61.9 | 0 |
| *Dorycnium hirsutum* | 0 | 0 | 4.08 | 12.3 | 0 | 0 | 20.4 | 4.08 | 59.2 | 0 |
| *Lathyrus grandiflorus* | 0 | 0 | 18.2 | 0 | 0 | 0 | 0 | 0 | 54.6 | 27.3 |
| *Ononis pusilla* | 0 | 0 | 0 | 0 | 18.2 | 9.09 | 18.2 | 0 | 54.5 | 0 |
| *Genista carinalis* | 0 | 0 | 0 | 0.28 | 12.2 | 5.82 | 5.26 | 0 | 54.3 | 22.2 |
| *Trifolium arvense* | 3.91 | 0 | 0 | 18 | 0 | 20.3 | 14.1 | 1.56 | 39.8 | 2.34 |
| *Trifolium repens* | 0 | 9.52 | 9.52 | 0 | 16.7 | 2.38 | 0 | 3.57 | 39.3 | 19 |
| *Trifolium hybidum* | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 25 | 12.5 | 37.5 |
| *Chamaecytisus eriocarpus* | 0 | 0 | 0 | 0 | 31.1 | 0 | 0 | 0 | 11.1 | 57.8 |
| *Astragalus glycyphyllos* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17.9 | 54.7 | 27.4 |
| *Securigera varia* | 0 | 0 | 0 | 0 | 15.9 | 0 | 2.27 | 0 | 56.8 | 25 |
| *Trifolium medium* | 0 | 0 | 0 | 0 | 1.9 | 0 | 0 | 5.24 | 61.4 | 31.4 |
| *Trifolium pignantii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.59 | 70.6 | 28.8 |
| *Trifolium pratense* | 0 | 0 | 0 | 0 | 17.6 | 8.82 | 0 | 17.6 | 29.4 | 26.5 |
| *Vicia cracca* | 0 | 0 | 0 | 0.63 | 3.13 | 1.88 | 0 | 1.25 | 61.9 | 31.3 |
| *Vicia laeta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4.76 | 42.9 | 52.4 |
| *Lathyrus laxiflorus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 58.1 | 41.9 |
| *Lathyrus niger* ssp. *niger* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 70.8 | 29.2 |
| *Lathyrus venetus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 54.3 | 45.7 |
| *Trifolium velenovskyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6.67 | 93.3 |
| *Lathyrus vernus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4.17 | 4.17 | 91.7 |
| *Lathyrus alpestris* | 0 | 0 | 0 | 0 | 1.79 | 0 | 0 | 0 | 8.93 | 89.3 |
| *Vicia sepium* | 0 | 0 | 0 | 0 | 13.6 | 0 | 0 | 0 | 0 | 86.4 |
| *Genista sagittalis* | 0 | 0 | 0 | 0 | 18.8 | 0 | 0 | 0 | 0 | 81.3 |
| *Chamaecytisus austriacus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 21.8 | 78.2 |
| *Lathyrus pratensis* | 0 | 0 | 0 | 0 | 17.8 | 0 | 0 | 1.11 | 17.8 | 63.3 |
| *Lotus corniculatus* | 1.39 | 2.78 | 0 | 9.72 | 13.9 | 11.1 | 5.56 | 1.39 | 22.2 | 31.9 |

Taxa showing a higher fidelity in the distinguished vegetation groups (Table 1) can be divided in five categories: a) taxa occurring most in lowland grasslands (e.g. *Trifolium cherleri*), b) those found in subalpine grasslands (e.g. *Anthyllis montana* ssp. *jacquinii, Astragalus angustifolius*); these taxa show a quite similar preference all over eastern Mediterranean (Güleryüz et al. 1998) and south Europe (Hennenberg & Bruelheide 2003), as well, c) taxa occurring in thermophilous shrublands (e.g. *Calicotome villosa, Anthyllis hermanniae*), d) taxa occurring more in azonal forests (e.g. *Amorpha fruticosa, Gleditsia triacanthos, Robinia pseudacacia*), and e) taxa preferring most the Sub-Mediterranean and sub-continental forests (e.g. *Trifolium striatum, Vicia grandiflora, Trifolium alpestre, Lathyrus vernus, Chamaecytisus austriacus*).

Results show that many legume taxa from those included in our analyses show a preferential occurrence to certain habitat and thus have a more or less narrow niche breadth. However, their distribution to habitat types in northern Greece has been affected by the history of disturbances and land use, factors which seems to have broadened legume species niche and not to have restricted their distribution. Furthermore, the Mediterranean climate of the study area, and its transition to sub-continental at the higher altitudes and the northern latitudes, as well as the traditional management practices seems to have modified some legume species niche from what it is known from other parts of their distribution (natural or man-made) area.

## References

**Braun-Blanquet J. 1964.** Pflanzensoziologie. Grundzüge der Vegetationskunde. Ed. 3. Springer, Berlin.

**Dafis S., E. Papastergiadou, T. Lazaridou and M. Tsiafouli. 2001.** Technical Guide for identification, description and mapping of habitat types of Greece. Thessaloniki. Greek Wetland and Biotope Centre (EKBY). (In Greek).

**Fotiadis G. 2004.** Phytosociological forest units of Greek part of mount Belles and of Krousia mountains. Ph.D. Thesis, Aristotle University of Thessaloniki (In Greek with English Abstract).

**Greuter W., H.M. Burdet and G. Long. (eds.) 1984, 1986, 1989.** Med-Checklist 1, 3, 4. Genève & Berlin.

**Güleryüz, G., H. Arslan, M. Gökçeoğlu and H. Rehder. 1998.** Vegetation mosaic around the first center of tourism development in the Uludağ Mountain, Bursa-Turkey. *Turkish Journal of Botany* 22 (5), pp. 317-326.

**Hennenberg K.J. and H. Bruelheide. 2003.** Ecological investigations on the northern distribution range of *Hippocrepis comosa* L. in Germany *Plant Ecology* 166 (2), pp. 167-188

**Hill M.O. 1979.** TWINSPAN – a FORTRAN program for arranging multivariate data in an ordered two-way table by classification of the individuals and the attributes. Ecology & Systematics, Cornell Univ., Ithaca, NY, USA.

**Merou Th., G. Fotiadis, S. Tsiftsis, K. Vidakis, M. Vrahnakis, I. Tsiripidis and V.P. Papanastasis. 2007.** Leguminosae of Northern Greece. Photo/Graphs Studio, Drama.

**Mucina L. 1997.** Conspectus of Classes of European Vegetation. *Folia Geobot. Phytotax.* 32, 117-172.

**Papanastasis V.P., C.N. Tsiouvaras, O. Dini-Papanastasi, T. Vaitsis, L. Stringi, C.F. Cereti, C. Dupraz, D. Armand, M. Meuret and L. Olea. 1999.** Selection and utilization of cultivated Fodder Trees and Shrubs in the Mediterranean Region. In: Papanastasis, V.P. (Compiler), Options M´editerran´eennes. Serie B: Etudes et Recherches, No. 23. Zaragosa, Spain, 93 pp.

**Real D., J. Warden, G.A. Sandral and T.D. Colmer. 2008.** Waterlogging tolerance and recovery of 10 *Lotus* species. *Australian Journal of Experimental Agriculture* 48 (4), pp. 480-487.

**Ricciarelli D' Albore G. and F. Intoppa 2000.** Fiori e Api. La Flora Visitata dalle Api e Dagli Altri Apoidei in Europa. Edagricole, Calderini.

**Strid A. (ed.). 1986.** Mountain Flora of Greece. Vol. 1. Cambridge Univ. Press, Cambridge.

**Strid A. and K. Tan (eds). 1991.** Mountain Flora of Greece. Vol. 2. Edinburgh Univ. Press, Edinburgh.

**Strid A. and K. Tan (eds). 1997.** Flora Hellenica. Vol 1. Koeltz Scientific Books, Königstein.

**Strid A. and K. Tan (eds). 2002.** Flora Hellenica. Vol. 2. A.R.G. Gantner Verlag K.G., Ruggell.

**Theodoropoulos K. 1991.** Bestimmung und Klassifizierung der pflanzensoziologischen Vegetationseinheiten im Universitätswald Taxiarchis Chalkidiki. Ph.D. Thesis, *Sci. Ann. Dept. Forest. Nat. Env. Aristotle Univ. Thessaloniki* 32 (18): 1-200 [In Greek with German Abstract].

**Tichý L. 2001.** JUICE 4.0. Software user's guide. Department of Botany, Masaryk University, Brno, CZ.

**Tsiripidis I., E. Bergmeier, G. Fotiadis and P. Dimopoulos. 2009.** A new algorithm for the determination of differential taxa. *Journal of Vegetation Science* 20: 233-240.

**Tutin, T.G., N.A.Burges, A.O.Chater, J.R. Edmondson, V.H. Heywood, D.M. Moore, D.H. Valentine, S.M. Walters and D.A. Webb (eds). 1993.** Flora Europaea. 2nd ed. Vol. 1. Cambridge Univ. Press, Cambridge.

**Tutin, T.G., V.H. Heywood, N.A. Burges, D.M. Moore, D.H. Valentine, S.M. Walters and D.A. Webb (eds). 1968–1980.** Flora Europaea. Vols 2–5. Cambridge Univ. Press, Cambridge.

**White C.L., C.D. Hanbury, P. Young, N. Phillips, S.C. Wiese, J.B. Milton, R.H. Davidson, K.H.M. Siddique and D. Harris 2002.** The nutritional value of *Lathyrus cicera* and *Lupinus angustifolius* grain for sheep. *Animal Feed Science and Technology*, 99: 45–64.

# Thermophilous grasslands of southeastern Europe

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## Abstract

A large proportion of grasslands found in southeastern Europe are thermophilous in the sense that they grow in the low elevation zone and are dominated by the warm season perennial grasses *Chrysopogon gryllus* and *Dichanthium ischaemum* (=*Bothriochloa ischaemum*). In fact, they are transitional between the typical Mediterranean grasslands dominated by annual grasses and the temperate grasslands dominated by perennial cold season grasses. In this paper, their distribution as well as their phytosociological, ecological and economic aspects are reviewed and discussed. They are distributed in the Quercetalia pubescentis zone, mostly in the Ostryo-Carpinion orientalis subzone, in large openings and represent the last stage of grassland colonization after the destruction of forests. Phytosociologically, these grasslands are classified in many associations or plant communities (e.g. Chrysopogono-Caricetum humilis, Thymo urumovii–Chrysopogonetum) mainly of the Festucetalia valesiacae order (Festuco-Brometea class), but also in other orders and classes such as Helianthemetea guttati, depending on their floristic composition. They are very productive grasslands with high grazing value for livestock. Because of their high plant diversity and the threat of vegetation succession, these semi-natural grasslands are under protection status in several areas (e.g. “Ponto-Sarmatic steppes”, which are a priority habitat type under the EU Directive 92/43).

**Key-words:** *Chrysopogon gryllus, Dichanthium ischaemum,* transitional grasslands, Balkan peninsula, grazing value

## Introduction

Grasslands are an important vegetation type in southeastern Europe both from the ecological and economic point of view. They are distributed throughout the region, from the sea level up to the peak of the mountains. With the exception of those found in the alpine zone of the mountains, which can be considered as climax plant communities, all the other grasslands are successional in the sense that they have been derived mainly from forests after their destruction by human activities. In the low elevation zone of the southern Greek peninsula and the islands as well as in the coastal areas bordering the Aegean, Ionian and Dalmatic seas, where the climate is typical Mediterranean, grasslands are dominated by annual grasses. However, as we move to higher elevations and inland, the annual are gradually replaced by perennial grasses. In the sub-mediterranean zone as well as in the warmer part of the continental zone, the dominant perennial grasses are *Chrysopogon gryllus* and *Dichantium ischaemum* (=*Bothriochloa ischaemum*), which are $C_4$ plants thus forming a distinct type of warm season or thermophilous grasslands. These grasslands are transitional between the typical mediterranean grasslands dominated by annual grasses and temperate grasslands dominated by cool season perennial grasses ($C_3$ plants).The aim of this paper was to review and discuss their phytosociology, ecology and grazing value so that their importance for conservation is demonstrated.

**Phytosociological aspects**

Horvat et al. (1974) classified thermophilous grasslands in the association Chrysopogonetum grylli despite their high variation in floristic composition from one area to another. According to Drăgulescu and Schumacher (2006), it is very easy to say that all these plant communities (with *Chrysopogon gryllus*) belong to the Chrysopogonetum grylli, but actually, only in Romania, there are four to six different vegetation types in this association. Until now, almost 23 different plant communities and associations with *Chrysopogon gryllus* have been described in this country. The association Chrysopogono-Caricetum humilis (=Stipo-Caricetum humilis) seem to occur in an altitude of about 400-500 m a.s.l.; it is also recorded in the western periphery of Western Carpathians, but without *Dichanthium ischaemum*. In addition, the Salvio nemorosae-Festucetum rupicolae and some other associations (Festuco valesiacae-Stipetum capillatae and Astragalo austriaci-Festucetum sulcatae) are also represented in the western Carpathians and the northern Pannonian Basin (Dúbravková et al. 2010). They include several continental species in contrast to the same grasslands of the central and southern Balkans where several sub-Meditteranean and Mediterranean species are found. In the Danube plain of Bulgaria, these transitional grasslands are found at 100 m a.s.l. and classified in the Festucion(-etalia) valesiacae (Festuco-Brometea) as Thymo urumovii-Chrysopogonetum grylli (Tzonev 2009).

According to Kojić et al. (2005), there are more than 13 described associations of hill meadows and pastures which have *Chrysopogon gryllus* as dominant species in Serbia and Montenegro; the most widespread of these associations are (a) Agrostio-Chrysopogonetum grylli (western and central Serbia) with acidophil and acido-neutrophil character, and (b) Teucrio-Chrysopogonetum grylli (eastern Serbia) on south exposures. Apostolova and Meshinev (2006) mention that the mesophytic-character grasslands with *Chrysopogon gryllus* and *Dichanthium ischaemum* are included inside the Agrostideto-Chrypogonetum grylli (Chrysopogono-Danthonion calycinae, Festucetalia valesiacae). This association is also strongly connected with *Quercus* forests as it is usually found in openings or in clear cut forests of these species. Apostolova and Meshinev (2006) claims that the widely distributed Botriochloetum ischaemi thymetosum pannonici (Festucion valesiacae) includes the grasslands dominated by *Dichanthium ischaemum* and *Chrysopogon gryllus* in Bulgaria. Except from these vegetation types, *Chrysopogon gryllus* and *Dichanthium ischaemum* occur also in other associations and transitional plant communities, such as Poo-Achilleetum pseudopectinatae (Trifolion cherleri, Heliantemetalia(-etea) guttati) (Sopotlieva 2009).

In Greece, vegetation units in which these two species occur are sometimes classified in Thero-Brachypodietea (Dafis et al. 2001), because of the high abundance of annual species. High abundance of annual species (almost up to 45%) has been also recorded in the steppe-like grasslands with *Chrysopogon gryllus* and *Dichanthium ischaemum* studied by Pirini et al. (2006) in the area of Vegoritida-Petron, northwestern Greece. In the same region, in grasslands where both of these species are found, a plant community, which had not more than 25% of annual species, was also classified in Festuco-Brometea (Pirini et al. 2006). In the same area, Pirini (2011) described the *Chrysopogon gryllus-Dichanthium ischaemum* comm. and classified it in Astragalo-Potentilletalia and in Festuco-Brometea.

**Ecological aspects**

Although both *Chrysopogon gryllus* and *Dichanthium ischaemum* are warm season grasses they do not have identical growth patterns. *Chrysopogon gryllus* flowers in late spring and gets dry in the summer much earlier than *Dichanthium ischaemum*. In addition, the latter flowers again during summer if it is rainy while the former does not (Papanastasis 1990). On the other hand, both species are very productive but *Dichanthium ischaemum* has higher productivity and better correlation with air temperature and rainfall (Papanastasis 1981). Finally, *Dichanthium ischaemum* is more flexible and a more affective colonizer that *Chrysopogon gryllus* (Papanastasis 1998).

Thermophilous grasslands have a very high plant cover (Tzonev 2009) and are very rich in plant species, both annual and, especially, perennial. In central Macedonia, northern Greece, it was found that annuals were more abundant in the low election zone (about 50 m a.s.l.), where *Chrysopogon gryllus* and *Dichanthium ischaemum* were the only perennial grasses present, than in the middle elevation zone (about 600 m a.s.l.), where other perennial cool season grasses were also present (Papanastasis 1982). In the Danube plain of Bulgaria, several species, mostly perennial, are found in these grasslands, such as *Eryngium campestre* and *Teucrium polium* (Tzonev 2009), while in Romania *Thymus pannonicus* and *Dorycnium herbaceum* are also recorded (Drăgulescu and Schumacher 2006). Finally, high abundance of the same two species is also found in serpentine soils of northern Greece (Tsiripidis et al. 2010); in this case, several xerophytic species, such as *Thymus sibthorpii, Teucrium capitatum,* and several legumes (more than 9 taxa) and grasses (more than 15 taxa) are found.

According to the Directive 92/43/EEC, thermophilous grasslands constitute the priority habitat type "6240* Sub-pannonic steppic grasslands" (European Commission 2007). Also, according to the same directive, many vegetation types of Thero-Brachypodietea (including these with *Chrysopogon gryllus* and *Dichanthium ischaemum*) are listed as priority habitat types (European Commission 2007). These grasslands are sometimes in association with broadleaved deciduous forests and with the priority habitat type "62C0* Ponto-Sarmatic steppes" (European Commission 2007). It seems that grazing keeps these grasslands open and when the grazing ceases the vegetation succession begins resulting in deciduous forests.

**Economic aspects**

Despite the fact that thermophilous grasslands have a high number of plant species, Kojić et al. (2005) believe that they have less economic value than other grassland plant communities (e.g. Brometum erecti). Nevertheless, thermophilous grasslands are important grazing areas for domestic animals, in late spring, summer and early autumn months. *Chrysopogon gryllus* and *Dichantium ischaemum* are both readily grazed by cattle and horses, while sheep prefer them when they are at the vegetative stage and before they develop their flowers stalks. Their nutritive content is comparable to other perennial grasses, but their value lies on the fact that they stay green in the summer when the other grasses have already matured (Papanastasis 1990). Also, they are both very resistant to heavy grazing (Koukoura 1978).

**Conclusions**

Thermophilous grasslands dominated by *Chrysopogon gryllus* and *Dichantium ischaemum* are: (a) xerophytic steppe-like grasslands, phytosociologically classified mainly in Festuco-Brometea class and probably in the Balkan Astragalo-Potentilletalia order; (b) of very high plant diversity suggesting a high ecological value, (c) of very high economic value as grazing areas because they have favorable to animals floristic composition and high quantities of biomass (given the xerophytic nature of these grasslands), (d) distributed in low (in the northern part of their distribution) to medium (in the southern part of their distribution) altitudes indicating their adaptation to harsh and continuous anthropogenic impact, (e) connected with forest vegetation since they are found inside forest openings or have a pre-forest character; and (f) are protected under the Directive 92/43/EEC due to their high ecological value, with at least three different priority habitat types in the south, central and north Balkan Peninsula. The most serious threat for these grasslands is vegetation succession, while grazing seems to be the most important factor for their conservation.

## References

**Apostolova I. and T. Meshinev. 2006.** Classification of semi-natural grasslands in north-eastern Bulgaria. *Annali di Botanica*, VI: 29-52.

**Dafis S., E. Papastergiadou, T. Lazaridou and M. Tsiafouli. 2001.** Technical Guide for identification, description and mapping of habitat types of Greece. Thessaloniki. Greek Wetland and Biotope Centre (EKBY). Thessaloniki, 908 pp. (In Greek).

**Drăgulescu C. and B. Schumacher. 2006.** Wiesen mit *Chrysopogon gryllus* in süd-siebenbürgen. *Contribuţii Botanice*, XLI (2): 53-59.

**Dúbravková D., M. Chytrý, W. Willner, E. Illyés, M. Janišová and J. Kállayné Szerényi. 2010.** Dry grasslands in the Western Carpathians and the northern Pannonian Basin: a numerical classification. *Preslia* 82: 165-221.

**European Commission. 2007.** Interpretation Manual of European Union Habitats. 142 pp.

**Horvat I., V. Clavać and H. Ellenberg. 1974.** Vegetation Südosteuropas. Geobotanica Selecta, vol. 4, Gustav, Fisher Verlag 768 pp.

**Koukoura, Z. 1978.** Long term effects of grazing on a grassland of the low elevation in northern Greece. *Scientific Annals of the Agriculture and Forestry School*, 21(8):153-181. (In Greek with English Abstract).

**Kojić M., S. Mrfat-Vukelić and S. Dordević-Milošević. 2005.** Basic phytocenological and economical characteristic of natural meadows and pastures of Serbia. *Biotechnology in Animal Husbandry* 21(5-6): 187-191.

**Papanastasis V.P. 1981.** Species structure and productivity in grasslands of northern Greece, In: Components of Productivity of Mediterranean-climate Regions, Basic and Applied Aspects (N.S.Margaris and H.A.Mooney, eds). T:VS4, Dr. W. Junk Publishers, The Hague. pp. 205-217.

**Papanastasis V.P. 1982.** Production of grasslands in relation to air temperature and precipitation in northern Greece. Dasiki Erevna, 3(III)-Appendix. (In Greek with English Abstract).

**Papanastasis V. 1990.** Phenology and range readiness of representative grasslands in Macedonia. *Scientific Annals of the Department of Forestry and Natural Environment*, ΛΓ/1(6):211-270. (In Greek with English Abstract).

**Papanastasis V.P. 1998.** Growth characteristics and distribution pattern of C4 grasses *Dichanthium ischaemum* and *Chrysopogon gryllus* in N. Greece. In: Progress in Botanical Research. Proc. 1st Balkan Botanical Congress (I. Tsekos and M. Moustakas, eds). Kluwer Academic Publishers, Dordrecht. pp. 121-124.

**Pirini B. C. 2011.** The ecosystem of Lakes Vegoritida and Petron: flora, vegetation and plant geography. PhD Thesis, Aristotle University Thessaloniki (In Greek with English Abstract).

**Pirini C., I. Tsiripidis, V. Karagiannakidou and D. Babalonas. 2006.** *Artemisia campestris* inland vegetation type in the "NATURA 2000" network site "Limnes Vegoritida – Petron" (GR 1340004). Proceedings of IV Balkan Botanical Congress, Sofia. pp. 314-320.

**Sopotlieva D. 2009.** Poo bulbosae-Achilleetum pseudopectinatae: a new plant association. *Phytologia Balcanica* 15(2): 235-244.

**Tsiripidis I., A. Papaioannou, V. Sapounidis and E. Bergmeier. 2010.** Approaching the serpentine factor at a local scale – a study in an ultramafic area in northern Greece. *Plant Soil* 329: 35-50.

**Tzonev R. 2009.** Syntaxonomy of the natural and semi-natural vegetation of the middle Danube plain in Bulgaria. *Biotechnol. & Biotechnol. Eq.* 23:354-359.

# Landscape composition of rangelands within the "Natura 2000" habitat network in Greece

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## Abstract

Rangelands constitute an important part of the habitat type ecological network "Natura 2000" of protected areas in Greece. In this paper, the five rangeland types present in this network, namely grasslands, phrygana, shrublands, forest ranges and wet grasslands, were identified and analysed some aspects of their landscape composition along four altitudinal zones. According to these results, 57 rangeland habitat types can be found in Greece, covering an area of 1,169,403 ha or 47% of the total mapped area. The most common rangeland types are those where woody plants are dominant, covering about 65% of rangelands. Diverse mosaic pattern is evident in all altitudinal zones but it prevails in the middle altitudes, while rangelands above 1200 m seem to be more homogenous composed of extensive shrublands. Forest ranges make the most fragmented landscapes in all altitudinal zones except above 1200 m where their presence is relatively limited.

**Key words:** Edge density, cover, mean patch size, pastoral landscapes, patch density

## Introduction

Lands used for extensive livestock grazing, i.e. rangelands, are part of the habitat types network "Natura 2000" in Greece. They constitute important areas for nature conservation because they have been shaped by grazing activities for thousands of years (Papanastasis and Chouvardas 2005), resulting in pastoral landscapes of various types. Their conservation largely depends on the continuation of livestock husbandry and other agricultural activities (Caballero et al. 2009). For their sustainable management, however, their types and conservation status need to be investigated so that the necessary measures are accordingly implemented. The aim of this study was to identify the rangeland types present in the habitat types network of "Natura 2000" and evaluate their landscape composition.

## Materials and methods

In order to draw a picture of the landscape composition of rangelands, data from the habitat type mapping (MINENV 2001) were used. This mapping covers 19% of the terrestrial part of the country and it is distributed in 237 areas, most of them belonging to "Natura 2000" network. Initially a single layer with all polygons of the 237 areas was created and polygons with null values or with area less than 1 ha were removed. Then, according to the description of the habitat types (Dafis et al. 2001) polygons corresponding to the four types of rangelands found in Greece, namely grasslands, phrygana, shrublands and forest ranges (Papanastasis and Noitsakis 1992) were selected plus wet grasslands (Table 1).

**Table 1.** Rangeland habitat types from the mapping of 2001.

| Rangeland type | Habitat types |
|---|---|
| Grasslands | 6110 Karstic calcareous grasslands, 6170 Alpine calcareous grasslands, 6173 Stepped and garland grasslands, 6210 Semi-natural dry grasslands on calcareous substrates, 6211 Sub-continental steppic grasslands, 6220 Pseudo-steppe with grasses and annuals, 6230 Nardus grasslands on siliceous substrates, 6420 Mediterranean tall-herb and rush meadows, 6430 Eutrophic tall herbs, 6432 Subalpine and alpine tall herb, 6510 Lowland hay meadows, **6270* *Spartium junceum* steppes, 6280 Mediterraneo-montane grasslands, 6290 Mediterranean subnitrophilous grasslands, 6450 Helleno-Moesian riverine and humid clover meadows, 651A Mesophile pastures** |
| Shrublands | 4060 Alpine and subalpine heaths, 4090 Endemic oro-Mediterranean heaths with gorse, 5110 Stable *Buxus sempervirens* formations on calcareous rock slopes, 5130 *Juniperus communis* formations on calcareous heaths or grasslands, 5210 Mediterranean matorral: Juniper formations, 5211 *Juniperus oxycedrus* matorral, 5212 *Juniperus phoenicea* matorral, 5213 *Juniperus excelsa* and *J. foetidissima* matorrals, 5310 Laurel thickets, **5340 Garrigues, 5350 Pseudomaquis, 5160 Subcontinental and continental deciduous thickets (Prunion fruticosae)** |
| Phrygana | 5320 Low formations of *Euphorbia*, 5330 Thermo-Mediterranean and pre-steppe brush, 5331 Tree-spurge formations, 5420 Aegean phrygana, 5430 Phrygana formations |
| Wet grasslands | 1410 Mediterranean salt meadows, 1420 Mediterranean halophilous scrubs, 1430 Iberia halo-nitrophilous scrubs, 1510 Salt steppes, 3170 Mediterranean temporary ponds, **1260 Halophytic grass and fhryganic meadows, 72A0 Reed beds, 72B0 Rush meadows** |
| Forest ranges | 2270 Wooded dunes with *Pinus pinea* and/or P. pinaster, 9170 Eastern oak-hornbeam forests, 9250 *Quercus trojana* woods, 9290 Cypress forests, 9310 Cretan *Quercus brachyphylla* forests, 9320 Olea and Ceratonia forests, 9340 *Quercus ilex* forests, 9350 *Quercus macrolepis* forests, 9410 Acidophilous forests, 9540 Mediterranean pine forests with endemic pines, 9562 Grecian juniper woods, 9563 Stinking juniper woods, **925A Mixed thermophilous forests with *Ostrya carpinifolia* and *Carpinus orientalis*, 925B *Celtis australis* forests, 934A Greek kermes oak forests, 934B Sclerophyllous forests of *Crataegus monogyna*** |

* Habitat types in bold are not included in Annex I of the Habitats Directive (92/43/EC).

For these five types a new layer was created where the rangeland type was added as another attribute. Spatial data were processed with the GIS Software ArcGIS v9.3, while landscape metrics were calculated with Patch Analyst v5.0 (Rempel et.al. 2012), an extension of the ArcGIS. Four indices were used: class cover for an overview of the rangelands' cover distribution and fragmentation, mean patch size and patch density as overall measures of fragmentation and landscape pattern and edge density (ED) as a measure of fragmentation (Leitao et. al. 2006). The mathematical formulas of the chosen indices are those described by McGarigal και Marks (1995). In order to explore the diversity of these indices with elevation, the altitude to the centroid of each polygon (based on the ASTER GDEM Version2 for Greece - www.jspacesystems.or.jp/ /ersdac/GDEM/E/4.html) was attributed and each polygon was classified according to the altitudinal zones used by Papanastasis et al. (1986). Then a separate layer of all rangeland types for each altitude class was produced and Patch Analyst was employed for each layer.

**Results and Discussion**

From the 237 habitat types, 57 were characterised as rangelands, covering an area of 1,169,403 ha or 47% of the total mapped area.The distribution of rangelands in the mapped areas is presented in figure 1. Cover of each rangeland type with altitude is presented in figure 5. Cover of grasslands and phrygana is increasing and decreasing respectively with altitude, as expected from the ecology of the dominant species of each type. The decreased cover of wet grassland type with altitude is also expected since the relevant habitat types are bound to water bodies mainly found in low elevation and coastal areas. Very high cover by shrublands in the zone over 1200 m is a sign of abandonment from pastoral activities (Sitzia et.al. 2010). Abandonment due to the limitation of transhumance activity can also explain the sharp fall of forest ranges in the zone over 1200 m, but other reasons should also be considered, such as the grazing exclusion policy from such landscapes considered as degraded forests. Diverse mosaic structure appears in all altitudinal zones but the relatively higher values of patch (Figure 3) and edge density (Figure 4) in the middle altitudes indicate that pastoral landscapes of diverse mosaic prevail between 600 and 1200 m.

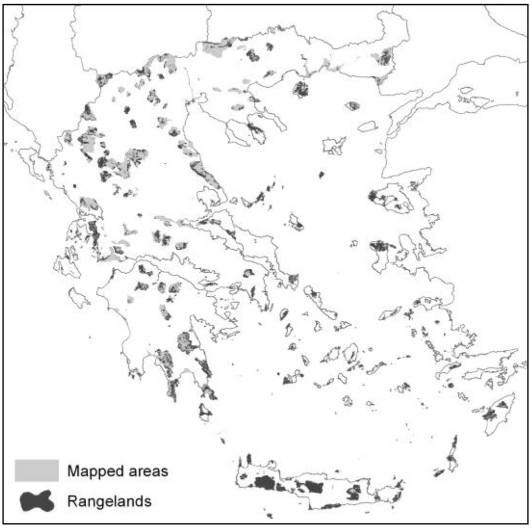


**Figure 1.** Rangelands distributed within the mapped area of the habitat type network "Natura 2000".

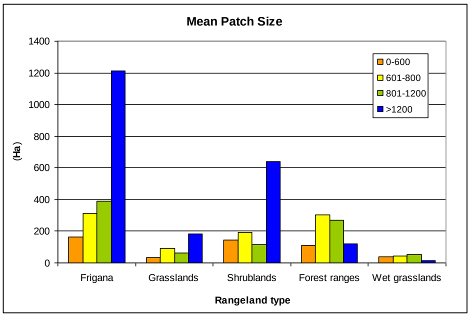


**Figure 2.** Mean patch size of rangelend types in each altitudinal zone.

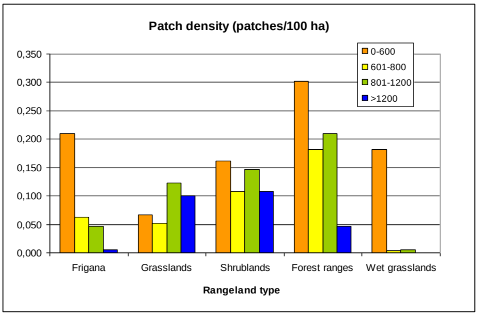


**Figure 3.** Patch density of rangelend types in each altitudinal zone

Above 1200 m, the high cover percentage of shrublands indicates a less heterogeneous landscape. Relatively high values of patch and edge density of forest ranges in combination with relatively low values of mean patch size and high cover values indicate that this is the most fragmented rangeland type. Grasslands and shrublands show lower fragmentation, especially in the high altitudes where both types present high values of cover (Figure 5) and mean patch size (Figure 2).

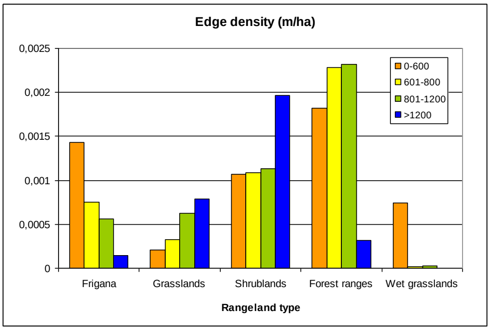


**Figure 4.** Edge density of rangelend types in each altitudinal zone

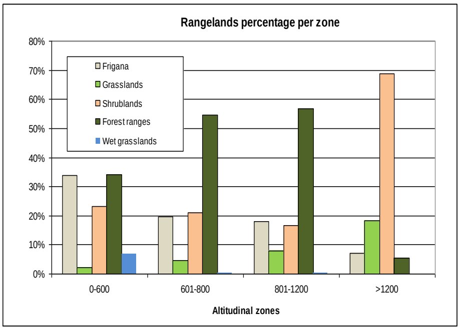


**Figure 5.** Rangelands cover in each altitudinal zone

## Conclusions

Rangelands of Greece are important areas for conservation of nature presenting different composition with altitude, originating from both the ecology of specific rangeland types and the pastoral activities.Diverse mosaic pattern is evident in all altitudinal zones but it prevails in the middle altitudes, while rangelands above 1200 m seem to be more homogenous. Forest ranges have the most fragmented landscapes in all altitudinal zones except above 1200 m where their presence is relatively limited.

## Refernces

**Caballero, R., F. Fernandez-Gonzalez, R. Perez-Badia, G. Molle, P-P. Roggero, S. Baggela, P. D'Ottavio, V.P. Papanastasis, G. Fotiadis, A. Sidiropoulou and I. Ispikoudis. 2009.** Grazing systems and biodiversity in Mediterranean areas: Spain, Italy, Greece. *Pastos*, XXXIX (1): 3-154.

**Dafis, S., E. Papastergiadou, E. Lazaridou and M. Tsiafouli. 2001.** Technical guide for the identification description and mapping of habitat types in Greece. Greek Biotope/Wetland Centre (EKBY). 393 p. (in Greek).

**Leitao, B.A., J. Miller, J. Ahern and K. McGarigal. 2006.** Measuring Landscapes, A Planner's Handbook. IslandPress, Washington. 272 p.

**McGarigal, K. and B.J. Marks. 1995.** FRAGSTATS: spatial pattern analysis program for quantifying landscape structure. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR. 122 p.

**Rempel, R.S., D. Kaukinen. and A.P. Carr. 2012.** Patch Analyst and Patch Grid. Ontario Ministry of Natural Resources. Centre for Northern Forest Ecosystem Research, Thunder Bay, Ontario. p.

**Sitzia, T., P. Semenzato and G. Trentanovi. 2010.** Natural reforestation is changing spatial patterns of rural mountain and hill landscapes: A global overview. *Forest Ecology and Management* 259: 1354-1362.

**MINENV. 2001.** Identification, Description and Mapping of Habitat Types of Greece. Operational Programme Environment. Hellenic Ministry for the Environment, Physical Planning and Public Works, Subproject 3.Action 3.3. (In Greek).

**Papanastasis. V.P. and V.I. Noitsakis. 1992.** Range ecology. Giahoudi-Giapouli, Thessaloniki. 224 p.

**Papanastasis. V.P. and D. Chouvardas. 2005.** Application of the state-and-transition approach to conservation management of a grazed Mediterranean landscape in Greece. *Israel Journal of Plant Science*, 53:191–202.

**Papanastasis, V.P., P. Platis, G. Halyvopoulos and A. Tepeli-Malama. 1986.** Forest land under grazing. Prefecture of Drama. North Greece rangeland survey programme. Forest Research Institute of Thessaloniki Bulletin 1.

# Methods for estimating leaf area in forages species

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## Abstract

Leaf area is an important variable for ecophysiological studies since it plays an important role in light interception, photosynthesis, water and nutrient use, crop growth and development. Moreover, understanding the properties of the leaf area could provide valuable information regarding cultural practices such as irrigation, fertilization, pruning etc. Nevertheless, determination of the leaf area is not an easy task, and there has been a great variety of methods developed. We present the most frequently used, direct and indirect techniques to estimate leaf area in forage species, and their advantages and disadvantages are discussed. Direct methods usually require removing leaves and then determining the leaf area; these methods are destructive and require adequate, potentially expensive, equipment. Indirect, non-destructive, methods are user friendly, less expensive, and can provide accurate leaf area estimation. The latter methods offer reliable and inexpensive alternatives in horticultural experiments and may be also used to determine the relationship between leaf area and plant growth rate. However, selection of the most appropriate method for leaf area estimation should be based on experimental goals and available equipment.

**Key words:** Non-destructive methods, optical techniques, portable leaf area meter, prediction models, planimeter

## Introduction

Quantitative evaluation of vegetation abundance and distribution in grassland is an important tool to measure the productivity and health of both grazed and protected grasslands (He et al. 2007). Leaf area (LA) is an important component to determine light interception, photosynthesis, water and nutrient use, crop growth and development (Caliskan et al. 2010). Moreover, LA could provide information regarding plant growth analysis, plant soil–water relations, and the effects of different plant treatments such as irrigation, fertilization, pruning etc (Sousa et al. 2005, Ugese et al. 2008). Measuring LA is useful in analysing the plant canopy architecture and it also allows determination of the leaf area index (LAI) (Dheebakaran and Jagannathan 2009). Accurate methods to determine LA of plants can be valuable in physiological and agronomic research and ecosystem function modelling.

In the literature most studies focus mainly on estimation of LA of forest and agricultural crop and only few have attempted to estimate LA in other plant types such as shrub and grass canopies (Caliskan et al. 2010, Gonsamo Gosa et al. 2007). Here we review studies dealing with the most frequently used techniques to estimate leaf area in forage species, and we discuss their advantages and disadvantages.

**Methods for measuring and estimating leaf area**

There are various methodological approaches to measure plant LA, both direct and indirect. Direct methods usually require removing leaves and then determining directly the LA using optical techniques, planimetry photography, digital photography etc (Caldas et al. 1992, Torri et al. 2009). Leaf area can be assessed directly by using the harvesting method. After leaf collection, LA can be calculated by means of either gravimetric or planimetric techniques (Daughtry 1990, Jonckheere et al. 2004b).

In the gravimetric or photogravimetric method photocopies of the leaves are used based on the weight of the paper cut out of the leaf tracing, compared to the weight of known areas on the same paper. The gravimetric method correlates dry weight of leaves and LA using predetermined green-leaf-area-to-dry-weight ratios (leaf mass per area, LMA). It provides an accurate measurement of the area, but is a laborious technique when applied to a large number of leaves (Caldas et al 1992, Li et al*.* 2008). Furthermore, attention must be paid to the large spatial and temporal variations in LMA of many species. The gravimetric method is convenient when LAI has to be estimated out of very large leaf samples (Jonckheere et al. 2004b).

The planimetric method is based on the principle of the correlation between the individual LA and the number of area units covered by that leaf in a horizontal level. There are different planimeter types in the market for this purpose e.g. the Li-3100 (Licor, Nebraska, USA) that provides apart from the leaf area, also leaf length and width. The planimeter is a less time consuming technique but the precision is limited especially for relatively small and rolling leaves of forage species. A second type of planimeter is the video image analysis system, consisting of a video camera, a frame digitiser, a monitor, and a computer with appropriate software to analyse the data (Caldas et al. 1992, Jonckheere et al. 2004b). Many researchers have developed related protocols using a common desktop scanner and public domain software to measure existing leaf area. Measuring LA with a desktop scanner requires two steps: (a) to create an image file and (b) to calculate the area presented by the image (O'Neal et al. 2002). These methods permit automatic calculation of LA, leaf number, length and width and the area lost from herbivores or diseases depending on the computer programs used. Extremely small leaf areas less than 0.15cm$^2$ can be measured by using the high-resolution adjustment scanner. The method is useful for growth analysis photosynthesis measurements and studies of herbivory (Caldas et al. 1992).

Direct measurement of LA is usually time consuming and labour intensive and often destructive. Consequently, many researchers have looked for alternative indirect and less time consuming methods (Brenner et al. 1995, Rico-García et al. 2009, Mokhtarpour et al. 2010). In indirect methods, LA is derived from other (more easily determined) parameters. Two categories of non-destructive, indirect methods are often reported: the regression analysis (mathematical equations) and the optical techniques (Rico-García et al. 2009). Leaf area can be estimated by using mathematical equations, which only require simple measurements of the leaf length and width (Mokhtarpour et al. 2010). Many researchers have developed mathematical equations to estimate LA by measuring leaf length and leaf width and calculated different combinations of them (Cittadini and Peri 2006, Serdar and Demirsoy 2006). Since leaf development is strongly related with crop growth, knowing the change in leaf area may be useful for estimating crop growth (Caliskan et al. 2010). Mathematical equation for estimating LA reduces sampling effort and cost, and is likely to increase precision in cases where samples of small leaf size are difficult to handle (Dheebakaran and Jagannathan 2009). Such equations allow researchers to estimate LA in relation to other factors such as drought stress and insect damage (Williams and Martinson 2003).

Many researchers have tried using new equipment and tools such as hand scanners or laser optic apparatuses for estimating plant LA, but these are very expensive investments for basic and simple research (Cirak et al. 2005, Serdar and Demirsoy 2006). Portable leaf area meters such as the Li-3000C (LICOR, Lincoln, NE), CI-201 (Delta-T devices, Cambridge) AM300 (ADC Bioscientific Ltd) or the handheld laser leaf area meter (CID Bio Science) overestimate the leaf area of small size leaves of forage plants.

Another non-destructive method to estimate leaf area is the spray method. In order to apply the method a room plant spray bottle or other similar device and a light but rigid sheet of non- porous material are necessary. Compared to the most of the other methods the spray method is cheaper, precision is slightly lower, but the measuring times are similar. The spray method could apply to any leaves, which are nearly flat, regardless of their shape (Korva and Forbes 1997).

**Discussion**

There are only few comparative studies dealing with methods measuring LA for grassland vegetation, despite the broad use of such methods in ecological studies (He et al. 2007). Most methods used to estimate LA involve defoliation and suffer of being destructive and laborious (time consuming) for forage species. Moreover, destructive sampling is undesirable, especially in studies involving small plots or small number of plants. Also, these methods require expensive equipment and high level of technical competence for operation and maintenance (Ugese et al. 2008). The estimation of LA with a desktop scanner is inexpensive and accurate for the small leaves of the forage species, while the desktop scanner has advantages in certain experimental situations where a prefeeding measurement of the leaf is impossible or undesirable and small amounts of feeding occur (O'Neal et al. 2002).

Non-destructive estimation of leaf area offers researchers reliable and inexpensive alternatives in horticultural experiments. Non-destructive LA measurements are often desirable because using the same plant over time can reduce variability in experiments in contrast to destructive sampling. Additionally, it eliminates the need for expensive leaf area meters (Sezgin and Çelik 1999). Portable leaf area meters usually overestimate the LA of small size and rolling leaves of forage species and are also very expensive for basic and simple research (Caliskan et al. 2010).

The estimation of leaf area by mathematical equation or regression analysis is a useful tool when plants cannot be destroyed for direct methods. Leaf area models, which can estimate leaf area without damaging the plant, can provide several advantages in horticultural experiments. Moreover, these models enable researchers to measure leaf area on the same plant during the plant growth period, reducing experimental noise (Serdar and Demirsoy 2006) This allows day to day estimates of leaf area throughout the growing season on the same plants without using extensive field plots and/or labor intensive leaf area harvesting and sampling (de Jesus Jr et al. 2001). Disadvantages of regression analysis include a priory development of an equation for each plant species and even variety (Li et al. 2008, Rico-García et al. 2009). The spray method, although not expensive, cannot serve as an alternative for forage species since it applies only in flat leaves.

**Conclusions**

Direct methods to measure leaf area in forage species are the most precise but extremely time consuming. Non-destructive and mathematical approaches of modelling can be very convenient and useful for plant growth estimation. There are instruments providing non-destructive and rapid but not accurate estimates of leaf area for forage species. However, selection of the most appropriate method for estimation of the leaf area should be based on experimental goals and available time and equipment.

## References

**Brenner A.J., M. Cueto Romero, J.Garcia Haro, M.A Gilabert, L.D. Incoll, J. Martinez Fernandez J, E. Porter, F.I. Pugnaire and M.T. Younis. 1995.** A comparison of direct and indirect methods for measuring leaf and surface areas of individual bushes. *Plant Cell and Environment,* 18:1332-1340.

**Caldas L.S., C. Bravo, H. Piccolo and C.R.S.M. Faria. 1992.** Measurement of leaf area with a hand-scanner linked to a microcomputer. *Revista Brasileira de Fisiologia Vegetal*, 4:17-20.

**Caliskan O., M.S. Odabas, C. Cirak and F. Odabas. 2010.** Modeling of the individual leaf area and dry weight of oregano (*Origanum onites* L.) leaf using leaf length and width, and SPAD value*. Journal of Medicinal Plants Research*, 4:542-545.

**Cirak C., M.S. Odabas and A.K. Ayan. 2005.** Leaf area prediction model for summer snowflake (*Leucojum aestivum* L.). *International Journal of Botany*, 1(1): 12-14.

**Cittadini E.D. and P.L. Peri. 2006.** Estimation of leaf area in sweet cherry using a non-destructive method. *Revista de Investigaciones Agropecuaria (Argentina)*, 35:143-150.

**Daughtry C.S.T. 1990.** Direct measurements of canopy structure. *Remote Sensing Rev*iews, 5:45-60.

**De Jesus Jr W.C., F.X.R. do Vale, R.R., Coelho and L.C. Costa. 2001.** Comparison of two methods for estimating leaf area index on common bean. *Agronomy Journal*, 93: 989.

**Dheebakaran G. and R. Jagannathan. 2009.** Estimation of Total Leaf Area by Non-destructive methods in Horse-eye Bean, *Mucuna pruriens*. *Madras Agriculture Journal*, 96(1-6):113-115.

**Gonsamo Gosa A., G. Schaepman-Strub, L. Kooistra, M. Schaepman and P. Pellikka. 2007.** Estimation of leaf area index using optical field instruments and imaging spectroscopy. Proceedings of $5^{th}$ EAReL Workshop on Imaging Spectroscopy. Bruges, Belgium. pp. 23-25.

**He Y., X. Guo and J.F. Wilmshurst. 2007.** Comparison of different methods for measuring leaf area index in a mixed grassland. *Canadian Journal of Plant Science*, 87:803-813.

**Jonckheere I., S. Fleck, K. Nackaerts, B. Muys, P. Coppin, M. Weiss and F. Baret. 2004.** Review of methods for in situ leaf area index determination: Part I. Theories, sensors and hemispherical photography. *Agricultural and Forest Meteorology*, 121:19-35.

**Korva J.T. and G.A. Forbes. 1997.** A simple and low-cost method for leaf area measurement of detached leaves. *Experimental Agriculture*, 33:65-72.

**Li Z., C. Ji, J. Liu and D. Li. 2008.** Leaf Area Calculating Based on Digital Image. In: D. Li (ed). Computer and Computing Technologies in Agriculture. International Federation for Information Processing Vol. 259 (II). Springer, Boston . pp. 1427-1433.

**Mokhtarpour H., C.B.S. Teh, G. Saleh, A.B. Selmat, M.E. Asadi and B. Kamar. 2010.** Non-destructive estimation of maize leaf area, fresh weight, and dry weight using leaf length and leaf width. *Communications in Biometry and Crop Science*, 5:19-26.

**O'Neal M.E., D.A. Landis and I. Rufus. 2002.** An Inexpensive, Accurate Method for Measuring Leaf Area and Defoliation through Digital Image Analysis. *Journal of Economic Entomology*, 95:1190-1194.

**Rico-García E., F. Hernández-Hernández, G.M. Soto-Zarazúa and G. Herrera-Ruiz. 2009.** Two new methods for the estimation of leaf area using digital photography. *International Journal of Agriculture and Biology*, 11:397-400.

**Serdar U. and H. Demirsoy. 2006.** Non-destructive leaf area estimation in chestnut. *Scientia Horticulturae*, 108:227-230.

**Sezgin U. and H. Çelik. 1999.** Leaf area prediction models (Uz elik-I) for different horticultural plants. *Turkish Journal of Agriculture and Forestry*, 23:645-650.

**Sousa E.F., M.C. Ara jo, R.P. Posse, E. Detmann, S. Bernardo, P.A. Berbert and P.A. Santos. 2005.** Estimating the total leaf area of the green dwarf coconut tree (*Cocos nucifera* L.). *Scientia Agricola*, 62:597-600.

**Torri S.I., C. Descalzi and E. Frusso. 2009.** Estimation of leaf area in pecan cultivars (*Carya illinoinensis*). *Ciencia de investigación agrarian*, 36:53-58.

**Ugese F.D., K.P. Baiyeri and B.N. Mbah. 2008.** Leaf area determination of shea butter tree (*Vitellaria paradoxa* CF Gaertn.). *International agrophysics*, 22:167-170.

**Williams III L. and LE. Martinson. 2003.** Nonde-structive leaf area estimation of 'Niágara' and 'De Chaunac' grapevines. *Horticultural Science*, 98:493-498.

# Effects of several plant species on the spatial distribution of the European hare (*Lepus europaeus*) at the microhabitat scale

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## Abstract

The influence of three shrubby species (kermes oak – *Quercus coccifera*, Spanish broom – *Spartium junceum* and yellow kidney vetch – *Anthyllis hermanniae*) and three herbaceous (brusch grass – *Chrysopogon gryllus*, pineleaf pink – *Dianthus pinifolius* and common chicory – *Cichorium intybus*) on the European hare's (*Lepus europaeus*) use of space at the microhabitat scale was investigated in a Mediterranean rangeland in northern Greece. The number of hares' pellets in 0.5 m radius plots around and in 2 m distance from 10 individuals of each plant species was counted. In addition, the number of twigs (shrubs) and shoots (herbs) per individual bitten by the hare was also counted. Surprisingly, Spanish broom (*Spartium junceum*), a shrubby species which is rarely consumed and it is considered as non-preferred for most of the herbivores, was the most often visited and browsed by the hare in relation to all the other plant species studied. These Spanish broom – hare interactions are innovative, and open new ways for a holistic rangeland management based on the regulation of hare's use of space at the microhabitat scale, through the spatially distribution of specific plant species that provide food and shelter against predators. The evaluation of the hare's grazing intensity and use of space could be based on the number of twigs/shoots bitten by this herbivore, which is a less laborious and time-consuming parameter to estimate in relation to the pellet-count one.

**Keywords:** plant-herbivore interactions, vegetation composition, animal behavior, rangeland management, wildlife management.

## Introduction

Understanding the principles shaping spatial distribution patterns of herbivores constitutes one of the insights of ecology. Abiotic (e.g. slope, distance to water, physical barriers etc.) and biotic (e.g. vegetation composition, productivity and quality of forage, etc.) components of habitats have been well documented as critical factors influencing the use of space by herbivores (Senft et al. 1987, Smith 1988). In most cases however, the availability of forage resources plays crucial role as herbivores spend more time in areas where the resource levels are high (Senft et al. 1987). Several management practices (water development, placement of salt and supplement, fencing, grazing systems, etc.) have been implemented to modify and control grazing distribution of domestic and wild herbivores (Bailey et al. 1996). Investigating the interactions between plants and herbivores, indubitably, will contribute to a more sustainable and profitable use of the valuable natural resources in Mediterranean rangelands. Nowadays, these ecological interactions receive increasing interest since they play a major role in range and wildlife conservational strategies (Holechek et al. 2001).

European hare (*Lepus europaeus* – hereafter hare) uses more intensively habitats with increased heterogeneity, especially at the within- habitat scale (Vaughan et al. 2003, Smith et al. 2004). Hare's use of space is also influenced by the structure of the vegetation, i.e. it uses more intensively the grazed sites with a sparse and short vegetation height (Karmiris and Nastis 2007, Karmiris et al. 2010). However, for vulnerable species, such as the hare, availability both of forage and cover (shelter against predators) have been reported as critical factors affecting the use of space (Kuijper and Bakker 2008, Karmiris and Nastis 2009). Under this perspective, the presence of specific plant species which constitute the bulk of the diet of the hare and/or provide shelter against predators might influence the spatial distribution of the hare at the microhabitat scale.

The aim of this study was to investigate: (i) the effects of the presence of six shrubby and herbaceous species, known to provide food and/or cover for wild herbivores, on the European hare's spatial distribution at the microhabitat scale in a typical Mediterranean rangeland in northern Greece and (ii) the potential to use the parameter 'number of twigs and shoots' to evaluate the hare's grazing intensity and the use of space at the microhabitat level.

**Material and Methods**

The study was conducted in a 600 ha rangeland, located about 1-2 km north of the city of Thessaloniki in central Macedonia, Greece. The climate is semiarid (average annual precipitation 416 mm), with cold winters and hot dry summers. The soil, formed mainly by limestone and gneiss, is shallow of low productivity and partially degraded.

All study area is a part of the suburban forest of Thessaloniki (Kedrinos Lofos). Several measures have been applied in order to protect this area from development and to maintain its protective and aesthetic role, such as hunting banning and limitations to livestock grazing. The suburban forest was once dominated by the Calabria pine (*Pinus brutia*). About three-quarters of the total study area were burned by a wild fire in the summer of 1997. The experimental area was affected heavily by the fire (more than 90% was burned). As a consequence, the study area is now a mosaic of patches consisting of the remnant Calabria pine forest (approximately 5%), regenerated pine forest (20%), kermes oak (*Quercus coccifera*) shrubland (50%) and grassland (25%).

The major plant species that constitute the bulk of the diet of the hare and/or provide shelter against predators in this area are the kermes oak, Spanish broom (*Spartium junceum*), yellow kidney vetch (*Anthyllis hermanniae*), brusch grass (*Chrysopogon gryllus*), pineleaf pink (*Dianthus pinifolius*) and common chicory (*Cichorium intybus*) (Karmiris and Nastis 2009, Karmiris and Nastis 2010). Ten individual plants of each of the aforementioned species were randomly selected and the number of hares' pellets in 0.5 m radius experimental plots around each individual was counted. Control plots of the same size and similar vegetation structure which however did not contain the targeted plant species were also established at within 2 m distance from the experimental plots. Faecal pellets were counted every 30 days and subsequently removed from each plot. In addition, the number of twigs (shrubs) and shoots (herbs) bitten by the hare per individual plant was also counted in the experimental plots. Hare's bite marks are easily recognizable especially when other domestic and wild herbivores do not graze in common (Bang and Dalstrøm 2004).

Statistical differences in grazing intensity of hares between experimental and control plots were tested using paired samples-t-test. Simple linear regression was used in order to detect significant relationship between the number of twigs and shoots bitten by the hare and the number of pellets. All tests were considered significant at the $P < 0.05$ probability level (Zar 1984).

**Results and Discussion**

The number of hare's pellets accumulated per 30 days (Figure 1) in experimental plots (0.5 m radius) with Spanish broom (m = 12, SE = 3.3) was significant greater ($t_9 = 2.672$, P = 0.026) than that in control plots (m = 2.3, SE = 0.7). Since the 95% confidence interval of the mean differences was not containing the value (0), we reject the null hypothesis that hare's grazing intensity was not influenced by the presence of this species. Spanish broom was both visited and bitten, i.e. hare was attracted in order to feed for sure. Except food, this observed reaction of hares may also be the outcome of the hare's need to hide which, Spanish broom may provide due to its shrubby formation. Because, in the present study kermes oak and other shrub species as well as the regenerated pine stands which they still have a shrubby form provide numerous suitable shelters for hares, cover cannot be considered as a limited resource for hares in our case. Consequently, the hare's use of space at the microhabitat scale should be mainly influenced by the availability and the spatial distribution of forage resources and less by the availability of shelters against natural enemies. These results are innovative and highly valuable seeing that the hare's use of space can be manipulated through the spatially distribution of Spanish broom, which is non-preferred by livestock and other wild herbivores. As our knowledge of the mechanisms regulating the interactions between plant and herbivores get enriched, the predictions we make on their moving and feeding behavior and consequently the holistic rangeland management are more realizable, which eventually may lead to the opening of innovating conservational avenues – worthwhile to walk.

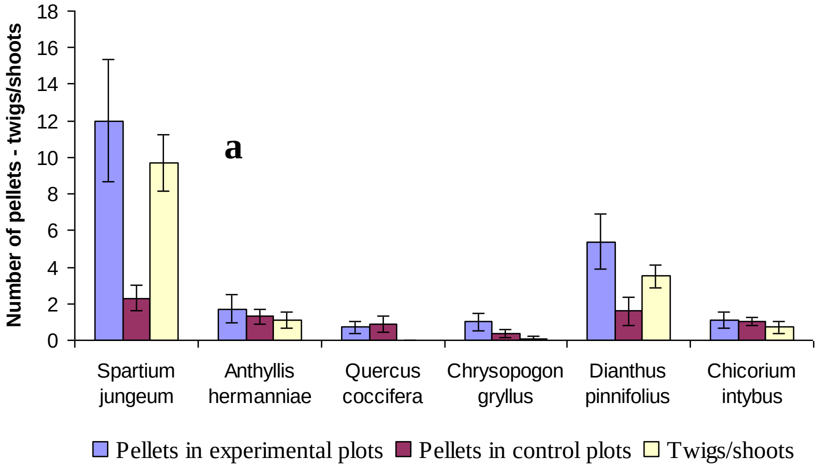


**Figure 1.** Number of hare's pellets (±SE) per 30 days in 0.5 m radius experimental and control paired plots around three shrub and three herb species and number of twigs/shoots bitten by the hare per species. Letters indicate significant differences in the mean number of pellets between experimental and control plots (paired-t-test, P < 0.05).

The estimated regression equation of number of pellets (Y) on number of bitten twigs and shoots (x) was found as $Y = 0.424 + 1.282x$, a significant linear relationship (d.f. = 58, P < 0.001) with a large effect size (adjusted $R^2$ = 0.694) (Cohen 1988). That means, the parameter 'number of twigs/shoots' can be used to evaluate the hare's grazing intensity and the use of space at the microhabitat level, as well as the parameter 'number of pellets'. The use of the former parameter is advantageous against the use of the latter one, as the counting of bitten twigs/shoots is much quicker and accurate; especially in cases where dense and low height herbaceous vegetation covers the soil surface which obscures and makes the finding of the pellets a time-consuming procedure.

## Conclusions

The hare's use of space at the microhabitat level depends on the spatial distribution of the Spanish broom, a shrubby species which provide both food and cover for this medium-sized wild herbivore and it is usually avoided by other wild and domestic herbivores. In Mediterranean rangelands where available cover for vulnerable prey species, such as the hare, is usually not limited due to the presence of many shrubby formations and solitary shrubs; the hare's use of space at the microhabitat scale should be mainly influenced by the availability and the spatial distribution of forage resources and less by the availability of shelters against natural enemies. In areas where the number of twigs/shoots bitten by the hare could be recognized without doubt, grazing intensity and use of space by hares at the microhabitat scale could be evaluated by counting the bitten twigs/shoots, a less laborious and time-consuming method than the pellet-count one.

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## References

**Bailey D.W., J.E. Gross, E.A. Laca, L.R. Rittenhouse, M.B. Coughenour, D.M. Swift and P.L. Sims. 1996.** Mechanisms that result in large herbivore grazing distribution patterns. *Journal of Range Management*, 49:386-400.

**Bang P. and P. Dalstrøm. 2004.** Animal tracks and signs. Oxford University Press. 264 pp.

Cohen J. 1988. Statistical power analysis for the behavioral sciences. 2nd ed., Academic Press, New York. 474 pp.

**Holechek J.L., R.D. Pieper and C.H. Herbel. 2001.** Range management principles and practices. Prentice-Hall, Upper Saddle River, New Jersey. 587 pp.

**Karmiris I. and A. Nastis. 2007.** Intensity of livestock grazing in relation to habitat use of brown hares (*Lepus europaeus*). *Journal of Zoology*, 272:193-197.

**Karmiris I. and A. Nastis. 2009.** Small ruminants as manipulators of brown hare (*Lepus europaeus*) habitat in kermes oak rangelands. *Options Méditerranéennes*, 85:171-176.

**Karmiris I. and Nastis A. 2010.** Diet overlap between small ruminants and the European hare in a Mediterranean shrubland. *Central European Journal of Biology*, 5:729-737.

**Karmiris I., I. Pappas, Z. Koukoura and M. Kitsos. 2010.** Plant cover influences on the use of microhabitats by the European hare (*Lepus europaeus*) in recently burned rangelands. In: A. Sidiropoulou, K. Mantzanas and I. Ispikoudiss (eds). Range Science and Life Quality.

Proceedings of the 7th Panhellenic Rangeland Congress. pp. 217-222. (In Greek with English Abstract).

**Kuijper D.P.J. and J.P. Bakker. 2008.** Unpreffered plants affect patch choice and spatial distribution of European brown hares. *Acta Oecologica*, 34:339-344.

**Senft R.L., M.B. Coughenour, D.W. Bailey, L.R. Rittenhouse, O.E. Sala, and D.M. Swift. 1987.** Large herbivore foraging and ecological hierarchies. *BioScience* 37:789-799.

**Smith M.S. 1988.** Modelling: three approaches to predicting how herbivore impact is distributed in rangelands. New Mexico State Univ. Agr. Exp. Sta. Res. Rep. 628.

**Smith R.K., N.V. Jennings, A. Robinson and S. Harris. 2004.** Conservation of European hares *Lepus europaeus* in Britain: is increasing habitat heterogeneity in farmland the answer? *Journal of Applied Ecology*, 41:1092-1102.

**Vaughan N., E.-A. Lucas, S. Harris and P.C.L. White. 2003.** Habitat associations of European hares *Lepus europaeus* in England and Wales: implications for farmland management. Journal of Applied Ecology, 40:163-175.

**Zar J.H. 1984.** Biostatistical analysis. 2nd edition. Englewood Cliffs, NJ: Prentice-Hall. 620 pp.

# Litter and green biomass in a traditionally managed alkali landscape in Hungary (Hortobágy)

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## Abstract.

The study of biomass and its effect on species richness in grasslands and wetlands improves our understanding on vegetation dynamics. We provided detailed analysis of the aboveground biomass (total biomass, green biomass and litter) in an alkali landscape along a long productivity gradient. In the lowland area of Hungary (Hortobágy Puszta) we selected alkali (i-v) and loess grasslands (vi-viii) and wetlands (ix-xiii) for our study. The studied association types were the following: (i) *Puccinellia* open alkali grasslands, (ii) *Artemisia* and (iii) *Achillea* short alkali grasslands, (iv) *Juncus* short alkali grasslands, (v) *Alopecurus* alkali meadows, (vi) *Festuca* loess grasslands, (vii) *Bromus* loess grasslands, (vii) *Stipa* loess grasslands, (ix) *Bolboschoenus* alkali marshes, (x) *Typha latifolia* marshes, (xi) *Carex vesicaria* marshes, (xii) *Typha angustifolia* marshes and (xiii) Reeds (*Phragmites australis*). In grasslands, the lowest total biomass (sampled at the peak of biomass production) scores were found in open alkali grasslands (a mean of 113 $g/m^2$), while the highest ones in *Alopecurus* alkali meadows (a mean of 2,316 $g/m^2$). In wetlands higher scores were typical, ranging from a mean of 990 $g/m^2$ (detected in *Bolboschoenus* alkali marshes) to 3,052 $g/m^2$ (detected in Reeds). In grasslands, the highest amount of litter was detected in *Alopecurus* alkali meadows (as much as 1,856 $g/m^2$) while in wetlands the highest amount of litter was found in Reeds (as much as 1,268 $g/m^2$). Species richness was the highest at medium total biomass scores both in grasslands and wetlands. Our results suggest that litter is one of the major factors controlling species richness in highly productive grasslands and wetlands.

**Key words:** biodiversity, humped-back, grassland, phytomass, steppe

## Introduction

Diversity of grasslands has decreased dramatically worldwide during the last century (Bakker & Berendse 1999). Several factors affect species richness via changing the amount of biomass; thus, studies of the major biomass components are important for effective biodiversity conservation. At the landscape scale, the humped-back relationship is most commonly observed between species richness and biomass in studies representing a long productivity gradient (Mittelbach et al. 2001). The ascending part of the humped-back curve is generally explained by decreasing stress, and increasing heterogeneity of nutrients, increasing amounts of litter and water availability (Rajaniemi 2003). The descending part of the curve is likely shaped by the increasing rate of competition, decreasing patchiness and microsite availability and by the accumulation of a thick litter layer (Mittelbach et al. 2001, Xiong & Nilsson 1999). We provided a detailed analysis of the major biomass components (total aboveground biomass, green biomass and litter) in eight types of alkali and loess grasslands and five types of wetlands in an alkali landscape in Hortobágy, Hungary. We studied a broad spectrum of grasslands and wetlands which occur in a large area in a certain landscape providing a broad productivity gradient. No such studies have been published from continental alkali communities so far, even though they occur in large areas in Central and Eastern Europe and are habitats of community interest in the Natura 2000 network.

**Materials and methods**

We studied five types of alkali grasslands: (i) *Puccinellia* open alkali grasslands; (ii) *Artemisia* and (iii) *Achillea* short alkali grasslands; (iv) *Juncus* short alkali grasslands and (v) *Alopecurus* alkali meadows; and three types of loess grasslands: (vi) *Festuca*, (vii) *Bromus* and (viii) *Stipa* loess grasslands. The studied wetlands were (ix) *Bolboschoenus* alkali marshes, (x) *Typha latifolia* marshes, (xi) *Carex vesicaria* marshes, (xii) *Typha angustifolia* marshes and (xiii) Reeds (*Phragmites australis*). The study area is located in Hortobágy, East Hungary near the towns of Karcag, Nádudvar, Egyek, Tiszafüred, Hortobágy and Balmazújváros. The region is characterised by alkali and loess grasslands traditionally managed by mowing or grazing (by cattle and/or sheep). These grasslands generally form a heterogeneous landscape-mosaic in accordance with the uneven pattern of soil salt and water contents. Grasslands with the lowest productivity are *Puccinellia* open alkali grasslands characterised by high soil salt content and high seasonal differences in groundwater table. These grasslands are generally adjacent to higher-laying dry grassland types characterised by the high cover of *Festuca pseudovina*, *Achillea* and *Artemisia* short alkali grasslands. At lower elevations, near to *Puccinellia* open alkali grasslands, *Juncus* short alkali grasslands are situated. These grasslands are characterised by lower salt content and higher soil moisture level than the *Puccinellia* open alkali grasslands. At the high-elevated loess plateaux adjacent to short alkali grasslands, loess grasslands were historically typical. Nowadays, only small fragments of these types of grasslands remain in near natural state. In our study three types of loess grasslands were sampled: *Festuca, Bromus* and *Stipa* loess grasslands. In low-laying and moderately wet areas with low alkali salt content the high-productivity *Alopecurus* alkali meadows are situated. At the lowest elevations there are several types of marshes. The *Bolboschoenus* alkali marshes are characterised by high salt content, while the other wetland types (*Typha latifolia* marshes, *Carex vesicaria* marshes, *Typha angustifolia* marshes and reeds) are characterised by lower salt content. We studied three independent stands of each (i-viii) grassland type. Within each stand 10 aboveground biomass samples (green biomass and litter; harvested at the soil surface in 20×20-cm-sized plots) were collected in June 2009. We studied three stands of each (ix-xiii) wetland types, and we collected three, 50×50-cm-sized aboveground biomass samples within each stand in June 2011. Both grassland and wetland samples were collected randomly at the peak of biomass production. They were dried (65°C, 48 hours), then sorted to vascular plant species and litter. The species lists in every biomass sample were recorded. Dry weights were measured with 0.01 g accuracy. To obtain relationships between various biomass and species richness data, the Spearman rank correlation and Gaussian-fitting were applied.

**Results**

In grasslands we found the lowest total biomass and litter scores in *Puccinellia* open alkali grasslands, while the highest ones in *Alopecurus* alkali meadows. In grasslands the relationship between total biomass and species richness showed a humped-back curve ($R^2$= 0.79). The highest species richness was detected at 750 g/m$^2$ total biomass score (Table 1). In the studied grasslands, where the amount of litter was relatively low (up to 400 g/m$^2$) we detected a strong positive correlation between litter and species richness (Spearman, $R$= 0.84, $P$ < 0.001). In grasslands, where the amount of litter was higher, litter was negatively correlated with species richness (Spearman, $R$= - 0.95, $P$ < 0.001). The correlation between green biomass and species richness was positive for the whole gradient (Spearman, $R$= 0.47, $P$ < 0.05). In wetlands, the lowest total biomass scores were found in *Bolboschoenus* alkali marshes, while the highest ones in Reeds. Litter scores were lowest in *Typha latifolia* marshes and highest in Reeds (Table 1). In wetlands the relationship between total biomass and species richness also showed a humped-back curve; however, there were no significant relationships neither between total biomass scores and species richness nor between the amount of litter and species richness. For total biomass and litter scores see Table 1.

**Table 1**. Biomass and litter scores of the studied grasslands and marshes (mean ± SE).

| Association type | Total biomass (g/m$^2$) | Litter (g/m$^2$) |
|---|---|---|
| *Puccinellia* open alkali grasslands | 112.5±30.2 | 39.7±14.6 |
| *Achillea* short alkali grasslands | 155.9±19.1 | 76.2±14.4 |
| *Artemisia* short alkali grasslands | 197.0±6.4 | 82.6±6.5 |
| *Juncus* short alkali grasslands | 352.1±42.0 | 208.6±38.5 |
| *Alopecurus* alkali meadows | 2,315.7±18.8 | 1,856.4±108.1 |
| *Festuca* loess grasslands | 378.2±7.3 | 210.5±8.6 |
| *Bromus* loess grasslands | 832.0±74.2 | 160.8±56.4 |
| *Stipa* loess grasslands | 1,117.8±52.3 | 516.0±77.1 |
| *Bolboschoenus* alkali marshes | 989.7±156.7 | 386.1±92.2 |
| *Typha latifolia* marshes | 1,568.8±222.0 | 344.5±80.0 |
| *Carex vesicaria* marshes | 1,851.8±250.9 | 844.5±168.0 |
| *Typha angustifolia* marshes | 2,442.4±353.6 | 1,254.1±313.9 |
| Reeds | 3,051.5±272.0 | 1,268.0±190.6 |

**Discussion and conclusions**

The range of total aboveground biomass detected in this study is in line with other reports studying a long biomass gradient in grasslands and in wetlands (see Waide et al. 1999). In our study, the peak of the humped-back curve was at 31% of the studied biomass maximum (at 750 g/m$^2$) in grasslands and at 40% of the studied biomass maximum (at 2,000 g/m$^2$) in wetlands. In former studies the peak was detected within the range of 25.7% and 60.7% of the studied biomass maximum (Cornwell & Grubb 2003). Several factors might be jointly responsible for the differences in the location of peaks, like climatic factors (Hawkins et al. 2003), disturbance regime (Biswas & Mallik 2011), vegetation type and some landscape properties like landscape-level heterogeneity and rate of fragmentation (Dolt et al. 2005). The biomass scores and biomass-species richness relationship in plant communities are important both from the agricultural and nature conservation point of view. A slight increase or decrease of total biomass production can result in a decrease of species richness in those communities which are situated at the peak of the total biomass-species richness humped-back curve. In the studied case the loess grasslands are at the peak of the humped-back curve. Thus, it is necessary to consider this relationship in the planning of the appropriate grazing and mowing management.

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## References

**Bakker J.P. and F. Berendse. 1999.** Constraints in the restoration of ecological diversity in grassland and heathland communities. *Trends in Ecology and Evolution*, 14:63–68.

**Biswas S.R. and A.U. Mallik. 2011.** Species diversity and functional diversity relationship varies with disturbance intensity. *Ecosphere*, 2(4): art52.

**Cornwell W.K. and P.J. Grubb. 2003.** Regional and local patterns in plant species richness with respect to resource availability. *Oikos*, 100:417–428.

**Dolt C., M. Goverde and B. Baur. 2005.** Effects of experimental small-scale habitat fragmentation on above and below-ground plant biomass in calcareous grasslands. *Acta Oecologica*, 27:49–56.

**Hawkins B.A., R. Field, H.V. Cornell, D.J. Currie, J-F. Guégan, D.M. Kaufman, J.T. Kerr, G.G. Mittelbach, T. Oberdorff, E.M. O'Brien, E.E. Porter and J.R.G. Turner. 2003.** Energy, water, and broad-scale geographic patterns of species richness. *Ecology*, 84:3105–3117.

**Mittelbach G.G., C.F. Steiner, S.M. Scheiner, K.L. Gross, H.L. Reynolds, R.B. Waide, M.R. Willig, S.I. Dodson and L. Gough. 2001.** What is the observed relationship between species richness and productivity? *Ecology*, 82: 2381–2396.

**Rajaniemi T.K. 2003.** Explaining productivity-diversity relationships in plants. *Oikos*, 101: 449-457.

**Waide R.B., M.R. Willig, C.F. Steiner, G.G. Mittelbach, L. Gough, S.I. Dodson, G.P. Juday and R. Parmenter. 1999.** The relationship between productivity and species richness. *Annual Review of Ecology Systematics*, 30: 257-300.

**Xiong S. and C. Nilsson. 1999.** The effects of plant litter on vegetation: a meta-analysis. *Journal of Ecology*, 87:984–994.

# Some Vegetation Characteristics of an Upland Rangelandin Eastern Anatolia

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## Abstract

The objective of the study was to provide information on the current situation of upland rangelands in eastern Anatolia. For this purpose, a transhumant area was selected and sampled in the years of 2000 and 2001, in Erzurum province. Two distinct range sites were determined in the experimental area, a dry site and a subirrigated one. Grasses were the dominant family in both sites but the dominant species were different. Sheep fescue was the dominant species in the dry site and matgrass in the subirrigated. Canopy coverage was over 40% in both sites. The range condition class for the dry and the subirrigated site was fair and poor, respectively. The carrying capacity in the dry and subirrigated site was 2.2 and 2.0, respectively, for the 2.5 months of the upland period. Although botanical composition and range condition of the sites was undesirable, these sites can be classified as healthy in the rangeland condition classes due to enough density and diversity. The result of the experiment indicates that it is essential to develop new management strategies in order to maintain or improve the current conditions of the upland rangelands in the area. It can be proposed that at least 2 ha of rangeland area should be allocated per animal unit during the upland period.

**Key words:** Upland rangelands, transhumance, botanical composition, range condition

## Introduction

Rangelands cover 52% of the Eastern Anatolia region in Turkey. Rolling topography and unsuitable climatic conditions restrict the field crop area and production in the region, rendering animal husbandry dependent on rangelands important in agricultural production. Uneven topography causes significant differences in plant growth during the growing season. For instance, plants reach grazing stage in some areas, whereas in some others the plants might be just entering the growing stage. Thus, transhumant grazing system is more common in the region (Altin et al. 2011).

Grazing in uplands is an essential part of livestock feeding in the region. Livestock grazing alters the vegetation structure which is vital for the sustainable use of the rangelands. In general, overgrazing can reduce canopy cover, alter botanical composition and decrease range condition class (Oztas et al. 2003). Additionally to grazing, site characteristics especially topography and soil moisture status are major factors in controlling distribution and abundance of species in the rangeland vegetation (Firincioglu et al. 2007). Due to uneven distribution of vegetation, spatial distribution of grazing changes during the grazing season. Grazing animals congregate and linger on the riparian areas due to supplying green forage and water through the summer dry period, hence, the detrimental effect of grazing is more severe in these areas (Holechek et al. 2004)

Although upland rangelands play a significant role in livestock production in this region, there is limited information about their vegetation structure. The aim of this study was to estimate the changes in botanical composition, canopy coverage, and range condition and health under current conditions and outline the implementation of possible rangelands rehabilitation techniques for the Eastern Anatolian uplands.

**Material and Methods**

This study was conducted at the upland rangelands of Tortum district of Erzurum province of Turkey in the years of 2000 and 2001, where transhumant grazing system is applied. Two major range sites, dry and subirrigated steppe, were determined in the area ($41^{o}18^{'}$ E, $40^{o}22^{'}$ N) before setup of the experiment. The dry range site was located at an average altitude of 2550 m with smooth rolling topography and having no ground water. The sub-irrigated range site was located at an average altitude of 2500 m with 10% slope from west to east and with the water table reaching up to surface in some places in the spring.

The climate of the study area is characterized by cold winters and slightly warm and dry summers with most precipitation occurring from late autumn to early summer. The annual total precipitation in the year of 2000 and 2001 was 305 mm and 424 mm respectively, below the long term average (450 mm). The long term annual average temperature of the experimental area was 6 °C. It was 5.4 and 5.9 °C during the experimental years, respectively.

Soil analysis performed according to Soil Survey Laboratory Staff (1992) procedures revealed that the dry and subirrigated range sites had sandy-clay and loam soil texture, 7.4 and 5.2 % of organic matter, 5.5 and 5.0 of pH, respectively. The soils of both sites were poor in lime and phosphorus but rich in potassium.

Botanical composition of the range sites was determined by the line intercept method developed by Canfield (1941) in July 2000 and 2001.

Measurements were performed using 8-line intercept transects (10 m long transect each) based on the basal area. The range condition score, condition and health classification were determined for each range site using the 2-year average botanical composition values according to the criteria suggested by Koc et al. (2003), consisting of a combination of range condition classification (Dyksterhius 1949) and rangeland health methods of the Committee on Rangeland Classification (National Research Council 1994). Forage production of the sites was not sampled because the sites were open to public grazing. Therefore, carrying capacity was determined based on ecological principles using a scale developed for Turkish rangelands based on botanical composition data (Koc et al. 2003). The results are presented as area per animal unit (500 kg live weight) for 75 days of the grazing season, as upland rangelands are grazed from mid June to beginning of September (Altin et al. 2011).

The data was evaluated by descriptive statistics using EXCEL software.

**Results and Discussion**

A total of 48 species consisting of 15 grasses, 5 legumes and 28 the other families in the dry site and 35 species consisting of 6 grasses, 6 legumes and 23 the other families in the subirrigated site were recorded. Grasses percentage in botanical composition was 46.81 and 58.01 in the dry and subirrigated site, respectively. Dominant species in the botanical composition was sheep fescue (*Festuca ovina*) with 21.73 percentage in the dry site, and matgrass (*Nardus stricta*) with 41.79 percentage in the subirrigated site. Legumes contributed 9.53% in the dry site and 2.27% in the subirrigated site to botanical composition. The contribution of the other families was 43.66% and 39.72% in the dry and subirrigated site, respectively.

The distribution of species based on response to grazing showed great differences between the sites. Therefore, the dry site was classified as fair and the subirrigated site as poor in the range condition classes. A total of 12 species belongingto a decreaser group, contributed a 26.86% in the botanical composition of the dry site whereas nine decreaser plants were recorded and their percentage in the botanical composition of the subirrigated site was 5.78. Increaser species were 28.78% and 11.79% in the botanical composition of the dry and subirrigated site, respectively. Invader species abundance in the botanical composition of the dry site was lower than in the one of the subirrigated site (82.43%). Canopy coverage was 40.33% and 46.69% in the dry and subirrigated site, respectively. Rangeland health was classified as healthy for both sites. The required range area for an animal unit during the grazing period was 2.2 and 2.0 ha in the dry and subirrigated site, respectively.

Grasses were the most common family group in both sites. Light rains during the growing season favor grasses over the other families in semi-arid conditions (Herbel and Pieper 1991), thus, grasses are common in the dry site of the experimental area. Similarly, grasses were also the dominant species in the botanical composition of the subirrigated site. This is because plants with extensive root system are not well adapted to poorly aerated root areas due to excess water (Altin et al. 2011).

Sheep fescue, a drought resistant short grass, was the dominant plant species in the dry site, whereas matgrass a mesophyte short grass, dominated the subirrigated site. The high abundance of these plants is related to the heavy grazing pressure as heavy grazing shifted the composition of range vegetation from tall grass to short grass and from higher productive plants to low productive and unpalatable plants (Firincioglu et al. 2009). Another indicator of overgrazing in the experimental areas was the high abundance of invasive species in the botanical composition. It is well documented that these plants benefit over desired range plants under heavy grazing conditions (Holechek et al. 2004).

Canopy coverage on both sites was above the critical values, which require 30% of basal cover to prevent accelerated erosion (Marshall 1973). Both sites were classified as healthy in the range health class, as a consequence of the high canopy coverage. Although invader plant species were common in both sites, there was no serious erosion risk and plant diversity was adequate to implement ecosystem functions.

Animals congregate on wet areas during the summer drought period due to supplying green forage and water, hence, the detrimental effect of grazing is more severe on these areas (Holechek et al. 2004). Thus, the range condition class was lower for the subirrigated site compared to the dry one. There is a linear relationship between the range condition class and the carrying capacity (Koc et al. 2003), the lower carrying capacity in both sites originated from a lower range condition class in the experimental area. The botanical composition and range condition classes of the sites revealed that upland rangelands suffer from heavy grazing pressure as is also the case with similar areas all around the country (Koc and Gokkus 1998).

In conclusion, although upland rangelands do not suffer from early and late season grazing, heavy grazing pressure is a serious problem during the upland season on these rangelands. In order to at least maintain or even improve the current conditions, it is essential to improve the current grazing practices. Under current conditions, at least 2ha of rangeland area should be allocated per animal unit during the 2.5 months of the upland period with respect to sustainable use of the upland rangelands in the study area.

**Table 1.** Botanical composition (%), basal coverage (%) and range condition and health class of the range sites

| Attributes | Dry Site | | Subirrigated Site | |
|---|---|---|---|---|
| | Species Number | Percentage | Species Number | Percentage |
| Plant Groups | | | | |
| Grasses | 15 | 46.81 | 6 | 58.01 |
| Legumes | 5 | 9.53 | 6 | 2.27 |
| The others | 28 | 43.66 | 23 | 39.72 |
| Total | 48 | | 35 | |
| Response to Grazing | | | | |
| Decreaser | 12 | 26.86 | 9 | 5.78 |
| Increaser | 7 | 28.78 | 3 | 11.79 |
| Invader | 29 | 44.36 | 23 | 82.43 |
| Dominant Species | *Festuca ovina* (21.73%) | | *Nardus stricta* (41.79%) | |
| Basal Coverage (%) | 40.33 | | 46.69 | |
| Range Condition | Fair | | Poor | |
| Health Class | Healthy | | Healthy | |
| Carrying Capacity (Required area (ha) | 2.2 | | 2.0 | |

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**References**

**Altin M., A. Gokkus and A. Koçç 2011.** Meadow and Range management. I. General Principles. Ministry of Agriculture and Rural Affairs Publ., (In Turkish), 376 pp.

**Canfield R.H. 1941.** Application of the line interception method in sample range vegetation. *Journal of Forestry,* 39: 388-394.

**Dyksterhuis E.J. 1949.** Condition and management of range land based on quantitative ecology. *Journal of Range Management,* 2: 104-115.

**Firincioglu H.K., S.S. Seefeldt B. Sahin and M. Vural. 2009.** Assessment of grazing effect on sheep fescue (*Festuca valesiaca*) dominated steppe rangelands, in the semi-arid Central Anatolian region of Turkey. *Journal of Arid Environments,* 73: 1149–1115

**Firincioglu H.K., S.S. Seefeld and B. Sahin. 2007.** The effects of long-term grazing exclosures on range plants in the Central Anatolian Region of Turkey. *Environ. Manage.* 39: 326-337.

**Herbel C.H. and R.D. Pieper. 1991.** Grazing management. In:J.Skujin (ed). In Semiarid Lands and Deserts: Soil Resources and Reclamation. Marcel Dekker, Inc. pp. 361-385.

**Holechek J.L., R.D. Pieper and C.H. Herbel. 2004.** Range Management: Principles and Practices. Pearson Education, Inc., New Jersey. 607 pp.

**Koc A. and A. Gokkus. 1998.** Suggestion from previous studies for better range and meadow management in the Eastern Anatolia Region. Proceeding Eastern Anatolia Agricultural Congress. pp. 419-428. (In Turkish with English abstract).

**Koc A., A. Gokkus and M. Altin. 2003.** Comparison of world-widely used methods in definition of range condition and a suggestion for Turkey. Proceeding 5th Field Crop Congress of Turkey. pp. 36-42. (In Turkish with English abstract).

**Marshall J.K. 1973.** Drought land use and soil erosion. In: J.V. Lovett (ed). The Environmental, Economic and Social Significance of Drought. Angus and Robertson. pp. 55-77.

**National Research Council. 1994.** Rangeland Health: New Methods to Classify, Inventory, and Monitor Rangelands. National Academy Press, Washington. 182 pp.

**Oztas T., A. Koc and B. Comakli. 2003.** Changes in vegetation and soil properties along a slope on overgrazed and eroded rangelands. *Journal of Arid Environments,* 55: 93-100.

**Soil Survey Laboratory Staff. 1992.** Soil Survey Laboratory Methods Manual. USDA-SCS. Soil Survey Investigations Report No: 42, 400 p.

# Effect of regional conditions on post-fire vegetation restoration rate in Mediterranean rangeland ecosystems.

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## Abstract

After fire in natural ecosystems begins the secondary procession, which in certain time restores the vegetation to the succession stage, as it was before the fire occurred. This natural restoration of vegetation depends mainly on the type of vegetation, the climatic and soil conditions and fire intensity. The restoration rate is the main factor for their evolution. The purpose of this research was to evaluate the rate of restoration of vegetation on rangeland ecosystems after fire and to study the probability of reducing the time of grazing forbiddance. The research was conducted in burned forest areas of the prefecture Lakonia and Ileia 3 years after the fire of year 2007. In this area two ecotopes were selected: 1) shrubland and 2) Allepo pine woodland, in which the following parameters were measured: a) the soil cover with vegetation, b) participation of species in the composition of vegetation, c) the total annual production, d) the total height of the dominant shrubs e) the amount and the height of seedlings of *Pinus halepensis*. Our results indicated, that three years after the fire all the ecotopes had soil cover with vegetation greater than 75%, which means that the restoration of vegetation has created foliage cover able to protect the soil from erosion. Furthermore the restoration rate of vegetation in both shrublands and Aleppo pine woodlands has created a dynamic development process such as to ensure their stability.

**Keywords:** drought index, post fire restoration, rangelands, grazing.

## Introduction

The Mediterranean-type vegetation is one of the world's major fire-prone biomes (Capitanio and Carcaillet, 2008). In areas where this type of vegetation occurs, fire is a crucial process controlling the vegetation dynamics and structure and the post-fire regeneration processes are highly dependent on the pre-fire vegetation (Pausas et al. 2008). The behavior of plant communities and plant cover can regulate and control the soil processes in the post-fire period, due to its influence on organic matter inputs, soil structure, soil erosion risk and hydrologic processes (Granged et al. 2011). The restoration rate is the main factor for their revolution. The lawmaker anticipates the forbiddance of grazing in burned areas. However, in rangelands ecosystems with high capacity, long-term forbiddance of grazing, creates accumulation of large quantities of dry biomass, increasing in this way the risk of new fires. The purpose of this research was to evaluate the rate of restoration of vegetation on rangelands ecosystems after fire and to study the probability of reducing the time of grazing forbiddance.

**Materials and Methods**

The research was conducted in burned forest areas of the prefecture Lakonia, 3 years after the fire of year 2007. In this area two ecotopes were selected: 1) shrubland, in which the dominant shrub species were *Quercus coccifera, Phyllirea latifolia,Pistacia lentiscus and Arbutus unedo* 2) Aleppo pine woodland, in which the dominant shrub species of the understory were: *Quercus coccifera, Pistacia lentiscus* and *Arbutus unedo*. Totally 6 range units were selected in each prefecture: 3 shrublands and 3 Aleppo pine woodlands in which the following parameters were measured: a) the soil cover with vegetation, b) participation of species in the composition of vegetation with the line point method (Cook and Stubbendieck 1986) c) the total annual production with quantrants 50 X50, d) the total height of the dominant shrubs e) the amount and the height of seedlings of *Pinus halepensis*, in fifteen quantrants 50 x 50 cm . In each plot the seedlings were classified into two classes according to their height (20-50cm and 50-100cm). As regeneration index we defined the number of seedlings per square meter. From the data, was calculated the grazing capacity and the grazing stocking rate expressed in small monthly animal units for 9 months grazing, as such as and the rangeland footprint (grazing stocking rate/grazing capacity). Based on the total monthly rainfall and the average monthly temperature during the three years after fire, we calculated the drought index de *Martonne,* according to the formula: J=2P/T+10, where T is mean annual temperature and P is mean annual amount of precipitation, One-way ANOVA was used to compare the means in two ecotopes with the LSD posthoc test (Kinnear and Grey 2008).

**Results and discussion**

The change of drought index values during the period (2008-2010) in Lakonia and Ileia prefecture is shown in Figure 1. The climate of Lakonia is drier than Ileia prefecture since the values of drought index were < 20 for longer period during the year, which indicates long drought periods (Koleva and Alexandrov 2008). Consequently, Ileia prefecture had more favourable climatic conditions (temperature, rainfall) for vegetation growth than Lakonia. In order to evaluate the effects of regional climatic conditions on the rate of vegetation restoration after fire, total soil cover with vegetation and total annual forage production was measured (Table1). Total vegetation soil cover and annual forage production of Ileia prefecture were significantly increased, by 16% and 49.5% respectively, in contrast to Lakonia prefecture.

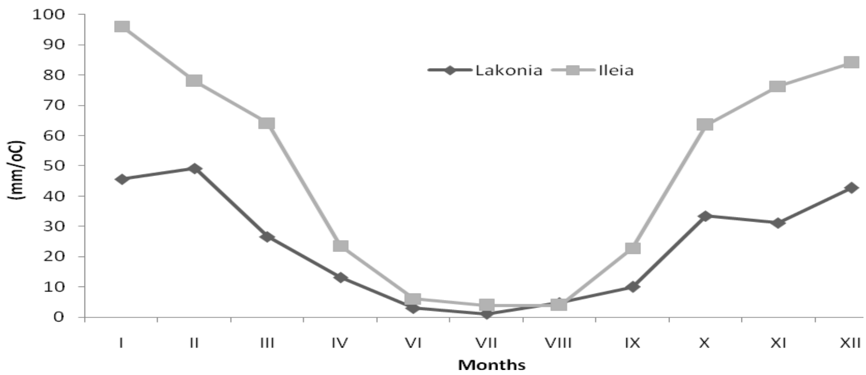


**Figure 1.** Mean drought index values de Martonne (J) of Lakonia and Ileia prefecture during 2008-2010 (3 years after fire).

**Table 1.** Total soil cover with vegetation in 2010 (%), total annual forage production in 2010 (kg/ha) and mean drought index value de Martonne (J) (year 2008-2010), in burned areas of Lakonia and Ileia prefecture.

| Prefecture | Drought index (2008-2010) | Total annual forage production (kg/ha) | Total soil cover with vegetation (%) |
|---|---|---|---|
| Lakonia | 18.4 | 2755 b* | 79.8 b |
| Ileia | 37.9 | 4119 a | 92.4 a |

*Letters in the same row indicate differences at 0.05 significant level using LSD posthoc test

Furthermore, three years after fire, in all ecotopes vegetation cover was greater than 75% whereas annual production of woody species in shrubland and Aleppo pine ecotypes of Ileia prefecture was significantly higher by 89.3 and 86.1% respectively, than Lakonia prefecture ones (Table 2).The rapid recovery of the vegetation is in line with other studies in the Mediterranean region (Van der Merwe and Van Rooyen 2011). These results indicate that drought index affects vegetation soil cover and annual forage production with higher index values accelerating the post fire regeneration rate.

**Table 2.** Annual woody and herbaceous forage production (kg/ha) and vegetation soil cover (%) in different ecotypes of burned areas in Lakonia and Ileia prefecture, in 2010.

| Prefecture | Ecotope | Annual production of woody species | Annual production of herbaceous species | Vegetation soil cover (%) |
|---|---|---|---|---|
| Lakonia | Shrubland | 1546 d | 910.6 a | 75.0 d |
| | Aleppo pine | 2018 c | 1036 a | 84.5 c |
| Ileia | Shrubland | 2926 b | 892 b | 90.0 b |
| | Aleppo pine | 3755 a * | 766 b | 95.5 a |

*Different letters in the same row indicate differences at 0.05 significant level using LSD posthoc test

In Mediterranean ecosystems, where water availability is a limiting factor for the vegetation (Archibold 1995), regional patterns of vegetation structure and composition are determined by a dryness gradient. Thus, vegetation cover is higher in areas with higher water availability than in drier areas (Lloret et al. 2005).

Rangeland footprint in woodland and shrubland of Ileia prefecture was lower or near one (Table 3), indicating that three years after fire period the extent of vegetation regeneration in these ecotypes, could permit livestock grazing. In Lakonia prefecture the rangeland footprint was bigger than one in all ecotopes and was estimated that it will probably take two more years to restore the vegetation to a degree to permit grazing. In the contrary, the lower values of rangeland footprint of Ileia prefecture permit the grazing in all ecotopes three years after fire. Grazing will contribute to Aleppo pine seedlings development, because of reducing the competition with annual herbage vegetation. Annual herbaceous species exerted a detrimental effect on seedlings density in both prefectures (Table 4), whereas increased vegetation cover reduced seedling density, mainly due to interspecific resource (water and nutrient) competition. Recent studies have been reported same results investigated post fire regeneration of *Pinus halepensis* stands in Mediterranean area (Prevosto and Ripert 2008).

**Table 3**. Mean grazing stocking rate and grazing capacity (goats and sheeps/ha / 9 months grazing) in each ecotype of burned areas of Lakonia and Ileia prefecture in 2010.

| Prefecture | Ecotope | Grazing capacity | Grazing stocking rate | Rangeland footprint (Grazing stocking rate/Grazing capacity) |
|---|---|---|---|---|
| Lakonia | Shrubland | 1.5 | 3.1 | 2.0 |
| | Aleppo pine | 1.6 | 2.3 | 1.4 |
| Ileia | Shrubland | 2.0 | 2.2 | 1.1 |
| | Aleppo pine | 1.8 | 1.3 | 0.72 |

**Table 4**. Height class distribution and regeneration index of *Pinus halepensis* seedlings (seedling/ha), annual herbaceous species composition in vegetation and mean shrub height (cm) of Aleppo pine burned areas of Lakonia and Ileia prefecture in 2010.

| Prefecture | Ecotope | Seedlings 20-50 cm (seedling/ha) | Seedling height 50-100 cm (seedling/ha) | Annual herbaceous species composition (%) in vegetation | Mean shrub height (cm) |
|---|---|---|---|---|---|
| Lakonia | Aleppo pine | 69330 | 21330 | 9.6 | 81.0 |
| | | 37330 | 8000 | 11.7 | 81.0 |
| | | 32000 | 2660 | 12.0 | 73.3 |
| Ileia | Aleppo Pine | 79578 | 39591 | 13.5 | 120.0 |
| | | 41670 | 65120 | 17.0 | 106.0 |
| | | 53266 | 18667 | 27.3 | 142.7 |

**Conclusions**

Drought index affected post fire restoration process. Three years after the fire all the ecotopes in both prefectures had soil cover with vegetation higher than 75%, which means that the restoration of vegetation has created foliage cover able to protect the soil from erosion. Based on regeneration index values the Aleppo pine regeneration was satisfactory.

## References

**Archibold O.W. 1995.** Ecology of world vegetation. Chapman & Hall, London. 234 pp.

**Capitanio R. and C. Carcaillet. 2008.** Post-fire Mediterranean vegetation dynamics and diversity: a discussion of succession models. *Forest Ecology and Management*, 255:431-439.

**Cook C. W. and J. Stubbendieck. 1986.** Range Research: Basic Problems and Techniques. Society for Range Management, Colorado. 317 pp.

**Granged A.J.P., L.M. Zavala, A. Jordán and G. Bárcenas-Moreno. 2011.** Post-fire evolution of soil properties and vegetation cover in a Mediterranean heathland after experimental burning: A 3-year study. *Geoderma*,164: 85-94.

**Kinnear P.R. and C.D. Gray. 2008.** SPSS 15 made simple. Psychology Press, Hove. 356 pp.

**Koleva E. and V. Alexandrov. 2008.** Drought in the Bulgarian low regions during the 20th century. *Theoretical and Applied Climatology*, 92:116-119.

**Lloret F., H. Estevan, J. Vayreda and J. Terradas. 2005.** Fire regenerative syndromes of forest woody species across fire and climatic gradients. *Oecologia*, 146: 461-468.

**Pausas J.G., J. Llovet, A. Rodrigo and R.Vallejo. 2008.** Are wildfires a disaster in the Mediterranean basin? – A review. *International Journal of Wildland Fire*, 17:713-723.

**Prevosto B. and C. Ripert. 2008.** Regeneration of Pinus halepensis stands after partial cutting in southern France:Impacts of different ground vegetation, soil and logging slash treatments. *Forest Ecology and Management*, 256:2058-2064.

**Van der Merwe H. and M.W. van Rooyen. 2011.** Vegetation trends following fire in the Roggeveld, Mountain Renosterveld, South Africa*. South African Journal of Botany,* 77:127-136.

# Wet grasslands and biodiversity: a case study from Greece

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## Abstract

Wet grasslands host a rich biodiversity. Many of the Natura 2000 areas in Greece include or consist of wet grasslands habitats. One of these areas is the "Epanomi Lagoon", North Greece - Thessaloniki, which is designated as a Special Areas of Conservation (SAC) and Special Protection Area under the Bird and Habitats Directives (Natura 2000 EU Protected Area Network). The Hellenic Ornithological Society (HOS)/ BirdLife Greece has been monitoring Epanomi's biodiversity status (particularly birds) since the 1980s, and since 2008, intense and methodical bird monitoring has being carried out by volunteers. The monitoring protocol registers birds' presence and behavior, habitat threats and human activities. The scope of this paper is to publish the most recent methodical monitoring results of HOS regarding the biodiversity status of typical Greek wet grasslands and to connect these results to current human activities. The protected area covers nine wet grasslands habitat types hosting almost 120 different bird species. The wet grasslands host 20 different species of waders. It seems that the core factors for high biodiversity in such types of protected areas are the presence of water and habitat heterogeneity. Human activities that could have negative effects on biodiversity were illegal waste disposal and traffic. HOS has proposed several versions of a management plan since 1998, in which key issues have been water presence and sustainable human activities.

**Keywords**: birds, waders, human activities, Natura 2000 Areas, Epanomi lagoon

## Introduction

Grasslands provide highly valued diverse habitats and offer an enormous range of ecosystem services that benefit the overall population. They support a huge range of biodiversity, act as barriers to forest fires, protect water resources and store carbon (Reynolds and Frame 2005). For carbon storage especially, it is estimated that grasslands store around 34% of the global stock in terrestrial ecosystems (European Commission 2008). Wet Grassland is defined as "Periodically inundated pasture or meadow with ditches, which maintain the water levels containing standing brackish or fresh water. Almost all areas are grazed and some areas are cut for hay. Sites may contain seasonal water-filled hollows and permanent ponds with tall fen species such as reeds, but not extensive areas" (Treweek et al. 1997). The Tayside Biodiversity Partnership (2009) categorized wet grasslands into the following types: Semi-natural floodplain grassland, Water meadows, Wet grassland with intensive water level management on drained soils and Lochside wet grassland. Joyce and Wade (1998) used a simpler classification for wet grasslands, since they included under wet grasslands “floodplain meadows and coastal grazing marshes or pastures, which landscape was been formulated through traditional low-intensity farming”.

Most of the wet grasslands in Greece have been incorporated into the EU Network of Protected Areas Natura 2000. However, the designation of a protected area is not enough to ensure a good conservation status for species and habitat types. A recent assessment has shown that only 7% of Natura 2000 grasslands sites are in favorable condition (European Commission 2009), so they could also be considered as threatened habitat types, mainly due to land use changes of the last 50 years (eg. overgrazing, land abandonment, urban development, illegal waste disposal, flood defense, land drainage, etc.) (Joyce & Wade 1998).

Regarding bird species and their habitats, the Hellenic Ornithological Society (HOS)/ BirdLife Greece maintains a monitoring scheme the Important Bird Areas (IBA) Network of Greece for more than 25 years now. Most of the Gr-IBAs have been designated as Natura2000 Areas. Since there is a long-time monitoring of birds and their habitats (Portolou et al. 2009), while birds are considered as a trustworthy indicator for surveying the biodiversity status of an area (it has been used as one of the main EU environmental indicator for evaluating the existing CAP/ Rural Development Regulation Program), it is safe to state that HOS IBA’s monitoring is providing a rather good picture of the trends of the Greek fauna and their habitat status. Unfortunately, during the last three decades, the conservation status of Greek birds is a general decline, trend that seems to apply to the majority of species, from common (Kominos et. al 2009) to threatened (Legakis & Maragou 2009). Moreover, the monitoring of certain bird species groups (such as the waders which prefer wet grasslands for nesting and feeding), has shown that bird species whose habitat requirements include a dependence on the presence of water, have been declining more rapidly (HOS 2012) and their threats are connected mainly to human activities (Korbeti & Deli 2011).

**Material and methods**

As a case study, “Epanomi Lagoon”, North Greece - Thessaloniki was selected as a typical natural wet grassland area of Greece (figure 1). This lagoon is included in the Natura 2000 EU Protected Area Network as a Site of Special Areas of Conservation (GR1220012) and a Special Protection Area (GR1220011) under the Bird and Habitats Directives. It is also a Wildlife

Refuge under the national protected areas network. The majority of the wetland is semi-stated owned.

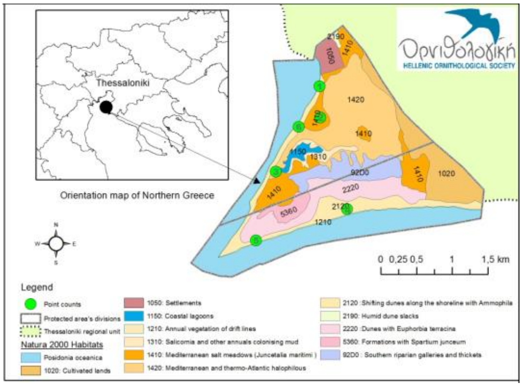


**Figure 1.** Epanomi lagoon map, divided into parts (north/south) & Natura 2000 habitat types.

HOS is monitoring Epanomi's biodiversity status (focused on birds) from the 80s, and since 2008, intense and methodical bird monitoring has been carried out by volunteers. For the monitor, a protocol has been developed which registers birds' presence and behavior, habitat's threats and human activities and is in line with the old monitoring protocol of the 80s and 90s. The monitoring protocol consists of six panoramic count points dividing the wetland into two parts; north (351ha) and south (339ha). The north part has more habitats compared to the south, as a direct result of water abundance. The threatened bird species have been classified according to two systems; one volunteer (scientific) and one mandatory (EU legislation). The scientific classification groups species into classes accordingly to their rarity and distribution. The threatened species are the ones that are characterized as Species of European Conservation Concern/SPEC grouped to classes 13 (IUCN 2011, BirdLife International 2004). The mandatory classification is based on EU legislation, the Directive 2009/147/EC on the Conservation of Wild birds where the most threatened species are listed in Annexes I and II.

The survey periods were divided into four periods according to bird behavior in the Epanomi region: spring migration (Febr to Mar), breeding period (Apr to Jul), autumn migration (Aug to Oct) and wintering (Nov to Jan). The monitoring is ongoing, but for the purpose of this publication, the data that was used is from the period 02/2009 – 12/2011 corresponding to six (2009), eight (2010) and seven (2010) field visits per year.

**Results and Discussion**

The protected area includes twelve terrestrial habitats,of which nine can be considered as wet grasslands (Fig. 1, except 1020, 1050 & 1150). The survey verified that Epanomi lagoon is an important wetland for Greece since it hosts a variety of threatened bird species. Up to now, 119 bird species have been recorded. Forty two percent of the bird species of Epanomi lagoon are Species of European Conservation Concern/ SPEC (SPEC1:1sp.|SPEC2:14sp. |SPEC3:35sp.). Almost half (48%) of Epanomi lagoon's bird species are listed in the Annexes of EU Directive 2009/147/EC (Annex I:30 sp.|Annex II:27 sp.). The rarest species recorded in the area (June 2009) was Audouin's gull (*Larus audouinii*).

Twenty different Wader species are present in the wet grasslands of Epanomi Lagoon (*Actitis hypoleucos, Arenaria interpres, Burhinus oedicnemus, Calidris alpina, C. ferruginea, C. minuta, Charadrius alexandrines, C. dubius, Glareola pratincola, Numenius arquata, Philomachus pugnax, Pluvialis apricaria, P. quatarola, Podiceps cristatus, P. nigricollis, Recurvirostra avosetta, Tringa erythropus, T. nebularia, T. stagnatilis* and *T. totanus*).The majority of birds (individuals) and the greatest variety of species were recorded during the breeding period, especially in April and May. This period has the highest distribution and quantity of water since the lagoon's hydrological balance is based solely on atmospheric precipitation rather than surface run off. May is usually the last "wet" month because in the wetland there are several active channels due to 60'-70' drainage plans.

The distributions of wader species in the north and south parts of the wetland (Table 1) shows that waders preferred mainly the north part of the wetland, probably due to water abundance and the diverse mosaic of wet grassland habitats present there. The south part was highly appreciated by people, especially during the summer period. Among human activities observed in the lagoon, the ones that could have a negative effect on the biodiversity, were illegal waste disposal and high number of cars crossing the wetland (on-off road driving) Similar problems were observed in a neighboring wetland (Kourakli et al. 2011).

Epanomi lagoon doesn't have a management plan, although HOS proposed several versions for it since '98. All of them included enhancement of water presence (more wet areas for more time) and encouraged sustainable activities (fishing, recreation, education, etc.). The main reasons for this is the wetland it has a rather complicated ownership status, while Greece hasn't set as a priority yet to develop management plans for Natura 2000 Areas.

**Table 1.** Parts of the lagoon that waders were recorded vs human activities.

| Period | Part | Species | Human activities | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | waste disposal | Fishing | Husbandry | cars* | pedestrians | Swimming** | beach bars |
| Spring migration | North | 8 | | √ | | √ | | | |
| | South | 2 | | √ | | √ | | | |
| Breeding | North | 19 | | | | √ | | √ | |
| | South | 3 | | | | √ | | √ | √ |
| Autumn migration | North | 8 | √ | √ | | √ | | √ | |
| | South | 0 | √ | √ | | √ | | √ | √ |
| Wintering | North | 10 | √ | √ | √ | √ | √ | | |
| | North | 0 | | √ | | √ | | | |

* Cars = on & off road driving/ **Swimming= passing through wet grassland so to go for swimming

## Conclusions

Epanomi lagoon is a protected area that has a variety of Natura 2000 terrestrial habitat types of which nine could be consider as wet grasslands. In the lagoon, 119 bird species were recorded of which almost half are under threat of extinction. The wet grasslands of the Epanomi lagoon are important for several bird species; particularly for waders (20 species) and especially during the breeding period. The north part of the wetland attracted more wader species and individuals, probably due to water abundance and the diverse mosaic of the wet grasslands. Human activities that could have negative effects on biodiversity were illegal waste disposal and cars' circulation. Furthermore, there are various drainage constructions that negatively affect the water economy of the area, threatening habitats to permanent drainage.

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## References

**BirdLife International, 2004.** Birds in the European Union: a status assessment. Wageningen, The Netherlands: BirdLife International.

**European Commission, 2009.** Report from the Commission: Composite report on the conservation status of habitat types & species as required under Art.17 of the habitats Directive.Brussels, Belgium.

**European Commission, Environment Directorate-General, 2008.** Life and Europe's grasslands: restoring a forgotten habitat. http://www.wri.org/publication/content/8272.

**HOS, 2012.** Mid- Winter Water Bird Counts, 1980-2012. Unpublished data.

**IUCN Red List of Threatened Species, 2011.** http://www.iucnredlist.org.

**Joyce C. and P. Wade, 1998.** European Wet Grasslands: Biodiversity, Management and Restoration. ISBN: 9780471976196.

**Kominos Th., A. Dimalexis and D. Portolou, 2009.** Gr Common Bird Monitoring Scheme. HOS http://files.ornithologiki.gr/docs/hcbm/HCBM_2007_2009.pdf.

**Korbeti M. and H. Deli 2011.** Safeguarding special sites for birds, nature and people - A decade of advocacy cases 2000 - 2012. HOS http://files.ornithologiki.gr/docs/politiki/ Anafora%20Kataggelion.pdf.

**Kourakli P, A. Bounas, H. Tsilianidis and G. Fotiadis, 2011.** Grasslands of coastal Salinas for birds, for nature, for people. 8th European Dry Grassland Meeting.13-17 June, 2011, Uman, Ukraine.

**Legakis A. and P. Maragou 2009.** Red Data Book of the Greek Fauna. Hellenic Zoological Society.

**Portolou D., S. Bourdakis, Ch. Vlachos, Th. Kastritsis and A. Dimalexis, 2009**. The Important Bird Areas of Greece.

**Reynolds S.G. and J. Frame, 2005.** Grasslands: Developments Opportunities Perspectives. FAO and Science Publishers. ISBN 9789251050422.

**Tayside Biodiversity Partnership, 2009.-**Tayside Biodiversity Action Plan - Farmland - Wet Grassland. http://www.taysidebiodiversity.co.uk/Section2_ Farmland_F5.html.

**Treweek J., M. Drake, O. Mountford, C. Newbold, C. Hawke, P. Jose, M. Self and P. Benstead, 1997.** The Wet Grassland Guide: Managing Floodplain and Coastal Wet Grasslands for Wildlife- RSPB Management Guides, UKISBN: 0903138867.

# Cutting and water deficit effect on water use efficiency of forage species

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## Abstract

Water use efficiency (WUE) is a widely used concept connecting different processes directly or indirectly related to biomass production and water used. The different ratios of WUE proposed in the literature are based on agronomical, ecophysiological approaches or combination of them. Water deficit influences plants by closing the stomata, indirectly reducing photosynthesis, leaf extension and growth. Moreover the reduction of transpiration due to stomatal closure is greater than photosynthesis. Furthermore, water deficit changes root growth and distribution, therefore modifying the plant ability to extract water from the soil. The relationship between water deficit and WUE is controversial. Many researchers report higher WUE under water deficit, while others lower. On the other hand, cutting parameters, such as timing, frequency and intensity affect the values of WUE, as they affect the harvestable biomass and evapotranspiration. Nevertheless, the absolute values of WUE vary markedly depending on plant, soil, climatic factors and management practices. Regardless of the method used, WUE could still be considered as a useful selection criterion for superior performance, particularly, in a dry environment.

**Key words**: cutting, drought, grassland, stomatal closure, water use efficiency

## Introduction

Worldwide, water availability for agriculture is steadily reducing, because of overuse and observed decline in annual precipitation and increase in the annual mean temperatures. Under these conditions, the use of less water to achieve high yield is a major objective of the modern agriculture (Tambussi *et al*. 2007, Moreno *et al*. 2008).

Water use efficiency (WUE) is an index generally used to describe the relationship between the agriculture product (output) and the water used (input) (Fairweather et al. 2008). Improving the efficiency of water use, under given climate and soil conditions, may result from better managing of several factors, including water availability, fertility, pests and diseases, crop or pasture species variety, cutting intensity, planting date, soil water conditions at planting, plant density and row spacing. Therefore, improving water use efficiency requires an understanding of the whole system and should not focus solely on managing irrigation water (Cox et al. 1988, Ritchie and Basso 2007, Fairweather et al. 2008). Ritchie and Basso (2007) have used extensive literature data to demonstrate that, under most circumstances, increases in yield resulting from crop management also result in increases in WUE. This occurs because management usually has little influence on the duration of an annual crop growth cycle and evapotranspiration (ET) but may have a large influence on yield. Although cutting is a common practice for forages there are few publications concerning its relation with the WUE concept.

Generally, WUE is considered as a crucial parameter, where water is scarce, although the aspect that it is an elusive ratio, regardless the estimation method used, was expressed as well (Tambussi *et al*. 2007, Blum 2009). Nevertheless, the selection of forage species for dry areas should not be based on WUE alone. Yield and nutritive value need also to be considered (Neal *et al*. 2011). This review focuses on water availability and cutting management effect on the WUE of forages species.

**Definition of WUE**

The relationship between plant biomass accumulation (W) and plant water loss through transpiration (TR) quantified by de Wit since 1958 as water use efficiency (WUE), given by the ratio WUE=W/TR. Nowadays, there are many acceptable definitions that can be used to describe WUE. The resulting forms are sometimes overlapping and confounded. The values derived from all these different concepts are not always directly associated, resulting to conclusion export inability (Anyia and Herzog 2003). For these reasons, in each particular study the concept of WUE should be accurately defined. The agronomic approach, which is at the interest of farmers and agronomists, refers to plant WUE and focuses in concepts based on harvestable biomass and the amount of irrigation applied in the field. The ecophysiological approach, at the interest of plant physiologists and biochemists, refers to concepts of leaf gas exchange, based on analysis, at a given instant, of the relationship between photosynthesis and transpiration (Instantaneous WUE) or stomatal conductance (Intrinsic WUE) per unit of leaf area and trying to explain the mechanism at the level of the plant tissue (Passioura 2006, Lelievre et al. 2011). Combinations of the agronomic and ecophysiological approach are based mainly on yield and transpiration (Lazaridou and Noitsakis, 2003). In forage crops, WUE is based on seasonal or annual above ground dry biomass. It should be taken into account that the major quantity of the water applied to perennial forages is used for transpiration (85%), only 10% for evaporation, while 5% is lost as drainage below the root zone (Greenwood et al. 2008).

Different forms of the WUE concept, developed the last century, have been discussed by Fairweather et al. (2008), Blum (2009), Tambussi et al. (2007), Moreno et al. (2008) and others.

**WUE under water deficit**

Water use efficiency is often considered an important determinant of yield under stress and even as a component of crop drought resistance. It has been used to imply the production of rainfed plants per unit water used, resulting in ‘‘more crop per drop’’ (Greenwood et al. 2009).

Plants under water deficit close their stomata, indirectly reducing photosynthesis, leaf extension rate and growth, while the reduction of transpiration due to stomatal closure is greater than the reduction of photosynthesis. In addition, stomatal conductance to water loss under water deficit is not completely eliminated, and water continues to be lost. Furthermore, several species growing under water deficit increase the root to shoot ratio, as root growth is stimulated to increase water uptake at the expense of shoot growth, changing the root depth and density. It should be noted that the ability to increase water extraction from the soil is an important mechanism for drought tolerance and avoidance (Moreno et al. 2008, Lelièvre et al. 2011, Neals et al. 2011).

There is evidence that drought tolerant species increases WUE with increasing drought stress and reduced water supply (Blum 2009, Moreno et al. 2008). However, there are variations both among and within species (Karatassiou et al 1998, Neals et al. 2011). Neal et al. (2011) indicated that the yield difference between species, rather than the water use, was the primary determinant of $WUE_t$ (defined as Dry Matter yield for total water used in a year). These researchers studied fifteen species in annual basis and found that perennial forages have a greater yield potential and $WUE_t$ in a given environment. Therefore, for any forage species, strategies that maximize yield potential, rather than strategies that try to reduce water use, will have greater potential to increase annual $WUE_t$. Moreover, the evaluated $C_4$ species had higher annual $WUE_t$, than $C_3$ species. Deficit water supply led to a significant decline in annual $WUE_t$ for all species except alfalfa.

Studying ten grass species, under three soil moisture levels, Bahrani et al. (2010) found that water deficit negatively affects the water use efficiency (shoot dry weight/total water use). Nonetheless, contradictory results have been reported for alfalfa, the most studied forage species, under water deficit. Higher WUE is reported by Lazaridou and Noitsakis (2003), Lindenmayer et al. (2008) and Ismail and Almarshadi (2011), while a decrease of WUE of alfalfa has been reported by Carter and Sheaffer (1983) and no effect by Neals et al. (2011). The differences in the results concerning the same species could be attributed either in the method of estimating WUE or to irrigation quantity and timing (Moreno et al. 2008).

**WUE under cutting**

Cutting, which can be described in terms of timing, frequency and intensity (amount of leaf and stem removed) may reduce water use either directly (leaf area reduction) or indirectly (negative effects on root growth and distribution). The effect of cutting on yield is well documented (Cox et al. 1988, Snyman 2005). However, although effects of cutting on WUE are expected, these are not thoroughly studied.

Asseng and Hsiao (2000) calculated WUE ($CO_2$ assimilation rate per unit land area/ET) just before last cutting, after cutting, during regrowth, and during the initial senescence phase of alfalfa. Before cutting, WUE of the alfalfa normalized, it declined dramatically after cutting, but steadily increased following the canopy regrowth. Late in autumn, under less favorable growing conditions, WUE declined again.

In the perennial ryegrass (*Lolium perenne*) frequent cutting (once every 2 weeks from April to September) and low height (20mm) reduced water use in the first year only. In later years, infrequent cutting (twice a year) led to higher yields and higher water-use efficiencies, but did not affect total water use (Cox et al. 1988). WUE of the species *Cleistogenes squarrosa, Agropyron cristatum and Potentilla acaulis,* subjected to four grazing intensities, increased significantly from non-grazed plots to moderately grazed plots, then decreased in high-grazed plots. However, *Artemisia frigida* responded differently (Peng et al. 2007).

In moderately species-rich temperate grassland, increasing the mowing frequency from 1 to 3 cuttings per year had no significant effect on WUE. In addition, timing of cutting influenced the WUE of alfalfa. When alfalfa was harvested during the period from pre-bud to the bud initiation stages, the WUE was higher than when harvest was performed at a later stage. The post-bud growth period also coincides with higher ET, as the plant stand reaches full canopy cover and remains at or near full canopy cover until the bloom stage. In contrast, cutting early in the season (in advance of pre-bud) will reduce the potential for highest biomass yields. This same strategy will result in decreased stand longevity, which offsets the benefits of increased WUE by harvesting at an earlier growth stage (Bauder et al. 2011). Li et al. (2011) have shown that the forage yield and WUE of Siberian wildrye (*Elymus sibiricus* L.) were the lowest at early heading stage harvest, while the highest at flowering stage regardless of the water regime. Water use efficiency (biomass retained / total water use) of three tree legumes (*Leucaena leucocephala* cv. *Tarramba,* L. *pallida x L. leucocephala* (KX2) *and Gliricidia sepium*), was higher for the April and June (mid dry season) cuttings but not for the earlier cutting (wet season) or when being left uncut. Moreover, the peak of this effect depended on species (Butisantoso et al. 2004).

Nevertheless, higher WUE values are not always associated to increased biomass. Although the different aspects of WUE render comparison of results of different studies rather challenging, WUE is still an important index and a useful selection criterion for superior performance, particularly, in a dry environment.

## References

**Anyia A.O. and H. Herzog. 2003.** Water use efficiency, leaf area and leaf gas exchange of cowpeas under midseason drought. *European Journal of Agronomy,* 20: 327-339.

**Asseng S. and T.C. Hsiao. 2000.** Canopy $CO_2$ assimilation, energy balance, and water use efficiency of an alfalfa crop before and after cutting. *Field Crops Research*, 67:191-206.

**Bahrani M.G., H. Bahrami, and A.A.K. Haghighi. 2010.** Effect of water stress on ten forage grasses native or introduced to Iran. *Grassland Science*, 56: 1–5. doi: 10.1111/j.1744-697X.2009.00165.x

**Bauder T., N. Hansen, B. Lindenmeyer, J. Bauder, and J. Brummer. 2011.** Limited Irrigationof Alfalfa in the Great Plains and Intermountain West. https:// www.certifiedcropadviser.org/files/certifications/certified/education/selfstudy/

**Blum A. 2009.** Effective use of water (EUW) and not water-use efficiency (WUE) is the target of crop yield improvement under drought stress. *Field Crops Research*, 112:119-123.

**Budisantoso E., M. Shelton, B.F. Mullen and S. Fukai. 2004.** Cutting management of multipurpose tree legumes: effects on green herbage production, leaf retention and water-use-efficiency during the dry season in Timor, Indonesia. In: T. Fischer et.al. New directions for a diverse planet. Proceedings of the 4th International Crop Science Congress. On line at http://www.cropscience.org.au/icsc2004/poster/5/2/677_budisantosoe.htm

**Carter P.R. and C.C. Sheaffer. 1983.** Lucerne response to soil water deficits. I. Growth, forage quality, yield, water use, and water-use efficiency. *Crop Science*, 23:669-675.

**Cox R., T.W. Parr and R.A. Plant. 1988.** Water use and water-efficiency of perennial ryegrass swards as affected by the height and frequency of cutting and seed rate. *Grass and Forage Science*, 43:97-104.

**Fairweather H., N. Austin and M. Hope. 2008.** Irrigation insights 5-Water use Efficiency an information package. Land and Water, Australia, pp 1-67.

**Greenwood K.L., A.R. Lawson and K.B. Kelly. 2009.** The water balance of irrigated forages in northern Victoria, Australia. *Agricultural Water Management*, 96: 847-858.

**Ismail S.M. and M.H. Almarshadi. 2011.** Effects of Water Stress Applied with Sub-surface Drip Irrigation on Forage Productivity and Water Use Efficiency of Alfalfa under Precise Irrigation Practice in Arid Climate. *American-Eurasian Journal of Sustainable Agriculture*, 5(1): 97-106.

**Karatassiou M., B. Noitsakis and Z. Koukoura. 1998.** The water use efficiency of annual and perennial forage species in low elevation grasslands. In: Boller B. and F.J. Stadelmann (eds). Breeding for a multifunctional agriculture. Proceedings of the 21st Meeting of the Fodder Crops and Amenity Grasses Section of EUCARPIA. pp. 70-72.

**Lazaridou M. and B. Noitsakis. 2003.** The effect of water deficit on yield and water use efficiency of lucerne. In: Kirilov A., N. Todorov and I. Katerov (eds). Optimal Forage Systems for Animal Production and the Environment. *Grassland Science in Europe*, 8:344-347.

**Lelièvre F., G. Seddaiu, L. Leddab, C. Porquedduc and F. Volaire. 2011.** Water use efficiency and drought survival in Mediterranean perennial forage grasses. *Field Crops Research*, 121(3): 333–342.

**Li Z., W. Zhang and Y. Gong. 2011.** The yield and water use efficiency to first cutting date of Siberian wildrye in north china. *Agricultural sciences in China,* 10(11):1716-1722.

**Lindenmayer B., N. Hansen, M. Crookston, J. Brummer, and A. Jha. 2008.** Strategies for Reducing Alfalfa Consumptive Water Use. In: J.A. Ramírez (ed), proceedings Hydrology Days, 26-28 March, 2008, Colorando, USA. pp 52-61.

**Moreno M.T., J. Gulías, M. Lazaridou, H. Medrano and J. Cifre. 2008.** Ecophysiological strategies to overcome water deficit in herbaceous species under mediterranean conditions. *Cahiers Options Mèditeranèennes*. 79:247-256.

**Neals J.S., W.J. Fulkerson and B.G. Sutton. 2011.** Differences in water-use efficiency among perennial forages used by the dairy industry under optimum and deficit irrigation. *Irrigation Science*, 29:213-232.

**Passioura J. 2006.** Increasing crop productivity when water is scarce- from breeding to field management. *Agricultural Water Management*, 80:176-196.

**Peng Y., G.M. Jiang, X.H. Liu, S.L. Niu, M.Z. Liu, D.K. Biswas. 2007.** Photosynthesis, transpiration and water use efficiency of four plant species with grazing intensities in Hunshandak Sandland, China. *Journal of Arid Environments*, 70:304-315.

**Ritchie J.T. and B. Basso. 2008.** Water use efficiency is not constant when crop water supply is adequate or fixed: The role of agronomic management. *European Journal of Agronomy*, 28:273-281.

**Snyman H.A. 2005.** Rangeland degradation in a semi-arid South Africa. In: influence on seasonal root distribution, root/shoot ratios and water use efficiency. *Journal of Arid Environments*, 60:457-481.

**Tambussi E.A., J. Bort, and J.L. Araus. 2007.** Water use efficiency in C3 cereals under Mediterranean conditions: a review of physiological aspects. *Annals of Applied Biology*, 150:307–321.

# Variability in responses of animal groups to grassland restoration

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## Abstract

Understanding the diverse responses of animal groups to grassland restoration is vital for restoration planning. Here we summarise responses of seven animal taxa (orthopterans, bees, carabid beetles, spiders, amphibians, birds, mammals) to grassland restoration in Hortobágy National Park (E-Hungary). Species richness did not vary but abundance increased with time in orthopterans. Carabid species richness and abundance, and spider and bird abundance decreased after a peak in Year 1 after restoration. Both species richness and abundance of amphibians increased after Year 2. There were no changes in species richness and abundance of bees and small mammals and in the species richness of spiders and birds. Our results show that the responses to grassland restoration can greatly vary among animal taxa. Trends in several arthropod taxa could be explained by vegetation changes, whereas vertebrates showed fluctuations due to factors other than restoration per se.

## Introduction

Grassland restoration on former croplands is a frequent habitat restoration in Europe and most studies have followed vegetation development to measure restoration success (Kiehl et al. 2010; Török et al. 2011). We know much less on how grassland restoration affects animal assemblages and thus monitoring should be extended to trophic groups other than plants (Dixon 2009; Woodcock et al. 2008).

This paper describes post-restoration changes in species richness and abundance of four invertebrate and three vertebrate taxa important in grassland biodiversity and ecosystem services. We evaluated these changes in the largest grassland restoration project in Europe, conducted in the Egyek-Pusztakócs marsh and grassland complex in Hortobágy National Park (E-Hungary).

## Materials and methods

760 hectares of cropland were restored by sowing two low-diversity seed mixtures (two or three grass species depending on soils) between 2005 and 2008. Grassland restoration was generally successful (Lengyel et

al. 2012), more so on former alfalfa fields (Török et al. 2010) than on former sunflower or cereal fields (Vida et al. 2010). Insect assemblages changed from generalist to more specialist between Year 1 and 2 (Déri et al. 2011). For further details, please see http://life2004.hnp.hu or Lengyel et al. (2012).

We sampled grasshoppers and crickets (Orthoptera), bees (Hymenoptera: Apoideae), ground beetles (Coleoptera: Carabidae), spiders (Araneae), and frogs and newts (Amphibia), birds (Aves) and small mammals (Mammalia: voles, mice and shrews). We used standardised sweep-netting for sampling orthopterans and vegetation-dwelling spiders and yellow plate traps for sampling bees. Pitfall traps were used to sample carabid beetles and ground-dwelling spiders, and amphibians in an exceptionally wet year. Birds were censused in standardised point counts and we sampled small mammals by live trapping. We sampled croplands (start of restoration), restorations of four different ages (2005-2008) and natural grasslands (restoration targets). Each category was replicated by at least three sites. For Orthoptera, Carabidae and Araneae, data for croplands are from 2005, for natural grasslands from 2007, for restored grasslands from 2009. In all other taxa, data are from one year (Apoidea: 2010, Amphibia: 2010, Aves: 2009, Mammalia: 2011). We analysed species richness and abundance among six habitat types by one-way ANOVAs, after log-transforming the data when necessary, and used Tukey's HSD test for post-hoc comparisons.

**Results and discussion**

Species richness (SR) did not change considerably for Orthoptera (Fig. 1A), although their abundance (Ab) increased greatly with time (Fig. 1B). The SR of bees decreased gradually but non-significantly with time on restorations (Fig. 1C), and bee Ab was lower in restorations and natural grasslands than in croplands (Fig. 1D). Both the SR and Ab of Carabidae beetles increased in Year 1 and then decreased afterwards to below that on croplands (Fig. 1E, F). Although SR of spiders did not vary (Fig. 1G), their Ab decreased continually from a peak in Year 1 (Fig. 1H). Amphibians were more numerous in older restored grasslands than in younger ones or natural grasslands, both in SR (Fig. 2A) and Ab (Fig. 2B), mainly because of the Danube Crested Newt (*Triturus dobrogicus*). Bird SR did not change (Fig. 2C), although their Ab showed a peak in Year 1 and decreased slightly afterwards (Fig. 2D). Both the SR and the Ab of small mammals fluctuated widely, resulting in no discernible pattern (Fig. 2E, F).

We found that responses to grassland restoration can greatly vary among animal taxa. No change in total SR was most frequent (orthopterans, bees, spiders, birds, mammals) followed by increasing (amphibians) or decreasing (carabids) trends. Decreasing trends in Ab were the most frequent (bees, carabids, spiders, birds), followed by increasing trends (orthopterans and amphibians) and no trend (small mammals). The trends found may be related to vegetation changes. Litter accumulation and lack of propagula of dicotyledonous plants can lead to a low diversity of vegetation, which is typical in target grasslands and may influence arthropod assemblages. In bees, for example, transient species abundant in the weedy, flower-rich early stages decreased and the few species characteristic to the target natural grasslands increased in Ab. Alternatively, it is also possible that total SR and Ab are not the best indicators of post-restoration trends in animal diversity. First, species are likely to differ in their response to restoration, e.g. restoration may favour specialists over generalists, which can go unnoticed when total SR and Ab are considered. Second, changes in trends of a few rare species may be more important for conservation. Our previous findings, for example, showed that although combined SR did not change, species composition became more similar to that of natural grasslands, resulting in increasing naturalness of arthropod assemblages (Déri et al. 2011). Finally, it is also possible that post-restoration changes occur at longer time scales and that the short time since restoration (5-6 years at maximum) may not reliably detect changes on longer time scales.

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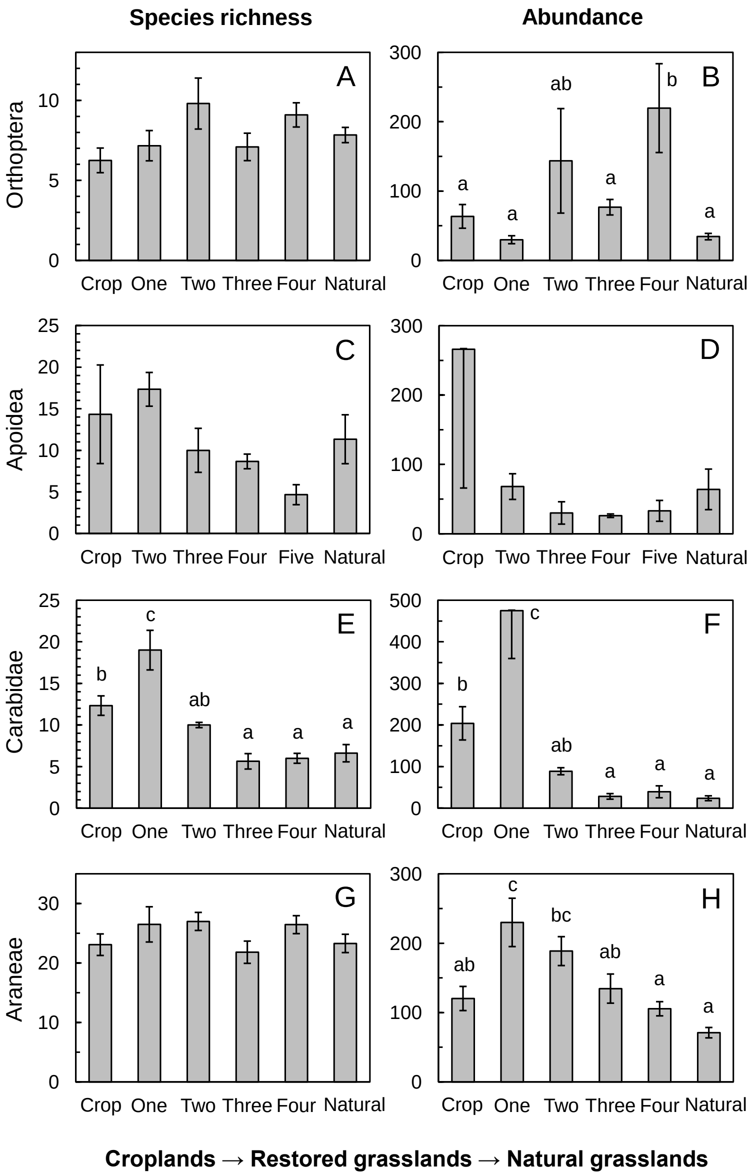


**Figure 1.** Mean ± S.E. of total species richness (left) and abundance (right) of four invertebrate groups in croplands, grassland restorations of four different ages and natural grasslands. Different lowercase letters indicate statistical significance between groups (Tukey's HSD, $p < 0.05$).

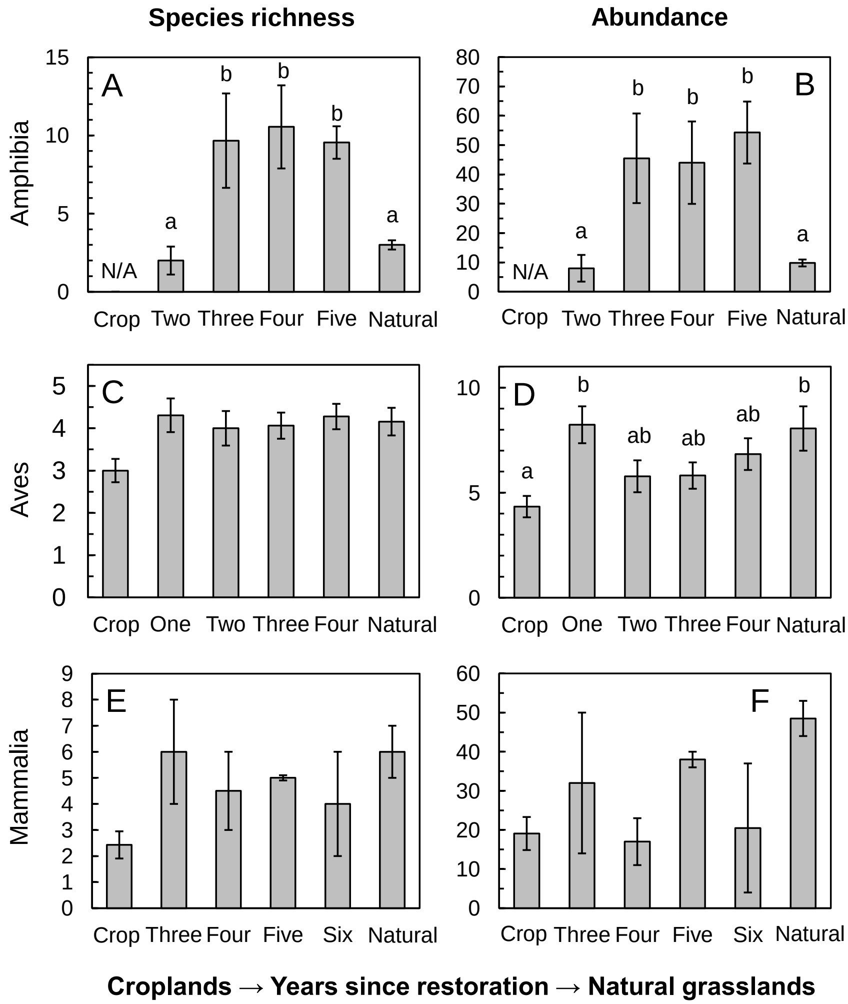


**Figure 2.** Mean ± S.E. of total species richness (left) and abundance (right) of three vertebrate groups in croplands, grassland restorations of four different ages and natural grasslands. Different lowercase letters indicate statistical significance between groups (Tukey's HSD, $p < 0.05$).

## References


**Déri, E., T. Magura, R. Horváth, M. Kisfali, G. Ruff, S. Lengyel, and B. Tóthmérész. 2011.** Measuring the short-term success of grassland restoration: the use of habitat affinity indices in ecological restoration. *Restoration Ecology* 19:520-528.

**Dixon, K. W. 2009.** Pollination and restoration. *Science* 325:571-573.

**Kiehl, K., A. Kirmer, T. W. Donath, L. Rasran, and N. Hölzel. 2010.** Species introduction in restoration projects - Evaluation of different techniques for the establishment of semi-natural grasslands in Central and Northwestern Europe. *Basic and Applied Ecology* 11:285-299.

**Lengyel, S., K. Varga, B. Kosztyi, L. Lontay, E. Déri, P. Török, and B. Tóthmérész. 2012.** Grassland restoration to conserve landscape-level biodiversity: a synthesis of early results from a large-scale project. *Applied Vegetation Science* 15:264-276.

**Török, P., B. Deák, E. Vida, O. Valkó, S. Lengyel, and B. Tóthmérész. 2010.** Restoring grassland biodiversity: sowing low-diversity seed mixtures can lead to rapid favourable changes. *Biological Conservation* 143:806-812.

**Török, P., E. Vida, B. Deák, S. Lengyel, and B. Tóthmérész. 2011.** Grassland restoration on former croplands in Europe: an assessment of applicability of techniques and costs. *Biodiversity and Conservation* 20:2311-2332.

**Vida, E., O. Valkó, A. Kelemen, P. Török, B. Deák, T. Miglécz, S. Lengyel, and B. Tóthmérész. 2010.** Early vegetation development after grassland restoration by sowing low-diversity seed mixtures in former sunflower and cereal fields. *Acta Biologica Hungarica* 61 (Suppl):246-255.

**Woodcock, B. A., A. R. Edwards, C. S. Lawson, D. B. Westbury, A. J. Brook, S. J. Harris, V. K. Brown, and S. R. Mortimer. 2008.** Contrasting success in the restoration of plant and phytophagous beetle assemblages of species-rich mesotrophic grasslands. *Oecologia* 154:773-783.

# Herbage production and number of plant species in subalpine meadows of two mountains with different geological background and soil characteristics in Northern Greece

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## Abstract

In this study, the effect of soil macro-nutrient concentrations on herbage production and number of plant species in subalpine meadows of Jenna Mountain and Belles Mountain were investigated. In each study area, 9 sampling plots (4x4 m) were placed and herbage production was collected, and the number of plant species was recorded monthly from May to September 2011. The texture of soils was determined, and the concentrations of organic matter, total Nitrogen, Phosphorus, exchangeable potassium were measured. A total of 129 species were recorded on Mt Jenna while 161 species were recorded on Mt Belles. The average herbage production was significantly higher ($p<0.05$) on Mt Belles. A positive correlation between herbage production and soil N, K and OM were observed on Mt Belles while no such correlations were observed on Mt Jenna. On both mountains there was a negative correlation between the number of species and herbage production. Results from soil analysis showed that the concentrations of total N and OM were higher ($p<0.05$) in the 0-10 cm depth compared to the 10-20 cm depth. Exchangeable K was higher ($p<0.05$) on Mt Belles, however total N was higher ($p<0.05$) on Mt Jenna. It seems that the climatic conditions as well as the geological background may have affected these findings.

**Key words:** subalpine meadows, biomass, plant species, potassium, nitrogen

## Introduction

There has been a lot of research in recent years focused on the factors that affect the floristic diversity of meadows. Especially for subalpine meadows, where human intervention is kept to a minimum as compared to farm meadows, the most important factors are forage production and soil parameters (De Deyn et al. 2004).

It is known that forage production depends on soil fertility (Tallowin et al. 1994). Several researchers noted that increased soil nitrogen, after fertilization, decreases the number of species in the plant community (Elisseou et al. 1995, Willems et al. 1996). Also other soil nutrients, such as phosphorus and potassium, can result in a decrease to floristic diversity

(Bobbink et al. 1991, Aerts et al. 2003). Usually, pH determines the species in a plant community and shows high correlation to plant diversity but, in some temperate regions of southwest Europe, it was not correlated with pH at all (Janssens et al. 1998). Moreover, Koerselman and Meuleman (1996) stated that the ratio N/P is a significant determining factor for floristic diversity and they concluded that when it ranged between 10 and 14, the highest floristic diversity was achieved. However, other researchers (Marrs 1993, Smith1994) reported that grasslands with higher biodiversity are found on soils with a low nutrient status.

The aim of the study was to determine the effects of soil characteristics of two distinct areas with different geological background, on the herbage production and the number of plant species.

**Materials and methods**

The study was conducted in 2011 at Mt Jenna and Mt Belles which have different geological backgrounds, in Greece. A subalpine meadow area was selected on each mountain to investigate herbage production as well as the number of plant species. On Mt Jenna (longitude 22° 13′, latitude: 41° 09′) the sampling sites were located at an altitude of 1770m – 1900m. The parent material is of volcanic origin, mostly trachyte, and sandstone. On Mt Belles (longitude 22° 53′, latitude: 41° 20′) the sampling sites were located at an altitude of 1680m-1790m. Mt Belles has a uniform geological background with metamorphic rocks, mostly gneiss. The mean temperature during the growth period was 24.5°C and 10.06°C and precipitation was 40 mm. and 25.7mm for Mt Belles and Mt Jenna, respectively.

Nine sampling plots (4x4m) were selected to determine herbage production and samples were taken at monthly intervals from May to September of 2011 coinciding with the growing period, of each subalpine meadow. Plant species were collected and identified using the Treatises Mountain Flora of Greece (Strid 1986, Strid and Tan 1991) and Flora Europaea (Tutin et al. 1964-1980).

Soil cores were collected from two different depths, 0-10 cm and 10-20 cm, with 3 replications in each plant sampling plot in the two study areas. Percentage of clay (Bouyoucos 1962), sand and silt, organic matter (Walkley and Black 1934), total Nitrogen (Kjeldahl), Phosphorus (Olsen) and exchangeable potassium (Page et al 1982) were measured.

Statistical analysis was done using JMP ® 8 (Sall et al. 2007). The average, standard deviation and correlation coefficients were determined. ANOVA analysis (students'–*t* test) was used to determine significant differences (p≤0.05) between the two different depths as well as between the two study areas for the nutrients' content, herbage production and number of species.

**Results and Discussion**

A total of 129 species consisting of 33 families and 83 genera were recorded in the subalpine meadows of Mt Jenna. Most of the taxa of this area belong to Caryophyllaceae (14), Asteraceae (12), Rosaceae (11), Poaceae (10) and Fabaceae (9) family. On Mt Belles,161 species consisting of 34 families and 107 genera were recorded. Most of the taxa belong to Caryophyllaceae (19), Asteraceae (19), Lamiaceae (12), Poaceae(14), Fabaceae (9), Rosaceae (9) and Scrophulariaceae (8) family. 25 species were common in both study areas.

Mean average herbage production was higher on Mt Belles (Table 1). The peak of herbage production on Mt Jenna was in August while on Mt Belleswas in July. There were differences (P<0.05) in herbage production between the two mountains for May, June and July, while no such differences were observed for August and September.

**Table 1.** Herbage production in Mt Jenna and Mt Belles

| Herbage production kg/ha | Study area | May | June | July | August | September | Average |
|---|---|---|---|---|---|---|---|
| | Jenna | $314^{a}$±212 | $974^{a}$±461 | $1939^{a}$±1180 | $2062^{a}$±1006 | $1195^{a}$±398 | $1296^{a}$±721 |
| | Belles | $899^{b}$±216 | $1720^{b}$±746 | $2496^{b}$±1289 | $1889^{a}$±951 | $1288^{a}$±722 | $1658^{b}$±606 |

Data are average values ±S.D. (n=9). Different letters in columns indicate significant differences between study areas (*P*<0.05).

Soils on Mt Jenna are classified according to USDA (1951) as Sandy loams and on Mt Belles as Loamy sands. Soil analysis results showed that the concentrations of K, total N, and organic matter were higher (p<0.05) in depth 1 compared to depth 2, while there was no difference in the concentration of P (Table 2). Exchangeable K was higher (p<0.05) on Mt Belles, while the opposite was observed for total N.

For the area on Mt Belles there was a positive correlation between herbage production and K, OM and N content of the soil while there was no correlation between herbage production and P (Table 3). These findings are in accordance with the results of other researchers (Van der Woude et al. 1994, Koerselman and Meuleman 1996, Aerts et al 2003). In contrast, there were no correlations for the area on Mt Jenna. This may be due to the fact that for the period of May to early June low temperatures prevailed on Mt

Jenna accompanied by snowfalls which resulted in low biomass accumulation.

**Table 2.** Soil characteristics in two depths on Mt Jenna and Mt Belles

| | JENNA | | BELLES | |
|---|---|---|---|---|
| | Depth 1 | Depth 2 | Depth 1 | Depth 2 |
| OM% | 8.91[a]±3.17* | 4.11[b]±1.76 | 8.31[a]±3.51 | 4.93[b]±1.21 |
| $N_t$% | 0.56[a,c]±0.17 | 0.32[b,c]±0.09 | 0.39[a,d]±0.16 | 0.27[b,d]±0.06 |
| P mg/kg | 10.34[a]±8.27 | 6.18[a]±6.15 | 10.33[a]±5.91 | 6.97[a]±3.89 |
| $K_{ex}$ mg/kg | 153.97[c]±96.4 | 82.94[c]±66.30 | 200.68[d]±144.38 | 163.84[d]±113.60 |

*Data are average values ±S.D. (n=18 for JENNA and n=9 for BELLES). Different letters in columns indicate significant difference between study areas (*P*<0.05). Depth 1: 0-10 cm, Depth 2: 10-20 cm

**Table 3.** Correlation coefficients (r) of measured parameters on Mt Jenna and Mt Belles

| | **BELLES** | | **JENA** | |
|---|---|---|---|---|
| | Number of species | Herbage production | Number of species | Herbage production |
| Number of species | - | -0.50* | - | -0.42* |
| Herbage production | -0.50* | - | -0.42* | - |
| N | -0.24 | 0.26 | 0.02 | -0.14 |
| K | -0.06 | 0.41* | 0.02 | -0.12 |
| P | -0.28* | 0.19 | 0.08 | 0.06 |
| OM | -0.32* | 0.28* | 0.04 | 0.02 |

Level of significance: * p<0.05

The statistical analysis showed a negative correlation between herbage production and number of species for Mt Belles as well as for Mt Jenna. The results are in accordance with Grime (1979), Tilman et al. (2001) and Poldini et al. (2011). On Mt Bellesa negative correlation was observed between the number of plant species and soil OM, P and N concentration. Janssens et al. (1998) have reported a correlation only with P and K, while Marrs (1993) and

Mountford et al. (1993) only with N. On Mt Jennano such correlations were observed.

## Conclusions

The concentrations of soil macro-nutrients (N, P and K) had a positive effect on the herbage production of Mt Belles, while there was a negative effect on the number of plant species. No such relations were observed for Mt Jenna. On both mountains a negative correlation was found between the number of plant species and the herbage production. It seems that the climatic conditions as well as the geological background may have affected the results.

## References

**Aerts R., H. de Caluwe and B. Beltman. 2003.** Is the relation between nutrient supply and biodiversity co-determined by the type of nutrient limitation. *Oikos*, 101: 489–498.

**Bobbink R. 1991.** Effects of nutrient enrichment in Dutch chalk grassland. *J. Appl. Ecol*., 28: 28–41.

**Bouyoukos G.J. 1962.** Hydrometer method improved for making particle size analysis of soil. *Agron. J.*, 54: 464-465.

**De Deyn G.B., C.E. Raaijmakers and W.H. van der Putten. 2004.** Plant community development is affected by nutrients and soil biota. *J. Ecol.*, 92: 824-834.

**Elisseou G.C, D.S. Veresoglou and A.P. Mamolos. 1995.** Vegetation productivity and diversity of acid grasslands in nothern Greece as influenced by winter rainfall and limiting nutrients. *Acta Oecol*.,16(6):687–702.

**Janssens F., A. Peters, J.R. Tallowin, J.P. Bakker, R. Bekker, F. Fillat and M.J. Oomes. 1998.** Relationship between soil chemical factors and grassland diversity. *Plant Soil*, 202: 69-78.

**Grime JP, K. Thompson, R. Hunt, J.G. Hodgson, J.C.G. Cornelissen and I.H. Rorison. 1997.** Integrated screening validates primary axes of specialisation in plants. *Oikos*, 79: 259-281.

**Koerselman W. and A. F. M. Meuleman. 1996.** The vegetation N:P ratio: a new tool to detect the nature of nutrient limitation. *J. Appl. Ecol*., 33: 1441–1450.

**Marrs R.H. 1993.** Soil fertility and nature conservation in Europe: theoretical considerations and practical management solutions. *Advances in Ecological Research*, 24: 241–300.

**Mountford J.O., K.H. Lakhani and F. Kirkham. 1993.** Experimental assessment of the effects of nitrogen addition under hay-cutting and aftermath grazing on the vegetation of meadows on a Somerset peat moor. *J. Appl. Ecol*., 30: 321–332.

**Page A.L., R.H. Miller and D.R. Keeney (eds)., 1982.** Methods of soil analysis, Chemical and Microbiological properties.Agronomy No 9 (Part 2) SSSA Inc.,Wisconsin, USA.

**Poldini L., G. Sburlino, G. Buffa, and M. Vidali. 2011.** Correlations among biodiversity, biomass and other plant community parameters using the phytosociological approach: A case study from the south-eastern *Alps. Plant Biosystems,* 145 No. 1: 131–140

**Sall J., L. Creighton and A. Lehman. 2007.** JMP® Start Statistics: A Guide to Statistics and Data Analysis Using JMP®, Fourth Edition. Cary, NC: SAS Institute Inc.

**Smith R.S. 1994.** Effects of fertilisers on plant species composition and conservation interest of UK grassland. In: Haggar, R.J., Peel, S. (Eds.), Grassland Management and Nature Conservation, Occasional Symposium No. 28. British Grassland Society, Reading, pp.64–73.

**Strid, A. (ed.). 1986.** Mountain Flora of Greece, Vol.1. Cambridge Univ. Press,Cambridge.819 p.

**Strid, A. and K. Tan (eds.). 1991.** Mountain Flora of Greece. Vol. 2. Edinburch University Press, Edinburch. 974p.

**Tilman D., C. Lehman , and K.T. Thomson. 1997.** Plant diversity and ecosystem productivity: theoretical considerations. Proc. Natl. Acad. Sci USA, 94: 1857–1861

**Tilman D, PB Reich, J. Knops, D. Wedin, T. Mielke and C. Lehman. 2001.** Diversity and productivity in a longterm grassland experiment. *Science*, 294: 843–845

**Tutin T., V. Heywood, N. Burges, D. Valentine, S. Walters and D.Webb (eds.) 1964-1980.** Flora Europaea, Vol. 1-5. Cambridge

**USDA U.S. Dept. Agr. Soil Survey Staff 1951.** Soil Survey Manual. U.S. Dept. Agr. Handbook #18, U.S. Gov. Print Office, Washington DC

**Van der Woude B.J., D.M. Pegtel and J.P. Bakker. 1994.** Nutrient limitation after long-term nitrogen fertiliser application in cut grasslands. Journal of Applied Ecology, 31: 405–412

**Walkley A. and I.A. Black. 1934.** An examination of the Degtjiareff method for determining soil organic matter and a proposed modification of chromic acid titration method. *Soil Sci*., 37: 29-38.

**Willems J.H. and M.G.L. Van Nieuwstadt. 1996.** Long-term after effects of fertilization on above-ground phytomass and species diversity in calcareous grassland. *Journal of Vegetation Science*, 7: 177–184.

# Single or mix mycorrhizal fungi inoculum? The potential role of different mycorrhizal fungi

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## Abstract

Seeded plants of several grass species were grown in a mix or single culture for a 3-year period, at a site situated inside the Taxiarchis University Forest (Chalkidiki, northern Greece) with sub Mediterranean climate. One hundred 10-litres in volume containers were filled with mix soil from B and C horizons with sandy loam texture and low available phosphorus. The soil parent material was para-gneiss. Ten replicated treatments were inoculated with Gigaspora margarita BEG 34, ten with Glomus intraradices BEG 144, ten with Acoulospora longulata BEG 8, ten with a mixture of the BEG isolates used and ten with a mixture of indigenous species. Plant tissue analysis suggested that accelerated growth occurred after mycorrhizal application. However, significant variations on growth were observed at different fungal treatments and seasons. It is suggested that variations on growth could be explained by differences on the ability to access phosphorus and the limited phosphate source at the soil used, the inter-fungal interactions and the functional compatibility with the host plant.

**Key words:** mycorrhizal symbiosis, soil properties

## Introduction

The majority of the terrestrial plants form an obligatory symbiosis with soil borne fungi, forming arbuscular mycorrhizal (AMF) symbiosis which is the most abundant mycorrhizal among plants. There is a large literature about the plant fungal interactions, as far as the plant physiology concerns. There is also an adequate of knowledge about the mechanisms of the symbiosis. Despite the large literature on the AMF symbiosis little is known about the role of AMF when applied in open field experiments, particularly in the Mediterranean regions. Productivity of the Mediterranean lands is closely depended upon the soil properties and the climatic conditions. The fungal symbiont allows the plants to withstand harsh soil environment and colonise sites of low nutrient availability. The mycorrhizal fungi could expand the rhizospheric zone to a vast area, forming a mycorrhizosphere. The efficacy of the mycorrhizosphere is determined from both the plant and the soil conditions. The soil properties, along with the plants could affect the chain of events from the fungal spore germination to root colonisation. Soil pH, temperature, moisture, light, aeration, inorganic compounds and the presence of bacteria are among those affecting AMF spore germination

(Garbaye 1994). AMF have been found in soils with pH 2.7 to 9.2 (Killham 1994). Different AMFs could have their optimum at different soil conditions. In particular, Acaulospora spp. have been reported widely in acidic soils (Nicolson and Schenk 1979, Young et al. 1985, Morton 1986); Glomus spp. were found in soils of pH>5.5 but were absent in soils of pH 4.5 and lower (Wang et al. 1993); Gigaspora spp. have been reported in more acidic soils than Glomus spp. (Clark 1997). Thus, soil properties could initially affect the fungal biodiversity, since it is possible that different fungal species could have different symbiotic compatibility optimum at different soil properties. Such variations may result in a different plant growth response, when plants are in symbiosis with different fungal species or with different mix of AMFs. Such differences upon growth responses could determine plant biodiversity in natural lands. Significant efforts have been made recently to apply AMF commercially at various field applications. However, the provenance of the fungal species or genera was overlooked. Considering the evidence of AMF functional compatibility along with differences on the host AMF dependency, and by that, observed plant diversity could be determined by the existing fungal biodiversity; the research about the application of AMF in various field trials is necessary (Van der Heijden et al. 1998).

Mediterranean soils are heavily disturbed and often the surface soil is removed by erosion. Phosphate bioavailability could be very limited under such harsh soil conditions. The host plants grown in grasslands are usually of high mycorrhizal dependency, particularly at limited soil phosphate availability conditions. Differences occurring on growth performance should be related to the symbiont compatibility not only with the host plant but also with the soil environment. The present research investigates the potential use of various single fungal species inoculum along with some mix inoculum cultures, upon the grassland production when the plant dependency on AMF is high.

**Materials and methods**

One hundred 10-litres in volume containers were filed with fine soil material originated from a C and B-soil horizon over paragneiss. The soil pH was 5 and the extractable P 6.9 mg/kg. The soil material was sprayed with VAPAM in order to minimise any microbiological activity. Ten containers received seed mix of Poa, Cynodon, Plantago and Agrostis respectively.

Five containers from each plant treatment were inoculated with single BEG AMF isolate (Glomus intraradices BEG 144, Gigaspora margarita BEG 34, Acoulospora longula BEG 8), or with a mix of the five selected BEG isolates, or with a mix of indigenous AMFs. For the period of three years, all plant material was harvested at early July and late September at the end of the growth period. Dry weight determination and a complete plant tissue analysis were conducted to the plant material collected at each harvest. Soil analysis was conducted to both sites were the C% and the organic matter was estimated (Nelson and Sommers 1982), the organic N%, the extractable P (Olsen and Sommers 1982). Plant tissue analysis was also conducted and N%, P, Mg, Ca, K, Na were measured. Mycorrhizal colonisation was estimated with the grid line intersect method. Randomly selected plants were used in order to measure the effects of the indigenous AMF population.

**Results**

Mycorrhizal colonisation resulted variations at the plant growth after inculcation with different AMF fungi originated from the BEG or with a mix of the selective BEG isolates or with a mix of indigenous fungi (Figure 1). Inoculation with indigenous fungi has a better result on plant growth up to 78% at the early stages of growth of the experiment. Inoculations with G. intraradices however, enhance the growth of plants significantly better three years after the initial inoculation. Colonisation with Acoulospora resulted to the minimal or no beneficial growth. Plant tissue analysis suggests that the effect of AMF inoculation clearly enchase plant growth, except from those inoculated by A. longula. Finally the data suggesting that different fungal treatment show different phosphate levels.

**Discussion**

Data analysis clearly shows the beneficial effect on plant dry weight after mycorrhizal inoculation with selective AMF isolates. The plant response varies in relation to the isolate used. The source of this variation needs further consideration. It is clearly that the effectiveness of different AMF isolate variation is depended upon the soil conditions, simply because different fungi can compensate the soil environment differently. The increased efficacy of plants inoculated with indigenous AMF species at the early years of the experiment was gradually reduced since changes occurred at the soil used as substrate. The extractable P of the soil used as a substrate to non-inoculated control plants was reduced to approximately 50% one year after the beginning of the experiment. The plants used the available forms of P at the substrate used, by that, all the extractable P values were dropped. The P at the given pH of the substrate material used is immobile and not available to the plant roots. Colonisation with AMF resulted in rather constant extractable P levels to the soil. However, it changes gradually while colonisation by AMF resulted in a significant reduction of extractable soil P, particularly after inoculation with G. intraradices. Changes of the extractable P level occurred gradually since the fungal symbionts used the available P in plant favour. Indigenous AMF were more efficient to use the soil resources at the beginning of the experiment. However this was not the case at later time where plants with more biomass and P at the tissue were in symbiosis with G. intraradices. The ability of plant roots in symbiosis with G. intraradices was high enough to uptake rock phosphate. The ability of G. intraradices to uptake rock phosphate efficiently was reported previously at different conditions and different hosts (Duponnois et al. 2005). Presumably, the indigenous mycorrhizal species were in harmony with the plant species used by providing them soil resources at rates easily compensate by the plant. The finding presented here clearly suggesting that the indigenous species can enhance growth from the early stages of plant growth. However, inoculation with an AMF isolate with an aggressive character could improve possibly at later stage the plant growth (Ouahmene et al. 2007).

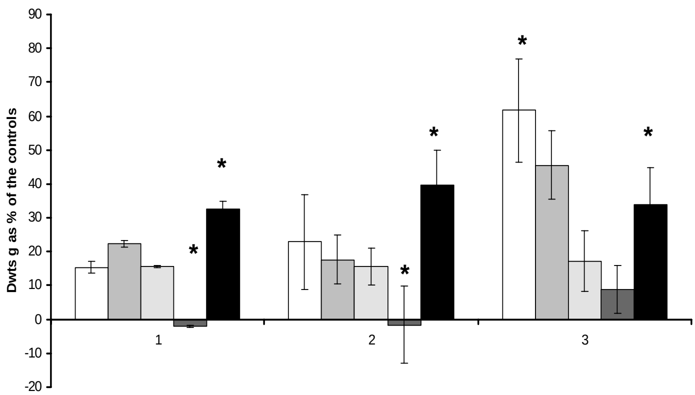


**Figure 1.** Effects on plant dry weights after inoculation with different arbuscular mycorrhizal fungi at the three years of the experiment. Glomus intraradices (empty), Gigaspora margarita (lined), Acaulospora longula (squered), mix of BEG isolates (sphere), indigenous AMF (filled). Bars are standard error. Data points marked with an asterisk are not significantly different from each other ($P < 0.05$).

The effect on plant growth of BEG's mix inoculums is also important. Clearly, the fungal species used were probably in competition for resources. Competition for carbon among different AMF species after colonisation of the same root system has been previously reported (citation). The competition of the different AMF species often results to a reduced host growth, as the plant fails to support the increased carbon fungal demands, particularly after inoculation with Glomus and Gigaspora spp. Similar interactions were possibly responsible for the relative reduced growth of the plants inoculated with the mix BEG inoculums.

Inoculation with Gigaspora margarita and Acoulospora longulata had no significant effect on plant dry weight. Possibly these AMF species didn't compensate the soil conditions and although formed symbiosis with the plants used their effects on growth were not different from the uninoculated control plants. The increased P nutrition of plants inoculated with G. margarita or A. longulata was not enough to promote growth against the controls. However, as the P level at the plants inoculated with the G. margarita or A. longulata did not change significantly at the 3-year period of the experiment. It is believed that gradually will overcome the controls simply because they will have a permanent access to the soil P, while the values of the plant tissue phosphate in the controls were gradually reduced.

Clearly the P uptake improved not only by the AMF effect on the inorganic soil. Mycorrhizal altered the soil conditions in favour of bacterial population due to the increase of sugar exudation to the soil (Hooker et al. 2007). Those conditions could change the bacterial population resulting to changes at the P uptake from inorganic sources (Mayer and Linderman 1986).

Mycorrhizal application should take under consideration the fungal species used and the soil conditions along with the nature of the agricultural product. The outcome of mycorrhizal applications on the field should take under consideration all the contributing partners to the symbiosis development, the soil conditions, the host plant and the inoculum used at the application.

## References

**Clark R B. 1997.** Arbuscular mycorrhizal adaptation, spore germination, root colonization, and host plant growth and mineral acquisition at low pH. *Plant Soil* 192: 15-22.

**Duponnois R; Colombek A; Hien V; Thioulouse J. 2005.** Fungus Glomus intraradices and rock phosphate amendment in fluence plant growth and microbal activity in the rhizosphere of Acacia holosericea. *Soil biology and Biochemistry* 37, 1460-1468.

**Engel R; Boller T; Wiemken A; Sanders I R. 1998.** Mycorrhizal fungal diversity determines plant biodiversity, ecosystem variability and productivity. *Nature* 396: 69-72.

**Garbaye J. 1994.** Tansley Review No 76. Helper bacteria: a new dimension to the mycorrhizal symbiosis. *New Phytol*. 128: 197-210.

**Hooker J E; Piatti P; Cheshire M V; Watson C A. 2007.** Polysaccharites and monosaccharlites in the hyphopsere of the arbuscular mycorrhizal fungi Glomus E3 and Glomus tenue. *Soil Biology and Biochemistry* 39, 680-683.

**Killham K. 1994.** Soil ecology, Cambridge University press, 254p.

**Meyer J R; Linderman R G. 1986.** Response of subterranean clover to dua inoculation with vesicular- arbuscular fungi and a plant growth-promoting bacterium, Pseudomonas putida. *Soil Biol. Biochem.* 18: 185-190.

**Morton J B. 1986.** Three new species of Acaulospora (Endogonaceae) from high aluminium, low pH soils in West Virginia. *Mycologia* 78: 641-648.

**Nelson D W; Sommers L E. 1982.** Total carbon, organic carbon and organic matter requirement. In Methods of Soil Analysis. Part 2. A L. Page, ed. Amer. Soc. of Agronomy and Soil Sci.Soc. of America, Madison, Wisconsin, USA, pp:539-577.

**Nicolson T N; Schenck N C. 1979.** Endogonaceous mycorrhizal endophytes in Florida. *Mycologia* 71: 178- 198.

**Olsen S R; Sommers L E. 1982.** Phosphorous. In: Methods of Soil Analysis. Part 2.A.L. Page, ed. Amer. Soc. Of Agronomy and Soil Sci.Soc. of America, Madison, Wisconsin, USA, pp: 403-427.

**Siqueira J Q; Hubbell D H; Mahmud A W. 1984.** Effect of liming on spore germination, germ tube growth and root colonisation by vesicular-arbuscular mycorrhizal fungi. *Plant Soil* 76: 115-124.

**Van der Heijden M G A; Klironomos J N; Ursic M; Moutoglis P; Streitwolf-Engel R; Boller T; Wiemken A; Sanders I R. 1998.** Mycorrhizal fungal diversity determines plant biodiversity, ecosystem variability and productivity. *Nature* 396: 69-72

**Wang G M; Stribley D P; Tinker P B; Walker C. 1993.** Effects of pH on arbuscular mycorrhiza. I. Field observations on the long-term liming experiments at Rothamstead, Woburn. *New Phytol*. 124: 465-472.

**Young J L; Davis E A; Rose S L. 1985.** Endomycorrhizal fungi in breeder wheats and triticale cultivars field- grown on fertile soil. *Agronomie J.* 77: 219-224.

# Pollen assemblage differences of northern and central Greece grasslands: some notes on grazing

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## Abstract

Vegetation and pollen trap data, obtained from 'open' areas and subalpine grasslands of Mts Pieria (north-central Greece) and Mt Tymfristos (central Greece), are compared. The highest achievable pollen taxonomic resolution is implemented in both pollen and vegetation taxa. Signs of previous intense human impact are still evident in both areas as indicated by the presence of various ruderal species. A number of local pollen taxa e.g. *Daphne*, *Marrubium*, *Astragalus*, *Scleranthus*, *Eryngium*, *Herniaria*, *Centaurea jakea* differentiate the pollen assemblages of Tymfristos traps from those of Pieria. The different dominant forest vegetation of the two sites diversifies further the pollen assemblages of their traps. Indicators of local (around the traps) grazing e.g. *Ranunculus acris*- type *Crepis*-type, *Cirsium*/*Carduus*, Rubiaceae, are recorded in all traps. Other pollen types like *Plantago lanceolata*- type, *Artemisia*, *Rumex acetosa*, *Urtica*, Chenopodiaceae indicate human activity (forest clearings/human settlements and grazing) in a regional scale.

**Key words**: pollen, vegetation, Tymfristos, Pieria, grazing

## Introduction

The Pollen Monitoring Programme (PMP) aims at 'monitoring pollen deposition across vegetation from closed forest to open situations as a basis for interpreting fossil pollen spectra' (http://www.pollentrapping.net/). Pollen trap transects in that respect have been established in Mts Pieria (7 traps, P1-P7) in north-central Greece and Mt Tymfristos (5 traps, TIM1-TIM5) in central Greece. Several of the traps are located near and above the forest limits, in the subalpine grasslands (P1, P2, TIM1, TIM2 and TIM3) as well as in openings in forested areas (P4 and P5).

The vegetation of both sites has been subjected to human impact and especially grazing pressure which is taking place in the subalpine grasslands and forest openings. In 2008 vegetation data were collected around the traps in both Pieria and Tymfristos.

In this study an attempt is made to compare the pollen assemblages of traps situated in 'open' areas of both sites and trace the influence of local vegetation as well as of grazing on the pollen assemblages of the different traps.

**Materials and Methods**

Pollen data in this study cover the period 2005-2009 in Mts Pieria (P1, P2, P4 and P5) and 2006-2010 in Mt Tymfristos (TIM1, TIM2 and TIM3) respectively. TIM2 (06-09) and P2 (06-09) are the only traps with four consecutive years of pollen data collection during the period 2006-2009. For all other traps missing years of collection were replaced by data of years 2005 (P1, P4, P5) or 2010 (TIM1, TIM3). Moreover, trap P4 has a 3-year data collection covering the period 2005-2007. Standard pollen preparation and counting procedures were followed for all traps (Hicks et al. 1996). The program TILIA and TCView 2.0.2 (Grimm 2004) was used for calculating pollen percentage (PP) values and preparing the pollen percentage diagram. The unconstrained clustering of traps was based on square root transformation (SRT) of PP values of all pollen taxa with values> 1% resulted in the zonation of the pollen diagram.

A total of 25 square plots, 24 around each trap and one including the trap, with a side of 0.5 m, were used to score plant cover. Sampling plots were located on concentric rings of 3, 6 and 9 m distance from the trap and covered the four main aspects (N, E, S, W) and their midpoints (NE, SE, SW, NW). DCA was performed on SRT percentage values in vegetation and pollen data of both sites using the CANOCO PC program, ver. 4.5 (ter Braak and Šmilauer 2002).

Pollen taxonomic resolution was facilitated by reference material, published keys and photos (Reille 1992, 1995, Chester and Raine 2001, Beug 2004). Plant identification is adjusted to the highest achievable pollen taxonomic resolution for the majority of taxa participating in the analysis. Plants were identified using Flora Hellenica (Strid and Tan 1997, 2002), Mountain Flora of Greece (Strid 1986, Strid and Tan 1991) and Flora Europaea (Tutin et al. 1968–1980, 1993).

**Results- Discussion**

*Vegetation- pollen relationship*

‘Open’ areas and subalpine grasslands of Mts Pieria are well separated from the subalpine grasslands of Mt Tymfristos for both vegetation and pollen data (Figure 1). Vegetation data show larger variability in relation to pollen data while trap P1 is clearly separated from the other traps in terms of surrounding vegetation.

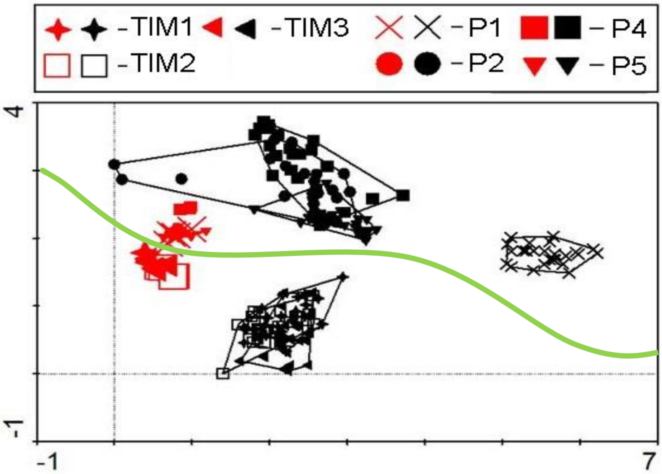


**Figure 1.** DCA of pollen and vegetation data of the seven traps. Black signs for pollen values, red signs for vegetation data. Taxa included in the analysis comply with the achievable pollen taxonomic resolution.

*Arboreal and herbaceous pollen representation*

The western flank of Mts Pieria, where the pollen traps are located, is dominated by forests of *Pinus nigra* and *P. sylvestris* while in Mt Tymfristos *Abies cephalonica* and *A. borisii-regis* are the dominant forest species. This is clearly seen in the pollen diagram where the corresponding pollen types dominate in the pollen assemblages (Figure 2). Shrubs of *Juniperus* spp. are found mainly on the subalpine grasslands, thus justifying the relatively larger values in the corresponding pollen traps (P1, P2, TIM1, TIM2 and TIM3).

Herbaceous pollen flora of the subalpine grasslands of Mt Tymfristos is more diverse than that of the subalpine and 'open' areas of Mts Pieria. Local, within the sampled vegetation, or extra-local found pollen taxa e.g. *Daphne*, *Marrubium*, *Astragalus*, *Scleranthus*, *Eryngium*, *Herniaria*, *Centaurea jacea* type, as well as regional pollen taxa e.g. *Spartium* differentiate the pollen assemblages of Mt Tymfristos pollen traps from those of Mts Pieria (Figure 2). A few pollen taxa are distinctive of the local (e.g. *Genista, Cuscuta, Bruckenthalia*) or regional (*Epilobium*) vegetation of the Pieria traps. Human impact, though not intense as in the past, is still manifested in both sites mainly as grazing pressure. Pollen taxa e.g. *Ranunculus acris*- type *Crepis*-type, *Cirsium/Carduus*, Rubiaceae, indicate grazing around the traps (Figure 2). The above mentioned pollen taxa together with *Stellaria* were considered indicators of local grazing pressure for sites with crystalline bedrock (Mazier et al. 2006). Mts Pieria have similar bedrock and this combination of grazing indicators is clearly present in traps P4 and P5.

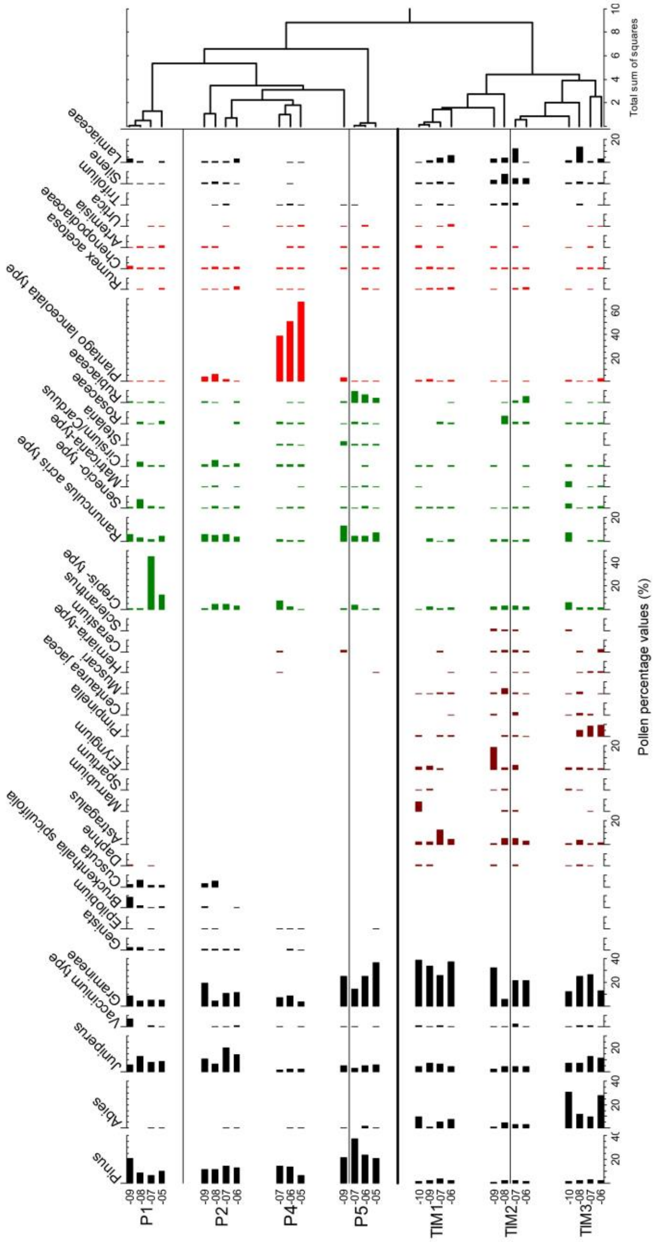


**Figure 2.** Pollen percentage diagram of certain pollen types recorded in Mts Pieria and Mt Tymfristos pollen traps.

Pollen taxa like *Plantago lanceolata*- type, *Artemisia*, *Rumex acetosa*, *Urtica*, *Chenopodiaceae*, indicate human impact which implies forest clearings, human settlements and/or grazing in a regional scale (Mazier et al. 2006). The local presence of *Plantago* around trap P4 is responsible for the corresponding high PP values of this taxon in the latter trap.

## References

**Beug H-J. 2004.** Leitfaden der Pollenbestimmung für Mitteleuropa und angrenzende gebiete. Verlag Dr. friedrich Pfeil, München. pp 542.

**Chester P.I. and J.I. Raine. 2001.** Pollen and spore keys for Quaternary deposits in the northern Pindos Mountains, Greece, *Grana*, 40:299-387.

**Grimm E. 2004.** TILIA and TGView 2.0.2. Illinois state museum, research and collections center, Springfield

**Hicks S., B. Ammann, M. Latatowa, H. Pardoe and H. Tinsley. 1996.** European Pollen Monitoring Programme. Project Description and Guidelines. Oulu University Press.

**Mazier F., D. Galop, C. Brun and A. Buttler. 2006.** Modern pollen assemblages from grazed vegetation in the western Pyrenees, France: a numerical tool for more precise reconstruction of past cultural landscapes, *The Holocene*, 16(1):91-103.

**Reille M. 1992.** Pollen et Spores d' Europe et d' Afrique du Nord. Marseille. pp 520.

**Reille M. 1995.** Pollen et Spores d' Europe et d' Afrique du Nord. Supplement 1. Marseille. pp 327.

**Strid A. (ed.). 1986.** Mountain Flora of Greece. Vol. 1. Cambridge Univ. Press, Cambridge.

**Strid A. and K. Tan. (eds). 1991.** Mountain Flora of Greece. Vol. 2. Edinburgh Univ. Press, Edinburgh.

**Strid A. and K. Tan. (eds). 1997.** Flora Hellenica. Vol 1. Koeltz Scientific Books, Königstein.

**Strid A. and K. Tan. (eds). 2002.** Flora Hellenica. Vol. 2. A.R.G. Gantner Verlag K.G., Ruggell.

**ter Braak C.J.F. and P. Šmilauer. 2002.** CANOCO Reference Manual and CanoDraw for Windows User's Guide: Software for Canonical Community Ordination (version 4.5).

**Tutin T.G., N.A. Burges, A.O. Chater, J.R. Edmondson, V.H. Heywood, D.M. Moore, D.H. Valentine, S.M. Walters and D.A. Webb (eds). 1993:** Flora Europaea. 2nd ed. Vol. 1. Cambridge Univ. Press, Cambridge.

**Tutin T.G., V.H. Heywood, N.A. Burges, D.M. Moore, D.H. Valentine, S.M. Walters and D.A. Webb (eds). 1968–1980.** Flora Europaea. Vols 2–5. Cambridge Univ. Press, Cambridge.

**Pollen Monitoring Program, PMP, 2012.** <http://www.pollentrapping.net/> (accessed 10/04/2012).

# Effects of species diversity and fungicides on organic matter and available soil phosphorus (P)

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## Abstract

The objective of this study was to determine whether the availability of soil P and soil organic matter were affected by the plant species richness and the restriction of arbuscular mycorrhizal fungi (AMF). The research took place in Northern Greece. Availability of soil nitrogen and P was deficient for plant growth. Six $C_3$ grasses, three legumes and four forbs native and relatively abundant in the study area, were used. These plants were sown as monocultures and in randomly selected mixtures of 2-3-4-7-10 and 13 species. These species were planted in containers containing 30kg of soil deficient in N and P for plant growth. To restrict the AMF colonization, the fungicide benomyl at first and the combination of fungicides thiophanate methyl and carbeplus after, were applied at half of the replications. At the end of the growth season soil samples were taken to determine organic matter content and soil P concentration. The results showed that both soil characteristics were not affected by the species richness in the mixtures.. The monocultures of grasses, legumes and forbs produced the same results. However the fungicide application reduced the organic matter content and the soil P availability. These effects of fungicides are probably due to the N that they contain.

**Key words**: species richness, species diversity, soil phosphorus, arbuscular mycorrhizal fungies (AMF), organic matter, fungicides

## Introduction

Species richness affects positively the primary productivity, contributes to the more efficient recycling of nutrients and increases the biological resistance of plant communities on biological invasions. Many researchers (Naeem et al. 1994, Naeem & Li 1997, 1998, Tilman et al. 1996) agree that a positive correlation between species diversity and effectiveness of ecosystem functions exists. However, others (Wardle et al. 1997, Berendse 1998, Grime 1997, 1998, Hooper & Vitousek 1998) believe that the attributes of the ecosystem are not necessarily determined by the richness of species, but mainly by the particular traits of the dominant species and the composition of functional groups. The published studies suggest that species richness affects the recycling of nutrients. Perhaps this is due to the positive effect of the species richness to the diversity of soil microbial community, which largely affects the rate of nutrient recycling. Mycorrhizal fungi make various contributions to plants the main of which is to the uptake of the usually limited phosphorus contributing thus, to greater plant growth (Hodge et al. 2001). The objective of this study was to determine whether the species richness and the restriction of arbuscular mycorrhizal fungi affect the availability of soil phosphorus and soil organic matter.

**Materials and methods**

The research was carried out in Taxiarchis Chalkidiki, 70 km southeast of Thessaloniki in an area atan altitude of 840m. The experiment was conducted in 296 pots (40×30×25 cm) filled with 30 kg soil from the research area. Some physicochemical characteristics of soil are presented in Table 1. There were two treatments (a) applying or not fungicide and (b) mixtures or monocultures of herbaceous plant species. Thirteen perennial herbaceous plant species, which represent the three main biotic forms of herbaceous groups, grasses, forbs and legumes, were used. Six of them were $C_3$ grasses (*Agrostis capillaris, Dactylis glomerata, Festuca ovina, Lolium perenne, Phleum pratense, Poa pratensis*), three were legumes (*Lotus corniculatus, Medicago sativa, Trifolium repens*) and four were forbs (*Cichorium indibus, Plantago lanceolata, Achillea millefolium, Rumex acetosa*). In April 240 seeds per pot were sown. There were 37 combinations of monocultures and 2-3-4-7-10 and 13 mixtures. *Plantago* roots, which were colonized by mycorrhizal fungi, were added in pots. An application of benomyl (0,6g per pot), was performed twice in July of the first year. The next year, the fungicides thiophanate methyl and carbeplus (0,15g per pot for each fungicide) were applied every 14 days.

**Table 1.** Physico-chemical characteristics of soil used in pots. The high value of the soil CEC is due to the involvement of fossil stretch mesh (vermiculite and montmorillonite).

| **soil type** | **sand** | **sludge** | **clay** | **Organic Matter** | **total N** | **CEC** |
|---|---|---|---|---|---|---|
| | (%) | (%) | (%) | (g $kg^{-1}$) | (g $kg^{-1}$) | ($cmol^{(+)}kg^{-1}$) |
| SCL | 42,8 | 22 | 35,2 | 6,4 | 1,344 | 40,01 |

The soil was taken from the pots the third year, dried out at 72 C for 48 hours, weighed and then pulverized to determine the concentration of phosphorus with the Olsen extraction method, and organic matter (as organic C) with the method of Walkley & Black. The experimental design used was completely randomized blocks with two treatments and four replications. ANOVA was used to analyse the data of soil phosphorus and organic matter. Additional orthogonal comparisons were used to compare the effects of groups of species (grasses, forbs, legumes) as well as mixtures of species in both control and application of fungicide.

**Results and Discussion**

The application of fungicides reduced the soil P availability. However, this reduction was not significant among the species monocultures and among the biotic forms. The species as monocultures or the groups of species in both the control and the application of fungicides did not vary significantly also. Regarding the species mixtures it was obvious that species diversity did not affect the soil P availability while the fungicide application reduced it. In the mixtures of 2 and 3 species significant reduction of soil P was observed with the application of fungicides. The mixture of 4 species at control and the mixture of 2 species with the fungicide application had the lowest values. These values were significantly lower only than those in the mixture of 3 species and of monocultures respectively. Soil P did not appear to correlate with the species diversity but only with the application of fungicides.

The soil organic matter content was approximately the same in all species monocultures, and it was decreased significantly with the application of fungicides. This decrease was statistically significant in all mixtures and in the three biotic forms. Significant reduction of organic matter with the fungicide application was observed only in the monocultures of *Festuca*, *Poa*, *Achillea*, *Plantago* and *Lotus*. There was no differentiation between biotic forms in both control and application of fungicides. Soil organic matter did not appear to be affected by species diversity neither at control nor with the application of fungicides. However, at the control, the values of the mixtures of 2 and 3 species were significantly higher only from the mean value of the monocultures. At the application of fungicides the mixtures of 3 and 4 species had the highest values, which were significantly higher only from the mixture of 2 species. As averages of control and fungicide application, the mixtures of 3 and 4 species had the highest values, but these were significantly higher only compared to the average of monocultures.

**Table 2.** Mean squares from the ANOVA analysis for the data of soil phosphorus and soil organic matter.

| source of variation | Freedom Degree | F values | |
|---|---|---|---|
| | | Olsen P | Organic |
| Blocks | 3 | 18,88*** | 118,35*** |
| Fungicide treatment (A) | 1 | 13,75** | 264,19*** |
| Species composition (B) | 36 | 1,24 | 0,66 |
| A × B | 36 | 1,41 | 0,88 |
| Error | 219 | 1,58 | 0,84 |

** and *** shows significant effect at $p < 0{,}01$ and $p < 0{,}001$,respectively.

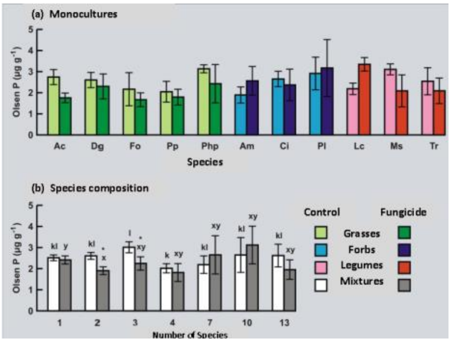


**Figure 1.** Effect of species, mixtures and fungicide application in the Olsen extractable phosphorus. The columns represent averages ± standard deviations. The * indicates significant difference between control and fungicide application within the same species composition, and columns at control or at application of fungicide, with the same letter are not significantly different.

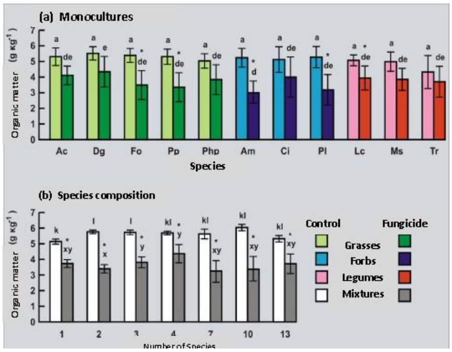


**Figure 2.** Effect of species, mixtures and fungicide application on soil organic matter. The columns represent averages ± standard deviations. The * indicates significant difference between control and fungicide application in the same species or same species composition, and columns at control or application of fungicide, with the same letter are not significantly different.

The results indicate that soil P and organic matter were not affected by the species diversity which participates in a plant community or from the groups of them. The applications of fungicides had an adverse effect on the two parameters of the soil (P and organic matter). These reductions could be due to the relatively high N content of fungicides. Thus, the addition of fungicides was a N source for the plants as there was a deficit at the containers, resulting in the better growth of plant biomass. Further growth of the roots seems to utilize more effectively soil P. Another factor that is likely to have influenced the use of P was the restriction of the colonization of arbuscular mycorrhizal fungies from the roots with the application of fungicides, although statistically significant (Karanika et al. 2007), it was only 21% lower compared to the control and its effect on the uptake of P is likely to be limited.

The addition of N with the application of fungicides seems to have affected the degradation of organic matter. The rate of degradation of organic matter in soil is determined by the stoichiometry and the requirements of decomposers for resources (nutrients) (Melillo et al. 1982, Hessen et al. 2004). When the ratio C:N of organic matter tends to be similar to the ratio required by decomposers, their populations are maximized and so is the rate of degradation (Melillo et al. 1982). In dry plant residues the ratio C:N is greater than 25. In decomposers the relevant ratio is much smaller than 25 (Hartley & Jones 1997). Therefore, the growth rates of decomposers and subsequently the degradation rates of organic matter increase when N is added to the organic matter. The C:N ratios of the three fungicides used are 3.0, 2.6 and 2.6, respectively. Their addition decreased the ratio C:N of soil organic matter hence the rate of degradation in pots which applied fungicides tend to be more intense and the remaining organic matter less.

**Conclusions**

The results of this study showed that the two features of the soil, P and organic matter were not affected by the number of plant species that participate in a plant community or by the groups of species. In some cases, significant differences between species mixtures on soil P and organic matter were observed but they do not indicate that the number of participating species is associated with the tested soil properties . The application of fungicides reduced significantly the P and organic matter of the soil. This reduction suggests that there is a severe rate of N recycling by adding fungicides.

## References

**Berendse, F. 1998.** Effects of dominant plant species on soils during succession in nutrient poor ecosystems. *Biogeochemistry* 42:73-88.

**Grime, J. P. 1997.** Biodiversity and ecosystem function: the debate deepens. *Science* 277:1260-1261.

**Grime, J. P. 1998.** Benefits of plant diversity to ecosystems: immediate, filter and founder effects. *Journal of Ecology* 86:902-910.

**Hartley, S. E., and C. G. Jones. 1997.** Plant chemistry and herbivory, or why the world is green. Pages 284-324 in Plant Ecology (2nd ed., M. J. Crawley, editor). Blakwell, London.

**Hessen, D. O., G. I. Agren, T. R. Anderson, J. J. Elser, and P. C. De Ruiter. 2004.** Carbon sequestration in ecosystems: The role of stoichiometry. *Ecology* 85:1179–1192.

**Hodge, A., C. D. Campbell, and A. H. Fitter. 2001.** An arbuscular mycorrhizal fungus accelerates decomposition and acquires nitrogen directly from organic material. *Nature* 413:297-299.

**Hooper, D. U., and P. M. Vitousek. 1998.** Effects of plant composition and diversity on nutrient cycling. *Ecological Monographs* 68:121-149.

**Karanika, E. D., D. A. Alifragis, A. P. Mamolos, D. S. Veresoglou. 2007.** Differentiation between responses of primary productivity and phosphorus exploitation to species richness. *Plant Soil* 297:69–81.

**Melillo, J. M., J. D. Aber, and J. F. Muratore. 1982.** Nitrogen and lignin control of hardwood leaf litter decomposition dynamics. *Ecology* 63:621–626.

**Naeem, S., L. J. Thompson, S. P. Lawler, J. H. Lawton, and R. M. Woodfin. 1994.** Declining biodiversity can alter the performance of ecosystems. *Nature* 368:734-737.

**Naeem, S., and S. Li. 1997.** Biodiversity enhances ecosystem reliability. *Nature* 390:507-509.

**Naeem, S., and S. Li. 1998.** A more reliable design for biodiversity study? A reply to D. A. Wardle. *Nature* 394:30.

**Tilman, D., D. Wedin, and J. Knops. 1996.** Productivity and sustainability influenced by biodiversity in grassland ecosystems. *Nature* 379:718-720.

# Bat diversity and activity at subalpine grasslands of Varnous and Triklarion Mountains (NW Greece)

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## Abstract

Habitat use by bats at high altitudes and particularly subalpine grasslands, is poorly known. Many bats are killed through collision with wind turbines installed on or near mountain tops, showing the need for bat diversity and activity surveys in high altitude areas, especially where wind farms are installed. We studied bat use of subalpine grasslands and beech forests near the tree line, in and near Prespa National Park, NW Greece, mostly at sites where large-scale wind farms have been, or are planned to be, constructed. We applied acoustic transects, point sampling and mist-netting in 2009, 2010 and 2011 in four areas. Both bat diversity and activity were high; we recorded 14 species: *Tadarida teniotis*, *Miniopterus schreibersii*, *Pipistrellus pipistrellus*, *P. nathusii, P. kuhlii, Hypsugo savii*, *Nyctalus noctula, N. leisleri, Myotis mystacinus, M. nattererii, M. blythii, Rhinolophus hipposideros, R. ferrumequinum* and *R. blasii.* These include species at high risk of collision with wind turbines. More species may be present. Two of the sites are heavily used by commuting and foraging bats in summer; in autumn there is still some activity even on cold nights. Our results show that high altitude areas may support important bat fauna, and suggest that the establishment of wind farms may increase bat mortality, as elsewhere in Europe. To reduce potential impacts on bats, long-term pre and post-construction monitoring surveys are of fundamental importance at sites where wind farms are planned or established. The importance of subalpine grasslands for bats should be further assessed through long-term research studies.

**Key words:** bat activity, Chiroptera, wind farms, mortality risk, bat conservation, Prespa National Park

## Introduction

Habitat use by bats at high altitudes and, in particular, over subalpine grasslands is not sufficiently known. However, many bats are killed through collisions with wind turbines installed on or near mountain ridges (e.g. Rodrigues et al. 2008, Rydell et al. 2010, Georgiakakis and Papadatou 2011). This evidence clearly shows the necessity to survey bat diversity and activity in high altitude areas, especially in the south of Europe where there are many species rich areas, high mountain ranges and large-scale wind farms established or planned to be installed on several mountains (e.g. Georgiakakis and Papadatou 2011).

Greece is a largely mountainous country in Mediterranean Europe and among the richest in terms of bat diversity (Hanák et al. 2001). Although many wind farms are foreseen to be installed or are already operating on top of forested hills and mountain ridges, we know very little about the use of these areas by bats. A recent study revealed high bat mortality on mountain ridges of Thrace, NE Greece, where large scale wind farms have been operating since 2003 (Georgiakakis and Papadatou 2011).

The area of Prespa in NW Greece hosts a uniquely rich bat fauna (Grémillet et al. 2010, Papadatou et al. 2011) with 26 species recorded to date. These include bats capable of hunting in open spaces and well above ground, such as *Nyctalus* and *Pipistrellus* species (Dietz et al. 2009), and hence at high risk of collision with wind turbines. Many of these often cross mountain ridges and passes when commuting between roosting and foraging sites, and when they move seasonally (migrate).

We studied the use by bats of subalpine grasslands and beech (*Fagus sylvatica*) forests near the tree line at high altitudes (up to *ca.* 2000 m asl) in and near Prespa National Park (PNP), mostly where wind farms have been installed or are planned to be constructed. We specifically aimed to assess bat diversity and activity within and between seasons, as well as across years. We report preliminary results from 2009 (Galand et al. 2010) alongside results from 2010 and 2011, when some more sites were included in the survey.

## Materials and methods

*Study area.* The Prespa lakes' watershed is shared between Albania, the Former Yugoslav Republic of *Macedonia* (FYROM) and Greece. The Greek part includes two Natura 2000 sites (GR 1340001 and GR 1340003 respectively), which together constitute the PNP. The geomorphological character of the area is determined by two lakes (Fig. 1) and the surrounding mountain ranges: Mt Vrondero and Mt Devas in the west, Mt Triklarion/Sfika in the south and Mt Varnous in the east-northeast reaching altitudes of over 2000 m asl. We surveyed bat habitat use at the following mountainous and subalpine sites: Bella Voda, Mazi-Kirko and Moutsara (Mt.

Varnous), and Sfika (Mt. Triklarion) (Table 1 and Fig. 1). Study sites at Mt. Varnous (siliceous substrate) are dominated by *Nardus stricta* grasslands with *Vaccinium myrtilus* (bilberry) and *Juniperus communis* ssp. *nana* (creeping prickly juniper), while rocky habitats and patches of *Fagus sylvatica* (beech) and other trees may be present. The site of Sfika consists of calcareous grasslands with great floristic diversity, often with hamaephytes in dense tussocks, such as *Astragalus angustifolius*, and patches of trees or isolated trees such as *Quercus pubescens, Acer campestre, Sorbus aria*, *Prunus* spp (Vrahnakis et al. 2011).


**Figure 1.** Study sites (in capital letters; white lines are transects (source: Google Earth, 2012)

*Field techniques.* We used acoustic transects and point sampling, as well as mist-netting, to survey bat habitat use in summer and autumn. A large scale wind farm, consisting of 34 turbines, has already been constructed on Bella Voda. Sites at Mazi-Kirko and Sfika have also been proposed for wind farm development.

We performed within-year repeated surveys at Bella Voda and Mazi-Kirko. Bella Voda was surveyed once in summer 2009 (22/7/2009; Galand et al. 2010), twice in summer (20/07/2010, 2/8/2010) and once in autumn (30/9/2010) 2010. Mazi-Kirko was surveyed once in summer and once in autumn 2010 (31/7/2010 and 1/10/2010 respectively). The rest of the sites were surveyed once in summer 2010 and 2011 (Moutsara: 1/8/2010 and 22/7/2011; Sfika: 24/7/2010 and 21/7/2011). An additional site between Moutsara and Kirko was visited in summer 2011 (24/7/2011). During acoustic transects, observers walked along pre-defined routes (each approx. 2-4 km long) and recorded the echolocation calls of passing bats using time expansion bat detectors (models: D240x, D980, Pettersson Elektronik). When point sampling, observers stood at fixed points for approx. 3 hours after sunset to record bat calls (with time expansion detectors) and to estimate bat activity (with heterodyne detectors). For further details on the acoustic methods, see Galand et al. (2010). Finally, observers used mist-nets to capture bats in the evening near forest edges, across forest roads or above water pools in summer 2010 (all bats were almost immediately released on site after collection of biometric data).

*Acoustic species identification.* We identified bat species using frequency and time parameters of their calls through quick species identification or statistical models (Papadatou et al. 2008). Bat recordings were analysed with BatSound Pro 3.32 (Pettersson Elektronik). Several calls were identified on site using heterodyne detectors (Galand et al. 2010).

**Results and discussion**

*Bella Voda.* Detailed accounts of the 2009 survey are given in Galand et al. (2010) and in Vrahnakis et al. (2010). Repeated acoustic transects (Fig. 1) showed that the site is generally heavily used by commuting and foraging *Tadarida teniotis* (Table 1) throughout the summer and in both 2009 and 2010. Repeated acoustic point sampling in both years on the mountain pass next to where the first wind turbine is installed (Prespa-Akritas-Florina ridge; Galand et al. 2010) showed that the specific location is heavily used by bats of several species (Table 1 and Galand et al. 2010). We believe these are bats mostly commuting from other areas (e.g. Florina plain and Pisoderi valley) to forage in the Prespa watershed, which is rich in hunting habitats and insect prey. The list includes at least 7 species (Table 1) that have been widely reported to be at high risk of collision with wind turbines (e.g. Rodrigues et al. 2008). Bat activity may differ between nights, even on approximately the same dates with one year difference (Fig. 2).Therefore repeated sampling is necessary to improve the representativeness of sampling. In the autumn, overall activity decreases but there are still bats commuting over the mountain, even on cold nights (approx. 4°C).

*Mazi-Kirko.* The site (Fig. 1) is heavily used in summer by commuting and foraging bats from several species, including at least 7 species at high risk of collision with wind turbines (Table 1). In autumn, bats still cross the subalpine grasslands to commute or hunt.

*Moutsara.* Only *N. noctula* was recorded near the highest point of the ridge, whereas the other species were found at lower altitudes, foraging near the tree line and along beech forest edges.

**Table 1.** Study sites and species or species groups identified

| Study site | Altitude (m a.s.l.) | Species |
|---|---|---|
| Bella Voda | 1900-2000 | ***Tadarida teniotis, Pipistrellus pipistrellus, P. nathusii, Hypsugo savii, Nyctalus noctula, Miniopterus schreibersii, N. leisleri/ E. serotinus/ V. murinus,*** *Myotis myotis/M. blythii, Myotis* species |
| Mazi-Kirko | 1900-2000 | ***P. pipistrellus, Hypsugo savii, Nyctalus leisleri, N. noctula, M. schreibersii, T. teniotis, P. nathusii/P. kuhlii, N. leisleri/ E. serotinus/ V. murinus, M. schreibersii/ P.pygmaeus,*** *Myotis myotis/M. blythii, Myotis* species |
| Moutsara | 1700-2000 | *Rhinolophus hipposideros, R. ferrumequinum, R. blasii,* ***N. noctula,*** *Myotis blythii, Myotis* species |
| Sfika | 1400-1700 | *Myotis mystacinus, M. blythii, M. nattererii,* ***P. pipistrellus,*** *P. kuhlii,* ***H. savii, M. schreibersii, P. nathusii****/P. kuhlii,* ***N. leisleri/ E. serotinus/ V. Murinus*** |

NOTES: Altitudinal ranges are approximate. In **bold**: species at high risk of collision with wind turbines (e.g. Rodrigues et al. 2008). Some bats were not identified at species level, so it is likely that more species are present.

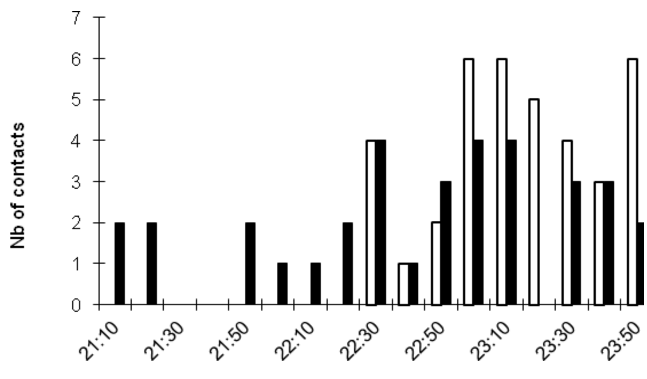


**Figure 2.** Bat activity on the Prespa-Akritas-Florina mountain pass over two summer nights. White bars: 22/7/2009, black bars: 20/7/2010. Nb of contacts: number of contacts with bats using a heterodyne bat detector.

*Sfika*. We covered a large area near the Prespa watershed, in Krystallopigi basin (Fig. 1). The highest activity of most species (Table 1) was recorded towards the lower and less exposed locations.

Our results show that subalpine grasslands and forests near the tree line are used by many bats, since both bat diversity and activity were high. The establishment of wind farms may therefore negatively impact on bats, as has been shown in other areas of Europe, including Greece (e.g. Rodrigues et al. 2008, Rydell et al. 2010, Georgiakakis and Papadatou 2011). This is particularly important for species that have been reported to be at high risk of collision with the turbines (e.g. Rodrigues et al. 2008), such as *N. leisleri, N. noctula, P. pipistrellus, P. nathusii, H. savii* and *T. teniotis,* which are present in these areas. Long-term systematic monitoring surveys of the bat fauna are therefore a prerequisite prior to the establishment of wind farms in these areas. Post-construction monitoring surveys are equally essential to assess bat mortality due to collision with turbines (e.g. at Bella Voda). If monitoring reveals bat mortality, mitigation measures such as curtailment of turbines at wind speeds lower than 6.0 m/sec should be implemented during night-time without significant loss in the production of electricity (e.g. Arnett et al. 2011).

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## References

**Arnett E.B., M.M.P. Huso, M.R. Schirmacher and J.P. Hayes. 2011.** Altering turbine speed reduces bat mortality at wind-energy facilities. Frontiers *in Ecology and the Environment*, 9: 209–214.

**Galand N., S. Declercq, T. Cheyrezy, S.J. Puechmaille, N. Deguines, X. Grémillet, E. Papadatou and Y. Kazoglou. 2010.** Bat survey on the subalpine grasslands of Mt Varnous (Florina, Greece): preliminary results. In: In: A. Sidiropoulou, K. Mantzanas and I. Ispikoudis (eds). Range Science and Life Quality. Proceedings of the 7th Panhellenic Rangeland Congress. pp. 305-314.

**Georgiakakis P. and E. Papadatou. 2011.** Impacts of wind farms on bats, Thrace, Greece, for the period July 2008-August 2010. WWF Greece, Athens. 48 pp. (*in Greek*)

**Grémillet X., T. Dubos, T. Le Campion. 2010.** Bilan chiroptérologique des prospections estivales organisées jusqu'en 2007 par le Groupe Mammalogique Breton dans le Parc National de Prespa, Macédoine occidentale (Grèce). *Symbioses,* 25:1-6.

**Hanák V, Benda P, Ruedi M, Horáček I, Sofianidou TS. 2001.** Bats (Mammalia: Chiroptera) of the Eastern Mediterranean. Part 2: New records and review of distribution of bats in Greece. *Acta Soc. Zool. Bohem.* 65: 279-346Papadatou E., R.K. Butlin and J.D. Altringham. 2008. Identification of bat species in Greece from their echolocation calls. *Acta Chiropterologica,* 10:127-143.

**Papadatou E., X. Grémillet, F. Bego, S. Petkovski, E. Stojkoska, O. Avramoski and Y. Kazoglou. 2011.** Status survey and conservation action plan for the bats of Prespa. Society for the Protection of Prespa, Agios Germanos. 191 pp.

**Rodrigues L., L. Bach, M.-J. Dubourg-Savage, J. Goodwin and C. Harbusch. 2008.** Guidelines for consideration of bats in wind farm projects. EUROBATS Publication series No. 3 (English version). UNEP/EUROBATS Secretariat, Bonn. 51 pp.

**Rydell J., L. Bach, M. J. Dubourg-Savage, M. Green, L. Rodrigues and A. Hedenström. 2010.** Bat mortality at wind turbines in northwest Europe. *Acta Chiropterologica*, 12(2):261-274.

**Vrahnakis M., E. Papadatou and Y. Kazoglou Y. 2010.** Grass-lands as bat-lands: evidence from Mount Varnous, Greece. *European Dry Grassland Group Bulletin,* 8:7-9.

**Vrahnakis M., G. Fotiadis and Y. Kazoglou. 2011.** Record, assessment and geographical representation of the rangeland and forest habitat types of the Natura 2000 sites of Prespa National Park (Ethnikos Drymos Prespon - GR 1340001, and Mt. Varnous (Ori Varnounta - GR 1340003)) and adjacent areas - Final Report. TEI of Larissa, Society for the Protection of Prespa, 107 pp. (+ Annexes) (*in Greek*).

# Plant traits as predictors of species response to succession in Mediterranean rangelands

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## Abstract

The objective of this paper was to identify plant traits that can predict plant response to succession in Mediterranean rangelands. Research was done in the Lagadas county of Thessaloniki, N. Greece. Four different vegetation states, with four replicates each, were studied: abandoned arable field, grassland, open shrubland and dense shrubland, representing various stages of secondary succession following grazing extensification. Seventeen plant traits (leaf, stem and whole plant traits) were measured or collected from the literature for the most abundant species of each plot. Species frequency was also measured on the herbaceous layer in order to quantify species response to vegetation succession. Vegetative plant height, life cycle and the life form of therophytes were the traits with the highest predictive capacity over species response to succession as single predictors, but their coefficients of determination were low. When more traits were combined their predictive capacity was increased. The combination of vegetative plant height, life cycle, leaf dry matter content, pollination mode and specific leaf area provided the best prediction for species response to succession. It is concluded that plant traits can capture species response to vegetation succession after grazing extensification in Mediterranean rangelands.

**Key words:** Vegetative plant height, life form, life cycle, secondary succession.

## Introduction

Mediterranean rangelands are closely related to grazing activities for many years. Over the last decades however, grazing extensification combined with cessation of firewood cutting has led to the invasion of shrubs in grasslands and resulted in their succession to woody communities (Papanastasis and Chouvardas 2005, Zarovali et al. 2007). Predicting plant species response to successional changes is of great interest for theoretical and practical purposes. Plant traits, especially the easily measured plant characteristics (soft traits) (Weiher et al. 1999), could be a useful tool towards this direction. Traits that could predict species response to grazing have been identified by Diaz et al. (2001) and de Bello et al. (2005) but not to vegetation succession. The objective of this paper was to identify plant traits that can predict plant response to succession in Mediterranean rangelands.

**Material and Methods**

Research was done in the Lagadas county of Thessaloniki, N. Greece. Four different vegetation states, with four replicates each, were studied: abandoned arable field, grassland, open shrubland and dense shrubland, representing various stages of secondary succession following grazing extensification. Seventeen plant traits (Table 1) were measured or collected from the literature for the most abundant species according to Zarovali et al. (2007) following the protocols of Cornelissen et al. (2003).

**Table 1. List of traits. Abbreviations and units/ categories used are presented.**

| | |
|---|---|
| Clon: Clonality (non clonal, clonal) | LPC: leaf phosphorus concentration |
| Def: defences (no defences, defences) | OnFl: onset of flowering (Jul. Day) |
| Disp: dispersal mode (unassisted, wind, animal, launching) | Phot. pathway: photosynthetic pathway ($C_3$, $C_4$)<br>Pol: pollination mode (insect, wind) |
| LC: life cycle (annual, perennial) | RPH: reproductive plant height (cm) |
| LCC: leaf carbon concentration (mg/g) | SLA: specific leaf area ($mm^2$/mg) |
| LDMC: leaf dry matter content (mg/g) | SM: seed mass (mg) |
| LF: life form (therophytes, hemicryptophytes, chamaephytes) | StDMC: stem dry matter content (mg/g)<br>VPH: vegetative plant height (cm) |
| LNC: leaf nitrogen concentration (mg/g) | |

Species frequency on the herbaceous layer was also measured, in order to quantify species response to vegetation succession. For this purpose a canonical correspondence analysis (CCA) was carried out on species frequency (response variable) in which vegetation succession was used as the only explanatory variable (values 1 to 4, from early to late successional stages). Species' scores on the ordination axis constrained by vegetation succession were used as their response. Downweighting of rare species and Monte Carlo permutation test (999 permutations) were used (Leps and Smilauer 2003). The relationship between species response to succession (dependent variable) and species traits (independent variable) was investigated by applying the best fit method of regression analysis. Furthermore, a stepwise regression was carried out in the same data set in order to determine the trait combination with the best prediction over species response to succession. A trait was included in the model if $p \leq 0.05$ and removed if $p \geq 0.10$. Traits with more than two categories were expressed as dummy variables (Tabachnick and Fidell 2001). All analyses were carried out using the software packages CANOCO 4.5 and PASW Statistics 18.0.

**Results and Discussion**

Species response to vegetation succession ranged from -2.48 to 3.39 (values on the constrained axis of CCA). Positive values indicated positive response to succession.

Plant traits that produced a significant regression model with species response to succession are presented in table 2. The linear, quadratic and cubic model of the vegetative plant height had the highest coefficients of determination than the models of all other traits. The differences in coefficients among the three models were very small, indicating that the linear model was enough for predicting species response, since the complexity of the other two models was not compensated by an increase in their explaining capacity. Life cycle could predict species response with three regression models. Each one explained 27.5% of the dependent variable, indicating that the linear model was enough for this trait, too. The life form of therophytes and hemicryptophytes and clonality produced each a significant linear model with species response to succession explaining 27.5%, 11.3% and 21.9% of the variance in species response respectively. Plant height, life cycle, hemicryptophytes and clonal species increased with succession, while therophytes decreased. Similar results have been reported by other researchers (e.g. Prach et al. 1997, Kahmen and Poschlod 2004, Castro et al. 2010).

On the other hand, leaf nitrogen concentration predicted species response with a cubic model (Table 2), which is non-linear, in contrast to Garnier et al. (2004) who have found that leaf nitrogen concentration decreases during succession. This could be attributed to the low values of leaf nitrogen concentration that some forbs had in the early stages of succession and to the presence of legumes in all successional stages (Papadimitriou et al. 2004). Onset of flowering had the lowest coefficients of determination, explaining 16.2% and 17.4% of species response with the quadratic and the cubic models respectively. Kahmen and Poschlod (2004) found that species flowered later at the advanced stages of succession than the ones in the early stages. *Chondrilla juncea*, a forb of the early successional stages that flowers at the end of July, seemed to be the reason for the unimodal response of species in our data set. When this species was omitted from the analysis, then onset of flowering produced a significant linear model with species response ($R^2$=0.131, p=0.030).

**Table 2. Regression models of plant traits (X) and species response to succession (Y). Only traits with a significant model are presented.**

| Plant traits | Regression model | $R^2$ | p. |
|---|---|---|---|
| VPH | Linear: $Y = -1.301 + 0.100x$ | 0.311 | 0.000 |
| | Logarithmic: $Y = -3.024 + 1.305\ln(X)$ | 0.249 | 0.002 |
| | Quadratic: $Y = -1.420 + 0.116x - 0.0004x^2$ | 0.312 | 0.002 |
| | Cubic: $Y = -1.7 + 0.179x - 0.004x^2 + 0.00006x^3$ | 0.313 | 0.006 |
| Life cycle[1] | Linear: $Y = -3.123 + 2.092x$ | 0.275 | 0.001 |
| | Logarithmic: $Y = -1.031 + 3.018\ln(X)$ | 0.275 | 0.001 |
| | Inverse: $Y = 3.153 - 4.184/X$ | 0.275 | 0.001 |
| Therophytes[2] | Linear: $Y = 1.061 - 2.092x$ | 0.275 | 0.001 |
| Hemicryptophytes[3] | Linear: $Y = -0.305 + 1.252x$ | 0.113 | 0.041 |
| Clonality[4] | Linear: $Y = -0.722 + 1.791x$ | 0.219 | 0.003 |
| LNC | Cubic: $Y = -33.952 + 5.340x - 0.260x^2 + 0.004x^3$ | 0.216 | 0.043 |
| Onset of flowering | Quadratic: $Y = -30.235 + 0.383x - 0.001x^2$ | 0.162 | 0.049 |
| | Cubic: $Y = -21.817 + 0.209x - 0.000003x^3$ | 0.174 | 0.039 |

[1]Life cycle 1: Annual, 2: Perennial; [2]Therophyte 0: No, 1: Yes;
[3]Hemicryptophyte 0: No, 1: Yes; [4]Clonality 0: No clonal, 1: Clonal;

Therefore, vegetative plant height, life cycle and the life form of therophytes were the traits with the higher predictive capacity as single predictors. Similar results have been found by Diaz et al. (2001) and de Bello et al. (2005) in relation to grazing. It should be noted though, that even for those traits the coefficients of determination were low.

When more traits were combined their predictive capacity was increased compared with the models of single traits. The stepwise regression showed that the combination of vegetative plant height, life cycle, leaf dry matter content, pollination mode and specific leaf area provided the best prediction for species response to succession (Table 3). These traits together explained 59.6% (Adj. $R^2$) of the variance in species response to succession. The combination of similar traits (plant height, life cycle and leaf mass) have been also found to give the best prediction over species response to grazing by Diaz et al. (2001).

**Table 3. Stepwise regression of plant traits (independent variable) and species response to succession (dependent variable).**

| Plant traits | B | Std. error | Beta (β) | t | Sig. | Model |
|---|---|---|---|---|---|---|
| (Constant) | -6.618 | 1.532 | | -4.318 | 0.000 | R=0.808<br>$R^2$=0.652<br>Adj. $R^2$=0.596<br>Std. error=1.176<br>F=11.624<br>Sig. = 0.000 |
| VPH | 0.069 | 0.021 | 0.383 | 3.262 | 0.003 | |
| Life cycle[1] | 1.892 | 0.500 | 0.474 | 3.785 | 0.001 | |
| LDMC | 0.014 | 0.003 | 0.485 | 3.981 | 0.000 | |
| Pollination[2] | -1.740 | 0.478 | -0.462 | -3.636 | 0.001 | |
| SLA | 0.069 | 0.033 | 0.252 | 2.067 | 0.047 | |

[1]Life cycle 1: Annual, 2: Perennial; [2]Pollination mode 1: Insects, 2: Wind

## Conclusions

Vegetative plant height, life cycle and the life form of therophytes are the traits with the higher predictive capacity of species response to succession as single predictors, but their coefficients of determination are low. When more traits are combined their predictive capacity is increased. It is concluded that plant traits can capture species response to vegetation succession after grazing extensification in Mediterranean rangelands.

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## References

**Castro H., V. Lehsten, S. Lavorel and H. Freitas. 2010.** Functional response traits in relation to land use change in the Montado. *Agriculture, Ecosystems & Environment, 137*:183-191.

**Cornelissen J. H. C., S. Lavorel, E. Garnier, S. Diaz, N. Buchmann, D. E. Gurvich, P. B. Reich, H. ter Steege, H. D. Morgan, M. G. A. van Der Heijden, J. G. Pausas and H. Poorter. 2003.** A handbook of protocols for standardised and easy measurement of plant functional traits worldwide. *Australian Journal of Botany, 51*:335-380.

**de Bello F., J. Leps and M. T. Sebastia. 2005.** Predictive value of plant traits to grazing along a climatic gradient in the Mediterranean. *Journal of Applied Ecology, 42*:824-833.

**Diaz S., I. Noy-Meir and M. Cabido. 2001.** Can grazing response of herbaceous plants be predicted from simple vegetative traits? *Journal of Applied Ecology, 38*:497-508.

**Garnier E., J. Cortez, G. Billes, M.-L. Navas, C. Roumet, M. Debussche, G. Laurent, A. Blanchard, D. Aubry, A. Bellmann, C. Neill and J.-P. Toussaint. 2004.** Plant functional markers capture ecosystem properties during secondary succession. *Ecology, 85*:2630-2637.

**Kahmen S. and P. Poschlod. 2004.** Plant functional trait responses to grassland succession over 25 years. *Journal of Vegetation Science, 15*:21-32.

**Leps J. and P. Smilauer. 2003.** Multivariate Analysis of Ecological Data Using CANOCO. Cambridge University Press, Cambridge, UK. 269 pp.

**Papadimitriou M., Y. Tsougrakis, I. Ispikoudis, and V. P. Papanastasis. 2004.** Plant functional types in relation to land use changes in a semi-arid Mediterranean environment. In: M. Arianoutsou and V. P. Papanastasis (eds). Ecology, Conservation and Management of Mediterranean Climate Ecosystems. Proceedings of the 10th MEDECOS Conference. pp. 1-6

**Papanastasis V. P. and D. Chouvardas. 2005.** Application of the state-and-transition approach to conservation management of a grazed Mediterranean landscape in Greece. *Israel Journal of Plant Sciences, 53*:191-202.

**Prach K., P. Pysek and P. Smilauer. 1997.** Changes in species traits during succession: a search for pattern. *Oikos, 79*:201-205.

**Tabachnick B. G. and L. S. Fidell. 2001.** Using multivariate statistics, 4th edition. Allyn & Bacon, Boston. 966 pp.

**Weiher E., A. van der Werf, K. Thompson, M. Roderick, E. Garnier and O. Eriksson. 1999.** Challenging Theophrastus: A common core list of plant traits for functional ecology. *Journal of Vegetation Science,10*:609-620.

**Zarovali M. P., M. D. Yiakoulaki and V. P. Papanastasis. 2007.** Effects of shrub encroachment on herbage production and nutritive value in semi-arid Mediterranean grasslands. *Grass and Forage Science 62*:355-363.

# Heavy metal transfer to forage material in amended soils in the area of Ptolemais – Greece

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## Abstract

A study of Selenium (Se), Cadmium (Cd), Nikelium (Ni) and Chromium (Cr) uptake by plants, conducted in the reclaimed mine soils of the Ptolemais basin, in North Greece, is reported in this paper. The aim was to estimate the influence of various soil parameters on the concentration of these elements in two plant categories, namely winter cereals and forage species. The results of elemental analysis indicated that the values of Cd, Ni and Cr were much higher than those present in regular soils. The values of bio-available Se in soils were low (< 7.9 ppb), well within the range of regular soils, while they were significantly higher in both plant categories (55-117.5 ppb). Results of multiple and stepwise regression analysis were used to develop models with high $R^2$ (0.82) of predicting Se uptake by plants using easily measured soil parameters such as pH, CEC, EC, clay percentage or Manganium (Mg). These results can be utilized by various local users and land managers, and also to optimize management of grazing livestock and improve their nutrition.

**Key words:** selenium, heavy metals, amended soils, bio-transfer, forage plants

## Introduction

Selenium (Se) is a naturally occurring trace element that can be concentrated and released in the waste materials from certain mining, agricultural, petrochemical and industrial manufacturing operations. One of the primary human activities responsible for mobilizing selenium in the environment is the procurement, processing and combustion of coal for electric power production (Lemly 1985). One of the pathways that provides for direct movement of Se into food chains is the uptake of Se by rooted plants. Mobilization of Se within the soil-plant systems is a highly complex subject (Neal 1990).

Forms and transformation of Chromium (Cr) in soils have great environmental and health implications. Therefore, the speciation of Cr in soils and its solubility in Cr-polluted soils have been widely studied (Barnhart 1997, Rudel et al. 2001). Contents of Cr in plants have recently received much attention due to the knowledge of its importance as an essential micronutrient in human metabolic processes, but also because of its carcinogenic effects. The world soil average content of Cr in soils has been determined as 60 mg/kg.

The concentration of Nikelium (Ni) in surface soils reflects the impact of both soil-forming processes and anthropogenic activities. Soils throughout the world contain Ni in the very broad range; however its mean concentrations are within the range 13–37 mg/kg. Organic matter (OM) exhibits a strong ability to absorb Ni, thus it is likely to be highly concentrated in coal and oil. The mechanism of Ni toxicity to plants is not fully understood, although the restricted growth of plants and injuries caused by an excess of this metal was observed for quite a long time. Increased Ni levels in food plants are associated with health hazards. The ready transfer of Ni from soils to vegetables has been illustrated by Frank et al. (1982).

Cadmium (Cd) is considered as being one of the most ecotoxic metals that exhibit adverse effects on all biological processes of humans, animals, and plants. Although Cd is considered to be a nonessential element for metabolic processes, it is effectively absorbed by both root and leaf systems and is also highly accumulated in soil organisms. The Cd content of plants is of great concern as a pathway of Cd to man and animals. The average Cd content for the Earth's crust is given as 0.1 mg/kg (Kabata-Pendias 2011).

The aim of this paper was to estimate the influence of various soil parameters on the concentration of Se, Cd, Ni and Cr in winter cereals and forage species in the reclaimed mine soils of Ptolemais-Amyntaion, northwest Greece.

**Materials and methods**

Ptolemais-Amyntaion basin region is located in the northwest of Greece. The lignite beds of this basin are under intense exploitation by open cast mining (Tsikiritzis et al. 2002). The depleted or abandoned mines are reclaimed and revegatated after being filled with a mixture of fly ash, overburden and inter-bedded sentiments removed from the working mines (Georgakopoulos et al. 2002a, b).

Eight sample sites were selected in the reclaimed mine soils, in two different locations. At each site, soil samples of two depths were collected (0-30 cm and 30-60 cm), as well as plant material. The latter was divided into two categories: winter cereals (wheat and barley) and forage species (*Cynodon dactylon, Briza maxima, Bromus benekenii, Chrysopogon gryllus, Dactylis glomerata, Holcus lanatus and Poa compressa).* The sieved soil was then used to determine the particle size analysis (Gee and Bauder 1986) the chemical properties of the soil and the concentration of Se, Cd, Ni and Cr (Page et al. 1982).

Mean values and their standard deviation were calculated for each plant category and each sampling site. The statistical procedure followed was stepwise multiple linear regression using JMP-7 statistical software of SAS (Sall et al. 2007, Lehman et al. 2005).

**Results and Discussion**

Results concerning the properties of soils are shown in Table 1, while the concentrations of Se, Cd, Cr and Ni, are presented in Table 2. Results concerning the concentrations of heavy metals in winter cereals and forage species from each sampling site are shown in Table 3.

**Table 1.** Soil characteristics in 8 sampling sites and 2 depths (depth 1: 0-30 and depth 2: 30-60cm, respectively)

| Sampling site | Depth 1 | | | | | Depth 1 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Clay (%) | Soil type | pH (soil:water ratio 1:1) | pH (KCl, 1N, 1:2.5) | Mn (mg/Kg) | Clay (%) | Soil type | pH (soil:water ratio 1:1) | pH (KCl, 1N, 1:2.5) | Mn (mg/Kg) |
| 1 | 7.2 | SL | 8.48 | 7.62 | 6.04 | 2.0 | SL | 8.55 | 8.24 | 1.14 |
| 2 | 26.4 | LS | 8.42 | 7.58 | 7.18 | 19.2 | LS | 7.91 | 7.88 | 6.56 |
| 3 | 20.0 | LS | 8.21 | 8.20 | 4.38 | 6.0 | SL | 8.32 | 8.05 | 1.70 |
| 4 | 4.0 | SL | 8.64 | 8.14 | 3.72 | 2.0 | SL | 9.39 | 9.59 | 2.20 |
| 5 | 28.4 | SCL | 8.32 | 7.90 | 5.72 | 18.0 | SL | 8.19 | 7.89 | 3.64 |
| 6 | 23.2 | SCL | 7.64 | 7.89 | 0.44 | 48.4 | C | 7.92 | 8.24 | 0.62 |
| 7 | 38.4 | CL | 8.49 | 8.13 | 2.32 | 42.4 | C | 8.26 | 8.15 | 2.52 |
| 8 | 16.0 | SL | 8.28 | 7.76 | 4.30 | 15.2 | SL | 8.16 | 7.63 | 7.08 |

**Table 2.** Soil concentration Se, Cd, Cr and Ni for two depths (depth 1: 0-30 cm and depth 2: 30-60cm, respectively)

| Sampling site | Depth 1 µg/kg | | | | Depth 2 µg/kg | | | |
|---|---|---|---|---|---|---|---|---|
| | Se | Cr | Ni | Cd | Se | Cr | Ni | Cd |
| 1 | 2.1 | 53.6 | 1344 | 33.2 | 7.9 | 62.8 | 472 | 25.2 |
| 2 | 3.8 | 578 | 678 | 117.6 | 4.5 | 244 | 3696 | 49.8 |
| 3 | 2.6 | 42.8 | 224 | 15.6 | 3.1 | 45.2 | 130 | 52.0 |
| 4 | 5.4 | 42.6 | 1054 | 14.4 | 5.4 | 154.8 | 1064 | 12.6 |
| 5 | 1.9 | 55.6 | 1056 | 25.4 | 2.6 | 99 | 952 | 49.8 |
| 6 | 2.0 | 65.6 | 1068 | 18.8 | 4.4 | 51.4 | 3696 | 22.2 |
| **7** | 2.3 | 226.0 | 840 | 59.8 | 2.9 | 86.8 | 1206 | 66.6 |
| 8 | 4.9 | 188.0 | 1686 | 51.2 | 2.5 | 184.2 | 6586 | 52.3 |

**Table 3.** Results of plant tissue analysis

| Site | **Winter cereals** µg/kg | | | | **Forage species** µg/kg | | | |
|---|---|---|---|---|---|---|---|---|
| | Se | Cr | Ni | Cd | Se | Cr | Ni | Cd |
| 1 | 85.00 | 2295 | 2650 | 50 | 92.50 | 2387 | 2231 | 52 |
| 2 | 74.50 | 4825 | 2750 | 40 | 117.50 | 3978 | 2861 | 47 |
| 3 | 92.50 | 8250 | 7250 | 60 | 92.25 | 7513 | 7311 | 58 |
| 4 | 81.75 | 14750 | 2600 | 80 | 91.25 | 10691 | 2543 | 83 |
| 5 | 78.75 | 2584 | 2870 | 65 | 85.00 | 4282 | 3100 | 68 |
| 6 | 85.25 | 3128 | 4800 | 52 | 84.00 | 3244 | 4520 | 50 |
| 7 | 55.00 | 5125 | 5240 | 85 | 80.00 | 4990 | 5500 | 63 |
| 8 | 97.50 | 6217 | 3600 | 49 | 85.00 | 6005 | 3910 | 56 |

Results indicated that the values of Cd, Ni and Cr were much higher than those present in regular soils. For the water soluble, and thus plant available, Se concentrations were low in soils but high in plant tissues. Therefore, for these highly disturbed soils, Se was transferred to plant species in very high rates, compared to the other three metals which showed a normal bio-transfer rate from soils to plants.

Means comparison using the student's *t*-test showed that there are no significant differences among the 8 sampling sites, between the two depths or between the two plant types. The next step was to use the multiple linear regression analysis, in a forward process. The final multiple regression model for Se is shown below:

$$Se_{plant} = 167.14 - 0.23(Clay\%) - 47.93(pH1) + 30.41(pH2) + 5.09\,(Mn) + 6.79\,(Se_{soil})$$

In this model the stepwise values of $R^2$ are shown in Table 4.

**Table 4.** The stepwise values of $R^2$

| Step | Parameter | Estimate | $R^2$ |
|---|---|---|---|
| | Intercept | 167.14 | |
| 1 | Clay (%) | -0.23 | 0.1694 |
| 2 | pH 1 (1:1 water) | -47.93 | 0.3666 |
| 3 | pH 2 (1:2.5 KCl) | 30.41 | 0.5066 |
| 4 | Mn (soil) | 5.09 | 0.6765 |
| 5 | Se (soil) | 6.79 | 0.8296 |

## Conclusions

The results indicate that the model derived for bio-available Se has a strong probability (up to 82%) to predict the measured value of Se uptake in plants using parameters that are common in basic soil analyses, relatively easy and economic to measure, as opposed to the expensive and time consuming measurement of Se in plants. Some precaution should be taken to utilize such a model beyond the range of the measured properties of the studied area and extrapolate it in similar areas. The results of this study can be utilized by various local users and land managers, and also to optimize management of grazing livestock and improve their nutrition.

## References

**Barnhart J., 1997.** Chromium chemistry and implications for environmental fate and toxicity. *J. Soil Contam. Spec. Issue* 6: 561–568.

**Frank R., K.I. Stonefi eld and P. Suda 1982.** Impact of nickel contamination on the production of vegetables on an organic soil, Ontario, Canada. 1980–1981. *Sci. Total Environ.* 26:41–65.

**Gee G.W. and J.W. Bauder, 1986.** Particle size analysis. pp 383-411. In A. Klute et al (eds) Method of Soil Analysis. Part 1-Physical and Mineralogical Methods. 1986. 2nd ed. Book Series No 9. ASA and SSSA, Madison, Wi.

**Georgakopoulos A., A. Filippidis, A. Kassoli-Fournaraki, A. Iordanidis, J.L. Fernández-Turiel, J.F. Llorens and D. Gimeno. 2002a.** Environmentally important elements in fly ashes and their leachates of the power stations of Greece. *Energ. Source* 24: 83-91.

**Georgakopoulos A., A. Filippidis, A. Kassoli-Fournaraki, J.L. Fernández-Turiel, J. F. Llorens and F. Mousty, 2002b.** Leachability of major and trace elements of fly ash from Ptolemais power station, Northern Greece. *Energ. Source* 24: 103-113.

**Haygarth P.M., 1994.** Global importance and Global cycling of Selenium. In Selenium in the Environment. Frankenberger, W.T.Jr and S. Benson, eds. Marcel Dekker Inc. New York.

**Kabata-Pendias A., 2011.** Trace elements in soils and plants. 4th ed., CRC Press LLC, USA, 534 pp.

**Lehman A., N. O'Rourke, L. Hatcher, and E. J. Stepanski, 2005.** JMP® for Basic Univariate and Multivariate Statistics: A Step-by-Step Guide. Cary, NC: SAS Institute Inc.

**Lemly A.D., 1985.** Ecological basis for regulating aquatic emissions from the power industry: The case with selenium. *Ecotoxicology and Environmental Safety* 29: 229-242.

**Newland L.W., 1982.** Handbook of Environmental Chemistry. Springer – Verlag. New York, pp. 45-57.

**Neal R.H., 1990.** Heavy Metals in Soils. Blackie Press. London, pp. 235-260.

**Page A.L., R.H. Miller and D.R. Keeney (eds), 1982.** Methods of soil analysis, Chemical and Microbiological properties. Agronomy No 9 (Part 2) 2nd Edition. SSSA Inc., Wisconsin, USA.

**Public Power Corporation S.A., 2003.** Development/Quality of life. Communication Department, Athens. Greece. 32pp. www.dei.gr

**Rudel H., A. Wenzel and K. Terytze , 2001.** Quantification of soluble chromium (VI) in soils and evaluation of ecotoxicological effects. *Environ. Geochem. Health* 23:219–224.

**Sall J., L. Creighton, and A. Lehman, 2007.** JMP® Start Statistics: A Guide to Statistics and Data Analysis Using JMP®, Fourth Edition. Cary, NC: SAS Institute Inc.

**Tsikritzis L.I., S.S. Ganatsios, O.G. Duliu, C.V. Kavouridis and T.D. Sawidis, 2002.** Trace elements distribution in soil in areas of lignite power plants of Western Macedonia. *J. Trace Microprobe Tech.* 20: 269-282.

# A study of the effect of habitat fragmentation on the population status of *Iris pumila* L. in Ukraine

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## Abstract

The goal of the study was to investigate the effect of isolation on populations of *Iris pumila* L., a typical Ukrainian steppe xerophyte which habitat has been split into a multitude of small fragments. Most of the studied populations clearly demonstrate prevalence of adult flowering plants. Seedlings are rare, which can be explained by drought during major parts of the vegetative seasons, the substantial matting of local soil, and human impacts, such as burning. Population success appears to depend on the size of the steppe fragment and the total human impact. In this preliminary genetic study of a relatively large *Iris pumila* populations no signs of gene pool depletion ware detected. Further research will hopefully reveal whether the genetic indices that have been estimated are also useful tools for other populations of the species – fragments of a previously continuous habitat. Meanwhile, due to the increasingly endangered status of the habitat and the practical absence of any population status monitoring, it makes sense to include this species into the Ukrainian Red List.

**Keywords:** *Iris pumila*, habitat fragmentation, genetic polymorphism, Ukraine

## Introduction

So far, only 3% of the territory of Ukraine remains fallow (Parnikoza et al. 2009). Of the 826 plant species listed in the Red List of Ukraine, 33.4% inhabit steppe biotopes. *Iris pumila* L., which is a characteristic species of the fescue-stipa (Cl. Festuco-Brometea Br.-Bl. et R.Tx.) steppes, is a non-Red List species that is still endangered. It is a typical steppe xerophyte of Ukrainian flora which habitat has been fragmented into multiple patches since the 18$^{th}$ century. The general population status of this species under the isolated conditions has not been studied in Ukraine. So the consequences of such isolation on its population genetics remain unknown.

Therefore, the goal of the present study was to address the consequences of isolation for *Iris pumila* L. populations from the perspectives of population ecology and genetics.

## Material and Methods

**General population assessment.** A number of field trips took place during the 2010-2011 seasons to survey the populations that had been investigated before during 2000-2009. Published data also was used (Sykura and Shycha 2010, for review see Parnikoza et al. 2011). A number of populations were studied in the Dnipropetrovsk -2, Mykolaiv region – 3 and in the Crimea - 2.

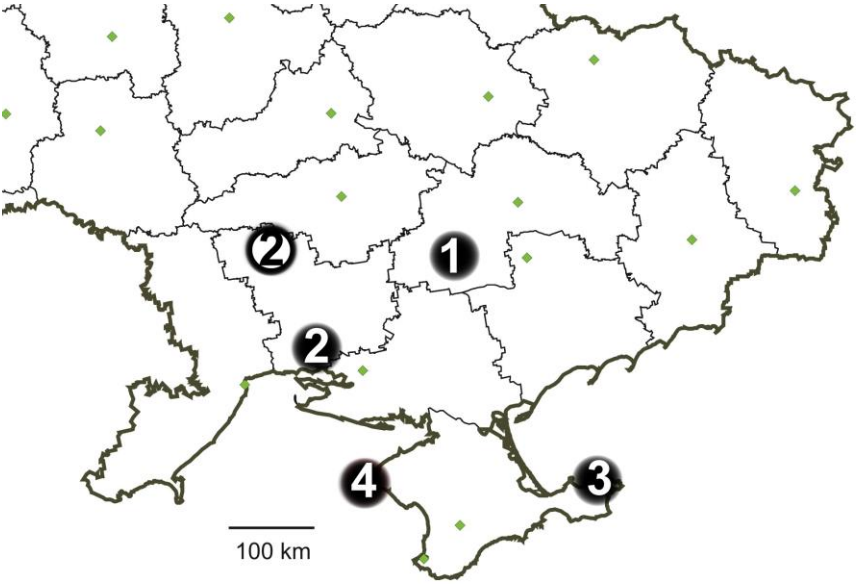


**Figure 1.** Geographic locations of the studied *Iris pumila* populations: 1 – Dnipropetrovsk region, 2 – Mykolaiv region, 3 – Kerch Peninsula (Crimea), 4 – Tarkhankut Peninsula (Crimea). Encircled is the location of the population near the Migia village studied by molecular genetics methods

Population size, fraction of ontogenetic stages, presence of successful flowering and fruiting were analyzed as described in Parnikoza et al. (2011). Special attention was paid to the effects of some adverse factors, such as burning, grazing, erosion, illegal collection of plants etc, on the populations.

**Molecular genetics studies.** For preliminary investigation eleven plants were used for molecular genetics analysis from a fragment of one population inhabiting petrophyle steppe areas near Migia which were the most numerous (over 1000 individuals) and well-studied on the population level. We mapped all analyzed individuals, including both mature generative and young pre-generative plants, on the area of 77 square meters. We used five types of molecular markers dispersed over both coding and non-coding genome regions: nine RAPD (random amplified polymorphic DNA), eight ISSR (inter-simple sequence repeats), six RGAP (resistance gene analog polymorphism), four LP-PCR (long primer PCR – markers based on genes controlling abiotic stress response), and seven IRAP (inter-retrotransposon amplified polymorphism) primer pairs.

**Results and discussion**

The studied populations numbered hundreds (near Mykolaiv on the Alauda Peninsula and near the Kolarovo village, as well as on the Tarkhankut and Kerch peninsulas in the Crimea) to thousands (near Migia). Population densities ranged from 2 to 10 plants per square meter. The population numbers apparently depended on the size of the local steppe fragment. Thus, the studied population fragment near Migia (Mykolaiv region) was part of a large population inhabiting non-arable petrophyle steppe.

All the studied populations were dominated by mature generative plants, ranging from 95 to 100%. This data was on contrary with data from the Rostov region of Russia (Fedyaeva et al. 2011) where populations of the species were balanced. In fact, mature generative plants may not flower in some years, but they differ from pre-generative individuals in that they have well-ramified systems of creepers and large beds. Flowering was observed in all of the populations, its presence, scale, and fruiting success being year-specific. For instance, any sign of successful fruiting was not found in some years (2005-2007) in the very dry plain steppes of the Kerch Peninsula in the Crimea. The dependence of fruiting on climatic conditions has been documented in multi-year studies of another meadow-steppe species – *Iris hungarica* (Waldst. et Kit) (Parnikoza et al. 2009). Given this dependence, the question of flowering and fruiting frequencies in *I. pumila* needs research on their population dynamics.

The studied populations are under profound human impact, the most extreme component of which being the habitat fragmentation. In particular, only solitary *I. pumila* plants were found in the Dnipropetrovsk region on tiny spots of virgin steppe along roadsides and river valleys. Undoubtedly, these are the most extreme forms of population existence.

Most populations of *I. pumila* suffer from the regular spring burning and grazing, which may restrict population renewal with juvenile individuals and, thus, promote the development of unbalanced populations dominated by mature generative plants. This scenario has been also demonstrated for other steppe perennials, like *Pulsatilla pratensis* Mill. and *Iris hungarica*, in the Lysa Gora tract in Kyiv that is subject to regular burning (Parnikoza et al. 2007, 2009).

The sporadic character of seedling fixation may have also been caused by the unfavorable climatic conditions during the vegetative season, as well as the notable matting of the local soil surface.

The erosion of the sea and estuary coasts is an additional factor that affects the populations. In the vicinity of the Black Sea, the species inhabits narrow stretches along the eroded coasts that gradually collapse, which puts the existence of the species in peril. Other factors that negatively affect the existence of the species are steppe afforestation, junkyards scattered over steppe patches, mining operations, and illegal archaeology. Additionally, deliberate illegal collection of ornamentally valuable plants was noted. The effect of all these factors is particularly unpredictable given the absence of real population dynamics data for the species from most parts of its habitat. As the species is not included into the Red List of Ukraine, it is practically beyond the monitoring studies carried out by natural reserves staff and other research institutions of Ukraine. Under such circumstances, population shrinkage and loss of genetic diversity may remain unnoticed.

The indicative molecular genetic study of the fragment of *I. pumila* population near Migia revealed a high level of genetic polymorphism as inferred from the pooled data for all the markers. The polymorphism (P) was 78.4%, the average number of alleles per locus (A) – 1.78 ± 0.018, the effective number of alleles per locus ($A_e$) – 1.33 ± 0,014, Shannon index (S) – 0.33 ± 0.01, Nei's gene diversity (expected heterozygosity $H_e$) – 0.208 ± 0.007, and the Jacard genetic distances between plants ($D_j$) – 34.31–52.77% (mean genetic distance – 45.13%).

The high level of genetic polymorphism of the studied population fragment is in agreement with the species biology, e.g. cross-pollination and perennial life cycle, and suggests no immediate threat of its genetic decay. In the studied population fragment, sexual reproduction prevails over vegetative, as none of the samples were clones, even those growing in close proximity (the shortest distance between a pair of samples was 16 cm).

Thus, indicative genetic analysis suggests no signs of gene pool depletion in this isolated population of *I. pumila*. Notably, similar results have been obtained by Hungarian researchers for populations of the restricted-range steppe endemic *Dianthus diutinus* Kit. (Nemeth et al. 2011).

Therefore, the size and the balance of ontogenetic stages in populations of *I. pumila* primarily depend on the size of the steppe fragment. According to the results within large steppe fragments, especially petrophyle patches, populations of this species can reach great numbers. Seed and vegetative renewal and bed outgrowth can be observed there. Similar results have also been reported for the Rostov-on-Don area in Russia (Fadyaeva et al. 2011). But the large area of the steppe remnant itself does not guarantee population success, as it can be opposed by severe human impact.

Still, we have only assessed a small population fragment near Migia. Comparison with other remote population fragments of various sizes and growing in different (e.g. dryer) conditions will demonstrate whether the genetic heterogeneity indices we obtained apply to other populations of the species.

Threats raised by the shrinking of the area of steppe fragments and the increased human impact make it necessary to consider inclusion of this species into the national Red List. This, among all, would promote inclusion of the species into national monitoring programs.

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## References

**Fedyaeva V. V., Shmaraeva A. N., Shishlova J. N. 2011.** Conservation of *Iris pumila* L. populations in Rostov-on-Don Area. In: (Novikov V. S. et al.) proceeding of the second Moscow international symposium "Iris-2011". Moscow 14-17 June 2011 – M.: MAKS Press: 128-132.

**Neméth A., Mihalik E., Makra O., Balogh L., Szatmári M. 2011.** Ex situ propagation and reestablishment of the Pannonian endemic *Dianthus diutinus*. Contribution of the Botanic Garden of the University of Szeged to the implementation of the LIFE06NAT/H/000104 project. In: Steppe Oak Woods and Pannonic Sand Steppes Conference 6-8 October 2011, Kecskemét, Hungary. Abstract book: 41-42.

**Parnikoza I. Yu., Shevchenko N. M., Bogomaz M. V., Shevchenko M. S. 2007.** The influence of grass burning on the dynamics of *Pulsatilia nigricans* Stork population of the regional landscape park „Lysa gora" (Kyiv) In: Shmalej S.V. et al. (Eds.) Collection of scientific manuscripts "Falz-Fein lections" – Збірник наукових праць. Фальцфейнівські читання, Kherson.: Vyszemirski: 4-5.

**Parnikoza I., Vasiluk O., Inozemtseva D., Kostushin V., Mishta A., Nekrasova O., Balashov I. 2009.** Steppes of Kyiv oblast: modern state and problem of conservation. – NECU, Kyiv. 164 pp.

**Parnikoza I. Yu., Troitskaya M. A., Troitskij M. A., Kunakh V.A. 2011.** *Iris pumila* L. in Ukraine // In: (Novikov V. S. et al.) proceeding of the second Moscow international symposium "Iris-2011". Moscow 14-17 June 2011 – M.: MAKS Press: 105-110.

**Sikura I. I., Shyscha E. N. 2010.** Genus *Iris* L. (*Iridaceae*) – род Касатик, Ирис (Касатиковые). – К.: Знания Украины, 195 pp.

# The impact of grazing on woody vegetation characteristics in cub-zone of Ostryo – Carpinion

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## Abstract

The present work deals with the impact of grazing in a disturbed Mediterranean ecosystem in Greece. The aim of this study was to investigate the impact of grazing on silvicultural and vegetation characteristics of woody species. The study area was divided into two parts a protected and a grazed one, which were then separated into three belts of different latitude. The characteristics measured were total height, diameter for trees and root collar diameter for shrubs, crown length, richness, density and abundance cover in order to obtain a clear perspective of the vegetation and to estimate and compare the diversity between parts. In total, there were 822 individuals, 480 of which in the protected part. From the sixteen woody species identified 6 species were common in both parts, with *Quercus coccifera* as the dominant species. The results showed that grazing has a negative effect on the silvicultural characteristics of the woody species, mainly to their height growth, as is evident in the protected part where differentiation and discrimination of the vegetation storeys occurs. In addition , the number of tree storey species in the protected part was higher than in the grazed part and as herbivores prefer eating specific species the number of left over species was reduced leaving only these that exhibit tolerance to grazing leading thus, the grazed ecosystem to a regressive succession., The slope position is a factor that affects richness, density, abundance –cover and diversity as significant differences were found among the middle slope, upper and foot slope in both parts.

**Keywords**: Mediterranean ecosystems, *Quercus coccifera*, protected and grazed areas, woody species.

## Introduction

The present work deals with the impact of grazing in disturbed ecosystems in sub-zone of Ostryo-Carpinion in Greece. The objectives of the study were: 1. The impact of grazing on silvicultural characteristics of woody species, 2. The study of differences among diversity, abundance-cover and density of vegetation between the grazed and protected parts.

## Materials and Methods

The study area was divided into two parts the first one, labeled "protected", and the second one, "grazed". Each of them was separated into three belts: upper slope (800 – 980 m), middle slope (600 – 800 m) and foot slope (400 – 600 m) (Mekuria et al. 2007). For each of the investigated belts three sample plots were selected, of 10x10 m representatives of the area (Khaznadar et al. 2009, Mihok et al. 2009). Silvicultural characteristics of woody species, such as total height (H, m), diameter (at breast height DBH, cm) for trees (height > 3 m), root collar diameter (D, cm) for shrubs (height <3 m), and crown length (L, m) were measured. For the complete imprinting of the woody vegetation two profiles 10x30 m were created. Additionally, for the woody species the number of species (richness), the number of individuals of each species (density) and the abundance cover were recorded in order to obtain a clear perspective of the vegetation and to estimate and compare the Shannon-Wiener index (H) between parts (Gairola et al. 2008).

The t-test (one-way ANOVA) was applied for statistical data analysis and comparisons of the average characteristics of forest vegetation.

**Results and Discussion**

In total, 822 individuals were counted. In the protected part there were 480 plants, 134 trees and 346 shrubs, while in the grazed part there were 342 individuals, 30 of which were trees and 312 shrubs. Sixteen woody species were identified. From these species, 12 were in the protected area - 5 in the tree storey and 12 in the shrub storey- and 10 in the grazed area – 4 in the tree storey and 10 in the shrub storey. The two parts had 6 species in common. Dominant species in the tree storey were *Quercus coccifera* and in the shrub storey were *Quercus coccifera*, *Phyllirea latifolia* and *Juniperus oxycedrus* mainly in the grazed part.

The results showed that grazing has a negative effect on the silvicultural characteristics of the woody species. Shoot grazing hinders height growth. As shrubs are grazed by herbivores it is difficult for them to gain height so as to make the new shoots inaccessible. In the grazed part low vegetation prevailed with many shrubs and a small number of trees. On the other hand, the higher shrubs and the presence of a greater number of trees in the protected part results in the differentiation and discrimination of the vegetation storeys. Ganatsas et al. (2004, 2010) indicate that the values of the silvicultural characteristics of woody species and that of the other vegetation characteristics were greater in protected sites, while the woody species of grazed sites had severe damages as a result of intense grazing. Primack (1978) reaches similar conclusions in a study on the effects of grazing on shrubs of New Zealand. He observed that the species of the grazed site showed a smaller height growth in relation to the species of the protected site (witness). Oba (1992) noted that in six years, the height of the shrubs decreased by 13.3% in the grazed part, while it increased 17% on the protected one. Hester et al. (2006) observed that, in semi-dried savanna, goat grazing results in a significant decrease in diameter of shrub vegetation on root collar. The results also showed that the number of tree storey species on the protected part was higher than the grazed part. The present study found that the intense pressure from herbivores and their preference for specific species reduced the number of species leaving only the grazing-resistant *Quercus coccifera*. Peper et al. (2010) observed that over a one-month period the number of species in a fenced, protected from animals area increased. Species rare in the grazed part appeared in the protected area. Aronson et al. (1993) and Todd and Hoffman (1999) mentioned that under conditions of intense grazing unwanted spiny shrubs replaced desirable species that had been dominant, while after a few years of protection the undesirable species disappeared. El-Keblawy et al. (2009) pointed that in a comparison among controlled grazing, over-grazing and absence of grazing, species diversity was greater under the controlled grazing regime.

**Table 1.** Silvicultural characteristics of woody vegetation and the *Q. coccifera* as the dominant species, in the Protected (Pp) and the Grazed part (Gp).

| | Total Height (m) | | | Diameter (cm) | | |
|---|---|---|---|---|---|---|
| Storey | Pp | Gp | pv | Pp | Gp | pv |
| Trees | 4.18(0.07)* | 3.51(0.09) | 0.0005 | 11.00 (0.32) | 9.34 (0.37) | 0.02 |
| Shrubs | 1.9(0.20) | 1.45(0.05) | 0.02 | 4.36 (0.18) | 3.60 (0.12) | 0.0005 |
| *Q. coccifera* | | | | | | |
| Arborescent form | 4.14 (0.08) | 3.47 (0.10) | 0.0005 | 11.91 (0.31) | 9.46 (0.35) | 0.005 |
| Shrubby form | 1.81 (0.06) | 1.46 (0.05) | 0.0005 | 6.40 (0.28) | 4.00 (0.16) | 0.0005 |

*The table shows the means and their standard errors ($p<0.05$).

Two representative profiles (vertical and horizontal) of each part of the study area, were constructed to complete the structure analysis (Fig. 1, 2).

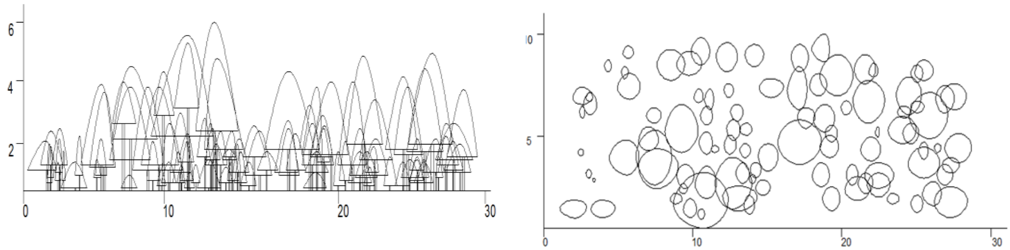


**Figure 1.** Profiles (vertical and horizontal) of vegetation in the Protected part.

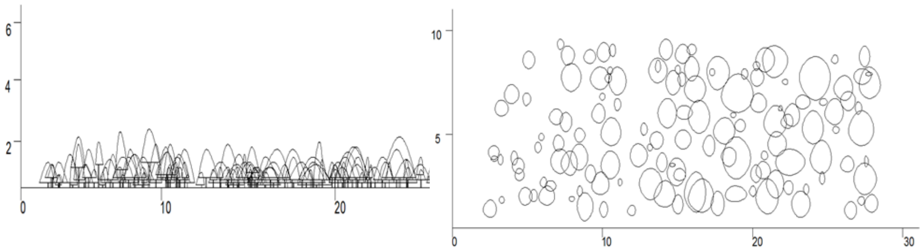


**Figure 2.** Profiles (vertical and horizontal) of vegetation in the Grazed part.

**Table 2**. Species richness and density in the Protected (Pp) and the Grazed part (Gp).

| | Richness | | | Density | | |
|---|---|---|---|---|---|---|
| Storey | Pp | Gp | pv | Pp | Gp | pv |
| Trees | 2.44 (0.44)* | 1.00(0.37) | 0.024 | 14.88 (2.20) | 3.44 (1.21) | 0.005 |
| Shrubs | 4.66 (0.40) | 4.33(0.37) | ns | 38.44 (3.69) | 34.66 (6,.29) | ns |

* The table shows the means and their standard errors (p<0,05).

**Table 3.** Species richness and density, per belt in the Protected (Pp) and the Grazed part (Gp).

| | Richness | | Density | |
|---|---|---|---|---|
| Belt | Pp | Gp | Pp | Gp |
| Upper slope | 6.66 (2.80)* | 6.33 (0.33) a | 41.66 (6.48) a | 27.66 (12.71) |
| Middle slope | 8.88 (0.88) | 5.33 (0.33) a | 65.00 (1.52) b | 32.00 (5.50) |
| Foot slope | 6.66 (0.88) | 4.00 (0.57) b | 56.66 (4.37) a | 54.33 (4.66) |

**Table 4.** Abundance -cover in the Protected (Pp) and the Grazed part (Gp).

Vegetation cover (%)

| Storey | Pp | Gp | pv |
|---|---|---|---|
| Trees | 44.44 (6.94)* | 15.83 (5.78) | 0.006 |
| Shrubs | 54.54 (7.01) | 30.00 (3.75) | 0.007 |

*The table shows the means and their standard errors (p<0,05).

**Table 5.** Shannon-Wiener Index, per slope belt in the Protected (Pp) and the Grazed part (Gp).

Shannon – Wiener Index

| | Upper slope | | Middle slope | | Foot slope | |
|---|---|---|---|---|---|---|
| | Shrubs | Trees | Shrubs | Trees | Shrubs | Trees |
| Pp | 1.37 | 0.83 | 1.4 | 1.09 | 1.72 | 0.74 |
| Gp | 1.72 | 0.72 | 1.32 | 0.26 | 0.81 | 0 |

## Conclusions

- Woody species in protected and grazed parts have different silvicultural and vegetation characteristics leading, as a result the grazed ecosystem to a regressive succession. The study showed that both height and diameter of individuals differ significantly in the two parts, as grazing pressure hinders the plants' growth.
- In it has been found A greater richness, density, abundance –cover was found in the tree storey of the protected part, while no significant differences were found in the shrub storey between the two parts.
- The Shannon - Wiener index was higher in the protected part than in the grazed one where there was a reduced proportion in the vegetation composition of the number of species preferred most by herbivores. The slope position (belt) is a factor that affects richness, density, abundance – cover and diversity as significant differences were found among the middle slope, upper and foot slope in both parts.

## References

**Aronson J., C. Floret, E.Le Floc'h, C. Ovalle and R. Pontanier, 1993.** Restoration and Rehabilitation of Degraded Ecosystems in Arid and Semi - Arid Lands. II. Case Studies in Southern Tunisia, Central Chile and Northern Cameroon. *Restoration Ecology* , 1(1): 8-17.

**El-Keblawy A., T. Ksiksi and El Alqamy, 2009.** Camel grazing affects species diversity and community structure in the deserts of the UAE. *Journal of Arid Environments*. 73: 347-354.

**Gairola S., R. Rawal and N. Todaria, 2008.** Forest vegetation patterns along an altitudinal gradient in sub-alpine zone of west Himalaya, India. *African Journal of Plant Science*, 2 (6): 42-48.

**Ganatsas P., T. Tsitsoni, M. Tsakaldimi and T. Zagas, 2010.** Reforestation of degraded Kermes oak shrublands with planted pines: effects on vegetation cover, species diversity and community structure. *New forests*:1-11

**Ganatsas P., T. Zagas, M. Tsakaldimi and T. Tsitsoni, 2004.** Postfire regeneration dynamics in a Mediterranean type ecosystem in Sithonia, northern Greece: ten years after fire. Proceedings 10th MEDECOS Conference, April 25- May 1, Rhodes, Greece.

**Hester A., P. Scogings and W. Trollope, 2006.** Long-term impacts of goat browsing on bush-clump dynamics in a semi-arid subtropical savanna. *Plant Ecology*, 183: 277-290.

**Khaznadar M., I. Vogiatzakis and G. Griffiths, 2009.** Land degradation and vegetation distribution in Chott El Beida wetland, Algeria. *Journal of Arid Environments*, 73: 369-377.

**Mekuria W., E. Veldkamp, M. Haile, J. Nyssen, B. Muys and K. Gebrehiwot, 2007.** Effectiveness of exclosures to restore degraded soils as a result of overgrazing in Tigray, Ethiopia. *Journal of Arid Environments*, 69: 270-284.

**Mihok B., K. Kenderes, K. Kirby, K. Paviour-Smith and C. Elbourn, 2009.** Forty-year changes in the canopy and the understorey in Wytham Woods. *Forestry*, 82(5): 516-527.

**Oba G., 1992.** Effects of controlled grazing on degraded dwarf shrub, annual grass semidesert vegetation type of Northwestern Kenya. *Land degradation and rehabilitation* 3:199-213.

**Peper J., A. Jabbarov and M. Manthey, 2010.** Short-time effects of grazing abandonment on semi arid rangelands in Azerbaijan. *Annals of Agrarian Sciense*, Vol. 8, No. 1.

**Primack R., 1978.** Effects of grazing on indigenous shrubs in tussock grassland at Cass, Canterbury, New Zealand. *New Zealand Journal of Botany*, 16: 461-469.

**Todd S., and M. Hoffman, 1999.** A fence-line contrast reveals affects of heavy grazing on plant diversity and community composition in Namaqualand, South Africa. *Plant Ecology*, 142: 169-178.

# Density and richness of soil seed banks in loess grasslands

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## Abstract

We studied the vegetation and seed banks in a *Salvio-Festucetum* loess grassland and in and formerly grazed and then abandoned *Cynodonti-Poëtum* loess pasture. We answered the following questions: (i) How dense are the local seed banks? (ii) Which species of the vegetation possess a seed bank? Soil samples were collected in early spring, 2010. Samples were concentrated and treated using the seedling emergence method. Percentage cover of vascular plants was recorded in twelve, 1-m$^2$-sized plots in June, 2009. We found that the mean densities of seed banks were similar in both grassland types (20,200 seeds/m$^2$ in *Salvio-Festucetum* and 22,800 seeds/m$^2$ in *Cynodonti-Poëtum*, respectively). Altogether, 94 species were detected both in vegetation and seed banks. In the pasture the species-poor loess vegetation (a mean of 10.2 species/m$^2$) was characterised by the high cover of *Festuca rupicola* (mean cover of 45%). Conversely, we detected significantly higher species richness in *Salvio-Festucetum* grassland (t-test; $p < 0.001$, mean, 27 species/m$^2$). The seed bank was characterised by common forbs (*Hypericum perforatum* 6,200 seeds/m$^2$, *Galium verum* 4,270 seeds/m$^2$, *Achillea collina* 2,100 seeds/m$^2$) and graminoid species (*Poa angustifolia* 1,060 seed/m$^2$, *Carex stenopylla* and *C. praecox* 2,480 seeds/m$^2$) in both grassland types. Dense seed banks were typical for *Conyza canadensis* (6,760 seeds/m$^2$) and *Veronica persica* (1,215 seeds/m$^2$). Most of the characteristic species of loess grasslands possessed only sparse seed banks (e.g. *Salvia austriaca*, *S. nemorosa*, *Pimpinella saxifraga*, *Medicago falcata*). Our results suggest that the seed bank can have only a limited role in maintaining species diversity in loess grasslands.

**Keywords**: biodiversity; grassland restoration; plant traits; secondary succession

## Introduction

The maintenance and recovery of species diversity in grasslands can be supported by soil seed banks as local propagule sources (Valkó et al. 2011). To design and/or improve conservation measures in grasslands the analysis of the composition and density of soil seed banks is also necessary. Persistent soil seed banks of characteristic grassland species enable the fast recovery of former diversity after disturbances and degradation (Bossuyt and Honnay 2008). However, in most of the studies only low density seed banks of grassland species were proven; some promising results were already published for dry grasslands (Kalamees et al. 2011). The species composition and density of seed banks are specific to the studied grassland and region; thus, it is necessary to have a seed bank analysis and persistency records for each grassland type. In spite of the high conservation value and species richness of loess grasslands, seed bank data only for a few characteristic species is available. The area of historically characteristic loess grasslands became fragmented in lowland areas in Central-Europe and elsewhere because of the agricultural intensification in the last century (Molnár and Botta-Dukát 1998). In most regions only species-poor degraded fragments of formerly species-rich grasslands remained, often surrounded by intensively managed agricultural lands. To preserve and restore loess grasslands it is necessary to understand how do soil seed banks contribute to the maintenance of species diversity. Vegetation and seed banks of (i) a traditionally managed loess grassland (*Salvio-Festucetum*) and (ii) a loess pasture (*Cynodonti-Poëtum*) were studied. We asked specifically the following questions: (i) How dense are the local seed banks? (ii) Which species of the vegetation possess seed banks?

**Material and methods**

The studied grasslands are situated near the town of Balmazújváros (Magdolna Puszta, traditionally managed loess grassland, N 47°35’01” E 21°17’54”) and village of Hortobágy (Nyírőlapos, degraded loess pasture, N 47°34’47”, E 21°15’30”). The climate of the region is moderately continental with an annual precipitation of 550mm and a mean temperature of 9.5°C. In each of the grasslands, twelve 1-$m^2$ plots were randomly marked, and the percentage cover of vascular plants was recorded in June, 2009. In the following spring, 2010, in each plot three soil cores (4-cm diameter and 10-cm depth, each 126 $cm^3$, in total 36 soil cores per grassland) were collected for seed bank analysis. The seedling emergence method of ter Heerdt et al. (1996) was used. Samples after bulk reduction were spread in a 3-4mm thick layer on the surface of trays filled with steam-sterilised potting soil. Germinated seedlings were identified and regularly counted and removed from the trays. Unidentified seedlings were transplanted and grew till identification. Spontaneous seed contamination was detected using sample-free trays filled with sterilised potting soil. Means of species richness of grasslands were compared using t-test (Zar 1999). Similarity between vegetation and seed banks was calculated by the Jaccard index. The vegetation and seed bank composition was compared using DCA ordination.

**Results**

Altogether 94 species were detected in the vegetation and seed banks. In the vegetation of the loess pasture 24 species, and in the loess grassland

52 species were found. For detailed species composition see Fig 1. The vegetation of the loess pasture was characterised by low species richness (a mean of 10.4 species/m$^2$) and the high cover of *Festuca rupicola* (a mean of 45%). In addition, only *Poa angustifolia* and *Galium verum* were present with higher mean cover than 5%. High species richness scores were typical in the loess grassland (a mean of 27 species/m$^2$, t-test - $p$<0.001). Species with higher cover than 5% were *Festuca rupicola*, *Cynodon dactylon*, *Thymus glabrescens*, *Poa angustifolia* and *Filipendula vulgaris*. In the seed bank of the degraded pasture 52 species, and in the loess grassland 44 species were found. In the degraded loess pasture, six species had higher mean seed bank density than 500 seeds/m$^2$: *Achillea collina* (2,100 seeds/m$^2$), *Carex praecox* and *C. stenophylla* (2,476), *Conyza canadensis* (6,764*), Epilobium tetragonum* (575), *Galium verum* (4,266), *Poa angustifolia* (951). In the seed bank of semi-natural loess grassland 11 species had higher seed density than 500 seeds/m$^2$; these were *Cynodon dactylon* (575 seeds/m$^2$), *Euphorbia cyparissias* (685), *Hypericum perforatum* (6,233), *Myosotis stricta* (1,967), *Plantago lanceolata* (1,017), *Poa angustifolia* (1,061), *Potentilla arenaria* (1,304), *Potentilla argentea* (1,326), *Stellaria graminea* (862), *Juncus compressus* (995), and *Veronica persica* (1,216). Some species characteristic to loess grasslands like *Knautia arvensis* (no seed bank), *Pimpinella saxifraga* (no seed bank), and *Salvia nemorosa* (66 seeds/m$^2$) had very sparse seed banks. No significant differences were obtained between the mean seed bank densities of the two grassland types (and 22,800 seeds/m$^2$ in the degraded loess pasture; 20,200 seeds/m$^2$ in the semi-natural loess grassland, respectively). Similarly, no significant differences were found in species numbers (means were 17.0 and 15.4 species/ m$^2$, respectively). The similarity of vegetation and seed banks were low in both grasslands (the Jaccard similarity ranged up to 0.35). In the degraded pasture 76% and in the semi-natural grassland 46% of the species detected in the vegetation possessed seed banks.

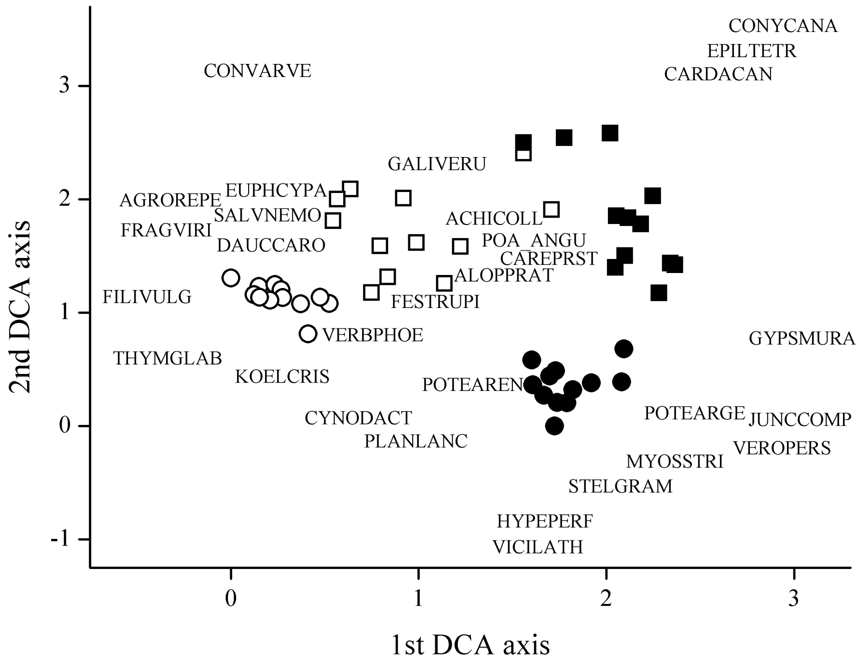


**Figure 1.** DCA ordination of vegetation and seed banks in the studied grasslands. Notations: loess grassland – circle, degraded loess pasture – rectangle; full symbols – seed banks, empty symbols – vegetation. The most frequent 30 species are shown using 4 letters of genus and 4 letters of their species names.

## Discussion and conclusions

For most of the characteristic grass species in vegetation only sparse seed banks were detected, which corresponds with former findings (Bossuyt and Honnay 2008). According to another study of the authors in sandy grasslands (Török et al. 2009), dense seed banks were only found for *Poa angustifolia*. In the present study, the most characteristic species of the loess grasslands possessed sparse seed banks. This result corresponds with other findings from several grassland types (e.g. sandy grasslands, Török et al. 2009; mountain hay meadows, Valkó et al. 2011).

In most seed bank studies in grasslands low to medium similarity was found between vegetation and seed banks (Bakker et al. 1996; Bossuyt & Honnay 2008). This was also supported by the present study. There are several reasons for this phenomenon: (i) In case of several perennials the seed production and seed bank formation are subordinated compared to vegetative reproduction (Bakker et al. 1996). (ii) The detection probability of rare species with aggregated seed banks is low (Thompson et al. 1997). (iii) There is a high chance of non detection of short-lived species with high fluctuations in cover (Török et al. 2009). (iv) The seed bank is mostly characterised by disturbance-tolerant and weedy species missing from aboveground vegetation in most native grasslands (Valkó et al. 2011).Our results suggest that local persistent seed banks have only a minor contribution to the maintenance of diversity in native loess grasslands.

**Acknowledgements**

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## References

**Bakker J.P., P. Poschlod, R.J. Strykstra, R.M. Bekker and K. Thompson. 1996.** Seed banks and seed dispersal: important topics in restoration ecology. *Acta Botanica Neerlandica*, 45: 460-490.

**Bossuyt B. and O. Honnay. 2008.** Can the seed bank be used for ecological restoration? An overview of seed bank characteristics in European communities. *Journal of Vegetation Science*, 19: 875-884.

**Kalamees R., K. Püssa, K. Zobel and M. Zobel. 2011.** Restoration potential of the persistent soil seed bank in successional calcareous (alvar) grasslands in Estonia. *Applied Vegetation Science*, 15: 208-218.

**Molnár Z. and Z. Botta-Dukát. 1998.** Improved space-for-time substitution for hypothesis generation: secondary grasslands with documented site history in SE-Hungary. *Phytocoenologia*, 28: 1-29.

**ter Heerdt G.N.J., G.L.R. Verweij, R.M. Bekker and J.P. Bakker. 1996.** An improved method for seed bank analysis: seedling emergence after removing the soil by sieving. *Functional Ecology*, 10: 144-151.

**Thompson K., J.P. Bakker and R.M. Bekker. 1997.** The soil seed banks of North West Europe: methodology, density and longevity. Cambridge University Press, Cambridge, UK.

**Török P., M. Papp, G. Matus and B. Tóthmérész. 2009.** Seed bank and vegetation development of sandy grasslands after goose breeding. *Folia Geobotanica*, 44: 31-46.

**Valkó O., P. Török, B. Tóthmérész and G. Matus. 2011.** Restoration potential in seed banks of acidic fen and dry-mesophilous meadows: Can restoration be based on local seed banks? *Restoration Ecology*, 19: 9-15.

**Zar J.H. 1999.** Biostatistical analysis. Prentice Hall, Upper Saddle River, NJ.

# SESSION 4

## Dry Grassland and Rural Societies

# The contribution of herbs to the quality of life: The case of Evros prefecture (A first approach)

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## Abstract

Herbs (aromatic, edible, medicinal plants) constitute an important natural resource. They are mostly used for medicinal purposes as they contain antioxidants, vitamins and trace elements. They have numerous other applications in aromatherapy, in human nutrition and in cosmetics. Additionally, they support agricultural activities such as apiculture and livestock farming. The aim of this paper was to investigate the attitudes of the local people in a remote rural area regarding the contribution of herb resources in the quality of their life, and to indicate the typology of these attitudes. The study was conducted in the area of Evros prefecture, Greece, with the use of a specially designed questionnaire. The data was processed using the methods of descriptive statistics and multivariate analysis. The results indicated that local people recognize the contribution of herb resources in human health and that they are products of high nutritional value. The inadequate management and wildfires were recognized as major threats. Finally, people value all of the intended benefits that herb resources offer and especially the protection of nature and the landscape and the enhancement of well being through healthy nutrition. The implementation of the non – linear analysis in principal components with optimal scaling method reveal that local people of Evros prefecture can be grouped according to their attitudes towards herb resources.

**Keywords:** herbs, quality of life, threats, attitudes, non – linear analysis in principal components

## Introduction

Herbs (aromatic, edible and medicinal plants) are a natural resource that is scattered into the natural ecosystems. They play an important role in the human health as many of them contain antioxidants, vitamins and micronutrients. Additionally, they are essential for many economic activities like apiculture, livestock farming and energy production (Kyriazopoulos et al. 2008). Herbs are also used in every day human diet. Mediterranean area is extremely rich in herb species while Mediterranean nutrition ought its name in the existence and use of many herbs species that are not met anywhere else (Hadjichambis et al. 2008). In modern societies some of the herbs are used, after processing, in cosmetics and health care (Singh and Chapagain 2006).

A series of case studies where herbs contribute in the economy of many rural communities has been reported in the literature. The aim of this paper was to investigate the attitudes of the local people in a remote rural area regarding the contribution of herb resources in the quality of their life, and to indicate the typology of these attitudes.

**Materials and methods**

The research was conducted in Evros prefecture, north – eastern Greece. The total area is 4,241.6 $km^2$.The majority of the local people are involved in agricultural activities (agriculture, livestock farming) as their main or secondary activity as well as in herb cultivation.

For the data collection a predetermined questionnaire and personal interviews were used. The research was carried out in 2009. The "population" under study was the total number of households in the Evros prefecture. Simple random sampling was the sampling method that selected, due to its simplicity and the fact that it requires a minimal knowledge of the population compared to any other method (Kalamatianou, 1997; Matis, 2001; Damianou, 2007).

In order to estimate the sample size, the following simple random sampling formula is used:

$$n=t^2\hat{p}(1-\hat{p})/e^2$$

Pre – sampling was conducted on a sample size of 50 households to estimate the variable with the greatest variance under the desired selected error, while the rest are estimated with a greater accuracy than was initially defined.

The variable "constitute organic products with high nutrition value" presented the largest sample size, with a proportion of approximately p=0.5, therefore 1-p= 0.5, which means that the sample size is:

$$n=t^2\hat{p}(1-\hat{p})/e^2=1.96^2\cdot 0.5\cdot(1-0.5)/0.05^2=384.16$$

The final sample is 385 households or individuals.

In order to group all the information that we received from the three multivariate questions we constructed an Indicator (I), with its value to represent and characterize in their total all the questions in every multivariate question. In order to estimate the above mentioned Indicator I the Non Linear Analysis in Principal Components with Optimal Scaling was applied (Van de Geer 1993a, 1993b, Gifi 1996, Siardos 1999, Meulman and Heiser 2004).

The optimal ranks were concerned to be z – scores as they have average = 0 and standard deviation = 1. Then, optimal ranks were transformed in a new scale with 0 to be the minimum and 100 to be the maximum value using the following equation:

$$t_i = [z_i - \min(z_i)]\, X\, 100 / [\max(z_i) - \min(z_i)]$$

Where:

zi: the optimal rank of the respondent i

ti: the transformed optimal rank of the respondent i

min(zi): the minor optimal rank

max(zi): the major optimal rank

The natural interpretation of the transformed ranks was the following:

Respondent having a total rank = 100 have stated or have attributed the highest preference of significance or agreement for the variables or the subjects of every question group, compared to the others.

Reliability as a meaning of internal consistency of the optimum ranks is tested and valuated using Cronbach's α index (Spector 1992). Satisfactory are considered reliability indexes equal or over 0.70 (Nunnally and Bernstein 1994, Malhotra 1996).

**Results**

Most of the respondents were men (59.2%), the average age was between 18 and 40 years old (55.0%) and they were secondary (34.0%) and tertiary graduates (41.7%). Most of them were wage workers (private sector and civil servants) and farmers (23.3%), while over 50% was involved in various agriculture activities as main or secondary occupation (51.4%). Mean annual net income was between 10,001 and 20,000 € (66.5%).

Respondents consider herbs as resources that contribute mainly to "preserve a good human health" (72.7% agree and absolutely agree), "constitute organic products of high nutrition value" (67.5% agree and absolutely agree), "can be used for disease prevention" (58.9%), while "contribute to nature protection" (52.0%). Most important threats for herb resources are "inadequate management of habitats" (27.3%), "wildfires" (19.7%) and "livestock farming" (17.4%). "Industrial development" was not considered to have any negative impacts in herb resources (40.0%). People, consider as priority for the protection and management of herbs "nature protection" (54.7%), "enhancement of living standards through healthy nutrition" (51.5%), "disease prevention" (49.2%) and "tourism growth (agro-tourism, collection, leisure and research of herbs)" (40.2%).

For optimal total indicator estimation in the selected multivariate questions the nonlinear analysis in principal components with optimal scaling in every one of the variables of every group of questions was applied and a representative indicator for every one of them was estimated (Table 1).

**Table 1.** Results of the optimal total indicator construction methodology

| Indicator | Cronbach's α | Total variance (%) | Max – dimension | Average | Median value | Standard deviation | K – S *Z* | Normal distribution |
|---|---|---|---|---|---|---|---|---|
| I1 (Contribution of herbs in quality of life) | 0.84 Satisfactory | 32.3 | 56 | 33 | 28 | 20 | 1.92 * | *p* < 0.01 non normal |
| I2 (Threats) | 0.84 Satisfactory | 47.3 | 24 | 37 | 34 | 22 | 1.67 * | *p* < 0.05 non normal |
| I3 (Priorities of benefits) | 0.88 Satisfactory | 67.0 | 15 | 72 | 79 | 27 | 2.58 * | *p* < 0.01 normal |

*. Statistically significant p < 0,01
K – S: Kolmogorov – Smirnov test for testing normal distribution

In Table 2 the relations between the three indicators were estimated. For indicators I1 and I2 positive, statistically significant and high relation (rho = 0.46, $p < 0.01$) was found.

**Table 2.** Relation between indicators

| | I1 | I2 | I3 |
|---|---|---|---|
| I1 | 1,000 | | |
| I2 | 0,461 * | 1,000 | |
| I3 | 0,191 * | 0,129 ** | 1,000 |

**. Statistically significant p < 0,05, *. Statistically significant p < 0,01

For a high percentage of the respondents the attitudes for the contribution of herbs in quality of life are in agreement with their attitudes for the existence of factors that constitute threats. We found positive, statistically significant and weak relation between indicators I1 and I3 (rho = 0.19, $p < 0.05$). For a low percentage of respondents the attitudes for the contribution of herbs in quality of life are in agreement with their attitudes for the priority of benefits. Finally, a positive, statistically significant and weak relation between indicators I2 and I3 (rho = 0.13, $p < 0.05$) was recorded. For a low percentage of respondents the attitudes for the related factors that constitute threats are in agreement with their attitudes for the priority of benefits.

## Conclusions

The indicators that were estimated by the application of the method of non linear analysis in principal components with optimal scaling were adapted very well in the collected data and represent in a high degree the attitudes of the local people towards herb resources. The local population can be grouped (3 groups) through which it can be concluded that local people introduce generally the same attitude for the factors and characteristics of herb resources that contributed in their quality of life and for the factors that threaten these resources. On the contrary, they introduced different attitudes towards the promotion of the benefits that occur using herbs in everyday life.

Policy makers that are design management and enhancement policies and plans for herb resources and for any other natural resource must consider local people's attitudes. They must have in mind that the implementation of such policies have to be well designed and organized in collaboration with local people which are the direct and final users of these policies. The results of this research are an important tool for development and enhancement of the unique local characteristics and implementation of certain targeted actions for the development of herb resources in order to improve local well being.

## References

**Damianou C. 2007.** Sampling Methodology: Techniques and Applications. Sofia Publications. Thessaloniki. (In Greek).

**Gifi A. 1996.** Non-Linear Multivariate Analysis. Chichester: John Willey & Sons Ltd.

**Hadjichambis A.C.H., D. Paraskeva – Hadjichambi, A. Della, M. Giusti, C. De Pasquale, C. Lenzarini, E. Censorii, M.R. Gonzales – Tejero, C.P. Sanchez – Rojas, J. Ramiro – Gutierrez, M. Skoula, C.H. Johnson, A. Sarpakia, M. Hmomouchi, S. Jorhi, M. El – Demerdash, M. El – Zayat and A. Pioroni. 2008.** Wild and semi – domesticated food plant consumption in seven circum – Mediterranean areas. *International Journal of Food Sciences and Nutrition,* 59(5):383–414.

**Kalamatianou A. 1997.** Social Statistics. Multidimensional Analysis Methods. The Economic, Athens. (In Greek).

**Kyriazopoulos A.P., E. Hormova, G. Fotiadis, Z.M. Parissi and E.M. Abraham. 2008.** Alternative uses of herbaceous species of the Gramineae family. In: K. Mantzanas and V.P. Papanastatis (eds). Range Science and Protected Areas. Proceedings of the 6th Panhellenic Rangeland Congress. pp 147-152. (In Greek with English Abstract).

**Malhotra N.K. 1996.** Marketing Research. An Applied Orientation. Englewood Cliffs: Prentice Hall.

**Matis K. 2001.** Forest Sampling. Management and Development Company Resources of Democritus University of Thrace, Xanthi. (In Greek).

**Meulman J. and W. Heiser 2004.** SPSS Categories 13.0. Chicago: SPSS Inc.

**Nunnally J.C. and I.H., Bernstein 1994.** Psychometric Theory (3rd ed.). New York: McGraw Hill Book Co.

**Singh B.K. and D.P. Chapagain 2006.** Trends in Forest Ownership, Forest Resources Tenure and Institutional Arrangements: Are They Contributing to Better Forest Management and Poverty Reduction? In Understanding Forest Tenure in South and Southeast Asia. Forestry Policy and Institutions. Working Paper 14:115 – 151. FAO, Rome.

**Siardos G. 1999.** Methods of multi-variable statistical analysis, Thessaloniki, Ziti. (In Greek).

**Spector P.E. 1992.** Summated Rating Scale Construction: An Introduction. Newbury Park: Sage Publications.

**Van de Geer J.P. 1993a.** Multivariate Analysis of Categorical Data: Theory. Thousand Oakes: Sage Publications, Inc.

**Van de Geer J.P. 1993b.** Multivariate Analysis of Categorical Data: Applications. Thousand Oakes: Sage Publications, Inc.

# Diachronic evolution of grasslands and open shrublands in pastoral landscapes of Greece

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## Abstract

In recent years, studies of diachronic evolution have been carried out in several pastoral landscapes of Greece based on aerial photographs. These studies covered a total area of 69,372 ha and included the Kolchiko and Hortiatis watersheds of central Macedonia, the Kopatsari and Askio region of western Macedonia and the valley of Portaikos – Pertouli in Thessaly. This paper aims to review all these studies so that the trends in grassland and shrubland evolution are evaluated. The transformation of these landscapes was evaluated by means of Geographic Informational Systems (G.I.S.) and sequential sets of aerial photographs and orthophotos, covering a period from 1945 to 1998. Changes in grassland pattern were evaluated by the use of landscape metrics. From these studies it became evident that the pastoral landscapes have changed significantly over the last 65 years in terms of land use/ cover structure and landscape pattern. A major trend has been the reduction of the area covered by grasslands in favour of forests, dense shrublands and agricultural lands. Furthermore, a reduction of open shrublands in favour of dense ones was also recorded. Landscape metrics revealed that grassland patches are becoming more fragmented and disperse over the years. The reduction of grasslands and open shrublands represent a major obstacle to employing sustainable practices in livestock husbandry.

**Key words:** G.I.S., landscape metrics

## Introduction

Mediterranean landscapes have significantly changed over the last decades due to land abandonment. In pastoral landscapes, in particular, these changes have usually involved the reduction of grasslands and open shrublands in favor of dense shrublands and forests (Papanastasis and Chouvardas 2005). Their evaluation can be accomplished by remote sensing analysis of satellite images or aerial photographs combined with G.I.S. which have become powerful tools for evaluating landscape changes through time (Farina 2000). Also, diachronic changes in landscape pattern can be easily evaluated with the use of landscape metrics (McGarical and Marks 1995).

Several studies have been carried out over the last years in various areas of central and northern Greece analyzing the temporal changes in pastoral landscapes and relating them with changes in the traditional management practices of animal husbandry and forestry (Chouvardas 2007, Chouvardas et al. 2009, Siarga 2009, Mitka et al. 2010). The aim of this paper was to review all these studies so that the trends in grassland and shrubland evolution are detected and evaluated.

**Materials and methods**

Five pastoral landscapes were studied covering a total area of 69.372 ha. They are located in the Kolchiko and Hortiatis watersheds of central Macedonia, the Kopatsari and Askio region of western Macedonia, and the valley of Portaikos – Pertouli in Thessaly (Figure 1). The temporal land use/cover changes were evaluated with G.I.S. on a diachronic set of aerial photographs and orthophotomaps (1945 – 1998). This procedure resulted in the creation of digital diachronic land use/cover data sets in vector and raster format (10x10m) for the time periods: 1945 – 1993 for Kolchiko (Chouvardas 2007) and Hortiatis (Chouvardas et al. 2009), 1963 – 1998 for Kopatsari (Mitka et al. 2010), 1945 – 1997 for Askio (Siarga 2009) and l945 – 1992 for Portaikos-Pertouli (Chouvardas 2007).

The programme Fragstats v 3.3 was employed to quantify landscape pattern and compare grassland patches in the pastoral landscape through time. Four metrics were included in the study (McGarical and Marks 1995): number of patches (NP) and mean patch size (MPS) as an overall measure of landscape fragmentation, edge density (ED) as a measure of the amount of ecotones (Farina 2000) and interspersion juxtaposition index (IJI) as a measure of patch dispersal. The mathematical formulas of the chosen indices can be found in the Fragstats user manual (McGarical and Marks 1995).

**Results and discussion**

Five landscape change maps and data sets were created for the time period from 1945 to 1998 (Figure 1). From these maps it is obvious that grasslands decreased in all cases resulting in spatial modification of the respective landscapes.

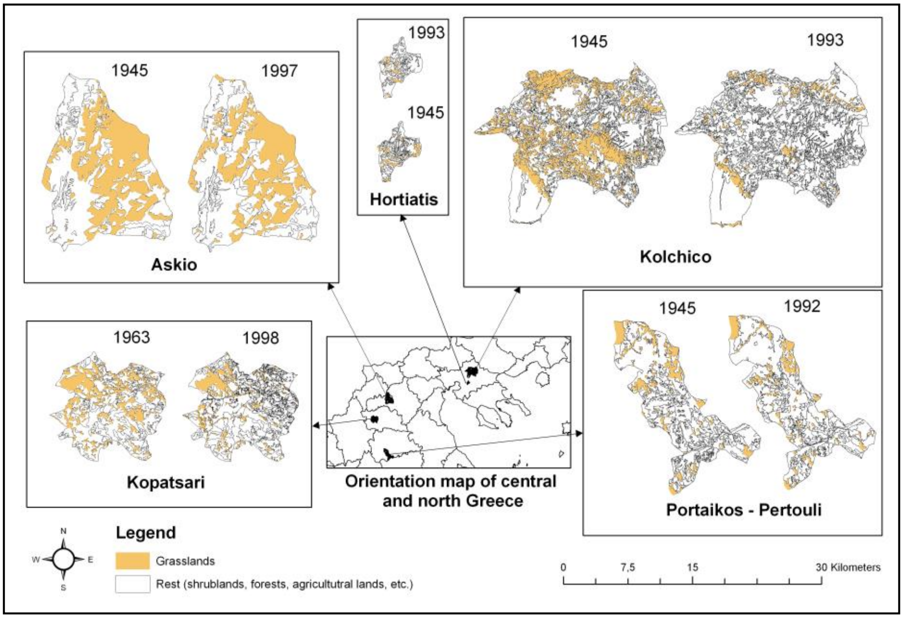


**Figure 1.** Landscape change map (1945 – 1998) of Greek pastoral landscapes.

From the temporal digital data sets, two tables were created showing the diachronic evolution of grasslands (Table 1) and shrublands (Table 2) of the five pastoral landscapes. It is clear from table 1 that there was a significant decrease of the area covered by grasslands in all landscapes during the time period 1945 -1998, namely by 78% in Kolchico, 45% in Hortiatis, 49% in Kopatsari, 14% in Askio and 23% in Portaikos – Pertouli. Grasslands in Kolchiko, Hortiatis and Kopatsari were mainly transformed into shrublands, agricultural lands and forests, while in Askio and Portaikos – Pertouli they were mainly transformed into shrublands and forests. The much higher grassland reduction in Kolchiko, Hortiatis and Kopatsari may be explained by the fact that a significant part of grasslands was transformed into arable land compared to Askio and Portaikos-Pertouli. This trend of grassland reduction is expected to continue in the near future as a projection model for Kolchiko predicted (Chouvardas and Vrahnakis 2009).

**Table 1.** Diachronic evolution of grasslands (ha) in Kolchiko, Hortaitis, Askio and Portaikos-Pertouli pastoral landscapes.

| | 1945 | 1960/1963 | 1992/1993 | 1997/1998 | 2013[1] |
|---|---|---|---|---|---|
| Kolchiko | 5861,43 | 4446,61 | 1280,70 | _ | 55,00 |
| Hortiatis | 227,34 | _ | 125.02 | _ | _ |
| Kopatsari | _[2] | 2875,10 | _ | 1454,09 | _ |
| Askio | 8410,49 | 7930,82 | _ | 7214,56 | _ |
| Portaikos – Pertouli | 1687,22 | 1516,75 | 1373,44 | – | – |

[1] Future projection model for Kolchiko landscape (Chouvardas and Vrahnakis 2009)
[2] Not recorded

As far as shrublands are concerned, table 2 shows that the total shrublands area of the pastoral landscapes (except Kopatsari landscape that had a limited area of shrublands) generally increased from 1945 to 1997, by an average rate of 19%. Looking at the three cover classes, however, it is obvious that the open cover class reduced by 25% as in grasslands. On the contrary, the medium and dense classes increased impressively (by 50.12% and 94.07%, respectively).

**Table 2.** Diachronic evolution of shrublands (Ha) in Kolchiko, Hortaitis, Askio and Portaikos-Pertouli pastoral landscapes.

| Open shrubland | | Medium shrubland | | Dense shrubland | |
|---|---|---|---|---|---|
| 1945 | 1992-1997 | 1945 | 1992-1997 | 1945 | 1992-1997 |
| 4215,30 | 3158,93 | 2959,70 | 4443,24 | 1290,59 | 2504,70 |

These results show that grasslands and open shrublands are at a risk of becoming extinct in the Greek pastoral landscapes, suggesting that direct measures should be taken in order to preserve and restore these two important pastoral resources. Grassland and open shrubland preservation is considered necessary for sustaining extensive livestock husbandry (Chouvardas and Vrahnakis 2009).

The estimation of landscape metrics for grassland patches revealed a temporal (1945 – 1998) decrease of MPS and an increase of IJI values for all pastoral landscapes (Table 3).

**Table 3.** Landscape metrics values (grassland class) from 1945 to 1998 in Kolchiko, Hortaitis, Askio and Portaikos-Pertouli pastoral landscapes.

| | NP[a] | | MPS[b] (ha) | | ED[c] (m/ha) | | IJI [d] (%) | |
|---|---|---|---|---|---|---|---|---|
| | 1* | 2** | 1 | 2 | 1 | 2 | 1 | 2 |
| Kolchiko | 177 | 68 | 33,16 | 18,84 | 55,96 | 12,04 | 80,03 | 86,33 |
| Hortiatis | 19 | 12 | 11,98 | 10,45 | 37,44 | 20,79 | 70,53 | 74,18 |
| Askio | 23 | 29 | 365,75 | 248,79 | 17,69 | 18,49 | 76,99 | 83,34 |
| Kopatsari | 102 | 97 | 28,19 | 14,99 | 41,17 | 32,50 | 58,10 | 64,58 |
| Portaikos – Pertouli | 48 | 61 | 35,16 | 22,51 | 18,75 | 17,58 | 52,48 | 54,22 |

[a]Number of Patches, [b]Mean Patch Size, [c]Edge Density, [d]Interspersion Juxtaposition Index. *1 means 1945 for Kolchico, Hortiati, Askio and Portaiko-Pertouli and 1963 for Kopatsari. **2 means 1992 for Portaikos – Pertouli, 1993 for Kolchico and Hortiatis, 1997 for Askio and 1998 for Kopatsari.

This trend of change in relation with the grassland area reduction (Table 1) suggests that grassland patches are becoming more fragmented and disperse over the years and, therefore sparser and isolated. Grassland edges showed a great reduction of their values (ED, Table 3) in most of the pastoral landscapes (except Askio), indicating the negative effect (ecotone reduction) that temporal transformations had in grassland structure. Finally, the temporal evolution of grassland patches (NP, table 3) showed that only two landscapes (Askio and Portaikos –Pertouli) had their numbers increased, probably due to the relatively lower reduction of their grassland area (Table 1).

According to Papanastasis and Chouvardas (2005), changes in the traditional management practices in animal husbandry and forestry are the main cause of changes in Mediterranean pastoral landscapes. Development planning must take into consideration the trends recorded in this study. Grassland and open shrublands are two natural recourses that are considered necessary for the sustainable development of livestock husbandry, for ecological integrity and for the social benefits that the people expect from these landscapes.

**Conclusions**

1. There has been a constant reduction of the area covered by grasslands and open shrublands in the pastoral landscapes of Greece since 1945 that is expected to continue in the near future.
2. There is a shift of shrublands from sparser to denser cover classes.

3. Grassland patches in the pastoral landscapes are becoming more fragmented and disperse over the years.
4. The reduction of grasslands and open shrublands represent a major threat to a sustainable livestock husbandry based on natural grazing resources.

## References

**Chouvardas D. 2007.** Estimation of diachronic effects of pastoral systems and land uses in landscapes with the use of Geographic Information Systems (GIS). Ph.D. Thesis. Aristotle University of Thessaloniki (in Greek, with English abstract). Pages 267.

**Chouvardas D. and M.S. Vrahnakis. 2009.** A Semi-empirical model for the near future evolution of the lake's koronia landscape. *Journal of Environmental Protection and Ecology*, 10(3):867–876.

**Chouvardas D., Ch. Evangelou, P. Kourakly, I. Ispikoudis, and V.P. Papanastasis. 2009.** Temporal evolution of forest landscapes in relation to socioeconomic changes: the case of Hortiatis watershed in Greece, In the Book: Woodland Cultures in Time and Space: tales from the past, messages for the future (E. Saratsi et al. eds). Embryo Publications, Athens. pp. 346 – 353.

**Farina A. 2000.** Landscape Ecology in Action. Kluwel Academic Publishers. The Netherlands. Pages 235.

**McGarigal K. and B. Marks. 1995.** FRAGSTATS: spatial pattern analysis program for quantifying landscape structure. Gen Tech. Rep. PNW-GTR-351. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 122pp.

**Mitka A., D. Chouvardas and I. Ispikoudis. 2010.** Temporal landscape changes (1963-1998) at the region of "Kopatsari" in the Prefecture of Grevena. In: A. Sidiropoulou, K. Mantzanas and I. Ispikoudis (eds). Range Science and Life Quality. Proceedings of the 7th Panhellenic Rangeland Congress. pp. 97-102. (In Greek with English Abstract).

**Papanastasis V.P. and D. Chouvardas. 2005.** Application of the state-and-transition approach to conservation management of a grazed Mediterranean landscape in Greece. *Israel Journal of Plant Science,* 53:191–202.

**Siarga M. 2009.** Analysis of temporal changes of land uses in Askio Municipality region with the use of G.I.S. MSc. Thesis. Aristotle University of Thessaloniki (in Greek). Pages 99.

# Environmental road construction in dry grasslands

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## Abstract

The road as every technical work should upgrade the area that crosses and should not destroy it. In other words, it must be compatible with the environment. The primary concern of a forest engineer should be the compatibility of such infrastructural works with the environment. "Compatibility with the environment" means to define, describe and assess the effects of a road construction work on the environment, and to take measures for its protection. Aim of this paper is to find the evaluation principles as far as the impacts on the landscape and environment by the road construction is concerned and opening it up in order to determine an objective and practical evaluation of different route alternatives, before the construction is completed. A combination of digital photogrammetry and GIS technology was used to evaluate the compatibility between the road and the natural environment. In order to evaluate the compatibility, practical criteria of the intensity of the human influence as well as criteria of the environment absorbency to such interventions were used. The digital maps and the spatial analysis were used for the efficient and reliable evaluation of these criteria. We tried to adapted the already existed assessment criteria for infrastructural works that are used to examine and evaluate the impact on the natural environment of such works, as well as to choose the best (compatible) environmental solution from various alternatives during the phase of the grassland roads' planning. From the analysis of the results of the above criteria we were led to useful conclusions regarding the construction of grassland roads.

**Key words:** impact, road construction, criteria, intensity, absorbency.

## Introduction

The rangelands are natural ecosystems covered by herbaceous or shrubby vegetation, that produce food for both wild and farm animals, while offering other goods and services (Papanastasiou and Noitsakis 1992). Fall on woodlands, because they come from forests that, at some point they have been degraded due to human activities (e.g., fires, illegal logging) and have been converted into lands for grazing. They are therefore common natural ecosystems. Specifically in the area of woodlands, technical works cause loss of vital green space and flood risk in the wider region resulting in continuing degradation of the quality of life in the rest region. Therefore it is clear that for each forest technical-development work it is necessary to control the compatibility with the environment.

Human impact strongly controls vegetation development patterns, in particular, in mountainous regions, due to tourists (Myers, Bazely 2003, Turton 2005). Roads, including mountain trails, are convenient ways for the movement of non-native species *via* human activities (Trombulak, Frissell 2000, Thiele, Otte 2008). As a result of human impact, roadside grassland vegetation decreases in cover, and native herbaceous plants are excluded by exotic ones (Goudie 2005).

The road as every technical work should upgrade the area that crosses and should not destroy it. In other words, it must be compatible with the environment. “Compatibility with the environment” means to define, describe and assess the effects of a road construction work on the environment, and to take measures for its protection. The primary concern of a forest engineer should be the compatibility of such infrastructural works with the environment.

Aim of this paper is to find the evaluation principles as far as the impacts on the landscape and environment by the road construction is concerned and opening it up in order to determine an objective and practical evaluation of different route alternatives, before the construction is completed.

**Materials and methods**

The road in construction is about 5,120 km length in the south of Province of Metsovo that is laid in the mountainous mass of Northern Pindos in Greece and includes mountainous settlements and villages. The total acreage of Province Metsovo amounts to 54,479.30 Ha in which 25% i.e. 13,515.20 Ha are grasslands.

We tried to adapted the already existing assessment criteria for forest road that are used to examine and evaluate the impact on the natural environment, as well as to choose the best (compatible) environmental solution from various alternatives during the phase of planning the grassland roads. The absorbency criteria and their importance (weights) are based on the opinions of experts (specialized scientists) and relevant literature and divided into (Drosos et al. 2006):

The rangeland criteria with weight coefficients three (3) are the following:

1. Kind of rangeland. Grasslands: 100%, silvopastoral systems: 75%, rangelands dominated by shrubs: 50%, rangelands dominated by subshrubs: 15%. 2. Rangeland ecological zones. Low zone: 0-600m: 100%,

Semi-mountainous zone: 600-800m: 100%, Mountainous or High zone: 800-1200m: 75%, Pseudo alpine zone: >1200m: 50-25%. 3. The site quality. I: 100%, II: 50%, III: 25%. The grading depended on the fact that some species are more widespread in certain areas only. In general, annual species' appearances are more frequent in low and semi-mountainous zone.

The topographical criteria with weight coefficients two (2) are:

4. The traverse of the ground. High >20%: 5-25%, medium 8-20%: 50%, mild <8%: 100%. 5. Aspects. Less than 1000m: northern: 100%, southern 50%, eastern or western 75%, over than 1000m: eastern or western: 100%, northern or southern: 70%. 6. The terrain relief. Mild: 100%, various: 50%, intense: 15%.

Social criteria with weight coefficients one (1) depend on the number of humans affected by the road. Distance plays a major role in impact (Table 1).

A questionnaire was drafted with the help of specialized scientists and the relevant literature with the intensity criteria that are divided into layout and construction criteria, as shown in table 1 (Drosos 2009), and they were sent to the forest offices of Greece. The weight coefficients of the intensity criteria were raised from the average score of grading of questionnaires.

To calculate the average intensity value on a scale of 100 (%), we multiply the grade of each criterion by its weight and in the end; we divide the sum of the products by the total sum of weights. The same applies to absorbency. To calculate the forest road's compatibility coefficient we multiply the average absorbency value by the average impact intensity value.

We can construct the road when the compatibility coefficient is above 60% or 0.60. If the coefficient compatibility is between 0.50-0.60 can be done but on certain conditions. If the compatibility coefficient is below 0.50 the effects will be very large and what is needed is to change the layout or to construct technical works to restore the natural environment.

**Results and Discussion**

The evaluation of the road intensity and ecosystem's absorbency are displayed in table 1.

In order to calculate the road's compatibility coefficient we have: $C_C = C_A \times C_I = 69.70\% \times 88.20\% = 61.48\%$. Where $C_C$ is the compatibility coefficient (%), $C_A$ is the average absorbency value (%) and $C_I$ is the average intensity value (%). Based on the results, we notice that the road under study is classified as acceptable, given the fact that its compatibility coefficient is

61.48%. And since $C_I$>50% and $C_A$>50%, the construction is accepted under no special condition.

**Table 1.** Evaluation of road

| **Criteria** | **Weights** | **Grade %** | **Sum** |
|---|---|---|---|
| **a. Criteria of absorbency (A)** | | | |
| 1. Kind of rangeland | 3 | 62 | 186 |
| 2. Rangeland ecological zone | 3 | 84 | 252 |
| 3. Site quality | 3 | 50 | 150 |
| 4. Slope | 2 | 50 | 100 |
| 5. Aspect | 2 | 92.5 | 185 |
| 6. Relief | 2 | 75 | 150 |
| 7. Distance from | | | |
| 7.1 Tourist resort | 1 | 100 | 100 |
| 7.2. National and country road network | 1 | 100 | 100 |
| 7.3. Railway | 1 | 100 | 100 |
| 7.4. Archaeological site | 1 | 100 | 100 |
| 7.5. Adjacent big city | 1 | 100 | 100 |
| 7.6. Adjacent village | 1 | 100 | 100 |
| 7.7. European path | 1 | 80 | 80 |
| 7.8. Natural or artificial lake or river | 1 | 100 | 100 |
| **b. Criteria of intensity (I)** | | | |
| **Layout** | | | |
| 1. Curve radii | 2.10 | 100 | 210 |
| 2. Gradient | 2.01 | 80 | 160.8 |
| 3. Gross section | 2.25 | 90 | 202.5 |
| 4. Road width | 2.04 | 70 | 142.8 |
| 5. Road gradient | 2.52 | 100 | 252 |
| 6. Distance of hairpin turn | 2.13 | 100 | 213 |
| 7. Distance from stream | 1.83 | 100 | 183 |
| 8. Distance from forest boundary | 1.65 | 90 | 148.5 |
| 9. Distance from dangerous sites | 2.40 | 100 | 240 |
| 10. View of morphological formations | 1.83 | 100 | 183 |
| 11. View of vegetation forms | 1.80 | 80 | 144 |
| 12. View of space projection | 1.70 | 70 | 119 |

| | | | |
|---|---|---|---|
| 13. View of compatible constructions | 1.60 | 100 | 160 |
| 14. View of water flows | 1.65 | 20 | 33 |
| 15. Visual absorption capability | 1.77 | 55 | 97.35 |
| **Construction** (only for existing road) | | | |
| 16. Machinery of earth works | 2.16 | 100 | 216 |
| 17. Material | 2.08 | 100 | 208 |
| 18. Seeding and mulching of side slope | 1.38 | 100 | 138 |
| 19. Road drainage system | 2.31 | 100 | 231 |

## Conclusions

This is the first attempt in order to adapt the intensity and absorbency criteria governing forest roads in rangeland roads. The criteria in table 1 are based on countable values and constitute indexes of environmental consequences from the road to the natural environment. The application of this method is considered to be reliable not only for the estimation of the existing roads but also for the study of their impact to the environment before the construction of new ones. A suitable database is required for the application of the method. Thus, the data processing is achieved quickly and the creation of digitized maps and diagrams for various suggested road nets are obvious. In conclusion, the developmental physiognomy of an area, such as Province of Metsovo, ought to be based on the viable development that is subject of the application of an integrated developmental plan, which depends on the conservation of the natural environment, the activation of the human and social resources, the utilization of the special social, cultural and financial characteristics. To the attachment of the above development model, major role would play the study of the intensity of impacts on the roads that have caused to the natural environment as well as the estimation of its absorbency. The study results will be directly exploited, as improvement standards for the construction of roads in grasslands, under the prism of the compatibility with the natural environment, particularly in regions with cover over than 25% with grasslands.

## References

**Drosos, V. C. 2009.** Environmental improvement of forest road. In: V. Kotzamanis, A. Kungolos, E. Mperiatos, D. Oikonomou, G. Petrakos (eds). Management and Protection of the Environment. Proceedings of the 2nd Pan-Hellenic Conference of Urban Planning and Regional Development. pp. 1025-1032. (In Greek with English Abstract).

**Drosos V. C., Giannoulas V.J., A.-K.G. Doukas. 2006.** Environmental Improvement of Forest Road from C in B Category. In: Ev. Manolas (editor). Sustainable Management and

Development of Mountainous and Island Areas. Proceedings of the 2006 Naxos International Conference. pp. 219 – 228.

**Goudie A. 2005.** The human impact on the natural environment: past, present, and future (6th edn). MIT Press, London. 376 pp.

**Myers J.H., D.R. Bazely. 2003.** Ecology and control of introduced plants. Cambridge University Press, Cambridge. 328 pp.

**Papanastasis V.P., Noitsakis B. 1992.** Rangeland Ecology. Giaxoudis-Giapoulis Publising, Thessaloniki. 244 pp.

**Thiele J., A. Otte. 2008.** Invasion patterns of *Heracleum mantegazzianum* in Germany on the regional and landscape scales. *Journal for Nature Conservation,* 16: 61-71.

**Trombulak S., C. Frissell. 2000.** Review of ecological effects of roads on terrestrial and aquatic communities. *Conservation Biology,* 14: 18-30.

**Turton S.M. 2005.** Managing environmental impacts of recreation and tourism in rainforests of the wet tropics of Queensland World Heritage Area. *Geographical Research*, 43: 140-151.

# Evaluation of the infrastructure development in Mediterranean Greek typical mountainous dry grassland

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**Abstract**

In the past few year on account of the one-dimensional economic development activity that destroys thoughtlessly the environment, gains ground, directly or indirectly, the notion that the development whether will be completed, that is to say simultaneously economic, social, technological and cultural, in harmony and with respect in the particular natural and cultural environment, which part of it is the man, or will not exist by no means. The following environmental resources (components) were identified: the fauna, the flora, the water capacity (water resources, water saving), the soil, the disturbance of soil and rocky lands, the landscape-physiognomy and the acoustic environment. However, the construction of a technical work can have negative impacts on the environment. These may be defined as changes of the environmental resources (natural and social), with a temporary or permanent character in respect to the time horizon within which these changes take place. The environment-friendly planning and design of a technical work must consider not only technical or economic parameters but also the effect of the construction (direct or indirect) upon the natural and social environment. This paper deals with the construction of a technical work in dry grassland, the environmental resources were identified, the impacts were evaluated and the criteria of estimating the alternative solutions were set out following the grouping of the environmental resources. The results proves that this method provides a way to evaluate the compatibility of the existing infrastructural works with the natural environment, and offers the possibility to choose the most compatible solutions for the environment in future.

**Keywords:** Evaluation, infrastructure development, mountainous dry grassland, consequence, alternative solutions.

## Introduction

In its narrow sense, “Grasslands” may be defined as ground covered by vegetation dominated by grasses, with little or no tree cover; UNESCO defines grassland as “land covered with herbaceous plants with less than 10 percent tree and shrub cover”. According to FAO (2005), grasslands (*sensu lato*) are among the largest habitat type in the world; their area is estimated at 52.5 million $km^2$, or 40.5% of the Earth landmass. Grasslands are of vital importance for raising livestock for human consumption and for milk and other dairy products. Grassland vegetation remains dominant in a particular area usually due to grazing, cutting, or natural or manmade fires, all discouraging colonization by and survival of tree and shrub seedlings.

The environmental impact assessment (EIA) is assessed the environmental impact of the investment project and proposed actions and interventions required in order to protect the natural environment (Doukas 2004).

The Directives 85/337 EEC and 97/11 EU require a more systematic assessment and evaluation of impacts on all aspects of the environment from almost all the projects and activities (public and private). These Directives provide for the investigation of alternatives during the siting of works, enforcement of environmental conditions in the implementation and operation of works and the as far as possible site restoration by the project.

Aim of this paper is to investigate the impacts of the construction and operation of a Processing Factory of Fisheries Products (PFFP), a Worksite of Aggregates (WA) and a Ski Center (SC) on dry grassland and the choice of the most compatible solution for the environment.

## Materials and methods

The research area is the wider region of Prefecture of Florina and especially the area between Pisoderi and Prespes Lakes. For the research assessed the environmental impacts of investment projects using criteria and followed by the choice of the best possible investment for the protection of natural and human environment in complete agreement with the size and return on each investment project. Development works in one location using (negative effect) or enhance (positive effect) some of its environmental benefits (Doukas, Drosos 2012).

The criteria were specified and setting of their weights based on the related Greek and international literature, the Joint Ministerial Decision (JMD) 69269/5387/90 and the opinions of experts (special scientists).

We accepted a situation as maximum (=100%). The percentage of deviation from this maximum situation should be subtracted from 100%. The result will be the grading of the criteria of the positive impacts. As for the negative impacts the percentage of deviation from this maximum situation that will be subtracted from 100% will be and the grading of the criteria.

To grade the criteria, aerial photographs and digital opthophotos of the area were used as well as and the geological map. Also the onsite measurements play a major role.

In order to calculate the coefficient I, for the negative impacts at the construction phase we multiply the grading of each criterion with its weight and in the end; we divide the sum of the products with the total sum of weights. The same applies for the coefficient II for the positive impacts at the construction phase and coefficient I and II for the negative and positive impacts during the operation phase.

The index "return on investment" (ROI) is used to evaluate the return of an investment or to compare the efficiency of different investments. To calculate ROI, the benefit (return) of an investment divided by its cost and the result is expressed as a percentage. In this paper we are going to refer to the financial investment with a roundabout way because if we want to refer in details we need detailed and comprehensive feasibility studies which are not the main goal of this paper.

**Results and Discussion**

All the possible environmental impacts both at the stage of construction and during the phase of operation are presented in Table 1. In Figure 1 is shown the tendency diagram of impacts of the investment projects. The investment cost for the PFFP roughly calculated to 218,000.00 €, for the SC at 70,840.00 € and last for the WA to 126,240.00 €. If we divide the positive to the negative affects resulting one factor that indicates whether an investment is green or environmentally sound as close as is it to the one.

So the PTTP comes first with 0.1155 and 1.2755 second the SC with 0.0792 and 0.993464 and last the WA with 0.070148 and 0.04657 for the construction phase and operation phase,_respectively. If we subtract the negative from the positive impact the investment that has a positive or the less negative result is preferable than the others. So the PTTP comes first with -44.69 and 10.439 second the SC with -67.85 and -0.35088 and last the WA with -77.32456 and -85.307 for the construction phase and operation phase,_respectively. WA needs heavy type drilling machinery and then need to take measures in order to restore the landscape or the surrounding area.

PTTP needs a coating by spot material and construction with dimensions that are compatible with the surrounding area in order not to change the natural landscape. As for SC need to construct protection works by erosion and there are big problems because of the intense annoyance of noise from the lifts and large hydrological impact in the diet of underground water or not.

**Table 1.** Possible environmental impacts both at the stage of construction and during the phase of operation

| Environmental impacts of the investment projects | Weights | Grade % | | | Sum | | |
|---|---|---|---|---|---|---|---|
| | | PFFP | SC | WA | PFFP | SC | WA |
| Construction phase | | | | | | | |
| Negative impacts | Natural environment | | | | | | |
| 1. Soil | 3 | 60 | 90 | 100 | 180 | 270 | 300 |
| 2. Relief | 2 | 50 | 80 | 90 | 100 | 160 | 180 |
| 3. Water | 3 | 70 | 90 | 100 | 210 | 270 | 300 |
| 4. Atmosphere | 2 | 50 | 70 | 90 | 100 | 140 | 180 |
| 5. Biosphere | 3 | 80 | 90 | 100 | 240 | 270 | 300 |
| 6. Microclimate | 1 | 0 | 10 | 20 | 0 | 10 | 20 |
| 7. Development of the area | 2 | 10 | 60 | 70 | 20 | 120 | 140 |
| 8. Landscape aesthetics | 1 | 30 | 40 | 60 | 30 | 40 | 60 |
| Subtotal I | 17 | | | | 880 | 1280 | 1480 |
| Coefficient I % | | | | | 51.76 | 75.29 | 87.06 |
| Positive impacts | Social environment | | | | | | |
| 9. Health of citizens | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10. Population | 2 | 10 | 10 | 10 | 20 | 20 | 20 |
| 11. Economic growth | 3 | 10 | 10 | 10 | 30 | 30 | 30 |
| 12. Common good | 2 | 10 | 10 | 10 | 20 | 20 | 20 |
| 13. Cultural heritage | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Subtotal II | 12 | | | | 70 | 70 | 70 |
| Coefficient II % | | | | | 5.83 | 5.83 | 5.83 |
| Operation phase | | | | | | | |
| Negative impacts | Natural environment | | | | | | |
| 1. Soil | 3 | 20 | 40 | 100 | 60 | 120 | 300 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2. Relief | 2 | 0 | 40 | 90 | 0 | 80 | 180 |
| 3. Water | 3 | 70 | 40 | 80 | 210 | 120 | 240 |
| 4. Atmosphere | 2 | 50 | 60 | 90 | 100 | 120 | 180 |
| 5. Biosphere | 3 | 80 | 90 | 100 | 240 | 270 | 300 |
| 6. Microclimate | 1 | 0 | 20 | 20 | 0 | 20 | 20 |
| 7. Development of the area | 2 | 20 | 40 | 100 | 40 | 80 | 200 |
| 8. Landscape aesthetics | 1 | 10 | 70 | 100 | 10 | 70 | 100 |
| Subtotal I | 17 | | | | 660 | 880 | 1520 |
| Coefficient I % | | | | | 38.82 | 51.76 | 89.41 |
| Positive impacts | Social environment | | | | | | |
| 9. Health of citizens | 3 | 0 | 10 | 0 | 0 | 30 | 0 |
| 10. Population | 2 | 90 | 80 | 0 | 180 | 160 | 0 |
| 11. Economic growth | 3 | 80 | 70 | 10 | 240 | 210 | 30 |
| 12. Common good | 2 | 80 | 70 | 10 | 160 | 140 | 20 |
| 13. Cultural heritage | 2 | 0 | 50 | 0 | 0 | 100 | 0 |
| Subtotal II | 12 | | | | 580 | 640 | 50 |
| Coefficient II % | | | | | 48.33 | 53.33 | 4.17 |

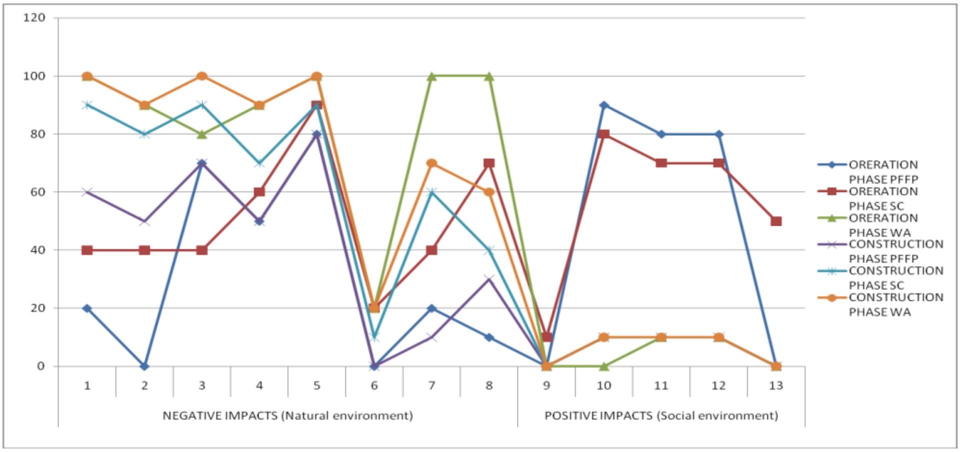


**Figure 1.** Diagram of impacts trends of the investments

**Conclusions**

To make the investment the entrepreneur should have net profit i.e. capital costs + amortization of capital + business profit. In this way the PTTP and SC are disadvantaged while the WA is advantaged. Considering the environmental cost of restoration, where the cost of WA is big for a sustainable green growth, so that the PTTP comes first second the SC due to the seasonal nature of the investment and last comes the WA. With this method we try first to ensure the environment and in the other hand to promote other kind of investments like green, viable and sustainable in a region.

## References

**Doukas A-K. G. 2004.** Forest Constructions and Natural Environment. Giaxoudis Publishing, Thessaloniki. 240 pp.

**Doukas A-K. G. and V. K. Drosos. 2012.** Forest Road Construction and Natural Environment. Tziolas Publishing, Thessaloniki. 450 pp.

**FAO 2005.** Grasslands of the World, eds J. M. SUTTIE, S. G. REYNOLDS & C. BATELLO. xxii+514 pp. Rome.

# Determinants of extensive sheep production systems in Central Greece

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## Abstract

Sheep breeding is regarded as an important activity for a large part of rural population in Greece. For this reason, the determinants of sheep production systems were investigated based on standardized questionnaires and in-depth interviews with all sheep breeders at the six districts of the Municipality of Kilada, Larisa, in Central Greece during 2010. The data were processed using Pearson's test ($p \leq 0.05$). Farmer's age, holding structure (family, individual) and flock size were considered as independent variables (determinants). Such results are expected to be useful for rangeland managers and policy makers. It was found that the older farmers avoid using temporary pastures and use more stubble fields during autumn. They also prefer to practice hand milking. On the other hand the younger farmers establish temporary pastures utilizing agricultural land of small size and tend to make higher investments in establishing and fertilizing them. They also use these pastures as long as possible during spring and appear to be willing to insert more milk-productive races such as "Chiotiko", to keep bigger flocks and to apply mechanized milking. Age-independent variables appear to be the use of rangelands, the practicing of transhumance and the grazing in snowing days. Cultivation cost/ha also seems to be an age-independent variable, either as self-made or as employed service, as well as watering of temporary pastures. Owners of family holdings are willing to lead their flocks in a long distance in order to secure natural forage but mainly during summer and autumn. The holdings which employ only family members invest more financial means for purchased feedstuffs such as hay of legume as they are not so willing to pasture on the rangelands during the winter days in contrast to the non-family shepherds. Farmers practicing transhumance seem to employ non family members for this purpose and return in October, later than farmers which employ only family members. The owners of big flocks have a tendency to keep longer transhumance period during autumn and they are also more willing to spend longer time on rangelands during winter. As a result, they use less condensed feedstuffs in autumn. Also, they do not have sheds in residential areas.

**Key words:** Rangelands, sheep farming system characteristics

## Introduction

Sheep farming is one of the most financially important production sectors in Greece. About 9 million animals belonging to 127937 holdings (NSSG 2009) are raised for milk and meat (lambs) production. The majority of these animals (85%) are extensively managed in marginal areas. Sheep production is based traditionally on grazing of communal natural grasslands, which can provide herbage to animals only for 6-7 months annually (Yiakoulaki et al. 2003). In order to fill the feed gap, the Greek farmers utilize alternative resources, including temporary pastures of annual winter cereals during early spring and cereal stubble fields after crop harvesting during summer-early autumn. In addition, they make extensive use of purchased feedstuffs throughout the year, resulting in high product cost. The latter is one of the main weaknesses of sheep farming in Greece and affects its competitive profile (Aggelopoulos et al. 2009).

Due to the great importance of sheep farming, several researches have been carried out regarding the socio-economic aspect and viability of this sector as well as the potential for further improving its competitiveness (Hatzigeorgiou et al. 1999, Aggelopoulos et al. 2009). However, information concerning the determinants of sheep production system is relatively limited. Such data are necessary for improving knowledge about livestock farming systems. This is expected to be useful for policy makers and rangeland managers in order to achieve a more effective and acceptable policy planning.

The aim of this study was to investigate the determinants of extensive sheep production system in the Municipality of Kilada, Larisa, Central Greece.

**Materials and methods**

This study was conducted in the municipality of Kilada, Larissa in central Greece, during the summer of 2010. This particular research area has been selected as sheep breeding is of great socio-economic importance for the rural community. Additionally, the ecological conditions of this area are typical for sheep breeding. Topography varies with the flat areas occupied by arable lands and the hills and mountains covered by natural vegetation. The latter is dominated by evergreen shrublands, mainly composed of kermes oak (*Quercus coccifera* L.) interspersed by openings with herbaceous species. This study was based on the collection of primary data through standardized questionnaires and in-depth interviews with all sheep farmers (n=60) of the six districts of the municipality of Kilada. The questions concerned the animal capital, the characteristics of the holdings, the farm and farmers' profile, the utilization conditions of natural resources (communal natural grasslands, temporary pastures, fields of cereal stubble, season of grazing, transhumance, etc.) and the supplemented feedstuffs (type, quantity, cost, feeding time). The data were processed by Pearson's test ($p \leq 0.05$). Age of holding owner, holding structure (family, individual) and flock size were considered as independent variables (determinants).

**Results and Discussion**

The mean age of the farmers is 56.4 years, ranging is from 27 to 80 years. Thus, farmers under 56 can be regarded as “younger”, while over 56 as “older”. In Table 1, the farmer’s age appears to be relevant for a great variety of technical and bio-economic characteristics. Specifically, the older farmers avoid using temporary pastures (-0.314). This is an option for younger farmers as the temporary pastures necessitate investment of time, work and financial means. Those who use temporary pastures normally utilize small areas of agricultural land (-0.343). This is in accordance with the socio-historical conditions of rural area in Greece where the agricultural land is divided in small holdings. Additionally, the younger farmers tend to use temporary pastures for as many months as possible during winter – early spring (-0.383) trying to cover the feed shortage of rangelands during this period. On the contrary, the older ones use more stubble fields in terms of months and hours/day (0.287 and 0.294, respectively) in autumn. This can be attributed to the easy accessibility of stubble fields by older farmers as well as to the appropriateness of climatic conditions. The younger farmers also seem to invest more financial resources in establishing temporary pastures (-0.284) and to use more fertilizers (-0.290), as they are more willing to take the risk of dynamic enterprising. They also appear to be willing to insert more milk productive races such as “Chiotiko” (-0.393), to keep big flocks -over 220 animals- (-0.372) and to apply mechanized milking (-0.350). On the contrary, the older farmers, keeping small flocks, prefer to practice hand-milking (0.412) as they are not –and don’t want to be- familiar with new technologies. There are also age-independent variables, which appear to be grazing in rangelands as this is the main -if not the only possible- option, the practicing of transhumance as this depends on a great range of possible determinants beyond the age (e.g. pluriactivity, family tradition, etc), the grazing in snowing days as this depends on factors other than age, such as the sensitivity of animals to extreme weather conditions. Age-independent variables also seem to be cultivation cost/ha, either as self-made or as employed service, and watering of temporary pastures.

**Table 1.** The effect of farmers' age on sheep production system in Central Greece

| | Age of farmer | | | | |
|---|---|---|---|---|---|
| | Co-efficient | Sign. | | Co-efficient | Sign. |
| Using temporary pastures | -0.314(*) | 0.015 | Cultivaltion cost/ha (self-made service) | -0.195 | 0.136 |
| Area of temporary pastures used | -0.343(**) | 0.007 | Cultivation cost/ha (employed service) | -0.068 | 0.606 |
| Hand-milking | 0.412(**) | 0.001 | Watering of temporary pastures | -0.057 | 0.664 |
| Mechanized milking | -0.350(**) | 0.006 | Keeping indoor when snowing | 0.144 | 0.272 |
| Duration of temporary pastures use in spring (months) | -0.383(**) | 0.003 | Grazing in rangelands | 0.144 | 0.272 |
| Cost/ha of establishing (seeding) temporary pastures | -0.284(*) | 0.028 | Transhumance | -0.087 | 0.507 |
| Using fertilizers (kg/ha) | -0.290(*) | 0.035 | | | |
| Duration of stubble use in autumn (months) | 0.287(*) | 0.026 | | | |
| Duration of stubble use in autumn (hours/day) | 0.294(*) | 0.023 | | | |
| Breeding race of "Chiotiko" | -0.393(**) | 0.002 | | | |
| Flock size | -0.372(**) | 0.003 | | | |

** Correlation is significant at the 0.01 level, * Correlation is significant at the 0.05 level

Owners of family holdings (Table 2) are willing to lead their flocks in a long distance in order to secure forage for their animals, but mainly during summer (0.264) and autumn (0.274). The holdings which employ only family members invest more financial means for purchased feedstuffs, such as hay of legume (0.378) as they are not so willing to lead their animals on rangelands during the winter days in contrast to the non-family shepherds (0.393).

Holdings practicing transhumance seem to employ non-family members (0.397) for this purpose and return later in October (0.408) than holdings which employ only family members. Obviously, the holdings which employ only family members try to avoid any hard working condition. This seems to be an assignment for non-family employees. Thus, the family holdings which employ non-family members do it in order to avoid difficult working condition apart from coping with high work load in case of big flock size (Table 3).

**Table 2.** The effect of holding's personal structure in extensive sheep production system in Central Greece

| | Family holding | | Family employees | | Non family employees | |
|---|---|---|---|---|---|---|
| | Co-efficient | Sign. | Co-efficient | Sign. | Co-efficient | Sign. |
| Distance travel during summer | 0.264(*) | 0.041 | 0.111 | 0.397 | -0.008 | 0.949 |
| Distance travel during autumn | 0.274(*) | 0.034 | 0.124 | 0.345 | 0.095 | 0.469 |
| Roughages (total cost annually) | 0.218 | 0.095 | 0.378(**) | 0.003 | 0.195 | 0.135 |
| Straw (total cost annually) | 0.036 | 0.787 | 0.173 | 0.187 | 0.393(**) | 0.002 |
| Transhumance | 0.056 | 0.672 | 0.222 | 0.089 | 0.397(**) | 0.002 |
| Return from transhumance | 0.000 | 1.000 | 0.159 | 0.225 | 0.408(**) | 0.001 |

** Correlation is significant at the 0.01 level, * Correlation is significant at the 0.05 level

The owners of big flocks (Table 3) have a tendency to keep longer transhumance period (0.597), as they return late in October and not in September, and also to spend a longer time on rangelands during winter (0.309). This is understandable, provided that the farmers with higher capital are motivated to exploit the available natural resources at the highest degree. As a result they use less quantity of condensed feedstuffs (-0.329), especially in autumn. They also do not maintain sheds in residential areas (-0.389) probably due to the limited agricultural land allocated in these areas for the big-sized flocks and to the EU legislation. Finally, as expected, the number of family (0.431) and non family employees (0.557) increase with the flock size.

**Table 3. The effect of flock size in extensive sheep production system in Central Greece**

| | Flock size | |
|---|---|---|
| | Co-efficient | Sign. |
| Return in late October from transhumance | 0.597(**) | 0.000 |
| Grazing on rangeland in winter (months) | 0.309(*) | 0.016 |
| Condensed feedstuff in autumn (kg/day) | -0.329(*) | 0.010 |
| Sheds in residential areas | -0.389(**) | 0.002 |
| Family employees | 0.431 (**) | 0.001 |
| Non family employees | 0.557 (**) | 0.000 |

** Correlation is significant at the 0.01 level, * Correlation is significant at the 0.05 level

## Conclusions

The older farmers avoid using temporary pastures which necessitate additional investment using instead more stubble fields in autumn. The younger ones establish temporary pastures (making higher investments in seeding and fertilizing) and use them as long as possible in spring. Moreover, they appear to be willing to insert more milk productive races, to keep bigger flocks and to apply more mechanized milking.

Owners of family holdings are willing to lead their flocks in a long distance during summer and autumn. The holdings which employ only family members invest more financial means for purchased feedstuffs as they are not so willing to lead their animals for grazing on the rangelands during the winter days in contrast to the non-family shepherds who are employed for coping with more difficult physical conditions and transhumance.

Owners of big flocks tend to be characterized by keeping longer transhumance and grazing period on rangelands, less consumption of condensed feedstuffs in autumn and higher number of employees. Their sheds also tend to be far away from residential areas.

## References

**Aggelopoulos, S., Soutsas, K., Pavloudi, A., Sinapis, E. and D. Petkou. 2009.** Suggestions for reformation in sheep farms based on production cost. *Journal of Food, Agriculture & Environment*, 7:561-566.

**Hatzigeorgiou, I., Vallerand, F., Tsiboukas, K. and G. Zervas. 1999.** Socio-economic situation of the sheep and goat livestock in Greece and prospects for future development. In: Laker, Milne (eds.), Livestock Production in the European LFAs. MLURI. pp. 17-23.

**NSSG (National Statistical Service of Greece). 2009.** Agricultural Statistics of Greece. National Statistical Service of Greece. Athens (Greece). (in Greek).

**Yiakoulaki, M.D., Zarovali, M.P., Ispikoudis, I. and V.P. Papanastasis. 2003.** Evaluation of small ruminant production systems in the area of Lagadas County. Proceedings of the 3rd Panhellenic Rangeland Congress “Range Science and Development of Mountainous Regions”, 395-402. Karpenisi (Greece). (in Greek with English summary).

# Grey wolf (*Canis lupus*) predation on livestock in the Prefecture of Trikala, central Greece

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## Abstract

The Grey wolf (*Canis lupus*) is the top predator in Greek ecosystems and the largest species of the Canidae family. The decline of wild ungulate populations has resulted in changing the wolf food habits, with livestock being its main food resource. In this study we analyzed wolf predation on livestock of Trikala Prefecture for the period 1999-2010. The total number of verified attacks recorded by HFIO (Hellenic Farmers Insurance Organization) and the Forest Service of Trikala is 2,561. The livestock is divided into 3 categories (goats, sheep and cattle) and the killed animals are 9,770. Most of the attacks occurred in areas with an altitude of 800 to 1,200 m. Autumn is the season with the largest number of attacks. Highest predation was recorded on sheep with 1,041 attacks. The presence of wolves in Greece is closely related to livestock animals and traditional farming. In order to estimate the effect of wolf predation on livestock a longitudinal monitoring is required as well as an analysis of all attacks at a national scale.

**Key words**: Grey wolf, *Canis lupus*, free ranging livestock, predation, wolf attack

## Introduction

The Grey wolf (*Canis lupus*) used to occur throughout North America, Europe and Asia, but its range is now significantly reduced, particularly in Europe (Delibes 1990). Despite years of persecution, the grey wolf still has one of the widest distributions among all mammals, occurring throughout the northern hemisphere, above 15 $^{o}$N latitude (Alderton 1994).

Religious beliefs of various nations and specific farming practices were the main leading factors for the population decline and shrinkage of the species distribution. Currently, it is estimated that there are about 600 wolves in Greece (Legakis and Maragou 2009). The species continues to face several problems due to the complicated legal status. In the Red Book of Greece (Legakis and Maragou 2009) the Grey wolf is considered as a vulnerable (VU) species. Up to 1991 it was considered a game species, while in 1993 it was excluded from the list of pest species. Its presence in an area depends on food availability. The habitat may also influence the level of predation on domestic stock (Alderton 1994). Over the last decades, the distribution of the species in Greece follows the distribution of the free ranging livestock. This continuous interaction and the decline of wild ungulate populations have resulted in changing the Grey wolf food habits, with livestock being its main food category (Papageorgiou et al. 1994, Pezzo et al. 2003, Magli et al. 2005). Garbage dumps and the remains of slaughterhouses are other alternative sources of food (Fritts et al. 2003, Mech and Peterson 2003, Peterson and Ciucci 2003, Legakis and Maragou 2009).

The aim of this study was to analyze the collected data related to the attacks of Grey wolf on livestock in the Prefecture of Trikala and to find out the conflicts between Grey wolf and human in order to understand the role and behavior of the species in Mediterranean ecosystems.

## Materials and methods

Data on Grey wolf attacks on livestock were collected from 1999 to 2010, in the Prefecture of Trikala in Thessaly, central Greece. In terms of topography the study area is mountainous (66%), semi mountainous (14%) and of the plain type (20%). The area is mainly covered by forests (30%), rangelands (42%) and cultivated land (20%). The climate is continental, with severe cold in winter and extremely hot summer. The average annual temperature in the lowlands is 16-17 $^{0}$C and lower on the mountain areas. According to the official data of the Hellenic Statistical Authority for 2008, the main livestock categories consist of 93,593 goats, 213,925 sheep and 28,540 cattle. Data on attacks by Grey wolf were obtained by HFIO and the Forest Service of Trikala for 1999-2010. We examined the seasonal and altitudinal distribution of attacks, in relation to livestock age classes as well as the number of livestock losses per attack.

## Results and Discussion

### Seasonal and altitudinal distribution of attacks

The number of attacks presents a seasonal variation (Fig. 1). During the winter period (November-April) approximately 50 attacks per month and per livestock category occur.

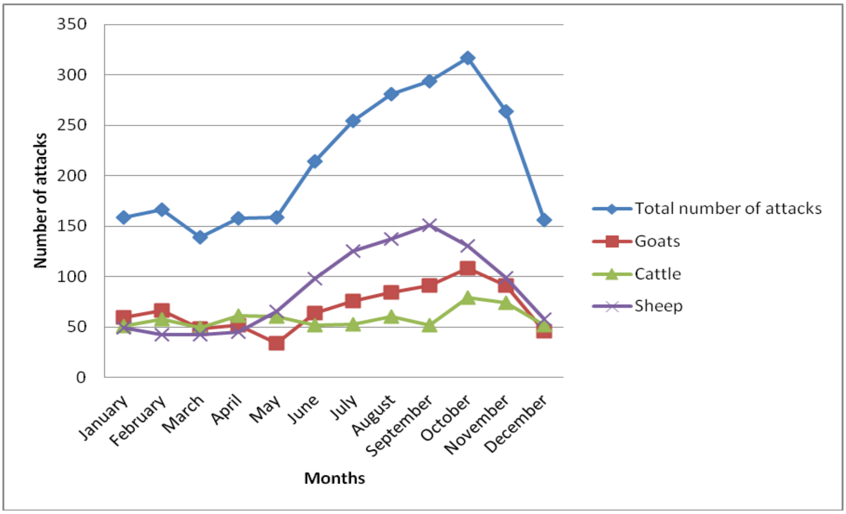


**Figure 1.** Seasonal distribution of Grey wolf attacks in the Prefecture of Trikala (average for 1999-2010)

The maximum number of attacks appeared during September and October. This period coincides with the post-weaning season where wolves raise their pups (Iliopoulos et al. 2009). From May to October sheep and goat flocks move from lowland to upland pastures (Papanastasis 2009) so prey availability is higher. An altitudinal analysis shows that the majority of attacks (1,046) took place in the mountainous areas (800-1,200 m) followed by the plain, the semi-mountainous and the high mountainous zones with 955, 478 and 82 attacks respectively. Villages in the plain zones that suffered higher predation are located on the foot of high mountains thus facilitating Grey wolf packs to approach them.

**Livestock losses and age class selection**

In the majority of attacks on sheep and goats, losses of less than 4 individuals per attack are observed. Surplus killing is frequent but severe losses (more than 15 individuals per attack) are recorded only in 34 attacks (Fig. 2). During attacks on cattle, wolves killed one individual at a time, while more individuals per attack were killed on only 62 cases. Highest predation was recorded in adults for each livestock category. Losses of lamps and kids were recorded on a small scale, because synchronized births keep them absent from pastures during the high predation period (May-October) (Iliopoulos et al. 2009).

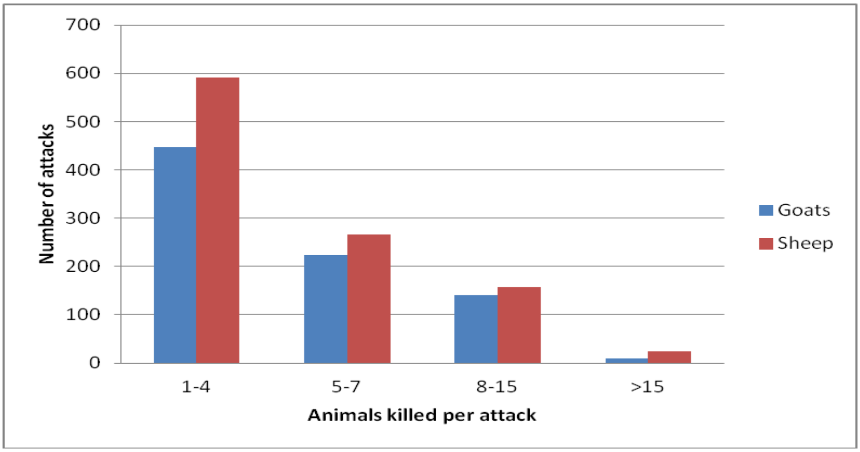


**Figure 2.** Livestock losses per attack in the Prefecture of Trikala (average for 1999-2010)

**Financial losses**

During the last years wolves caused significant livestock losses in the study area and high compensations were given to farmers. Today HFIO compensates 100% of the damage caused by wild animals. From 1999 to 2010 the government spent 876,500 € for livestock losses in the Prefecture of Trikala (Fig. 3).

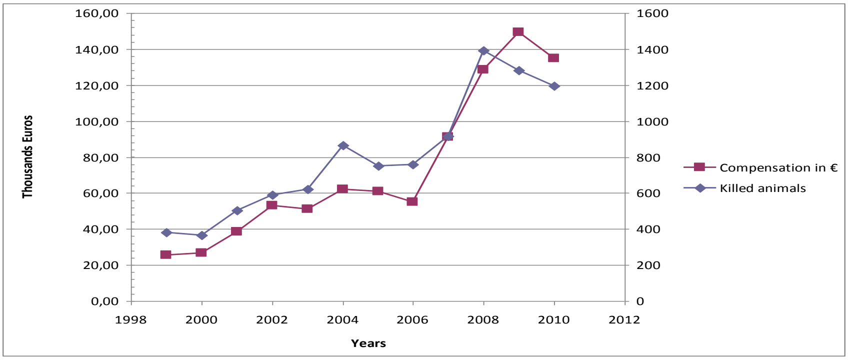


**Figure 3.** Annual livestock losses and compensations in the Prefecture of Trikala (average for 1999-2010)

**Conclusions**

- Most of the attacks occurred during summer and autumn and in high altitude pastures.

- Adult livestock suffered higher predation.
- The cost of compensations in a national scale seems to be high.
- The longitudinal monitoring of damages to livestock is vital for the conservation and management of the species (Boitani 2000).

**Acknowledgments**

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## References

**Alderton D. 1994.** Foxes, wolves and wild dogs of the world. Litho Link Limited, Welshpool, Powys, Wales.

**Boitani L. 2000.** Action plan for the conservation of wolves in Europe (*Canis lupus*). Nature and Environment, No 113. Council of Europe Publishing, Strasbourg: 1-84.

**Delibes M., ed. 1990.** Status and conservation needs of the wolf (*Canis lupus*) in the Council of Europe member states. Nature and Environment Series no. 47. Council of Europe, Strasbourg. 46 pp.

**Fritts S. H., R. O. Stephenson, R. D. Hayes and L. Boitani 2003.** Wolves and humans. [In: Wolves: behavior, ecology and conservation. D. L. Mech and L. Boitani, eds]. The University of Chicago Press, Chicago and London: 289-316.

**Iliopoulos Y., S. Sgardelis, V. Koutis and D. Savaris. 2009.** Wolf depredation on livestock in Central Greece. *Acta Theriologica*, 54: 11-22.

**Legakis A. and P. Maragou. 2009.** The Red Data Book of Threatened Animals of Greece. Hellenic Zoological Society, Athens. 528 pp. (In Greek)

**Magli D., D. Youlatos and Y. Iliopoulos 2005.** Winter food habits of wolves in central Greece. *Journal of Biological Research*, 4: 217-220.

**Mech D. L. and R. O. Peterson 2003.** Wolf-Prey Relations. [In: Wolves: behavior, ecology and conservation. D. L. Mech and L. Boitani, eds]. The University of Chicago Press, Chicago and London: 131-160.

**Papageorgiou N., C. Vlachos, A. Sfougaris and E. Tsachalidis 1994.** Status and diet of wolves in Greece. *Acta Theriologica*, 39: 411-416

**Papanastasis V. 2009.** Rangeland development. Giahoudis Press. Thessaloniki. 157 pp. (In Greek)

**Peterson R. O. and P. Ciucci 2003.** The Wolf as a Carnivore. [In: Wolves: behavior, ecology and conservation. D. L. Mech and L. Boitani, eds]. The University of Chicago Press, Chicago and London: 104-130.

**Pezzo F., L. Parigi and R. Fico. 2003.** Food habits on wolves in central Italy based on stomach and intestine analyses. *Acta Theriologica* 48: 265-270.

# Investigation on health promoting medicinal plants to breeding animals

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## Abstract

Herbivores prefer certain substances for self-medication whereas avoid others. Traditionally in many parts of Greece, breeders used to provide specific plants to their livestock for medicinal purposes. This knowledge and wisdom is getting extinct as young farmers prefer the use of the fast-acting medical substances rather the traditionally used medical plants. The purpose of this study was to investigate and record all traditionally used plants for medical purposes by farmers as well as the grazing preference of certain plant species by animals. For this aim an adequate number of questionnaires was prepared and distributed in livestock breeders of many rural parts of Greece. The results suggest that breeders from diverse areas react differently concerning the use of certain feed and plant species as medicine to face health problems of their livestock. Young farmers are more willing, but less aware than the elder ones in the use of plants for medicinal purposes to their livestock. The use of certain plants is related to the location of the farm. However, there are certain plants that are commonly used throughout different areas. Plants are used for many purposes such as tumours, bloating, cold, fever, intestinal problems, respiratory infections, inflammation, and birth complications as well as to improve the animal welfare.

**Key words:** diet selection, herbs, unconventional feed, Greece

## Introduction

For thousands of years, a wide variety of herbs have been used by animals and humans. Sometimes, the animals lead scientists in the discovery of molecules of interest as, many mammals, choose the same plant species not only to feed but also to heal themselves. For instance, a Navaho Indian legend describes how bears teach humans on the use of *Apiacea* sp. for healing purposes (Potier and Chast 2002). Researchers studied Kodiak bears on the way they chew *Apiacea* sp. roots and anoint themselves with the sticky mixture produced. This mixture is composed, among others, of coumarins, which are used for the treatment of skin, heart and brain diseases (Potier and Chast 2002). The anthropologist Richard Rangkam studied chimpanzees in Tanzania and noticed that animals sometimes would travel long distances to find and consume *Aspilia mossambicensis* leaves, which contain an antiparasitic substance (Potier and Chast 2002). Some apes of central Africa would consume certain plant species exclusively during the reproduction period (Potier and Chast 2002).

Female African elephants would cross over 20 kilometres to consume leaves of *Borraginaceae* sp. a few days before giving birth (Potier and Chast 2002). Herbs and spices are mentioned human history used for medicinal purposes (Anonymus 2012). Valuable knowledge from the father of medicine, Asclepius as well as from Kyron, Hippocrates, Theophrastus and others, on pharmaceutical plants is described in many ancient Greek writings (Page et al. 1968). Even if herbs have been widely used for medicinal purposes, there is only limited scientific research on the specific subject. In one of the few available studies, Mothana et al. (2012), used *Loranthus regularis* in carrageenan-induced rat oedema and pyrexia in mice and confirmed its use as a potential anti-inflammatory and antioxidant agent. In another study, Villalba et al. (2010) offered to sheep with gastrointestinal nematode infection feed of alfalfa or of a alfalfa:tannins mix. The researchers noticed that parasitized lambs increased their intake of alfalfa:tannins which self-medicated them against parasites.

In many parts of Greece, livestock breeders traditionally provide specific plants to their animals for medicinal purposes. This knowledge and wisdom is getting extinct as young farmers prefer the use of the fast-acting medical substances rather the traditionally used medical plants. The purpose of the certain study is to investigate and record all traditionally used plants for medical purposes by the breeders as well as the preference of certain plant species by grazing animals.

**Materials and methods**

An adequate number of questionnaires was prepared and distributed to livestock breeders of many rural parts of Greece. Specifically, 50 livestock breeders were chosen from two mountainous mainland prefectures (Eurytania and Trikala), from three islands (Kefalonia, Ikaria and Evia), and two lowland prefectures, two in mainland (Fthiotida and Attica) and one in Peloponnesus (Argolida). The questionnaire had 14 simple closed-type questions and only 5 requested for written additions (open type). The requested information was the age, gender, occupation (full or part time, years, traditional or new), livestock species, attendance of an educational seminar or a development program, grazing system type (village or flock system, intra or inter transhumant system, no specific type), livestock feed, observation of grazing of a specific plant in case of illness by the animals, the provision of a specific feed by the farmer in case of illness, the reasons for giving a specific feed, if the breeders were aware of pharmaceutical plants not present in their area and if they were willing to be informed on pharmaceutical plants for specific purposes. All questionnaires were anonymous.

**Results and Discussion**

Most of the breeders were male (average 70%), mainly in the mainland regions as opposed to the islands and the Attica (the prefecture with the capital Athens). Most of the breeders were over 60 years old (54%) and only 20% were in the age group of 21-40 mainly in Trikala prefecture. They were occupied in their farms for an average of 29 years, mostly part time (67%), and for personal use of the products (58%). Their land-enterprises were mainly inherited by their family (62%). All breeders from Argolida bought their farms and were full-time occupied for commercial use of the land. Livestock species were sheep (27%), goats (20%), poultry (17%), rabbits (8%), pigs (6), cattle (5%), horses (4%), bees (3%) and donkeys (2). Mostly of the above animals are freely grazing (43%) without any specific pattern. Sheep dominate in the mountainous Eurytania and mainland Trikala, in contrast to goat's dominance in Argolida and the islands. Only few of the questioned (18%) had attended an educational seminar or were included in a developmental program. Young farmers were more willing than the elder ones in the use of plants for medicinal purposes to their livestock. However, the young were facing their farms more as an enterprise, in comparison to the elder ones who seem to be more sentimentally connected to their animals.

Free grazing in state-owned land provided food for the livestock and, depending on the region, composed of corn (33%), fruits (21%), *Gramineae* species (16%), not specified (17%), oats (14%), barley (13%), *Trifolium* species (13%), hay (11%), *Quercus* spp. (14%), *Pistacia* spp. (10%), wheat (9%), *Arbutus* spp. berries (6%), Vegetables (6%), *Ceratonia siliqua* (5%), soy (5%), Berries (4%), *Erica* spp. (2%), *Salvia fruticosa (*2%), Maple (1%).

Only 4% of the breeders had noticed browsing of specific plant species when the animals had symptoms of illness and 8% had informed about the existence of pharmaceutical species in other areas than theirs. For example, *Cynodon dactylon* Pres. was mentioned to be used for self medication by animals, and specifically by dogs for parasites. Even though the mechanism of such effect is not scientifically known for all species, the use of herbs for the self-medication of animals has been proven for lambs and kids (Villalba et al. 2010, Burke et al. 2011). Interestingly, a 6% of the farmers from the mountainous Eurytania and Argolida were not willing to be informed of pharmaceutical plants, in contrast to all (100%) of the breeders from the other regions.

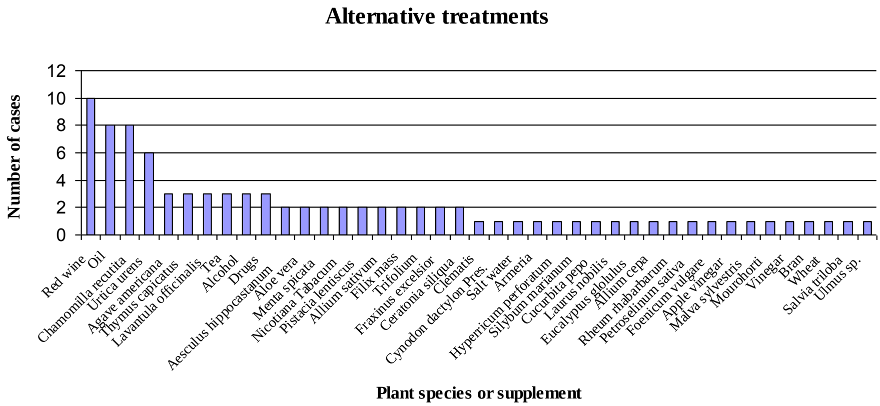


**Figure 1.** Plant species or other supplement used for alternative treatment

Red wine is widely used in animals as an alternative supplement for medicinal purposes followed by oil (Figure 1), *Chamomilla recutita* and *Urtica dioica* (nettle*).* These alternatives are also used for the treatment of human diseases. Most of the species used are area-dependent, meaning that they are only used in specific regions. The species used in at least two areas were oil, wine, *Aesculus hippocastanum (*horse-chestnut), *Aloe vera*, thyme, lavender, *Pistacia lentiscus* (mastic tree), garlic, tea, nettle, and camomile.

There is a great variety of plants used for pharmaceutical purposes and for a wide variety of diseases-problems. Most of these are also used for the treatment of human health problems such as the tea. Alipoor and Rad (2012) gave a detailed review on the therapeutical effects of tea (*Camellia sinensis*). Olive oil (*Olea europaea*) is used in many cases, and for humans mainly for their skin treatment. *Hyperricum perforatum (*St. John's wort) is a very popular herb, used for a variety of purposes (Table 1.). As Solórzano-Santos and Miranda-Novales (2011) mentioned, essential oils from aromatic herbs possess antibacterial properties and its use as antiseptics is promising.

## Conclusions

Herbs, plants and their products are widely used for the meditation of animals. Certain factors seem to affect the choice of a particular plant such as the location of the farming unit, the gender and the age of the breeder. The alternative use of plant species is very promising and should be further investigated.

**Table 1.** Plant species provided to animals for pharmaceutical purposes

| | |
|---|---|
| **Inflammatory** | *Allium cepa Apple vinegar Petroselinum sativa* |
| **Antiparasitic (internal)** | *Allium sativum Aloe vera Armeria Cynodon Dactylon* Pres. *Cucurbita pepo* |
| **Anuria** | *Aesculus hippocastanum* |
| **Bloating** | *Chamomilla recutita,* Alcohol (tsipouro), Wine (red) |
| **Burns** | *Hyperricum perforatum* oil |
| **Cold** | *Allium sativum, Chamomilla recutita, Hyperricum perforatum* oil, *Malva sylvestris* |
| **Diarrhea** | *Bran, Tea, Pistacia lentiscus, Thymus capicatus, Ulmus* sp. |
| **Dystocia** | *Bran* |
| **Epidermal parasites** | *Apple vinegar, Laurus nobilis,* oil |
| **For more milk** | *Trifolium* sp. |
| **For water consumption** | *Armeria* |
| **Haemostatic** | *Filix mass, Lavantula officinalis, Nicotiana tabacum, Thymus capicatus* |
| **Intestinal problems** | *Aloe vera, Apple vinegar, Armeria* sp., *Chamomilla recutita, Cynodon dactylon* Pres., oil, *Salvia triloba* |
| **Poisoning** | *Agave americana, Allium cepa, Lavantula officinalis, Silybum marianum,* vinegar, *Urtica urens* |
| **Psoriasis** | *Laurus nobilis* |
| **Rash** | *Aloe vera, Hyperricum perforatum* oil, *Laurus nobilis*, oil, *Thymus capicatus* |
| **Respiratory problems** | *Clematis vitalba, Eucalyptus glolulus, Lavantula officinalis* |
| **Stomach ulcer** | *Malva sylvestris, Salvia triloba, Urtica urens* |
| **Tumor destruction** | *Unknown herb called "mourohorti"* |
| **Turning** | *Fraxinus excelsior,* Wheat |
| **Turning up after birth** | Wine (red) |
| **Turning up for young sheep** | *Ceratonia siliqua* |
| **Vision problems** | *Foenicum vulgare, Salvia triloba* |
| **Vomiting** | *Menta spicata, Ulmus* sp. |

## References

**Alipoor B and A.H. Rad. 2012.** A review on the therapeutical effects of tea. *Asian Journal of clinical nutrition,* 4(1):1-15.

**Anonymus, 2012.** http://www.mccormickscienceinstitute.com/content.cfm?ID=10498, cited at 3/4/2012.

**Burke J.M., N.C. Whitley, D.A. Pollard, J.E. Miller, T.H. Terrill, K.E. Moulton, J.A. Mosjidis. 2011.** Dose titration of sricea lespedeza leaf meal on Haemonchus contortus infection in labs and kids. *Veterinary parasitology*, 181:345-349.

**Mothana R.A.A., M.S. Al-Said, A.J. Al-Rehaily, T.M. Thabet, N.A. Awad, M. Lalk, U. Lindequist. 2012.** Anti-inflammatory, antinociceptive, antipyretic and antioxidant activities and phenolic constituents from *Loranthus regularis* Steud. Ex Sprague. *Food chemistry,* 130:344-349.

**Potier, P. and F. Chast. 2002.** Le magasin du Bon Dieu, Book. 1st ed. Psihalos Editions, Athens, 279 pp.

**Solórzano-Santos F. and M.G. Miranda-Novales 2011.** Essential oils from aromatic herbs as antimicrobial agents. *Current opinion in biotechnology*, 23:1-6.

**Page, T.E., E. Capps, W.H. Rouse, and L.A. Post (Eds). 1968.** Theophrastus: Enquiry Into Plants. Vol. I& II. Published by W. Heinemann & Harvard University Press, p.p.205-211.

**Villalba J.J., F.D. Provenza, J.O. Hall and L.D. Lisonbee. 2010.** Selection of tannins by sheep in response to gastrointestinal nematode infection. *Journal of Animal Science,* 88:2189-2198.

# Dry grasslands management in Greece. Crucial points and proposals for a new sustainable policy: a case study of Epirus

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## Abstract

Greece has a rich heritage in grasslands which significantly contribute to the national economy. This paper examines the necessity of developing a new land use policy, under the CAP framework, focusing on the sustainable dry grasslands management. We studied the national and European legal frame concerning grasslands management, the current grasslands management and the main points of agricultural subsidies system relating with grassland management in five representative areas of Epirus, northwestern Greece. The results pointed out the complexity of the law in grasslands management providing evidence that more importance has been given to the economic management, in terms of tax payment (grazing right) and agricultural subsidies payment rather than to the proper application of critical factors such as grazing capacity and stocking rate. Finally, a conceptual framework, in very broad lines, for a new grasslands agreement addressing grasslands sustainability is presented. The agreement will be applied by “managers of grasslands” and can be financed by the Green Fund or even from a new agri-environmental measure within the CAP framework.

**Keywords:** land use policy, grasslands management, Greece

## Introduction

In Greece, the majority of grasslands can be considered as dry grasslands in the sense that they are mostly found in dry and poor-nutrient soils areas. Grasslands are important feeding resources for extensive livestock farming which stretch mainly in the rural and less favorable areas (LFAs) of the country. Most of these communal grazing areas are degraded by a long term high stocking rates application.

Although dry grasslands play a key role both to the maintenance of extensive livestock farming and the viability of the primary sector in LFAs of the country (Chatzitheodoridis et al. 2007), little importance has been given in the classification, mapping and sustainable management of these precious natural resources. The study aims to a short analysis of problems that are caused by communal and not-organized management of dry grasslands and a proposal of a new strategy for their preservation or restoration under the CAP framework.

**Materials and methods**

Epirus is located in the northwestern Greece. It is a typical Mediterranean mountainous area, ranging from 0 to 2637 m a.s.l. with great variation in topography, soil and climatic conditions. The climate is typical Mediterranean, characterized by rainy cold winters and dry warm summers (Soulis 1994). Grasslands management in Epirus represents well the grasslands management of the country. Vegetation belongs to the mediterranean zone of *Quercetalia ilicis*, (subzone *Quecion illicis*) (Dafis 1973, Horvat et al. 1974) and ranges from typical Mediterranean (macchie, phrygana) in the lower areas to subalpine in the more humid and higher areas. For the needs of this study, five representative areas of the Epirus region were selected. Grassland production data was adopted by studies recently conducted for these areas (Table 1). Generally the grasslands extend from lowlands to uplands and are suffering from high stocking rate values (Roukos et al. 2011).

**Table 1.** Studied areas of Epirus region.

| Area | Altitude(m a.s.l.) | Source |
|---|---|---|
| Xirovouni Mt | 1100 – 1453 | Roukos *et al*., 2010 |
| Theodoriana | 1100 - 2393 | Nikolaou *et al*. 2007 |
| Athamanio | 1100 - 2250 | Nikolaou *et al*. 2007 |
| Metsovo | 1400 - 1970 | Tzialla *et al*. 2000 |
| Grammos Mt (Aetomilitsa) | 1280 - 2120 | Vrahnakis *et al*. 2002 |

The main legal framework concerning grasslands management is based on the Commission Regulations (EU) No 65/2011 and No 1974/2006, the Council 92/43/EEC on the Conservation of natural habitats and the wild fauna and flora and the EC Directive 79/409 on the Conservation of Wild Birds, their latest modifications and their incorporation into the Greek legislation.

Grazing capacity was calculated according to Holechek et al. (2004) for a grazing period of 5 months per year and a proper use factor of 50 percent. An average grazing livestock population of the selected areas was taken from data provided by Municipalities, to which producers pay for rangeland utilization (grazing right). Also, the grazing capacity was adjusted for slopes as suggested by Holechek et al. (2004). Grasslands area vector data was obtained from Corine Land Cover 2000 (Bossard et al. 2000). Slope maps in each study area were created by conducting a spatial analysis using the raster calculator of spatial analyst tool of ArcMap software. A digital elevation model based on 50 m contours for the region was available generated for a 30 m resolution. Then, vector grasslands data was converted to raster data. Finally, the calculation of grassland area per each slope class in each study area was done by combining the raster data of slopes map and grasslands map so a unique output value was assigned to each unique combination of slopes and grasslands values for each study area. The cell size resolution of all interpolated layers was 50 m. The GIS platform used was ArcGIS version 9.3.

**Results and Discussion**

In Greece, although the competence of rangelands management has been assigned to the Municipalities (Law 3955/2011; Law 3852/2010; Law 3463/2006), the Ministry of Rural Development and Foods has set management rules and plans for all altitudinal zones rangelands independently of their property status (Law 1734/1987). However, the high elevation zone rangelands are characterized as forestall area and their management involves the General Secretariat for Forests (Law 998/1979 and Law 1737/1987), which recently has been administratively incorporated into the Ministry of Environment (Common Ministerial Decision 23111/2010). As the majority of dry grasslands in Greece are stretched into high elevation zones they constitute forestall areas and thus their management involves at least three different authorities (Ministry of Rural Development and Foods, Ministry of Environment, Municipalities or Cooperatives). This common responsibility of public authorities certainly complicates every attempt for proper grasslands management and has also resulted into the interruption of a grasslands improvement program since 2004. Under the current legal frame, it seems that the application of an intergrated grazing control system addressing rangeland sustainability is not feasible.

The Law states that farmers can graze their livestock at communal rangelands (Law 1080/1980; Law 1734/1987). This is called “grazing right” and the taxes payment range from 0.20 € to 0.53 € per grazing animal (Law 2130/1993). Specific management aspects (e.g. grazeable areas, number of grazing animals per farmer, duration of grazing and amount of “grazing right”) are determined annually by the Municipal Council. The communal rangelands area remaining after this allocation to the farmers can be leased by auction. The results reveal that the grazing right fees range from 2.55 to

35.00 € ha$^{-1}$ (Table 2). This range is related to the stocking density in communal rangelands but in non-communal rangelands the price is determined by the free market rules and can reach up to 12 times higher (Table 2). Therefore, the value of grasslands is often over-estimated aggravating the production cost.

A critical issue is that farmers who receive direct payments or participate in the rural development measures under Common Agricultural Policy (CAP) face penalties if they do not meet the stocking density cross-compliance obligations (0,2 – 3,0 AU ha$^{-1}$) (Common Ministerial Decision 262385/2010). The cross – compliance control is done by the Greek intergrated administration and control system (OSDE) which relates the grassland area with one or more cartographic parcels on an annual basis without a specific schedule.

**Table 2.** Grazing right taxes, forage production, grazing capacity and stocking rate of selected areas grasslands.

| Area Name | Property status | Grazing right tax* (€/ha) | Grasslands area (ha) | Production (kg DM ha$^{-1}$) | Animal units** | Grazing Capacity*** (AUM ha$^{-1}$) (a) | (b) | Stocking Rate (AUM ha$^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| Xirovouni Mt | Communal | 2.55 | 10.096 | 2586 | [illegible] | 0.862 | 0.275 | 0.528 |
| Athamanio | Cooperative | 7.00 | 1.502 | 2075 | | 0.691 | 0.241 | 0.304 |
| Theodoriana | Cooperative | 31.58 | 950 | 1850 | | 1.093 | 0.381 | 0.474 |
| Theodoriana | Communal | 2.84 | 1.290 | 1850 | [illegible] | 0.837 | 0.187 | 1.318 |
| Metsovo | Communal | 2.81 | 5.572 | 3850 | [illegible] | 0.454 | 0.272 | 0.452 |
| Grammos (Aetomilitsa) | Communal | 6.00 | 3.053 | 2659 | [illegible] | 0.885 | 0.319 | 0.451 |

*: Average grazing right tax payment, **: Animal Units (includes sheep and bovines),
***: Grazing capacity adjusted for slope (b) or not (a)

Grazing capacity and stocking rate values from the studied areas are given in Table 2. The results showed that communal grasslands are more overgrazed than non-communal grasslands enhancing the degradation of grasslands and contributing to poor range conditions (Holechek et al. 2004). This phenomenon of overgrazing is more intense when the grazing capacity value not adjusted for slopes is taken into consideration.

It certainly can be claimed that the following rangeland management policy in any case does not implement the grazing capacity determination even for the grasslands that are found in Natura sites. It is vitally important to adopt a new agreement for quality grasslands management addressing grassland sustainability. The agreement will be a new land use policy that can be financed by a new agri-environmental measure in the CAP framework (Arnalds and Barkarson 2003) or even by the Greek Green Fund. The “managers of grasslands”, who will come mainly from the structures of local self-government (Municipalities) and from the farmers’ cooperatives will be responsible for the policy implementation.

The main policy instrument will be a five-year (minimum) contract between the farmers and the central or the regional government. An extra subsidy, additional to the direct payments, will be provided to farmers participating into the program. Grazing right will be determined according to the grazing capacity of grasslands using a grazing fee formula (Torell et al. 2003) and providing flexibility to livestock operations so as to meet both temporal and spatial variability of grasslands production. Farmers will be obliged to implement strictly defined and periodically controlled management rules in order to receive the payment. The incomes of grazing right taxes will be reciprocal and thus finance the improvement of grasslands technical infrastructure (e.g. roads, water supply, etc.) and the program management costs.

The proposed policy is organized around six complementary objectives: (a) the simplification and unification of current legislation concerning grasslands management, (b) the development of a GIS-based application for dry grassland mapping and monitoring, (c) the long – term determination of dry grasslands forage production and quality, (d) the upgrading of technical infrastructure on co-financing basis, (e) a basis creation for the implementation of management measures, and (f) the development of a grasslands management program.

One crucial point is not only to set one supervising Agency to coordinate the agreement implementation but mainly to overcome the powerful forces of farmers’ grazing common practices which are deeply rooted in the rural traditions. Critical factors such as the economical importance of the payment, management costs and a regulations framework will strongly influence the likelihood of a farmer to sign a contract (Masé 2005).

**Conclusions**

This paper discussed the pathway of addressing sustainability in grasslands management in Greece. We suggested a new strategy framework, examining the policy measures that can be used to establish sustainable management. The feasibility of their implementation is depended on the farmers’ acceptance to participate in the program.

## References

**Arnalds, O. and B.H. Barkarson, 2003.** Soil erosion and land use policy in Iceland in relation to sheep grazing and government subsidies. *Environmental Science & Policy*, 6: 105–113

**Bossard M., J. Feranec J. and J. Otahel, 2000.** CORINE Land Cover Technical Guide – Addendum 2000. Technical report No 40. Copenhagen (EEA). 105 pp.

**Chatzitheodoridis F., A. Michailidis and G. Theodossiou, 2007.** Comparative analysis of sheep–goat farming in a typical Greek island: economy and environment. *Applied Economics and Policy Analysis*, 1 (1–2): 191–200.

**Dafis S., 1973.** Classification of forest vegetation in Greece. *Scientific Annals of the Department of Forestry and Natural Environment*, 15: 57-91 (In Greek).

**Holechek J., R. D. Pieper and C.H. Herbel, 2004.** Range Management, Principles and Practices. 5th Ed. Prentice Hall. 607 pp.

**Horvat I., V. Glavač and H. Ellenberg, 1974.** Vegetation Sudosteuropas. Gustav Fischer Verlag. Stuttgart.

**Masé G., 2005.** The management of dry grasslands in Switzerland. A Swiss federal program and its local practical application. *Biotechnologie, Agronomie, Société et Environnement*, 9 (2): 133-138.

**Roukos, C, K. Papanikolaou, S. Kandrelis , A. Mygdalia and F. Chatzitheodoridis, 2011.** A GIS-based assessment of Rain-Use Efficiency Factor and Grazing Capacity in Preveza Prefecture, Greece. *Journal of Agricultural Research*, 49 (1):97-107.

**Soulis N.V., 1994.** The climate of Epirus. Ioannina (in Greek). 216 pp.

**Tzialla C., M. Kassioumi and C. Goulas, 2000.** Grassland production and forage quality in two different climatological environments of Ioannina prefecture. In: T.G. Papachrisou and O. Dini – Papanastasi (eds). Range Science at the threshold of the 21$^{st}$ century. Proceedings of the 2nd Panhellenic Rangeland Congress. pp.109-116. (In Greek with English Abstract)

**Vrahnakis M.S., K. Iovi and N.M. Berdell, 2002.** Management of the pseudoalpine rangelands of the Grammos mountain. In: P.D. Platis and T.G. Papachrisou (eds). Range Science and Develpmnet of Mountainous Areas. Proceeding of the 3rd Panhellenic Rangeland Congress, p. 355-361. (In Greek with English Abstract)

**Torell L.A., N. R. Rimbey, L. W. Van Tassell, J. A. Tanaka and E. T. Bartlett, 2003.** An evaluation of the federal grazing fee formula. *Journal of Range Management*, 56: 577–584.

# Inventory and landscape structure analysis of agrosilvopastoral systems in Florina Regional Unit

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## Abstract

In northern Greece, traditional agrosilvopastoral systems (AS.S.) are in danger of being abandoned or converted to intensive monocultures. This could lead to their disappearance and subsequently loss of biodiversity, ecosystem stability and accumulated cultural knowledge. The purpose of this research was to carry out an inventory of the traditional AS.S. in Florina Regional Unit and evaluate them using landscape metrics. The AS.S. were identified and mapped using satellite images and orthophotos. Afterwards, two AS.S. were selected in Petres and Variko areas and landscape metrics were calculated using the program Fragstats. The AS.S. of Florina Regional Unit are 76 which cover an area of 5245,3 ha. The dominant tree species are oaks, poplars, walnuts and alders, while the dominant cultivations are alfalfa, corn, rye and barley. The landscape in the AS.S. of Variko appears to be in transitional stage. The geometric structure is evident in some places only, where the trees are still in linear arrangement. The tree coverage (index CA) is quite small and the distances between them very large (indexes PROX, ENN). In the AS.S. of Petres the absence of hedgerows is visible and the landscape appears to be abandoned. The tree coverage is very low (5,9%), they are scattered in the system (indexes ENN, PROX) and isolated (index LPI). From the analysis of landscape metrics it is concluded that they are a useful tool in interpreting agrosilvopastoral landscapes. Depicting landscape pattern may serve as an interpretative tool to monitor AS.S. abandonment.

**Key words:** abandonment, metrics, satellite images, Fragstats, GIS.

## Introduction

The agrosilvopastoral systems (AS.S.) are complex entities involving at least three distinct components: crops, trees and pasture/animals (Papanastasis 2004) and constitute one of the three types of agroforestry systems. AS.S. provide number of products (food, wood, fodder, medicine, fibre, mycorrhiza etc.) and ecosystem services (increased soil fertility, prevention of soil erosion, increased biodiversity, maintenance of nitrogen and carbon cycle, increased productivity etc.) (Torquebiau 2000). Traditional agrosilvopastoral systems maintain diverse landscape mosaic and are more stable than any other form of conventional agriculture on soil protection.

Over the last few decades, AS.S. face several threats due to land use changes, imposed by a concomitant change of the socio-economic conditions. In northwestern Greece, traditional AS.S. are in danger of being abandoned or converted to intensive monocultures (Papanastasis 2004). Their preservation is imperative to maintain ecosystem services, environmental benefits and economic commodities as part of a multifunctional working landscape. For these reasons it is necessary to create an inventory of the AS.S. of the area.

Moreover, socioeconomic changes in AS.S. are depicted in landscape structure (Nagendra *et al.* 2004). Therefore, the quantification of landscape pattern is fundamental in understanding the relations between structure and the ecological and socioeconomic processes that govern it (Turner 1989). For this purpose, several landscape metrics have been developed, which quantify landscape heterogeneity (O'Neill *et al*. 1988).

The aim of this study was the inventory of traditional AS.S. in Florina Regional Unit and structure analysis using landscape metrics.

## Materials and methods

### Study area

The study area was located in Florina Regional Unit in Western Macedonia, Greece (Fig. 1). The climate is characterized as continental, with cold winters, medium annual rainfall (645,7 mm) and mean annual temperature 12 $^{o}$C (Mantzanas *et al.* 2008). The area belongs to the sub-humid bioclimatic floor with harsh winters and the sub-Mediterranean bioclimate zone. Phytosociologically, the vegetation of the area belongs to the conformation of thermophilic subcontinental deciduous oaks.

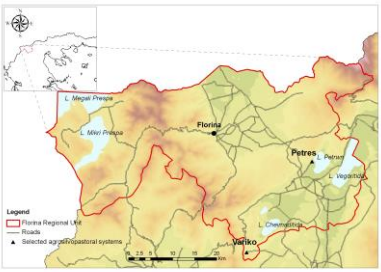



**Figure 1.** Study area

### Methods

The identification and mapping of the AS.S. was accomplished by using satellite images (2002-2009) from Google Earth™ 6.0 and orthophotos (2007-2009) of KTIMATOLOGIO S.A. On-site verification followed to verify the correctness of photo-interpretation and collect additional data. Digitized data of these systems were introduced in the program ArcGIS

9.3.1. (ESRI 2008). Only the AS.S. covering an area over 10 ha were selected for further analysis, which is the minimum management unit area in surveys on agroforestry systems (Papanastasis 1989).

In order to calculate landscape metrics, two characteristic AS.S were selected, Variko and Petres. A square area of 40ha was selected in each AS.S in which the tree canopy was digitized. The formed polygons were imported in raster format to the program Fragstats 3.3 (McGarigal et al. 2002) and ten landscape metrics of a) area, density and edge (Class Area-CA, Number of Patches-NP, Largest Patch Index-LPI, Total Edge-TE, Mean Patch Size Area Weighted-AREA) b) shape (Shape Index Distribution Area Weighted Mean-SHAPE, Perimeter Area Fractal Dimension-PAFRAC), c) isolation and proximity (Proximity Index Distribution Area-Weighted Mean-PROX_AM, Euclidean Nearest Neighbor Distance Distribution Mean-ENN) and d) connectivity (Radius of Gyration Area Weighted Mean-GYRATE), were calculated at class level.

**Results and Discussion**

Florina Regional Unit has 76 AS.S. which cover an area of 5245.29 ha (9.82 % of the total agricultural land), while the average AS.S. area is 69 ha (Fig. 2). The mean altitude of each system is 827.5 m., the mean slope is 10.7% and the mean aspect is south. AS.S. in Florina Regional Unit occupy mainly the mountainous (72.4 %) and semi-mountainous (27.6 %) zone. 64.5 % of these systems are intensely used and only 2.6 % are abandoned. Regarding the farm crops, 94.7 % are herbaceous and 5.3 % mixed trees and herbaceous. The major crops are alfalfa 27.6 %, corn 19.7 %, rye 19.7 % and barley 10.5 % and the main tree species are oaks (*Quercus* sp.), poplars (*Populus* sp.), walnuts (*Juglans regia*) and alders (*Celtis australis*).

The system of Variko (Fig. 3) is located south of Florina Regional Unit, at an altitude of 739 m, and occupies an area of 107.29 ha. The system of Petres (Fig. 4) is located north of Petres Lake, at an altitude of 726 m and occupies an area of 66.89 ha.

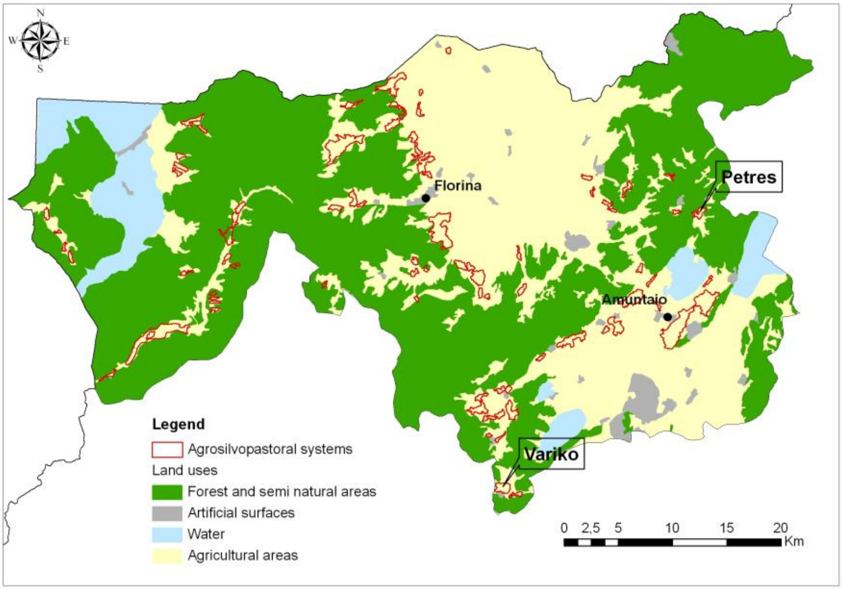



**Figure 2.** Agrosilvopastoral systems in Florina Regional Unit

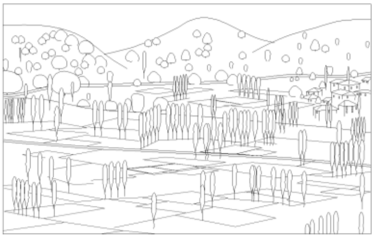
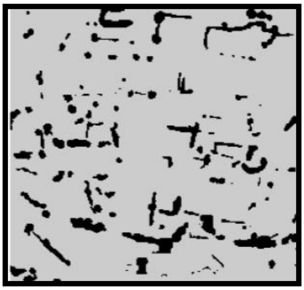


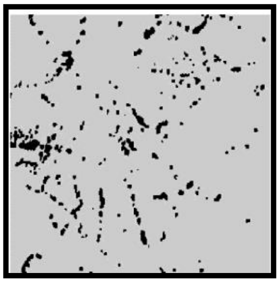
**Figure 3.** Agrosilvopastoral system of Variko

**Figure 4.** Agrosilvopastoral system of Petres

The selected 40ha square area with the digitized tree canopy for the two systems can be seen in figures 5a and 5b.



a



b

**Figure 5.** Digitized tree canopy the selected 40ha square in the agrosilvopastoral systems of a) Variko and b) Petres

For the selected AS.S. of Variko and Petres ten landscape metrics were calculated (table 1).

**Table 1.** Landscape metrics for the agrosilvopastoral systems of Variko and Petres in Florina Regional Unit.

| Landscape metric category | Landscape metric | Variko | Petres | Range |
|---|---|---|---|---|
| Area/density/edge | CA[1] (ha) | 4.21 | 2.36 | CA>0 |
| | NP[2] | 127 | 203 | NP≥1 |
| | LPI[3] (%) | 0.74 | 0.23 | 0<LPI≤100 |
| | TE[4] (m) | 12520.2 | 10145.7 | TE≥0 |
| | AREA_AM[5] (ha) | 0.10 | 0.03 | AREA>0 |
| Shape | SHAPE_AM[6] | 1.84 | 1.45 | SHAPE≥1 |
| | PAFRAC[7] | 1.27 | 1.26 | 1≤PAFRAC≤2 |
| Isolation/proximity | PROX_AM[8] | 19.12 | 33.22 | PROX≥0 |
| | ENN_MN[9] (m) | 11.36 | 9.63 | ENN>0 |
| Connectivity | GYRATE_AM[10] (m) | 17.27 | 7.43 | GYRATE≥0 |

[1]Class Area, [2]Number of Patches, [3]Patch Index, [4]Total Edge, [5]Mean Patch Size Area Weighted, [6]Shape Index Distribution Area Weighted Mean, [7]Perimeter Area Fractal Dimension, [8]Proximity Index Distribution Area-Weighted Mean, [9]Euclidean Nearest Neighbor Distance Distribution Mean, [10]Radius of Gyration Area Weighted Mean.

In Variko, the landscape seems to be in a transitional stage. There are several hedgerows functioning and some abandoned. The dominant tree species is poplar (*Populus thevestina*) in the boundaries of the fields and along the streams while few, isolated walnuts can be found inside the fields. Metrics NP and CA for Variko area indicate that tree coverage is very small, there are 127 tree patches which are quite isolated (ENN, PROX). The landscape is not dominated by large (LPI) or complex (PAFRAC) patches.

One of the major causes for the creation of this system was the limited available arable land. As a result, the locals were probably trying to exploit the land resources in the most profitable way. One of the reasons that may be responsible for maintaining the landscape was that in '82-'83 the inhabitants of Variko opposed the land consolidation and so a part of the area around the village remained intact. The decline of the local timber industry and the emergence of alternative energy sources have led to the abandonment of the systematic exploitation of poplar. But because the trees create a special microenvironment suitable for the cultivation of beans, reducing soil moisture, protecting crops from strong winds and helping to maintain relatively low temperatures in the summer, until now they remained for the most part (Sidiropoulou 2011).

In Petres, the abandonment is evident. The dominant tree species is oak (mainly *Quercus trojana*) and almond-leaf pear (*Pyrus amygdaliformis*). Metrics CA and NP show that tree coverage is very low 5.9%, while there are only 203 tree patches. The geometry of the crown of trees is very simple (SHAPE, PAFRAC). The trees are scattered throughout the system (ENN, PROX) and most of them are isolated (LPI). The absence of hedges is visible in the landscape (GYRATE).

In this system, the existence of old, single oak tree in the fields, suggests their use in the past. The trees were used for timber, fruit, charcoal, but especially for fodder. The oak leaves were collected and used as food for animals in unfavorable seasons (winter, dry periods), a practice common throughout Greece (Papachristou and Papanastasis 1994). While in the past the oaks formed hedgerows, today only some individuals remain probably as a result of fragmentation.

## Conclusions

The identification and inventory of AS.S. is possible using satellite images and orthophotos. The application of landscape metrics in the selected agroforestry landscapes shows that CA, NP, LPI, ENN, AREA, SHAPE, PAFRAC, PROX and GYRATE could possibly be indicators of abandonment and can capture the landscape structure of AS.S. Landscape metrics can serve as a tool for identification and comparison of different agroforestry landscapes and for the interpretation of socio-cultural conditions that shaped them.

## References

**ESRI, 2008.** ArcGIS version 9.3.1. Environmental Systems Research Institute, Redlands, California, USA.

**Mantzanas K., A. Sidiropoulou, M. Zarovali, O. Ntini-Papanastasi, P. Platis and I. Ispikoudis, 2008.** Structure and function of silvopastoral systems at Florina Prefecture. In: K. Mantzanas and V.P. Papanastasis (eds). Range science and protected areas. Proceedings of the 6th Panhellenic Rangeland Congress. pp.141-146. (In Greek with English Abstract)

**McGarigal K., S.A. Cushman, M.C. Neel and E. Ene, 2002.** FRAGSTATS: Spatial Pattern Analysis Program for Categorical Maps. Computer software program produced by the authors at the University of Massachusetts, Amherst. <http://www.umass.edu/ landeco/research/fragstats/fragstats.html/> (Accessed 24 January 2008).

**Nagendra H., D.K. Munroe and J. Southworth, 2004.** From pattern to process: landscape fragmentation and the analysis of land use/land cover change. *Agriculture, Ecosystems and Environment*, 101: 111– 115.

**O'Neill R.V., B.T. Milne, M.G. Turner and R.H. Gardner, 1988.** Resource utilisation scales and landscape pattern. *Landscape Ecology,* 2: 63–69.

**Papachristou T.G. and V.P. Papanastasis, 1994.** Forage value of Mediterranean deciduous woody fodder species and its implication to management of silvo-pastoral systems for goats. *Agroforestry Systems,* 27: 269-282.

**Papanastasis V.P., 1989.** Rangeland survey in Greece. *Herba* 2: 17-20.

**Papanastasis V.P., 2004.** Vegetation degradation and land use in agrosilvopastoral systems. In: S. Schnabel and A. Ferreira (eds). Sustainability of Agrosilvopastoral Systems-Dehesas, Montados. *Advances in GeoEcology*, 37: 1-12.

**Sidiropoulou A., 2011.** Analysis and evaluation of agroforestry systems using landscape indicators. PhD thesis. School of Forestry and Natural Environment, Thessaloniki.

**Torquebiau E., 2000.** A renewed perspective on agroforestry concepts and classification Comptes rendus de l'Académie des Sciences. *Life Sciences*, 323: 1009-1017.

**Turner M.G., 1989.** Landscape ecology: the effect of pattern on process. *Annual Review of Ecology, Evolution, and Systematics*, 20: 171-197.

# Land cover temporal evolution in Northeastern Corfu Island.

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## Abstract

This paper explores the possibility of analyzing the diachronical change of land cover and thus grassland transition in Corfu Island through the usage of 18$^{th}$ century Venetian cadastral maps and modern orthophotomaps. GIS software was used to integrate the historical cadastral and modern maps and analyze the impact of physiographic factors of the landscapes, such as altitude, slope and aspect on land cover change. The cadastral maps that were used determined three study areas: the landscapes of Spartillas, Episkepsi and Socraki areas. In 18$^{th}$ century the land cover in all study areas consisted of grasslands, shrublands, agricultural areas and mixed areas, creating diverse heterogenic landscapes. At that time, the impact of aspect proved fairly important, especially at the northern orientated landscapes of Episkepsi and Sokraki areas. Northern aspects in particular, were more likely to be dominated by natural grasslands and shrublands than agricultural land due to the negative effect of the ‘Boras’ local cold wind on agriculture. Venetians had a significant impact on the landscape by the reinforcement of olive groves, which expanded to their biological height limit. That is clearly illustrated in Spartillas landscape evolution to the 20$^{th}$ century, where the expansion of agricultural land (olive groves) took place over the grasslands. Episkepsi area evolved into a homogeneous agricultural landscape of olive groves, while Socraki area turned out to be more diverse. Overall, the methodology that was used in this paper is suitable for investigating long-term land cover changes with sufficient accuracy.

**Key words:** 18$^{th}$ century Venetian cadastral maps, grassland – shrubland, physiographic factors, G.I.S.

## Introduction

A lot of studies of land cover evolution in landscapes are using historical maps as a source for information about land cover in the past, dating from 19$^{th}$ century or earlier (Hamre et al. 2007). In many of these studies, the diachronic land use/ land cover interaction with physical geographical features is also investigated (Cousins 2001, Bender et al. 2005). There are various examples of historical landscape evolution: in some studies the area covered with grasslands increases (Jordan et al. 2005, Hamre et al. 2007) while in others decreases (Cousins 2001, Papanastasis and Chouvardas 2005). Most of the studies that use historical maps in order to analyze landscape evolution refer to Central and Northern Europe and only a few focuses on Mediterranean landscapes. The General State Archives –

Archives of Corfu Prefecture (GSA – ACP 1750) have a considerable coverage of detailed Venetian cadastral maps from 1722 onwards. Furst – Bjelis (2003) analyzed similar Venetian cadastral records and maps of the 18$^{th}$ century as textual and graphic documents in order to describe the cultural landscape of Dalmatia, but without the usage of GIS software advantages.
The aim of this study is (a) to explore the possibility of analyzing the diachronical change of land cover and thus the grassland transition in Corfu Island through the usage of Venetian cadastral maps register from the 18$^{th}$ century and modern orthophotomaps and (b) to survey the impact of physiographic factors of the landscapes, such as altitude, slope and aspect on land cover changes.

**Materials and methods**

Five cadastral maps of the 18$^{th}$ century were used (GSA – ACP 1750) delineating three different feuds of Venetian baronies situated at the northeastern part of the island. Their limits determine in total three corresponding study areas, which constitute the landscapes of Episkepsi (349.12ha), Socraki (147.88ha) and Spartillas (555.19ha) areas. The time spam encased by the Venetian maps ranges from 1744 to 1751. For simplicity reasons 1750 is used throughout the paper as the approximate age of the time layer.

The historical cadastral maps were geometrical corrected by using common ground control points (GCP's) on the modern orthophotomaps. Afterwards, the cadastral maps and a set of modern orthophotomaps were digitized using ArcGIS software, in order to create digital land cover map layers regarding the years 1750 and 1990. Five common land cover categories were recognized between the old cadastral maps and the modern orthophotomaps: (1) agricultural areas, (2) grasslands – shrublands, (3) mixed areas (consisted of cultivated and uncultivated areas), (4) abandoned agricultural areas and (5) other (villages, settlements).

ArcGIS was also implemented in order to analyze the impact of physiographic factors, such as altitude, slope and aspect on land cover change. The physiographic conditions were derived from 3D models of the three landscapes.

**Results and discussion**

The landscape of Episkepsi area (elevation zone from 0 to 480 m) is dominated by medium slopes (38.88%), followed by mild (20.87%) and steep (20.63%) slopes, while flat surfaces prevail (23.67%) followed by northern (15.31%) and northwestern (15.31%) aspects (Figure 1). Due to its variable physiographical conditions the 18$^{th}$ century (1750) land cover structure shows a great variety and spatial diversity, consisting of natural grasslands and shrublands (38.02%), mixed areas (35.58%) and agricultural areas (25.02%). On the contrary, in 1990 the same landscape is dominated by a large homogeneous agriculture area (95.36%) where the limited natural grasslands and shrublands areas (2.07%) are located to the upper and steeper slopes. The Socraki area (Figure 1) is a semi-mountainous landscape (elevation zone from 340 to 465 meters) dominated by medium slopes (30.97%) and mainly northern (24.46%) and flat (23.91%) aspects. In 1750 the area was predominated by mixed areas (69.52%). During the time period (1750 – 1990) there was a substantial increase (249.38%) of grasslands - shrublands and agricultural lands (68.55%) due to the elimination of mixed areas. Furthermore, the observed mixed area elimination was also promoted by a significant amount of abandoned agricultural areas (34.37%) in 1990. The abandonment of agriculture in the area was due to economic and social reasons (Skarlatou 2011). The Spartillas area (Figure 1) is mainly facing southern (34.65%) and flat (21.88%) aspects (elevation zone from 0 to 780 meters). The Spartillas area is dominated by medium (20.94%) or flat (19.83%) slopes, however in the middle of both parts of the area there is a very steep streak called *"Mega Gkremos"* meaning "*Mega escarpment*". In general, a significant increase of agricultural areas (386.60%) took place during the time period (1750 – 1990), mainly by occupying the mixed areas and in a lesser extent grasslands and shrublands.

Venetians had a significant impact on the landscape by reinforcing olive groves, which expanded to their biological height limit (500m at most). According to the registers that came with the Venetian maps, the agricultural land consisted of olive trees planted in a sparse union (10x10m) with vineyards and probably cereals in between them. The number of olive trees almost doubled (74.1%) from 1761 to 2006 resulting in the decrease of Corfiot landscape heterogeneity (Skarlatou 2011). The factor of altitude in regard to olive plantation height limit is clearly illustrated in Spartillas landscape evolution to the 20$^{th}$ century, where the expansion of agricultural land confined grasslands and shrublands at the uppermost parts of the landscape. Furthermore, olive groves expanded almost all over Episkepsi area, while the less favorable for olive planting landscape of Socraki area turned out to be more diverse, occupied by agricultural land, abandoned agricultural land and grasslands - shrublands.

As far as slope factor is concerned, in the $18^{th}$ century landscapes of Episkepsi and Spartillas area, grasslands – shrublands cover developed on the steep upper sections of hill slopes or on the highest flat plateau (over 600m) (Figure 1). In the landscape of Socraki area, the terraces constructed over the hills counterbalanced steep slopes. In 1990 though, agricultural areas develop in steeper surfaces than in 1750 due to the increase (Episkepsi and Spartillas area) or the introduction (Socraki area) of olive trees. The impact of aspect proved fairly important in 1750, especially at the north orientated landscapes of Episkepsi and Sokraki areas, since the northern aspects were more likely to be dominated by natural grasslands and shrublands than agricultural land. The reason was the negative effect of the 'Boras' on agriculture, a local cold wind coming in winter from Andriatic sea. At that time in Spartillas area, where southern aspects prevail, land cover pattern was less interspersed than in the two other landscapes. In modern time (1990), aspect factor was not considered important for landscapes evolution, especially in the areas that olive groves are dominating.

**Conclusions**

The $18^{th}$ century (1750) landscapes of Episkepsi, Socraki and Spartillas areas consist of grasslands, shrublands, agricultural areas and mixed areas, creating diverse heterogenic landscapes. In modern times (1990), the landscapes of Spartillas and Episkepsi areas became less diverse, comprised basically of monoculture of olive groves that were expanded till their biological limit. Only the semi-mountainous landscape of Socraki area partially kept its heterogeneity. Slope factor is counterbalanced by the plantation of olive trees. Aspect factor proved fairly more important in $18^{th}$ century rather than in modern time, since the northern aspects (due to the negative effect of the 'Boras' on agriculture) were more likely to be dominated by natural grasslands and shrublands than agricultural land. Overall, the Venetian cadastral maps can be digitized and analyzed with GIS and give a quite good idea of the landscape in 1750 in Corfu Island. The methodology that is used in this paper is suitable for investigating long-term land cover changes with sufficient accuracy and survey the possible contribution of the physiographic factors to the evolution of the landscape.

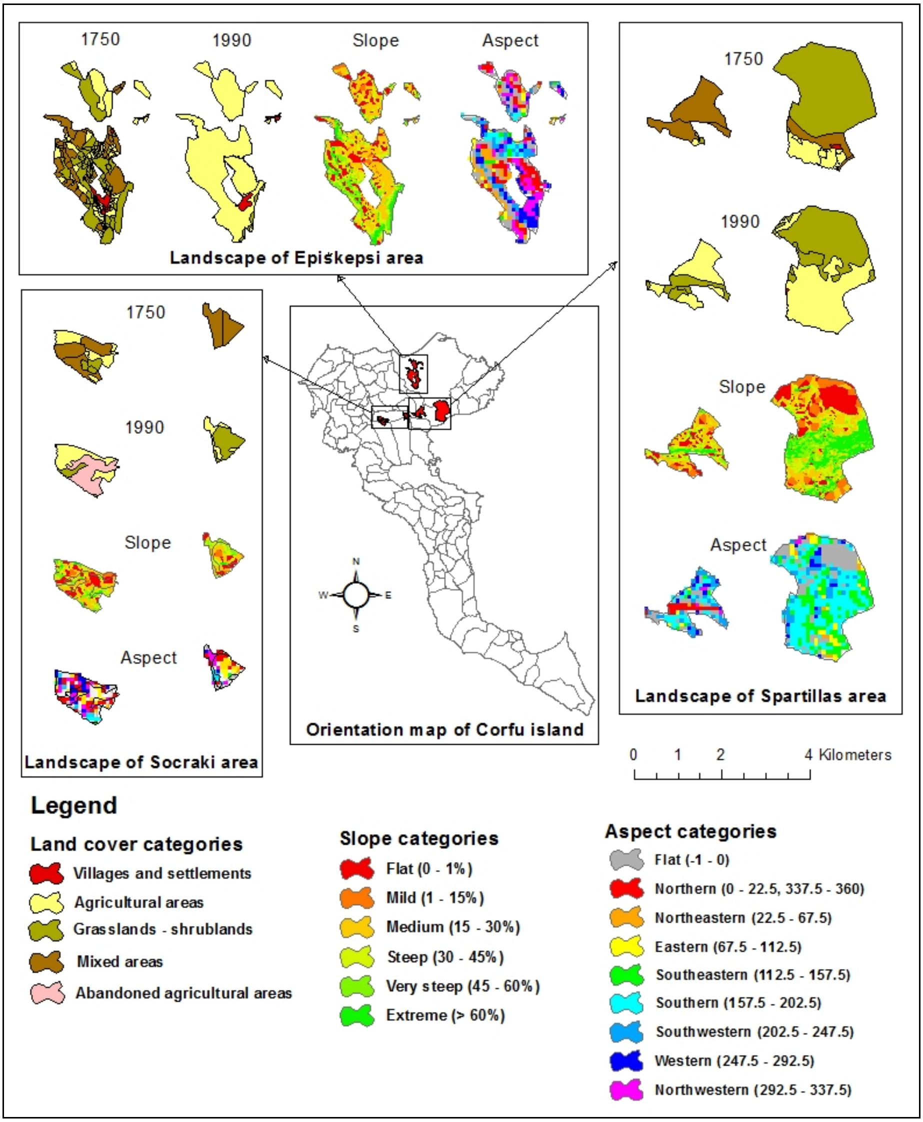


**Figure 1.** Maps of land cover (1750 – 1990), slope and aspect, showing the landscapes of Episkepsi, Socraki and Spartillas areas.

## References

**Bender O., H.J. Boehmer, D. Jens and K.P. Schumacher. 2005.** Analysis of land-use change in a sector of Upper Franconia (Bavaria, Germany) since 1850 using land register records. *Landscape Ecology,* 20:149–163.

**Cousins S.A.O. 2001.** Analysis of land – cover transitions based on 17th and 18th century cadastral maps and aerial photographs*. Landscape Ecology,* 16:41–54.

**Furst – Bjelis B. 2003.** Reading the Venetian Cadastral Record: an evidence for the environment, population and cultural landscape of the 18th century Dalmatia. *Hrvatski Geografski Glasknik,* 56(1):47–62.

**General State Archives – Archives of Prefecture of Corfu (GSA-ACP), Archives of Domestic Administration. 1750.** Files: No 1826 (landscape of Spartillas area), No 1841 - register No 3, No 1827, No 1841 - register No 3 (landscape of Episkepsi area), No 1826 (landscape of Socraki area).

**Hamre L.N., S.T. Domaas, I. Austad and K. Rydgren. 2007.** Land-cover and structural changes in a western Norwegian cultural landscape since 1865, based on an old cadastral map and a field survey. *Landscape ecology,* 22(10):1563-1574.

**Jordan G., A. van Rampaey, P. Szilassi, G. Csillag, C. Mannaerts and T. Woldai. 2005.** Historical land use changes and their impact on sediment fluxes in the Balaton basin (Hungary). *Agriculture, Ecosystems and Environment,* 108:119-133.

**Papanastasis V.P. and D. Chouvardas. 2005.** Application of the state-and-transition approach to conservation management of a grazed Mediterranean landscape in Greece. *Israel Journal of Plant Science,* 53:191–202.

**Skarlatou A. 2011.** The diachronical evolution of cultural landscape of Corfu and its relation to the history of the Island. Aristotle University of Thessaloniki, Doctoral Thesis. 204 pp.

# The attitudes of stakeholders on the management of protected areas: views of the local people and visitors to the Prespa Lakes National Park, Greece

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## Abstract

Protected areas are characterized by great ecological significance, due to the rarity of their fauna and flora, their biodiversity, as well as the geomorphologic formations. The integrated management of such areas requires appropriate planning in order to address any potential problems, which is why the opinions and preferences of visitors have a significant impact on the decisions taken by those responsible for the management of National Parks. The present research was carried out using a structured questionnaire, addressed to the local people and visitors of the Prespa Lakes National Park. Its objective was to examine the attitude of stakeholders regarding the protection - conservation of nature and the development of the region. More specifically, 236 questionnaires were collected from local residents and 400 questionnaires from visitors. The initial results have shown that the locals want the future growth of the region to focus mainly on tourism and agriculture. They believe that the development of the tourism sector will help to improve their financial situation. As regards visitors, they were very satisfied with the natural ecosystems of the area, and the rich fauna and flora; on the other hand, they were totally dissatisfied with the lack of public restrooms.

**Keywords**: visitor survey, protected area management, development, tourism

## Introduction

National Parks are natural areas of great ecological significance and major scientific interest, due to the rare fauna and flora, their biodiversity, the geomorphologic formations, their water, atmosphere and their environment, in general. Their protection from any direct or indirect human intervention is vital, in order to allow nature to evolve undisturbed, according to its laws and under the influence of the abiotic and biotic environment, which does not include humans (Ganatsas et al. 2001).

The integrated management of these areas requires proper handling and the views and preferences of visitors and local inhabitants play an important role in the decisions taken by those responsible for the management of National Parks (Trakolis 2001, Papageorgiou and Kassioumis 2005). The complexity and particular features of the environmental problems that arise from the management of protected areas have identified the processes and methods applied for citizen participation, as key instruments in resolving such problems (Beierle 1999). Thus, the participation of all relevant bodies and stakeholders is essential, in order to ensure that the implemented actions will arrive at the desired results. According to Walpole and Goodwin (2001), obtaining local support in protected areas is a key factor for the conservation of biodiversity. This paper is an attempt to contribute to the management of the Prespa Lakes National Park in an effective manner, by taking into account the views of the local population and visitors regarding the protection - conservation of nature and the development of the area.

**Research methodology**

The present research was carried out using a structured questionnaire, addressed to the local population and visitors of Prespa Lakes National Park. More specifically, simple random sampling was used to collect 236 questionnaires from local inhabitants and 400 questionnaires from visitors. Both research projects were carried out in 2010 using personal interviews and through the aid of structured questionnaires. For data processing, methods from descriptive statistics were used.

**Results and Discussion**

**Views of the local population**

As regards the individual characteristics of the local inhabitants, the majority are women and people over 41 years of age. Concerning their educational level, almost one in two has completed the Lower Secondary School (*Gymnasio*), while one in three is an Higher Secondary School (*Lykeio*) graduate. The majority of the sampleare farmers, fishermen and self-employed professionals, and their annual income is over 8,000 euros. As regards the future development of Prespa region, the locals believe that it should mainly be based on tourism, and lesser on agriculture. In fact, almost nine out of ten consider tourism to be the most promising sector, while over 65% choose agriculture. It is worth noting that the inhabitants are not interested in the development of industry or cottage housing.

**Prohibitions**

The wishes of the local citizens, regarding the activities that should be prohibited in the core of the National Park’s protected area, vary.

**Table 1.** Percentages regarding the local inhabitants' wishes, in relation to the prohibitions that exist in the core and peripheral zone of the protected area

| | Core | | Peripheral Zone | |
|---|---|---|---|---|
| Activity | To be prohibited (%) | Not to be prohibited (%) | To be prohibited (%) | Not to be prohibited (%) |
| 1.Construction of villages – housing | 88.5 | 11.5 | 24.7 | 75.3 |
| 2.Industry | 95.3 | 4.7 | 78.3 | 21.7 |
| 3.Grazing | 64.7 | 35.3 | 21.3 | 78.7 |
| 4.Logging | 88.7 | 12.3 | 41.7 | 58.3 |
| 5.Hunting | 89.4 | 10.6 | 51.9 | 48.1 |
| 6.Animal farming | 71.5 | 28.5 | 17.0 | 83.0 |
| 7.Cutting-uprooting plants | 87.7 | 12.3 | 65.5 | 34.5 |
| 8.Agriculture | 65.5 | 34.5 | 14.0 | 86.0 |
| 9.Fishing | 68.1 | 31.9 | 16.2 | 83.8 |
| 10.Forestry | 57.9 | 42.1 | 14.9 | 85.1 |
| 11.Recreation | 20.0 | 80.0 | 6.0 | 94.0 |

More specifically, almost nine out of ten wish for the following activities to be prohibited: the installation of industries, the construction of housing, logging, hunting, as well as cutting or uprooting plants. On the contrary, a large percentage, approximately 80%, believe that recreation activities should be allowed. As regards their knowledge of the activities that are prohibited in the peripheral zone, the majority of the locals wish for all activities to be allowed except for the installation of industries, cutting plants and hunting (Table 1).

**Tourism development and its impact**

As regards the existence or non-existence of the National Forest, more than nine out of ten citizens express the view that it should continue to exist and that the area should not be declassified. Concerning the reasons for which tourism must be developed, 97% approximately state that it will improve the financial situation of the inhabitants. Seven out of ten observe that if tourism continues and further develops, their culture will improve, and internal and external migration will be prevented. Furthermore, 88% believe that tourism will contribute to the creation of new jobs, and promote construction works in the area.

**Visitors' views**

After an examination of the individual characteristics of the visitors, and more specifically, their gender, we observe that there is a predominance of women (50.8%), and people aged over 30 years. Of those questioned, 31.8% are graduates of technological institutes, and approximately four out of ten are university graduates. Regarding their family status, over half are married, three out of ten are single, and 15.5 % are either widowed or divorced. Finally, concerning their occupation, most are employed in the public sector, while 11% are unemployed or pensioners, and finally, three out of ten are workers, students or housewives.

**Satisfaction, motivation and reasons to visit the National Park**

Visitor satisfaction as regards the National Park area was examined. It was found that approximately half the visitors state that they are satisfied with the area, 22% state they are minimally satisfied, while 3.8% state they are not at all satisfied, possibly because they had a totally different perception of the area. As regards their satisfaction in relation to the characteristics of the area, it is observed by the results that less than half are relatively satisfied with the information and services provided by the inhabitants and local bodies. Several of the visitors are interested in the local fauna and flora when visiting the area. Thus, almost half of them state that they are satisfied with its existence. Furthermore, the roads are a reason for which many people avoid visiting the area, since the results show that four out of ten visitors to the area state that they are not satisfied with their construction and maintenance. As regards tourism infrastructure, 50% of those questioned believe that there is sufficient accommodation available. Since the Prespa National Park is a wetland with rare bird species, visitors are given the opportunity to observe the birds from special infrastructure. Four out of ten visitors state that they are very satisfied with the existence of these observatories. In addition, the Prespa area is a mountainous region with rich flora, which is why it seems that over half are impressed by the natural beauty of the landscape. An important question addressed to the visitors, was also the main reason for which they were visiting the Prespa area. Four out of ten visited the area for cultural events, to eat at a local restaurant, and for recreation purposes. In addition, three out of ten visit the area mainly in order to observe the wildlife and landscape, and for walking in nature. Furthermore, several chose the area for hunting and fishing and, finally, about 10% chose to visit the area for entertainment (Table 2).

**Table 2.** Percentages regarding the main reason for visiting the National Park

| Main reason for visit | Frequency | Percentage (%) |
|---|---|---|
| 1. Entertainment | 39 | 9.8 |
| 2. Recreation | 78 | 19.5 |
| 3. To eat at a local restaurant | 76 | 19.0 |
| 4. Hunting/fishing | 54 | 13.5 |
| 5. Educational | 8 | 2.0 |
| 6. Nature walks | 22 | 5.5 |
| 7. Wildlife and landscape observation | 29 | 7.2 |
| 8. Photography/Video/Painting | 6 | 1.5 |
| 9. Cultural events | 81 | 20.2 |
| 10. Forest and its diversity | 3 | 0.8 |
| 11. Other | 4 | 1.0 |
| Total | 400 | 100 |

**Conclusions**

A study of the views of visitors and of the local inhabitants can serve as a useful tool for those responsible for the policies applied in the region. Such a study becomes more necessary in areas such as the Prespa Lakes National Park, where expected growth must be combined with the conservation of biodiversity. The local residents positively view the characterization of this area as protected, since they are able to attract large numbers of visitors in this way, and improve their financial situation. They wish for the development of agriculture and animal farming to continue. However, the Park's Management Body will have to set up an informative programme for the local population regarding the activities allowed in the various zones of the National Park. Visitors to the area express their satisfaction, mainly because of the rare fauna and flora, which gives them the opportunity to photograph the various species and local landscape. Nevertheless, they believe that the bad state of the roads and lack of public restrooms are factors that discourage people from visiting the area.

## References

**Beierle T.C., 1999.** Using Social Goals to Evaluate Public Participation in Environmental Decisions. *Policy Studies Review,* 16 (3/4): 75-103.

**Ganatsas P., T. Tsitsoni and T. Zagas, 2001.** Forest plant diversity in the Aspropotamos Site (GR 1440001) of the Natura 2000 network. In: Ph. Tsalides, V.A. Tsihrintzis and K. Mountzouridis (eds) Proceedings of Int. Conf. Ecological Protection of the Planet Earth I, Vol. I, pp. 399-407, Xanthi, Greece.

**Papageorgiou K., and K. Kassioumis, 2005.** The National park policy context in Greece-park users' perspectives of issues in park administration. *Journal for Nature Conservation*, 13(4): 231-246.

**Trakolis, D., 2001.** Local people's perceptions of planning and management issues in Prespes Lakes National Park, Greece. *Journal of Environmental Management*, 61: 227-241.

**Walpole M. J. and H. J. Goodwin, 2001.** Local attitudes towards conservation and tourism around Komodo National Park, Indonesia. *Environmental Conservation,* 28(2): 160-166.

# Rangelands and rural development: The case of Evros prefecture

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## Abstract

Rangelands are used in many countries for water supply, cattle – breeding, outdoor recreation and many other purposes related to improvement of life quality. The aim of this paper is the investigation of the attitudes of the local people in a remote rural area concerning the contribution of rangeland resources in the rural development. Our study was conducted with the use of a specially designed questionnaire and it took place in the area of Evros prefecture. The questionnaire included questions concerning items measuring various benefits and contributions in the quality of life by rangelands. The data were analyzed using descriptive statistics and the methodology of confirmatory factor analysis. Our results showed that the latent structure of overall benefits from rangelands is strongly related to three main factors of benefits, with most important being the recreational benefits factor, as viewed by the local people.

**Key words:** rural development, attitudes, confirmatory factor analysis method

## Introduction

Rangelands are essential for many human activities as they provide an important amount of raw material for livestock. Also, they provide water and appropriate habitats for wild flora and fauna. Through appropriate interventions could contribute in the development of recreation activities in a remote rural area (Solomon et al. 2007, Ispikoudis 2010).

Grazing of rangelands by livestock could provide a series of benefits to farmers as they can produce better in quality and quantity animal products and improve their income. Barrows (1990) estimated the high value of rangelands for cattle – breeders in Turkana, North Kenya, by collecting raw materials and other natural resources for their animals during the dry period. Harp et al. (2000) in their study indicated the positive impact of grazing in public rangelands in 7 local communities in Central Idaho, USA. In these communities, cattle–breeding has created a series of economic activities (multifunctionality) around the main economic activity of grazing that are related to the main one and they are dependent to each other. In Turkey, Boz et al. (2005) investigated the contribution of cattle – breeding in the quality of life of local people in Kahramanmaras region, northeastern end of the European part of Turkey. Some of the indirect benefits of cattle – breeding in rangelands are the increase of organic material in the ground due to the natural animal manuring. Through this process farmers can utilize a non productive land which was not available before.

In the current study we investigate the attitudes of the local people in a rural area about the overall benefits from rangelands were recorded and analyzed by applying Confirmatory Factor Analysis method.

**Materials and methods**

To investigate opinion of local community towards rural development through rangeland resources or rangelands we have used the method of personal interviews through a questionnaire. Specifically, the questionnaire included a total of 23 questions from which we use 11 for our research, all of them measured on an ordinal scale. The questions we use were related to possible amenity factors that influence quality of life of the local people (Tsiantikoudis 2011).

The survey was conducted the year 2009. Based on simple random sampling we have completed a total of 385 questionnaires (Tsiantikoudis 2011). We attempt to measure individual overall benefits from rangelands for the data collected by implementing a Confirmatory Factor Analysis (CFA) model.

Factor analysis is a statistical method for finding a small set of unobserved variables (also called latent variables or factors) which can account for the covariance among a larger set of observed variables (manifest variables). Depending on whether one wishes to explore patterns in the data or to test explicitly stated hypotheses, factor analysis is divided into exploratory factor analysis and confirmatory factor analysis, respectively. Confirmatory factor analysis is theory-driven. With CFA it is possible to place meaningful constraints on the factor model, such as setting the effect of one latent variable to equal zero on a subset of the observed variables. The advantage of CFA is that it allows for testing hypotheses about a particular factor structure. There are several statistical packages providing CFA model fitting, such as LISREL (Jöreskog et al. 2003) and Mplus (Muthen and Muthen 2001).

In the current study, CFA is utilized in order to measure individual overall benefits from rangelands for the data collected from local people. Specifically, by utilizing the 11 observed variables, we hypothesize that the overall benefits from rangelands use–as described by the respondents through the set of 11 observed variables–are a realization of three other latent structures expressing dimensions of benefits, specifically the following:

The first one includes the following questions: "Provide good income", "Significant cultural and historical value", "High protective value (floods etc)" and "Enhance the residence of local people" and represents the attitudes of the local people for the possible immaterial values of rangeland resources.

The second one of the three structures is constitute by the following questions: "Increase cattle–breeding activity", "Increase agricultural activity" and "Provide opportunities for the enhancement of organic cattle–breeding". It represents the attitudes of local people for the "enhancement of primary sector" and its benefit.

Finally, the third structure constitutes by the following questions: "Enhance landscape beauty", "Rich flora and fauna", "Provide opportunities for recreation and athletics" and "Contribute to hunting activities". This structure represents local people's attitudes about the recreational benefits of rangeland resources.

Due to the ordinal nature of our data we obtain the model estimates by implementing Weighted Least Squares WLS estimation methodology.

Confirmatory Factor Analysis then was used to test the hypothesized factor structure and to assess its fit to the data through significant tests on each factor loading (Jöreskog and Sörbom 1979). Specifically, we test the validity of our model by using several alternative fit statistics (see, for instance, Marsh and Balla 1994), available by the LISREL software.

## Results and Discussion

In the current section we present the results of the CFA model already described in the previous section. The following Table 1 and Figure 1 presents the observed items used in the CFA model as well as the three latent factors used for the establishment of the overall benefits latent structure.

As one observes from the results, the total benefit of rangeland resources is represented by the aforementioned three structures from which the structure of "recreation benefits" has the highest contribution in the configuration of the overall benefit (0.95). In this structure the most important factors are "Rich flora and fauna" (0.79) and "Provide opportunities for recreation and athletics" (0.78). Second in contribution is the structure of "primary sector benefits" (0.85). In this structure the most important factors are "Opportunities for the enhancement of organic cattle–breeding" (0.78) and "Increase agricultural activities" (0.73). Finally the third important structure in the configuration of the overall benefit is "Immaterial benefits" (0.74) having as most important factors "Enhancement of local peoples residence" (0.81) and "Significant cultural and historical value" (0.70).

**Table 1.** Factors concerning overall benefit and related observed items

| Factor | Questions |
|---|---|
| Possible Immaterial benefits from rangeland use [IMM_BNF] | Provide good income (Q1)<br>Significant cultural and historical value (Q2)<br>Protection value (floods) (Q3)<br>Enhance residence of local people (Q4) |
| Possible benefits from primary sector from rangeland use [PRIM_BFF] | Increase cattle – breeding activities (Q5)<br>Increase agricultural activities (Q6)<br>Provide opportunities for the enhancement of organic cattle–breeding (Q10) |
| Possible recreational benefits from rangeland use [REC_BNF] | Enhance landscape beauty (Q7)<br>Rich flora and fauna (Q8)<br>Provide opportunities for recreation and athletics (Q9)<br>Contribute to hunting activities (Q11) |

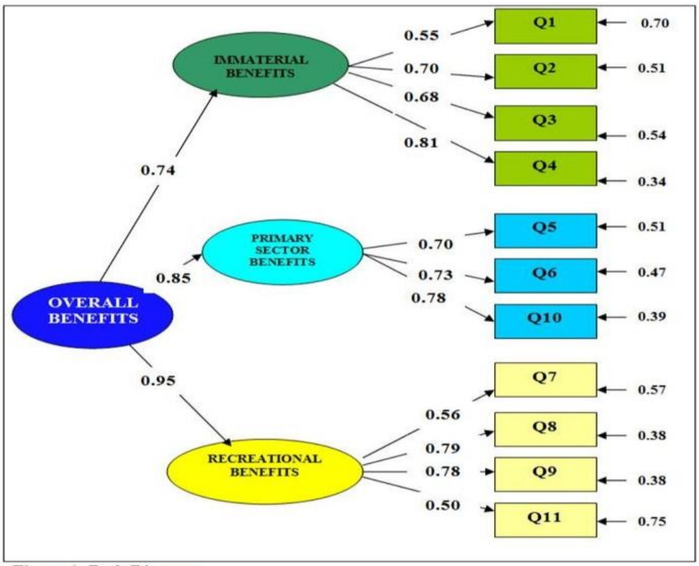


Figure 1. Path Diagram

Table 2 presents goodness-of-fit statistics along with the corresponding boundaries for acceptable model fit for each index in order to summarize results obtained for model fit by goodness of fit indices.

**Table 2.** Fit Indices obtained by LISREL

| Goodness of fit Indices | Index value for the second-order factor model | Accepted boundaries for close fit |
|---|---|---|
| **RMSEA** | 0.1 | 0.00 – 0.06 |
| **GFI** | 0.98 | > 0.90 |
| **AGFI** | 0.97 | > 0.90 |
| **NNFI** | 0.93 | > 0.90 |
| **NFI** | 0.94 | > 0.90 |

As the above results suggest, CFA indicated that the second-order factor model tested provided a good fit to the 11 observed variables.

## Conclusions

CFA method that has been applied in this study is adapted satisfactorily to our data and we can confirm this fact through the high loadings of the factors from every structure and also through the high loading value of the overall benefit structure on the three other factors. Local people of Evros prefecture estimate that the available rangeland resources can provide a series of material and immaterial benefits to their communities.

The implementation of such methods of attitude grouping in a local community provides the opportunity to the decision makers to design and implement concrete developmental policies in a remote rural area for the sustainable management of natural resources, such as rangelands. Through these policies, a local community can be developed, enhance its services and improve standards of living.

## References

**Barrow E., 1990.** Usufruct rights to trees: the role of Ekwar in dryland central Turkana, Kenya. *Human Ecology*, 18(2):163–176.

**Boz I., C. Akbay , G. Jordan and A. Kamalak, 2005.** Measuring Livestock Farmer’s Effect on Sustainable Agricultural and Rural Development. *Livestock Research for Rural Development*, 17(8). ISSN 0121–3784.(http://www.lrrd.org/lrrd17/8/boz17088.htm)

**Harp J.A., R.R. Loucksand N.J. Hawkings, 2000.** Spatial distribution of economic change from Idaho ranches. *Journal of Range Management*, 53(2):164–169.

**Ispikoudis I., 2010.** Livestock farming and quality of life. In: A. Sidiropoulou, K. Mantzanas and I. Ispikoudis (eds). Range Science and Life Quality. Proceedings of the 7th Panhellenic Rangeland Congress, 14–16 October 2010, Xanthi, pp. 3–9 (In Greek with English Abstract).

**Joreskog K.G. and D. Sorbom, 2004.** LISREL 8 User's reference guide. Scientific software international, Lincolnwood, IL.

**Joreskog K.G. and D. Sorbom, 1979.** Advances in factor analysis and structural equation models. New York: University Press of America.

**Marsh H. W. and J.R. Balla, 1994.** Goodness-of-fit in confirmatory factor analysis: The effects of sample size and model parsimony. *Quality and Quantity*, 28:185–217.

**Muthén L. K. and B.O. Muthén, 2001.** Mplus User's Guide (2nd edition). Los Angeles, CA: Muthén & Muthén.

**Solomon T.B., H.A. Snyman, and G.N. Smit, 2007.** Cattle–rangeland management practices and perceptions of pastoralists towards rangeland degradation in the Borana Zone of Southern Ethiopia. *Journal of Environmental Management*, 82(4):481–494.

**Tsiantikoudis S.Ch., 2011.** Economic analysis and valuation of the contribution of natural resources in regional development: Theoretical and empirical examination. Doctoral dissertation. Department of Forestry and Management of the Environment and Natural Resources, Democritus University of Thrace, Orestiada, Greece. p. 435 + annex.

# Pluriactivity and professionalism in buffalo farming system of a High Nature Value farming area in northern Greece

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## Abstract

The relation of pluriactivity and professionalism with the buffalo (*Bubalus bubalis*) farming system was investigated based on statistical analysis of standardized questionnaires and in-depth interviews conducted at the Municipalities of Sintiki and Irakleia, Serres in northern Greece during 2011. In this NATURA 2000 area, 2492 buffaloes (80% of the whole country's buffalo population) are raised. The data was processed by Pearson test ($p \leq 0.05$). In this paper, a distinction between complementary and total pluriactivity is proposed. It was found that buffalo breeders who are not oriented to milk production seem to have enough time to invest in agriculture (-0.540). The implementation of other husbandry -namely goat or sheep breeding simultaneous to buffalo- appears to be compatible with any other activity. Commerce (marketing of buffalo products to end users) tends to be encouraged by the use of agricultural land (for the establishment of temporary pastures and fields that are grazed by buffaloes after crop harvesting during summer) for buffalo breeding (0.555). Agriculture strongly appears to be an alternative occupation (0.789), while commerce seems to be incompatible with professionalism (-0.471). Breeders who feel "professionals" are mainly family employees (0.491) with a long family tradition (0.553). Professionalism does not become weaker in case of small buffalo herds or in case of simultaneous sheep breeding, but only in case of simultaneous breeding of goats (-0.540). The ownership status of agricultural land used for buffalo breeding does not seem to influence professionalism.

**Key words:** Buffalo production system, alternative activities, Natura 2000

## Introduction

Buffaloes (*Bubalus bubalis*) have been an integral part of livestock agriculture in Greece from the beginning of 20th century. Due to the mechanisation and intensification of agricultural production and also to the substitution of buffalo milk by milk produced by imported-improved dairy cattle, the number of buffaloes has been dramatically decreased during the last decades. Specifically, from the 70000 animals counted at the end of 50s, today only 3128 heads remain (CLGI 2011). The majority of this population, 2520 heads, is concentrated in the Municipalities of Sintiki and Irakleia, Serres, in northern Greece. Moreover, this area belongs to NATURA 2000 and is categorized in High Nature Value farming areas according to

IRENA-Indicator No. 26. For these reasons the area was selected to be studied.

The buffalo farming system is based on the utilization of rangelands and reflects more or less the sedentary extensive system of small ruminants, which has already been described by Yiakoulaki et al. (2003) and Evangelou et al. (2008). Under this system the animals have a permanent base, usually located near the farmer's village, from where they move every morning to rangelands and return at night. Buffaloes graze in rangelands for 6-7 months but they also utilize alternative forage resources, including temporary pastures of annual winter cereals during early spring and crop residues during summer-early autumn (Tsiobani et al. 2012). In addition, farmers make extensive use of purchased feedstuffs, mainly roughage and concentrates, during the entire period of the year. Buffalo herds are pure and they are permanently herded. They are raised for milk and meat purposes (Georgoudis et al. 1998). Milk is used for the production of cream, cheese, butter and yoghurt while meat and its products (minced meat, burgers, sausages and «kavourmas») reaches the end users at butcher shops, local or not.

Pluriactivity is a term commonly used across Europe and is defined as the phenomenon of farmers to have another gainful activity that can be a diversification of the holding or an activity not related to the farm that can take place on or off the farm (Evans and Ilbery 1993).

Professionalism has been defined as the perception of buffalo breeding as main occupation. This definition of professionalism as a feeling constitutes the most acceptable (or the least vulnerable) approach as any possible socio-technical dimension of such a notion may always be considered as inadequate (Paddock 1986). In general, data concerning pluriactivity and professionalism of livestock farming in Greece are very limited and there is no data about buffalo breeders. Such knowledge is an important tool for land managers and policy makers to promote an integrated sustainable development of the rural areas.

In this paper, the relation of pluriactivity and professionalism with the buffalo farming system was investigated in the Municipalities of Sintiki and Irakleia, Serres, in northern Greece.

## Materials and methods

The research was conducted with all breeders at 8 districts of Sintiki's Municipality and 2 districts of Irakleia's Municipality, Serres, in northern Greece during 2011. The climate of the area is characterized by dry-hot summer and cold winter. Mean annual precipitation is 450 mm and mean annual temperature is 15°C. The dominant woody species are *Fagus sylvatica*, *Acer monspessulanum*, *Quercus coccifera*, *Paliurus spina-christi*, *Carpinus orientalis*, *Phillyrea latifolia*, while the most common herbaceous species are *Chrysopogon gryllus*, *Briza media*, *Bromus arvensis*, *Lathyrus laxiflorus*, *Genista carinalis* and *Lotus angustifolius.*

The study was based on standardized questionnaires and in-depth interviews with the census population (N=17) of buffalo breeders of the area (Bryman 2001). The questions concerned the farms' and farmers' characteristics and the other entrepreneurial activities. The data was processed by Pearson test ($p \leq 0.05$).

As the present research has a more specific focus on buffalo farming system, it is purposeful to define pluriactivity at intra-farm or directly farm-related level. Therefore, pluriactivity has been more specifically operationalized as follows: a) "complementary pluriactivity" refers to buffalo breeding independent of whether it is exercised as main occupation and is defined as the number of the other entrepreneurial activities, such as agriculture, other husbandry –namely goat or sheep breeding simultaneous to buffalo– and commerce of buffalo products to end users, b) "total pluriactivity" is the number of entrepreneurial activities mentioned above plus buffalo breeding as main occupation.

**Results and Discussion**

As presented in Table 1, in the case of complementary pluriactivity, the other husbandry seems to be slightly more preferable (0.708) than the other components (agriculture and commerce of buffalo products to end users) which appear to be of similar importance (0.594 and 0.523, respectively). On the contrary, in the case of total pluriactivity, agriculture and other husbandry seem to be of similar importance (0.683 and 0.646), while commerce has no significance (0.280). This is understandable provided that agriculture and other husbandry as well as buffalo breeding as main occupation are markedly time consuming and profitable. Thus, they do not encourage the commerce of buffalo products to end users. The private ownership status of agricultural land, used for the establishment of temporary pastures and fields that are grazed by buffaloes after crop harvesting during summer, tends to enhance the development of commerce of buffalo products (0.555).

Agriculture is mainly considered to be an alternative occupation (0.789) and buffalo breeders who are not oriented to milk production (-0.540) seem to have enough time to invest in agriculture.

**Table 1.** Dimensions of pluriactivity in buffalo farming system in northern Greece

| | Exercising agriculture (no=0, yes=1) | | Exercising other husbandry (no=0, yes=1) | | Exercising commerce (no=0, yes=1) | |
|---|---|---|---|---|---|---|
| | Pearson coefficient | Sign. | Pearson coefficient | Sign. | Pearson coefficient | Sign. |
| Complementary pluriactivity (cp: fluctuating between 0 to 3) [apart from buffalo breeding, cp is defined as cp = agriculture (no=0, yes=1)+other husbandry (no=0, yes=1) + commerce (no=0, yes=1)] | 0.594(*) | 0.012 | 0.708(**) | 0.001 | 0.523(*) | 0.031 |
| Total pluriactivity (tp: fluctuating between 1 to 4) [tp= cp + buffalo breeding as main occupation (no=0, yes=1)] | 0.683(**) | 0.003 | 0.646(**) | 0.005 | 0.280 | 0.277 |
| Using private agricultural land (no=0, yes=1) | -0.040 | 0.879 | 0.251 | 0.332 | 0.555(*) | 0.021 |
| Exercising alternative occupation (no=0, yes=1) | 0.789(**) | 0.000 | 0.203 | 0.436 | 0.203 | 0.436 |
| Developing buffalo milk production (no=0, yes=1) | -0.540(*) | 0.025 | -0.139 | 0.596 | 0.451 | 0.069 |

* Correlation is significant at the 0.05 level (2-tailed) ** Correlation is significant at the 0.01 level (2-tailed)

In Table 2, the number of buffaloes is irrelevant (0.370 insign.) to the feeling of professionalism for buffalo breeders, though it would be expected to be an important quantitative determinant. Furthermore, the simultaneous sheep breeding does not contradict to the development of feeling of professionalism in buffalo breeding (-0.430 insign.). However, buffalo breeders who simultaneously keep goat flocks, seem to feel less professional in buffalo breeding (-0.540). This finding can be attributed to the higher net income that goats provide to the farmers compared to sheep

(Kitsopanidis et al. 2009). The ownership status of agricultural land (private or rented) used for buffalo breeding does not seem to influence professionalism.

**Table 2.** Determinants of professionalism in buffalo farming system in northern Greece

| | Professionalism | |
|---|---|---|
| | Pearson coefficient | Significance |
| Farm characteristics | | |
| Number of buffaloes (from 21 to 467) | 0.370 | 0.144 |
| Number of sheep (from 0 to 480) | -0.430 | 0.085 |
| Number of goats (from 0 to 20) | -0.540 (*) | 0.025 |
| Rented agricultural land (no=0, yes=1) | 0.387 | 0.125 |
| Private agricultural land (no=0, yes=1) | -0.378 | 0.134 |
| Farmer characteristics | | |
| Number of family employees (from 1 to 2) | 0.491 (*) | 0.045 |
| Family tradition (Number of breeders' generations fluctuating from 1 to 4) | 0.553 (*) | 0.021 |
| Personal initiative (no=0, yes=1) | -0.627 (**) | 0.007 |
| Other entrepreneurial activities | | |
| Agriculture (no=0, yes=1) | 0.190 | 0.464 |
| Commerce (no=0, yes=1) | -0.471 (*) | 0.056 |

* Correlation is significant at the 0.05 level (2-tailed) ** Correlation is significant at the 0.01 level (2-tailed)

The number of family employees (0.491) as well as the family tradition in buffalo breeding (0.553) seems to strengthen the perception of buffalo breeders as main occupation. On the contrary, those who have started this activity by personal initiative can hardly perceive it as main occupation (-0.627). Thus, the feeling of professionalism is inspired by family rather than developed by personal interest.

Agriculture seems to be compatible with buffalo breeding (0.190 insign.), while buffalo breeders who deal with commerce can not consider themselves (-0.471) as pure breeders.

## Conclusions

In this paper a distinction between total and complementary pluriactivity is proposed depending on including (or not) buffalo breeding as main occupation. Particularly, complementary pluriactivity seems to encourage the development of commerce, in contrast to total pluriactivity which appears to prevent it. In other words, the strict commitment to buffalo breeding as main occupation is a restriction rather than a basis for a sound entrepreneurial extension and effective diversification of rural economic activities.

Concerning professionalism feeling, it is noticeable that the number of buffaloes is irrelevant to this. Therefore, qualitative parameters seem to be more important than quantitative ones. Detecting these qualitative parameters is a question for future research.

## References

**Bryman, A. 2001.** Social Research Methods. Oxford University Press. 540 pp.

CLGI. 2011. Centre for Livestock Genetic Improvement of Nea Mesimvria. Thessaloniki, Greece. (in Greek).

**Evangelou, Ch., M.D. Yiakoulaki and V.P. Papanastasis. 2008.** Evaluation of sheep and goats breeding system and the subsidies paid in Askos village community of Lagadas county, Prefecture of Thessaloniki. Proceedings of the 6th National Conference on Rangelands (Range Science and Protected Areas). Leonidio, Arcadia, Peloponnesus, Greece, pp. 179-185. (in Greek with English summary).

**Evans, N.J. and B.W. Ilbery. 1993.** Pluriactivity, Part-time Farming and Diversification Debate. *Environment and Planning*, 25.

**Georgoudis, A.G., V.P. Papanastasis and J.G. Boyazoglu. 1998.** Use of Water Buffalo for Environmental Conservation of Waterland. Proceedings of the 8th World Conference on Animal Production, June 28 - July 4, 1998, Seoul, Korea.

**Kitsopanidis, G., M. Zioganas, E. Derva and V.P. Papanastasis. 2009.** Profitability of sheep and goat husbandry in the County of Lagadas prefecture of Thessaloniki. *Georgia-Ktinotrofia,* 3: 60-70. (in Greek).

**Paddock, C.E. 1986.** A critical view of factors affecting successful application of normative and socio-technical systems development approaches. *Information & Management*. 10(1): 49-57.

**Tsiobani, E., M.D. Yiakoulaki, N. Hasanagas, and K. Papanikolaou. 2012.** Evaluation of buffalo production system in the area of Lake Kerkini, Nothern Greece. Scientific Meeting of the Hellenic Society of Animal Science, Trikala, Greece, 3-5 October (in Greek).

**Yiakoulaki, M.D., M.P. Zarovali, I. Ispikoudis and V.P. Papanastasis. 2003.** Evaluation of small ruminant production systems in the area of Lagadas County. Proceedings of the 3rd Panhellenic Rangeland Congress “Range Science and Development of Mountainous Regions”, 395-402. Karpenisi (Greece). (in Greek with English summary).

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