# Changes in biodiversity composition and soil nutrient content with management in a Pyrenean grassland community

Ribas A.[1,2], Llurba R.[1], Ventura D.[1], Hodge A.[3] and Sebastià M.-T.[1,4]
[1] *Centre Tecnològic Forestal de Catalunya, Cra. de Sant Llorenç km 2, 25280 Solsona*
[2] *BABVE, Universitat Autònoma of Barcelona, 08193 Bellaterra*
[3] *Department of Biology, University of York*
[4] *ETSEA-Universitat de Lleida, 25198 Lleida*
Corresponding author: angela.ribas@ctfc.es

**Abstract**

We investigated the influence of livestock type on vegetation and biogeochemical cycling in grasslands with the objective of describing differences between agropastoral systems experiencing different managements from a trophic perspective. We sampled grassland plots in the Pyrenees of which four were grazed by sheep and four by cattle. We defined three patch types, based on the specific and functional plant composition: Legume-dominated (mostly by *Lotus corniculatus*); Grass-dominated (mainly by either *Festuca nigrescens* or *Nardus stricta*); and Forb-diverse (with *Myosotis sylvatica* and a diversity of other species). We sampled both above- and below-ground to obtain information about vegetation, roots (including mycorrhiza colonization) and soil nutrients. The above- and belowground plant biomass depended upon functional components of the patch and on grazing management. Plant allocation to green and dead matter changed between management types. Further, differences in grassland vegetation composition between cattle- and sheep-grazed areas found in previous studies were also confirmed. Higher P and $NO_3$ concentrations in cattle-grazed areas suggest eutrophication under this management, linked with lower mycorrhizal colonisation. Our results therefore confirm patterns in previous studies and provide a deeper insight into the mechanisms of biotic differentiation and biogeochemical processes associated with differences in grazing management.

Keywords: above-belowground system, carbon and nitrogen concentrations, functional diversity, land use changes, mycorrhizal colonization, patch scale.

## Introduction

Management regime of pastures influences soil C storage and, as has been observed previously, this effect can take place due to changes in plant species composition (Reeder and Schuman, 2002; Sebastià *et al.*, 2008) in addition to other factors. Studies suggest that changes in the pastoral management, such as grazing pressure, determine changes in the vegetation and functional groups' distribution of plants with specific attributes (de Bello *et al*., 2005), which leads to variations in carbon distribution among soil compartments (Casals *et al*., 2004). In addition, faecal-N incorporation associated with grazing has a recognized role in nutrient dynamics within the system (Bardgett *et al.*, 1998). Further, changes in herbivory may have an effect through two different processes mediated by the plant community, namely: 1) through changes in the plant community composition which in turn will affect the quality and quantity of the litter incorporated into the soil, as previously mentioned; and 2) through plant physiological changes associated with herbivory, including changes in C allocation patterns (Bardgett *et al.*, 1998). In this context, we wished to investigate how changes in herbivory behaviour may affect grassland ecosystems and the possible mechanisms associated with these changes, including interactions between the above- and

below-ground compartments and the subsequent impact upon nutrient cycles, by comparing grasslands under different management regimes.

## Material and methods

Eight plots were established in two neighbouring but differently managed grassland areas in the Pyrenees (1860-1950 m a.s.l.; 1º58' E, 42º19' N): four plots were grazed by sheep and four were grazed by cattle. Stocking rates were equivalent and the grasslands were pastured during summer. In each one of these plots we defined different patches based on specific and functional characterization of the plant community. Three types of patches were defined: 1) patches dominated by legume species (L), in particular by *Lotus corniculatus*; 2) patches dominated by grass species (G), including *Avenula pratensis*, *Agrostis capillaris*, *Festuca nigrescens*, *Koeleria macrantha*, *Poa bulbosa*, *Deschampsia flexuosa* or *Nardus stricta*; and 3) diverse patches (D), characterized by the presence *Myosotis sylvatica* ssp *alpestris*, in combination with other forbs, grass and legume species. At the patch scale, we sampled both above- and below-ground to obtain information about vegetation, roots, mycorrhizal colonisation and soil nutrients. Three neighbouring 5 x 5 cm core probes were introduced in the soil, in every patch dominated by each one of the species in each plot, and the first 10 cm of belowground material were collected. Aboveground biomass was determined in each of the three cores. In addition, one core was used to determine belowground biomass at 0-5 cm and 5-10 cm depth, the second core was used to analyze soil nutrient content and the third core was transported to the University of York for assessment of percentage of arbuscular mycorrhiza colonization (%RLC).

A split-plot model analysis was used to test for differences between treatments, including plot, management as main plot and patch type, representing Plant Functional type (PFT), as factors in the model. Detrended correspondence analysis (DCA) was used to compare vegetation characteristics among the patches.

## Results and discussion

Grass-dominated patches showed the highest differentiation between grazing managements, as found by Sebastià *et al.* (2008), with *Nardus stricta* and *Deschampsia flexuosa* showing a higher contribution in sheep grazed areas. Above- and below-ground responses of plant biomass depended upon functional components of the patches and on grazing management. Plant allocation to green and dead matter changed between the cattle and sheep grazing regimes (Figure 1). Statistically significant responses were found for aboveground biomass (Management x Plant Functional Type (PFT) $P = 0.03$). There was a tendency for soil carbon concentration to be higher in cattle grazed (mean value 12.5±0.49) than in sheep grazed areas (10.1±0.49, $P$=0.06). Similar results were found in carbon organic content. In addition, N (1.02±0.04 vs. 0.86±0.04) and P content (21.4±1.8 vs. 12.3±1.8) also tended to be higher in cattle-grazed than in sheep grazed areas. Grasses from sheep grazed areas showed a tendency to be more heavily colonized by arbuscular mycorrhizae than grasses from cattle-grazed areas (47.8±8.2 vs. 24.7±8.2). This tendency was not found for other patch types.

The differences found in plant biomass allocation between managements and the tendency towards eutrophication in cattle-grazed grasslands, with higher P and $NO_3$ concentrations, in addition to the lower mycorrhizal colonisation in those areas, suggest that ecophysiological processes are acting at the patch scale. The divergence in vegetation between the two differently managed areas found in this study (notably the increased proportion of *Nardus stricta* in the sheep-grazed grasslands), agree with those previously reported by Sebastià *et al.* (2008) at a larger sampling scale.

## Conclusions

These results therefore suggest that current changes in the Pyrenees such as the replacement of sheep- by cattle-grazing, could drive important changes in plant community structure and nutrient cycling in these grassland ecosystems.

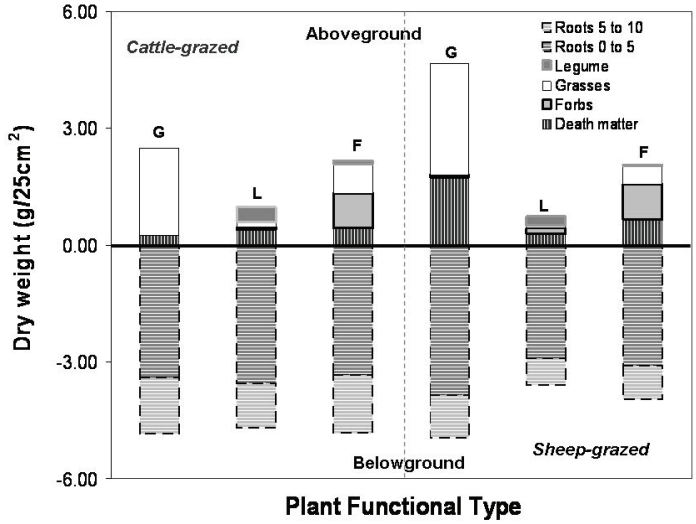


Figure 1. Plant biomass allocation per functional component, plant functional type (G=grasses, L=legume, and D=diverse) and management. These values correspond to biomass obtained from cores.


## Acknowledgements

This work was supported by the CARBOAGROPAS (CGL2006-13555-C03-01/BOS) and the OBAMA (CGL2009-13425-C02-01 /BOS) projects from the Spanish Ministry of Education and Science, and Consolider-Ingenio Montes SD2008-00040.


## References


Bardgett R.D., Wardle D.A. and Yeates G.W. (1998) Linking above-ground and below-ground interactions: how plant responses to foliar herbivory influence soil organisms. *Soil Biology and Biochemistry* 30, 1867-1878.

Casals P., Garcia-Pausas J., Romanyà J., Camarero L.l., Sanz M.J. and Sebastià M.T. (2004) Effects of livestock management on carbon stocks and fluxes in grassland ecosystems in the Pyrenees. *Grassland Sciences in Europe* 9, 136-138.

de Bello F., Leps J. and Sebastià M.-T. (2005) Predictive value of plant traits to grazing along a climatic gradient in the Mediterranean. *Journal of Applied Ecology* 42, 824–833.

Reeder J.D. and Schuman G.E. (2002) Influence of livestock grazing on C in semi-arid mixed-grass and short-grass rangelands. *Environmental Pollution* 116, 457-463.

Sebastià M.T., de Bello F., Puig L. and Taull M. (2008) Grazing as a factor structuring grasslands in the Pyrenees. *Applied Vegetation Science* 11(2), 215-222.