



12th European Heathland Workshop

12th-18th June 2011 Spain-Portugal

Southern European Heathlands – diverse landscapes under global change



Held at the Faculty of Biological and Environmental Sciences, University of León (Spain) and at the University of Trás-os-Montes e Alto Douro (Portugal) - <http://tehw.unileon.es>

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León, June 2011

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PREFACE

Heathlands in the north of the Iberian Peninsula (Spain and Portugal) represent the southernmost limit of this vegetation type in Europe. They occur in areas with both, Atlantic and Mediterranean climate, as well as in transitional zones, resulting in the most diverse heathlands in Europe, both in terms of their flora and their fauna.

Among the vegetation communities occurring along the north-south transition it is worth highlighting:

- The coastal heathlands and alpine and boreal heathlands (Habitats Directive code 4060) with *Juniperus communis*, *Vaccinium myrtillus*, *V. uliginosum* and *Calluna vulgaris*;
- Orocantabrian heathlands where *Erica australis*, *Pterospartium tridentatum* and *Daboecia catabrica* are co-dominant; and those dominated mainly by *Erica australis* (Habitats Directive code 4030);
- Endemic Oro-Mediterranean heathlands with *Genista hispanica* on calcareous soils (Habitats Directive code 4090) and *Genista florida* and *Genista obtusiramea* on siliceous soils;
- Mountain *Cytisus purgans* formation occurring within siliceous soils, which frequently occur together with another endemic *Genista* sp. (Habitats Directive code 5120);
- Temperate Atlantic Wet heaths with *Erica ciliaris* and *Erica tetralix* (Habitats Directive code 4020) are found at higher altitude and wetter areas.

The great variety of climatic, edaphic and geological conditions in this area results in the presence of numerous endemic species, many of which are currently in danger of extinction. Therefore the whole of the Cantabrian Mountains are considered internationally as a hot-spot for conservation, for heathlands and other vegetation types and for the endangered fauna associated with them.

Most heathlands and shrublands are linked to human activities in a direct or indirect way, mainly through the creation and use of large areas as extensive grazing lands. Historically, this activity had a great importance in the Iberian Peninsula, with transhumant livestock being a major economical activity for centuries at national level. Economical and cultural changes in time led to the reduction in importance of this activity which in turn resulted in important modifications in the distribution of shrub communities. Many of them increased in extent at the expense of grasslands, but others have become afforested as a result of natural succession to birch and oak forests.

In the current context of global change, heathlands in this geographical area are threatened by the abandonment of traditional management of rural areas; the increasing number and extent of wildfires; nitrogen deposition on naturally nutrient poor soils; increased afforestation with conifers and other disturbances on habitats which are considered of priority importance for conservation at European level. Political and technical intervention is therefore required at all levels, from local to national and European.

When identifying the required management strategies it is fundamental to take into account the current condition of these vegetation communities and the ecological, economical and social factors which led to it. We also need to know the potential impacts of our management choices on the ecosystem functions and services provided by these habitats.

One of the main objectives of the 12th European Heathland Workshop is to bring together a large number of experts on the ecology and management of heathlands from Portugal, Spain, France, Belgium, the Netherlands, Germany, Poland, UK, Norway, Denmark and Finland to discuss the ecological bases and management models within the framework of global change to conserve these ecosystems across Europe for the future.

Leonor Calvo
University of León (Dpt. of Biodiversity and Environmental Management)

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WORKSHOP PROGRAMME

■ **Sunday June 12 – Arrival - Avilés (Spain)**

Arrival of delegates in Avilés (Asturias)

17.00h: Workshop registration desk will be open at “Hotel Luzana” in Avilés

19.00h: Optional guided visit to Avilés (departure from Ayuntamiento de Avilés)

21.00h: Dinner at “Hotel Luzana” in Avilés

Stay overnight at “Hotel Luzana” in Avilés

■ **Monday June 13 – Full day excursion - Cabo Peñas and San Isidro (Spain)**

07.30-08.20h: Breakfast at “Hotel Luzana” in Avilés

08.30h: Departure by bus from Avilés (“Hotel Luzana”) to Cabo Peñas (Asturias)

09.00-10.30h: Visit to the coastal heathlands of Cabo Peñas
Welcome and introduction by Leonor Calvo (Organizing Committee)
Presentation of the coastal heathlands of Cabo Peñas (Asturias) by María Luisa Vera and Álvaro Bueno (University of Oviedo)

10.30h: Departure by bus from Cabo Peñas (Asturias) to San Isidro (León)
Presentation of the heathland management practices developed in the northern slope of the Cantabrian mountain range (Asturias) by Rocío Rosa, Rafael Celaya and Koldo Osoro (SERIDA)

13.30-14.00h: Lunch time in the field - San Isidro (packed meal)

14.00-18.00h: Visit to the research heathland areas in “San Isidro”, southern slope of the Cantabrian mountain range (León)
Presentation of ongoing research on the vegetation, soil and arthropod fauna of these heathlands by Leonor Calvo, Elena Marcos, Luz Valbuena and David Cuesta-Segura (University of León) and Borja Jiménez-Alfaro (University of Oviedo). There will also be a presentation of the historical evolution of the livestock husbandry in these heathlands

18.00h: Departure by bus from San Isidro to León city (approximate arrival time 20.00h)

21.30h: Dinner at the “Hotel Infantas de León”

Stay overnight at “Hotel Infantas de León”/” Hotel Aparthotel Campus San Mames” in León

■ **Tuesday June 14 – Full day workshop - Faculty of Biological and Environmental Sciences of the University of León, León (Spain)**

07.30-08.30h: Breakfast at “Hotel Infantas de León”/”Hotel Aparthotel Campus San Mames” in León

09.00h: *Poster placement*

09.30-10.00h: Official opening of the workshop

10.00-11.00h: Session 1 (Oral presentations) - *Heathlands: Anthropogenic Landscapes*

11.00-11.20h: Coffee break

11.20-12.00h: Session 1 (Poster presentations) - *Heathlands: Anthropogenic Landscapes*

12.00-13.00h: Session 2 (Oral presentations) - *The future of heathlands under global change*

13.00-14.30h: Lunch at the Cafetería of the University of León

14.30-15.00h: Session 2 (Poster presentations) - *The future of heathlands under global change*

15.00-17.00h: Session 3 (Oral presentations) - *The future of heathlands under global change*

17.00-17.20h: Coffee break

17.20-18.00h: Session 3 (Poster presentations) - *Heathland management and restoration: a key to maintain biodiversity*

19.00-20.30h: Guided visit to León (departing from “Hotel Infantas de León”/” Hotel Aparthotel Campus San Mames”)

21.00h: Departure by bus from San Marcos Parador to Quintana de Raneros (León)

21.30h: Dinner in a wine cellar (Bodega-Restaurante El Cercao) in Quintana de Raneros

Stay overnight at “Hotel Infantas de León”/” Hotel Aparthotel Campus San Mames” in León

■ **Wednesday June 15 – Full day excursion - Babia (León, Spain)**

07.30-08.30h: Breakfast at “Hotel Infantas de León”/” Hotel Aparthotel Campus San Mames” in León

08.30h: Departure by bus from León (“Hotel Infantas de León”/” Hotel Aparthotel Campus San Mames”) to Torrestío (Babia)

10.30-18.00h: Visit to the research heathland areas in “Torrestío” and “La Majúa” (Babia)

Walk through the heathland transhumant areas

Presentation of the traditional transhumant activities developed in these heathlands, and the geological aspects and vegetation of the area by Javier Ezquerro and Froilán Sevilla (Regional Government of Castilla and León), Manuel Rodríguez (Estación Agrícola Experimental, CSIC, León) and Ignacio Prieto (University of León)

Presentation of the role of transhumance practices on the conservation of vultures by Pedro Pérez Olea and Patricia Mateo-Tomás (IE University)

Visit to fossil site

13.00-14.00h: Lunch time in the field - Torrestío (packed meal)

Presentation of the future of traditional transhumant activities in the area by Javier Ezquerro (Regional Government of Castilla and León)

Presentation of ongoing research on the habitat assessment of the endangered heath tiger beetle by Angela Taboada (University of Lüneburg - University of León)

Discussion in the field of the management policies for heathland conservation included in the Habitat 2000- Rural development in the south of the Cantabrian mountain range

18.00h: Departure by bus from Torrestío to León city (approximate arrival time 20.00h)

21.30h: Dinner at “Hotel Infantas de León” in León

Stay overnight at “Hotel Infantas de León”/“Hotel Hotel Aparthotel Campus San Mames” in León

■ **Thursday June 16 – Transfer to Portugal and half-day workshop (“City Hall Auditorium”) - Montalegre (Portugal)**

08.00-09.00h: Breakfast at “Hotel Infantas de León”/“ Hotel Aparthotel Campus San Mames” in León

09.00h: Departure by bus from León (“Hotel Infantas de León”/“ Hotel Aparthotel Campus San Mames”) to Montalegre (approximate arrival local time 12.00h)
(Coffee break at Puebla de Sanabria)

12.30-14.00h: Lunch at “Hotel Quality Inn Montalegre” in Montalegre (Portugal)

14.00h: *Poster placement*

14.30-15.30h: Visit to the Ecomuseu de Barroso (in the way to the Pavilhão Multiusos/City Hall Auditorium, close to the Castle, Montalegre). Departure by foot from “Hotel Quality Inn Montalegre”

15.30-16.00h: *Welcome and introduction to the Montalegre Municipality and the National Park Peneda-Gerês*

16.00-17.20h: *Session 4 (Oral presentations) -- Heathland management and restoration: a key to maintain biodiversity*

17.20-17.40h: Coffee break

17.40-18.05h: *Session 4 (Poster presentations) - Heathland management and restoration: a key to maintain biodiversity and Burning - effective heathland management tool?*

18.10-19.50h: *Session 5 (Oral presentations) - Burning - effective heathland management tool?*

21.00h: Dinner at “Hotel Quality Inn Montalegre” in Montalegre

Staying overnight at “Hotel Quality Inn Montalegre” in Montalegre

■ **Friday June 17 – Full day excursion - National Park Peneda-Gerês (Portugal)**

07.30-08.45h: Breakfast at “Hotel Quality Inn Montalegre” in Montalegre

09.00h: Departure by bus from Montalegre (“Hotel Quality Inn Montalegre”) to the National Park Peneda-Gerês

09.30-19.00h: Visit to the National Park Peneda-Gerês
Presentation of the National Park Peneda-Gerês by Hermínio da Silva (University of Trás-os-Montes e Alto Douro) and Lucia Jorge (Secretariado dos Baldios de Trás-os-Montes e Alto Douro)

Visit to the areas of the ongoing project of peat-bog restoration in Mourela

Visit to the Mosteiro de Santa Maria de Júnias in Pitões das Júnias (Montalegre)

13.00-14.30h: Lunch at the restaurant Casa do Preto in Pitões das Júnias

Visit to the village of Pitões das Júnias and the Ecomuseu de Barroso in Pitões das Júnias. There will also be a visit to a local cattle breeder

Visit to heathland areas affected by prescribed fire as management practice in the way to Tourém

19.00h: Departure by bus to Montalegre (approximate arrival time 20.00h)

21.30h: Conference dinner at “Hotel Quality Inn Montalegre” in Montalegre

Staying overnight at “Hotel Quality Inn Montalegre” in Montalegre

■ **Saturday June 18 – Half-day workshop (“City Hall Auditorium”) and departure - Montalegre (Portugal)**

07.30-08.45h: Breakfast at “Hotel Quality Inn Montalegre” in Montalegre

09.00-10.20h: Session 6 (Oral presentations) - Heathland ecosystem services

10.20-11.30h: Conclusions and discussion about the next European Heathland Workshop 2013

12.00-13.00h: Lunch time at “Hotel Quality Inn Montalegre”

13.00h: Departure by bus:

Bus nº 1: Directly from Montalegre to Léon (approximate arrival local time 18.00h)

Bus nº 2: From Montalegre to Braga (approximate arrival local time 15.00h)

SCIENTIFIC PROGRAMME

■ Monday June 13 – Full day excursion - Cabo Peñas and San Isidro (Spain)

Presentation of the coastal heathlands of Cabo Peñas (Asturias) by María Luisa Vera and Álvaro Bueno (University of Oviedo):

- South Atlantic heathlands of Cabo Peñas (Asturias), Spain
Vera M.L., Bueno Á.

Presentation of the heathland management practices developed in the northern slope of the Cantabrian mountain range (Asturias) by Rocío Rosa, Rafael Celaya and Koldo Osoro (SERIDA):

- Increase in value of Cantabrian heathland areas through sustainable grazing systems
Celaya R., Rosa R., García U., Ferreira L.M.M., Martínez A., **Osoro K.**

Presentation of ongoing research on the vegetation, soil and arthropod fauna of these heathlands by Leonor Calvo, Elena Marcos, Luz Valbuena and David Cuesta-Segura (University of León) and Borja Jiménez-Alfaro (University of Oviedo). There will also be a presentation of the historical evolution of the livestock husbandry in these heathlands:

- Long term survey of heathlands in San Isidro pass, Cantabrian Mountains (NW Spain)
Calvo L., Tárrega R., Valbuena L., Marcos E., Suárez-Seoane S., Taboada A., Morán-Ordóñez A., Cuesta-Segura D., Villalón C., de Luis E.
- Burning and nitrogen deposition effects on soil characteristics in heathlands. Nitrogen cycle in Cantabrian heathlands
Marcos E., Villalón C., Calvo L., Tárrega R., Valbuena L., de Luis E.
- The importance of seed germination in the regeneration of Cantabrian heathlands after burning and nitrogen deposition
Valbuena L., Calvo L., Tárrega R., Marcos E., Suárez-Seoane S., Taboada A., Morán-Ordóñez A., Cuesta-Segura D., Villalón C., de Luis E.
- Entomological research in *Calluna*-heathlands of NW Spain
Cuesta-Segura D., Taboada A., Calvo L., Salgado J.M.
- Relict plant diversity in mountain refuges of San Isidro (Cantabrian range)
Jiménez-Alfaro B.

■ Tuesday June 14 – Full day workshop - Faculty of Biological and Environmental Sciences of the University of León, León (Spain)

09.00h: Poster placement

09.30-10.00h: Official opening of the workshop by
José Ángel Hermida Alonso, President of the University of León
Blanca Razquín Peralta, Dean of the Faculty of Biological and Environmental Sciences, University of León

Mariano Torre Antón, Managing Director of the Natural Environment Section,
Regional Government of Castilla and León
Leonor Calvo Galván, Organizing Committee
Estanislao de Luis Calabuig, Organizing Committee
Sally A. Power, Convenor European Heathlands Network

10.00-11.00h: **Session 1 (Oral presentations) - Heathlands: Anthropogenic Landscapes.**
Chairman: Werner Haerdtle

10.00-10.20h: Landscape ecology of the Cantabrian Mountains: natural history,
evolution and climatic change effects
de Luis E.

10.20-10.40h: The forest fires problem in the Cantabrian range. Implications for
management
Torre M.

10.40-11.00h: Management policies for heathland conservation included in the
Habitat 2000- Rural development in the south of the Cantabrian
mountain range
Ezquerro J., Sevilla F.

11.00-11.20h: *Coffee break*

11.20-12.00h: **Session 1 (Poster presentations) - Heathlands: Anthropogenic Landscapes.**
Chairman: Peter Kaland

11.20-11.25h: Heathlands in Finland: distribution, threats and management
Järvinen C.

11.25-11.30h: Spatial inventory of heathlands in north-western part of Poland
and Torun surroundings
Kunz M., Nienartowicz A.

11.30-11.35h: Traditional uses of the shrubland ecosystems of the NW Iberian
Peninsula
Casal M., Reyes O., Basanta M., García-Duro J., Pesqueira
X.M., Muñoz A., Álvarez R., Rivas M.

11.35-11.40h: Dynamics of Atlantic shrubland after traditional managements
Reyes O., Casal M., Pesqueira X.M., Muñoz A., Álvarez R.,
García-Duro J., Basanta M., Rivas M.

11.40-11.45h: Shrub regeneration after cutting in the Sanabria region, Spain
Fernández-Santos B., Martínez-Ruiz C., García J.A., Puerto A.,
Gómez J.M.

11.45-11.50h: Ecological consequences of heathland afforestation in
Pomerania, north-western Poland
Nienartowicz A., Kunz M., Deptuła M., Filbrandt-Czaja A., Pryła I.

11.50-11.55h: Long-term development of woodland on cattle grazed and un-
grazed heathland
Buttenschøn J., Buttenschøn R.M.

11.55-12.00h: Control of woodland development on heathland by goat grazing
Buttenschøn R.M., Buttenschøn J.

12.00-13.00h: **Session 2 (Oral presentations) - The future of heathlands under global change.** *Chairman: Nigel Webb*

12.00-12.20h: Bioindicators of nitrogen deposition impacts on heathland ecosystems
Power S.A., Southon G., Caporn S., Field C.

12.20-12.40h: Fate of airborne nitrogen in heathland ecosystems – results of a ¹⁵N tracer study
Friedrich U., von Oheimb G., **Härdtle W.**

12.40-13.00h: Competitive superiority of *Molinia caerulea* in *Calluna*-heathlands under high N availability.
von Oheimb G., Friedrich U., Dzedek C., Härdtle W.

13.00-14.30h: *Lunch at the Cafeteria of the University of León*

14.30-15.00h: **Session 2 (Poster presentations) - The future of heathlands under global change.** *Chairman: Inger Kappel Schmidt*

14.30-14.35h: Modern pollen deposition in heathlands and neighbouring forest phytocoenoses
Nienartowicz A., Filbrandt-Czaja A., Piernik A., Okrój M., Kunz M.

14.35-14.40h: Spatial distribution of Opiliones in four shrublands of the Cantabrian mountain range, NW Iberian Peninsula. The importance of vegetation structure
de Castro-Arrazola I., Taboada A., Marcos E., Tárrega R., Valbuena L., Calvo L.

14.40-14.45h: Heathlands in the Cantabrian Mountains (North Spain) under a climate change scenario
Vera M.L.

14.45-14.50h: Plant community responses to climate change: Results from the FACE experiment CLIMAITE
Nielsen J.K., Schmidt I.K.

14.50-14.55h: Long term impacts of N deposition and interactions with climate stress
Southon G., Green E.R., Power S.A.

14.55-15.00h: Effects of experimental summer drought and nitrogen addition on vitality and productivity of *Calluna vulgaris* from four different provenances
Meyer-Grünefeldt M., Belz K., Härdtle W., von Oheimb G.

15.00-17.00h: **Session 3 (Oral presentations) - The future of heathlands under global change.** *Chairman: Sally A. Power*

15.00-15.20h: Increased nitrogen deposition lowers food quality for fauna in heathlands, through a shift in nitrogen to phosphorus stoichiometry
Vogels J., van den Burg A., Remke E., Siepel H.

15.20-15.40h: Conclusions from 50 years of permanent plot analysis in Dutch heathlands
Remke E., Vogels J., de Smidt J.

15.40-16.00h: Trends in Danish Atlantic heath vegetation during the last decades
Johnsen I.

16.00-16.20h: Vulnerability of *Calluna vulgaris* in response to long-term climate manipulation and ecosystem disturbances
Schmidt I.K., Riis-Nielsen T., Kongstad J., Ransijn J., Damgaard C., Beier C.

16.20-16.40h: From molecular genetics to landscape ecology: New insights from invertebrates for a comprehensive approach in the conservation biology of heathlands
Assmann T., Drees C., Eggers B., Eggers J., Krause H., Renken A., Schäfer K., Schuldt A.

16.40- 17.00h: The role of transhumance on the supply of services in a highly diverse landscape: heathlands. A case of study in the Cantabrian Mountains (NW Spain)
Morán-Ordóñez A., Suárez-Seoane S., Calvo L., de Luis E.

17.00-17.20h: *Coffee break*

17.20-18.00h: **Session 3 (Poster presentations) - Heathland management and restoration: a key to maintain biodiversity.** *Chairman: Geert de Blust*

17.20-17.25h: How to reconstruct past grazing regimes of heathlands?
Baker A.

17.25-17.30h: Heathland farming as a boost for biodiversity conservation: ideas for the Netherlands
Fraão J., van den Burg A., Vogels J., Remke E., Lenders R.

17.30-17.35h: Reintroduction of Old Norwegian Sheep for restoring heathland in Flekkefjord Protected landscape, Vest-Agder, Norway
Vikøyr B., Thele S., Danielsen T., Haraldstad Ø.

17.35-17.40h: “Feral sheep” in coastal heaths – developing a sustainable local industry in vulnerable cultural landscapes
Norderhaug A., Garmo T., Hegrenes A., Nilsen L., Thorvaldsen P., Ulvund M., Vandvik V., Velle L.G., Øpstad S.

17.40-17.45h: Productive performance and foraging behaviour of cattle and horses grazing in Cantabrian heathlands
Celaya R., Ferreira L.M.M., García U., Rosa R., Osoro K.

17.45-17.50h: Horse performance grazing on heather- or gorse-dominated shrublands
Celaya R., García U., Ferreira L.M.M., Rosa R., Rodrigues M.A.M., Osoro K.

17.50-17.55h: An overview of the northern heathers (Ericaceae, Ericaceae)
Fagúndez J.

17.55-18.00h: Can mother shrub age have an influence on germination characteristics and on seed response to fire?
Pérez L., Fernández-Santos B., Martínez-Ruiz C., García J.A., Puerto A.

18:00-18.05h: Heathland as a “Selected habitat-type” in Norway – the first action plan and the new law for nature-biodiversity
Østebrot A.

■ Wednesday June 15 – Full day excursion - Babia (León, Spain)

Presentation of the traditional transhumant activities developed in these heathlands, and the geological aspects and vegetation of the area by Javier Ezquerro and Froilán Sevilla (Regional Government of Castilla and León), Manuel Rodríguez (Estación Agrícola Experimental, CSIC, León) and Ignacio Prieto (University of León):

- Spanish juniper (*Juniperus thurifera* L.) in the Cantabrian Mountains
Sevilla F.
- Torrestío: an example of the type of land use developed in the Babia region (León, Spain)
Prieto I.
- The future Natural Park of Babia and Luna
Ezquerro J.
- Transhumance in the Cantabrian mountain range: from wool to environmental conservation
Rodríguez M.

Presentation of the role of transhumance practices on the conservation of vultures by Pedro Pérez Olea and Patricia Mateo-Tomás (IE University):

- The role of transhumance in the conservation of the upland ecosystems of the Cantabrian Mountains: a case study with vultures
Mateo-Tomás P., Olea P.P.

Visit to fossil site (text by Esperanza Fernández-Martínez, University of León):

- Fossils along the path between La Majúa and Torrestío (Babia, north of León)
Fernández-Martínez E.

Presentation of the future of traditional transhumant activities in the area by Javier Ezquerro (Regional Government of Castilla and León):

- Past, present and future of transhumance in the Cantabrian range
Ezquerro J., Sevilla F.

Presentation of ongoing research on the habitat assessment of the endangered heath tiger beetle by Angela Taboada (University of Lüneburg - University of León):

- Habitat modelling for the conservation of the endangered and endemic heath tiger beetle *Cicindela sylvatica rubescens* in northern Spain
Taboada A., Renken A., Matern A., Assmann T.

Discussion in the field of the management policies for heathland conservation included in the Habitat 2000- Rural development in the south of the Cantabrian mountain range

■ Thursday June 16 – Transfer to Portugal and half-day workshop (“City Hall Auditorium”) - Montalegre (Portugal)

14.00h: Poster placement

14.30-15.30h: *Visit to the Ecomuseu de Barroso (in the way to the Pavilhão Multiusos/City Hall Auditorium, close to the Castle, Montalegre). Departure by foot from "Hotel Quality Inn Montalegre"*

15.30-16.00h: Welcome and introduction to the Montalegre Municipality and the National Park Peneda-Gerês by
President of the Câmara Municipal of Montalegre
Director of the National Park Peneda-Gerês

16.00-17.20h: **Session 4 (Oral presentations) - Heathland management and restoration: a key to maintain biodiversity.** *Chairman: Hermínio da Silva Botelho*

16.00-16.20h: One century of heathlands dynamics in mountain pastures of central Pyrenees (France): the case of the valleys of Luchon
Métailié J.P., de Munnik N.

16.20-16.40h: Long term management policies to protect European heathlands from urban pressures - Lessons from the heathlands of Dorset, UK
Tidball H., Sterling P.

16.40-17.00h: Objective controlled management in heathland, Berge, Flekkerøy, Oksøy-Ryvingen Protected landscape, Vest-Agder, Norway
Vikøyr B., Gunnarsli K.S., Haraldstad Ø., Kilander C.E., Lie A., Danielsen T.

17.00-17.20h: A ground-breeding heathland bird negatively affected by grazing sheep
Vermeersch G., Jollyn F.T., de Bruyn L., **de Blust G.**

17.20-17.40h: *Coffee break*

17.40-18.05h: **Session 4 (Poster presentations) - Heathland management and restoration: a key to maintain biodiversity and Burning - effective heathland management tool?** *Chairman: Mieczyslaw Kunz*

17.40-17.45h: LIFE Liereman: preparation, restoration and communication
Naedts F.

17.45-17.50h: Heath for Everybody: the experiences of a volunteer-based NGO in the conservation of heathlands
Rotsaert R.

17.50-17.55h: Post-fire successions along a 390 km latitudinal gradient in Northern *Calluna* heathlands
Velle L.G., Vandvik V.

17.55-18.00h: Fire effects on soil and *Pinus radiata* germination in a heathland of NW of Iberian Peninsula
del Valle M., Salgado J., **Reyes O.**, Casal M.

18.10-19.50h: **Session 5 (Oral presentations) - Burning - effective heathland management tool?** *Chairman: John Underhill-Day*

18.10-18.30h: Heathland fire ecology and management
Fernandes P.A.

- 18.30-18.50h: Resilience of heathland habitats after severe summer fires: results from a long-term survey
Clément B.
- 18.50-19.10h: Smoke-induced germination in coastal *Calluna* heathlands - a case of management-induced evolution?
Vandvik V., Daws M.I., Kaland P.E., Måren I.E., Spindelböck J.P., Velle L.G.
- 19.10-19.30h: Can old degraded Northern *Calluna* heathlands be restored through reintroduction of fire?
Velle L.G., Nilsen L.S., Vandvik V.
- 19.30-19.50h: *Calluna* dynamics related to grazing and prescribed burning in the Pyrenees
Faerber J.

■ **Friday June 17 – Full day excursion - National Park Peneda-Gerês (Portugal)**

Presentation of the National Park Peneda-Gerês by Herminio da Silva (University of Trás-os-Montes e Alto Douro) and Lucia Jorge (Secretariado dos Baldios de Trás-os-Montes e Alto Douro)

■ **Saturday June 18 – Half-day workshop (“City Hall Auditorium”) and departure - Montalegre (Portugal)**

09.00-10.20h: **Session 6 (Oral presentations) – Heathland ecosystem services.** *Chairman: Estanislao de Luis*

09.00-09.20h: Nature, culture and the fate of the heaths: the relationship between cultural service delivery and heathland conservation
Kirkpatrick A.H.

09.20-09.40h: Heathland management on a military domain: A unique combination of partners and tools as a key to success
Dictus C.

09.40-10.00h: Ecosystem service provision in dynamic lowland heathlands
Cordingley J.E., Newton A.C., Clarke R.T., Bullock J.M.

10.00-10.20h: Carbon consequences of heathland management and restoration
Alonso I.

10.20-11.30h: Conclusions and discussion about the next European Heathland Workshop 2013

12.00-13.00h: *Lunch time at “Hotel Quality Inn Montalegre”*

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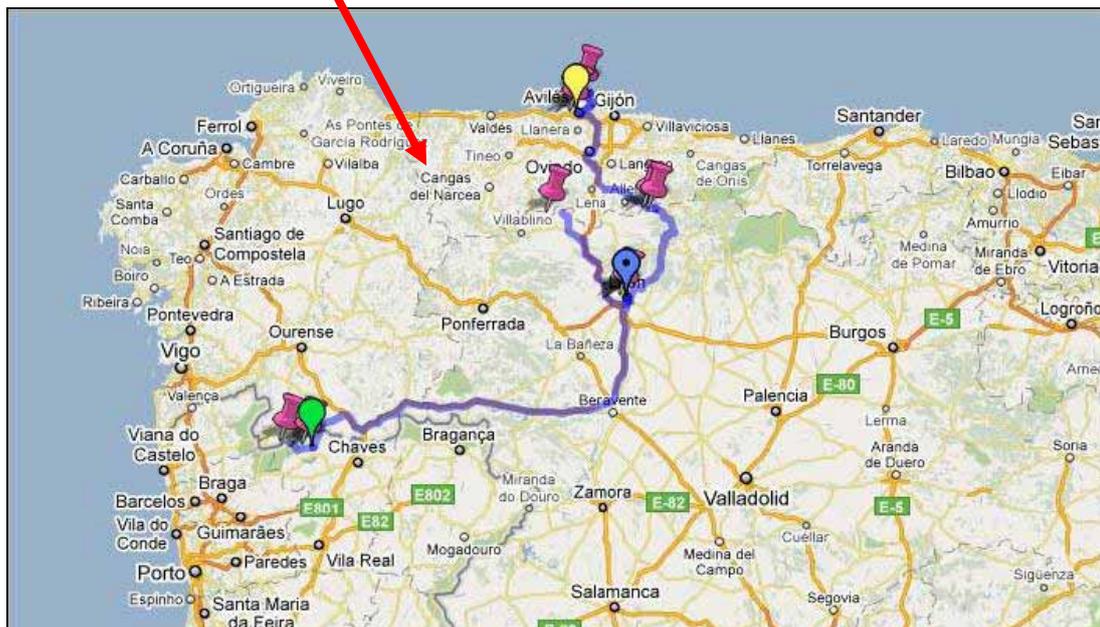
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Excursion Guide



Author: L. Calvo

GENERAL TRIP PLAN



Author: A. Morán-Ordóñez

- **Field trip 1:** Cabo Peñas (Asturias, Spain)- 13th June 2011
- **Field trip 2:** San Isidro (Asturias-León, Spain)- 13th June 2011
- **Field trip 3:** Babia (León, Spain)- 15th June 2011
- **Field trip 4:** National Park Peneda-Gerês (Portugal)- 17th June 2011

Field trip 1- CABO PEÑAS

South Atlantic heathlands of Cabo Peñas (Asturias), Spain

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Cabo Peñas (Cape Peñas) is the northern-most cape in Asturias (coordinates: 43° 39' 35" N, 5° 50' 28" W). This Cape lies in the central area of the Asturias coast, between Gijón and Avilés and has great scenic value. The Picos de Europa mountain range can even be seen on clear days. It is formed by hard rocks (Ordovician white quartzite) which withstand erosion well, producing impressive cliffs which can reach a height of 110 metres. The climate in this area is oceanic with an average temperature of 13.8°C and mean annual rainfall of 969 mm. The region is a good example of the Cantabrian coast, which is mostly high with cliffs, the beaches, dunes and marshes cover small areas and it is situated in the southern zone of the **Eurosiberian** region with a **temperate** macrobioclimate, but already showing significant **sub-Mediterranean** characteristics in the rainfall regime. Summers are dry enough. The zone has been inhabited and severely deforested since ancient times, as have the rest of the Cantabrian coast and mountain range, and the seaboard still more intensely. Palaeolithic sites have even been found in the Cabo Peñas area with utensils made of quartzite rock. Natural forests barely survive in this area, and many of the heathlands we will observe are the final degradation phase of forest vegetation stages which have already disappeared. If we exclude the band of aero-halophilic shrublands closest to the seaboard in the zone which has a significant set of indicator plants, the rest of the heathlands located a little further inland are the degradation stages of oligotrophic *Quercus robur* and *Quercus pyrenaica* forests.

The Atlantic heathland on Cabo Peñas which we are going to visit forms part of the “**Cabo Peñas Protected Landscape**” together with other cliffs and beaches with valuable dune systems. It is characterised by strong winds and poor and very acid soils. It was declared one of the **Regional Network of Protected Natural Spaces** (RRENPN) in 1995, as part of the *Development Plan for the Natural Resources of Asturias* (PORN), because its habitats and species are of interest to the community and are on the list of **Sites of Community Importance (SICs), within of the Nature 2000 Network**.

-Gorse-heathland with *Erica mackaiana*¹ generally developing in small depressions on moist, peaty soils, where *Erica ciliaris* (DH 4020: Moist Atlantic *Erica ciliaris* heathlands in temperate zones) frequently appears.

- Aero-halophilic heathlands, drier than the previous heathland, subjected to the direct influence of sea winds and characterised by the presence of *Ulex europaeus* fma. *maritimus* and *Erica vagans*² (DH 4040: Dry Atlantic coastal *Erica vagans* heathlands).

Transition stages between these two types of heathland can be found, as Cabo Peñas is a very windy place where the aerohaline influence can penetrate to further inland areas, during storms. We will cross these ecotones between both types of heathland during our visit.

¹ This has been systematised in the Ovetense and Galaic-Asturian association (*Gentiano pneumonanthe-Ericetum mackaiana* R. Tüxen & Oberdorfer 1958)

² This has been systematised in the abrupt siliceous coast association from Lugo to Cabo Peñas, in the centre of Asturias, *Angelicum pachycarpae-Ulicetum maritimi* F. Prieto & Loidi 1984)

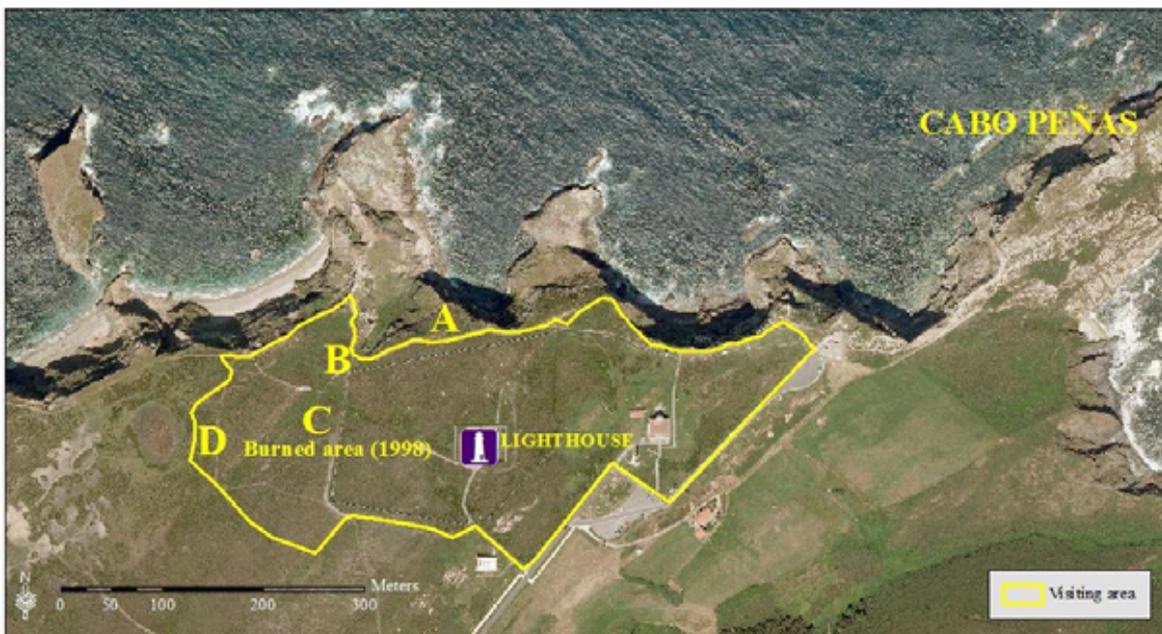
The most abundant type of heathland in the western central colinous-montaneous territories of the Cantabrian cornice is this *Erica mackaiana* moist heathland, which covers most of the Cabo Peñas area. It grows on organic, peaty soils with a very acid pH, since this is on quartzite. Dynamically, they are usually degradation stages of oligotrophic oak stands³. The presence of *Erica ciliaris* and *Erica mackaiana*, are typical in this heathland, with gorses (*Ulex europaeus* and *Ulex gallii*. s.l.) also appearing frequently and different species of heather: *Calluna vulgaris*, *Daboecia cantabrica*, *Erica cinerea* and *Erica vagans*. This is the most abundant type of heather in the central area of the Protected Landscape, in the Northwest of the Cabo Peñas peninsula, and is situated in a flat place corresponding to an ancient platform of elevated quartzite marine abrasion, which overlooks the sea forming spectacular cliffs about 100 m a.s.l. Other species we can find are *Lithodora prostrata*, *Potentilla erecta*, *Serratula tinctoria*, *Cirsium filipendulum*, *Laserpitium prutenicum* subsp. *doufourianum*, *Simaethis mattiazii*, *Agrostis curtissi* and, in wetter and clearer heathlands, *Molinia caerulea*.

DESCRIPTION OF THE ITINERARY

Our visit begins near the Peñas lighthouse, built in 1852, which is the main lighthouse with the furthest reach on the Asturias seaboard. A fire was earlier used to signpost this cape. At present the lighthouse is automated and computerised, so no daily control or lighthouse keeper is needed. The *Visitor reception centre and interpretation of the marine environment Peñas (MEMAP)* is located here: it provides information about the history of lighthouses and the lives of lighthouse keepers; relations between man and the sea, fishing etc; description of the storms and violent north-west winds (typical of the north coast of Spain). There is information about the marine biodiversity in the Cabo Peñas area and also scale models of sharks, whales, etc. with one of a giant squid outside.

Field trip: South Atlantic coastal heathlands. Cabo Peñas (Asturias). 13th of June, 2011.

Talks:
Ms Maria Luisa Vera (University of Oviedo)
Mr Alvaro Bueno Sánchez (Atlantic Botanic Garden, Gijón)



Author: A. Morán-Ordóñez

Fragments of a heathland dominated by *Ulex europaeus* and *Erica vagans* can be seen at the front of the lighthouse enclosure on richer soils and *Erica cinerea*, *Daboecia cantabrica*, *Calluna vulgaris*, *Asphodelus albus*, etc. grow on poorer soil at the back.

³ *Blecho spicanti-Quercetum roboris* (Br.-Bl., P. Silva & Rozeira 1956) Rivas-Martínez 1975, association which extends throughout the colinous-montaneous zone from the west to the centre of the Cantabrian coast, occupying poor soils developed on siliceous substrates (slate, sandstone and quartzite) in humid and hiperhumid territories

Zone A

The first part of our itinerary is along the cliff edge where the influence of sea winds and spray are significant, and we find aerohaline climatic shrubs, characteristic of the western siliceous seaboard of the Cantabrian coast mentioned before: aerohalophil heathland with *Ulex europaeus* fam. *maritimus*. The evolution of these shrublands towards more complex plant communities is constrained by the harsh environmental conditions. The strong winds and salinity on this belt bordering the cliffs prevent from developing into woods or tall shrub formations. On the first part of our itinerary, which is parallel to the coast, the constant presence of aerohaline plants typical of cliff communities can be seen. Their presence in these shrublands is what makes them unusual: *Spergularia rupicola*, *Silene uniflora*, *Daucus carota* subsp. *gummifer*, *Angelica plachycarpa*, *Plantago coronopus*, *Armeria pubigera* ssp. *depilata*, *Koeleria albescens*, *Jasione crispa* subsp. *maritima*, *Leucanthemum ircutianum* subsp. *crassifolium*, *Rumex acetosa* subsp. *biformis*.

Ramalina siliquosa, *Xanthoria parietina*, *Caloplaca marina* lichens appear on the cliff edges and rocky areas closest to the sea. *Ulex europaeus* fam. *maritimus* gorse and heaths resistant to a coastal environment: *Erica vagans*, *Erica cinerea*, *Calluna vulgaris* are dominant here, and more scarcely *Daboecia cantabrica*.

Sea kale (*Brassica oleracea* subsp. *marina*), classified as vulnerable in the Regional catalogue of threatened species of flora in the Principado de Asturias (1995), lives on this cliff and the nearby islets, as happens in other zones of the Cantabrian seaboard in habitats generally associated with nitrogen deposits from seabird excrement.

Continuing along the boardwalk there are other species (some of them nitrophilic) like: *Umbiliculus pendulinus*, *Urtica membranacea*, *Parietaria diffusa*, *Cuscuta epithymum*, *Galactites tomentosa*, *Pulicaria disenterica*, *Andryala integrifolia* or *Asphodelus albus*. It is possible to find other species typical of oligotrophic heathlands, *Lithodora prostrata*, *Agrostis curtisii*, *Potentilla erecta*, *Serratula tinctoria*, *Allium ericetorum* and meadows and hedges *Holcus lanatus* and *Lonicera peryclimenum*.

At the end of the walk along of fence (corner of the fence), towards the interior with its deep shady soil we can see the first large patches dominated by *Erica mackaiana*, frequently mixed with *Ulex europaeus*, while *Erica vagans*, *Erica ciliaris*, *Daboecia cantabrica* and *Calluna vulgaris* are scarcer. *Agrostis curtisii* and *Cirsium filipendulum* stand out among the meadow herbaceous species.

Zone B

We cross a small valley floor with deeper, moister soil protected from the sea winds, where species which cannot withstand salinity very well can grow, such as ferns (*Pteridium aquilinum*) mixed with the creeper *Smilax aspera* and herb species such as *Pseudarrhenaterum longifolium*, *Cirsium filipendulum* and *Potentilla erecta*. *Erica mackaiana* and *Ulex europaeus* dominate in the wettest zone while *Erica ciliaris* and *Erica vagans* are scarcer. On the drier slopes of small valleys, *Ulex europaeus*, *Calluna vulgaris* and *Erica cinerea* occur.

Zone C

As we move away from the coast, we reach a large flat area dominated by *Erica mackaina* Atlantic heather. This zone is often swept by strong winds, has poor, very acid (the pH is often between 3.2 and 4.3), organic, sometimes peaty soils; gorse (*Ulex europaeus*) and various species of heaths: *Calluna vulgaris*, *Daboecia cantabrica*, *Erica cinerea*, *Erica vagans* are also present and *Erica ciliaris* on the wettest soil. Other species can grow in these heathlands: *Lithodora prostrata*, *Simaethis mattiazii*, *Cirsium filipendulum*, *Serratula tinctoria*, *Agrostis curtisii*, *Allium ericetorum* etc. Parts of these heathlands **have suffered fires which impair their conservation**. In 1988, one of the worst fires occurred in an area of this heathland, although fire intensity varied spatially. Organic material and the seed bank were destroyed in the most affected soils, losing a large quantity of soil (even over 5 cm deep), as the zone is exposed to strong winds and the ashes were not deposited on the surface. In these zones where the fire was more severe there were no resprouts or establishment of woody species seedlings during the first few years post-fire; the heaths had a low regeneration. In the first few years, even the gorse (*Ulex europaeus*), a species which regenerates vigorously in sites affected by light burn, did not colonise the areas with severe burn, being colonised by herbaceous species. The appearance of this burned heath has changed over time. Four years after the fire, *Holcus lanatus*, *Plantago coronopus*, *Andryala integrifolia*, *Laserpitium prutenicum* subsp.

doufourianum, *Jasione crispa* subsp. *maritima*, *Tripleurospermum maritimus*, even *Cotula coronopifolia* were growing in the most affected areas. At present, 22 years later, there are still zones with very little woody species cover where the fire was more severe, with small bare areas which are being colonised by *Cladonia* gr. *Cladina*, mosses, *Agrostis curtisii*, seedlings of *Calluna vulgaris* and small clumps of *Erica cinerea*. *Simaethis mattiazii* and *Ulex europaeus* are also present in this zone. However, in other zones which did not present any gorses and heaths in the first few years after the fire, at the present, *Brachypodium pinnatum* is abundant, mixed with patches of *Ulex europaeus*, *Erica vagans*, *Erica mackaiana*, *Erica ciliaris*, while the presence *Erica cinerea*, *Daboecia cantabrica*, *Lithodora prostrata* and *Cirsium filipendulum* is scarce.

Zone D (around the lagoon):

We can visit a small lagoon on the Cabo Peñas area, which can be periodically dry. Most of the lagoon is covered by *Eleocharis palustres*, larger than *Eleocharis multicaules* which mainly grows on the edge. *Cotula coronopifolia*, *Litrum salicaria*, *Hidrocotyle vulgaris*, *Carum verticillatum*, *Hypericum elodes*, are among the most notable plants also living in this environment. *Molinia caerulea* is also found here. This grass is also abundant on the path back, growing in the moister areas of heathland. Near the path, *Simaethis mattiazii* can often be seen, another species typical of oligotrophic heathlands in the north of Spain. Exceptionally we can find *Salix repens*.

FAUNA

This part of the littoral presents a considerable degree of humanisation, limiting the fauna. The following mammal can be highlighted: the European hare (*Lepus europaeus*), introduced as a hunting species in meadow and shrub zones and currently scarce. Some small carnivores, like the marten or the fox, can live in the zone. The European tree frog (*Hyla arborea*), a species protected in the Principado of Asturias, lives in the wet zones of Cabo Peñas. Seoane's viper (*Vipera seoanei*) lives in the shrubs and is endemic in the Northwest of the Iberian Peninsula. The black green lizard (*Lacerta schreiberi*), endemic to the western third occidental of the Iberian Peninsula, also lives in shrubs and on the fringes of hedges. The Iberian rock lizard (*Podarcis muralis rasquinetti*) is found on the island of Herbosa as a local endemism. The Cabo Peñas littoral is of faunistic interest, mainly due to the presence of nesting seabirds, some of them legally protected. The European shag (*Phalacrocorax aristotelis*) and the European storm-petrel (*Hydrobates pelagicus*), included in the Regional Catalogue of Threatened Species and which nest on the nearby islets, can be highlighted as important seabirds in the Cabo Peñas area. The peregrine falcon (*Falco peregrinus*, also protected) occasionally nests on the coastal cliffs. The yellow-footed seagull (*Larus michahellis*) is often seen on this coast, forming colonies of breeding pairs on nearby islands. In 2003 this area of the Asturias littoral was partly included in the European list of Special Protection Zones for Birds (ZEPAS) to guarantee long-term protection and administration of bird species, especially migratory ones, and their habitats. Cabo Peñas is a privileged spot for observing migratory seabirds, mainly in autumn (shearwaters, gannets).

The aims of declaring a landscape protected are to halt the deterioration of the littoral fringe; to conserve and restore the threatened ecosystems, mainly in those included in the Regional, National and Community Catalogues; to classify the seaboard; to enhance the knowledge of the zone and to improve living conditions in the population centres.

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Field trip 2: SAN ISIDRO

Increase in value of Cantabrian heathland areas through sustainable grazing systems

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INTRODUCTION

In the NW of the Iberian Peninsula, less-favoured areas covered with heathland vegetation occupy around 1,000,000 ha. Specifically in Asturias, heathlands extend over 223,000 ha, which account for a fifth part of the regional area. As a consequence of abandonment and reduction in grazing pressure, these heathland areas produce great accumulations of woody phytomass that can reach 20-35 t DM/ha after four or five years in the absence of grazing (Celaya et al., 2007a; Benavides et al., 2009; Jáuregui et al., 2009). This phytomass consists of a highly combustible matter, increasing fire risk. During the last decades, there have been many wildfires in northern Spain and Portugal, most of them related to heathland areas, causing serious environmental and economic losses.

During the last twenty years, the SERIDA research team on Animal Production Systems, in collaboration with CECAV-UTAD (Portugal), SALUVET (Universidad Complutense de Madrid) and Instituto de Ganadería de Montaña (CSIC-Universidad de León), has studied the grazing management of Cantabrian heathlands with the aim of enhancing rural development and sustainability of these poor environments. The final objective was to establish profitable grazing systems, mostly focused on meat production but also on quality fibre, while maintaining high biodiversity levels. The studies were carried out in an experimental farm of 200 ha established in 1991 and located at an altitude of 800-1000 m in Illano (western Asturias). In general, they have verified that the difficult situation of heathland areas can be overcome by developing profitable and sustainable grazing systems with appropriate livestock and proper management according to the available vegetation, thus increasing in value these underutilized lands and enhancing the conservation of local flora and fauna. Research centred on six main aspects:

- the nutritive value of heathland vegetation and its potential for livestock production;
- the grazing behaviour and performance of different domestic herbivore species;
- the establishment of improved pastures on heathland areas to get the sustainability of productive grazing systems;
- the dynamics of vegetation and its consequences on biodiversity under different grazing managements;
- the use of tannin-containing heather to control gastrointestinal parasites in goats;
- the economic analysis of production costs and profitability.

This paper summarizes the main results and findings on those mentioned aspects.

CANTABRIAN MOUNTAIN HEATHLANDS

Southern European heathlands, and specifically in the NW of the Iberian Peninsula, present a high variability in their botanical composition depending on soil and climatic characteristics, as well as on management practices. They vary from coastal wet heathlands, heather bogs, lowland or mountain heather-gorse shrublands, tall heather scrublands, to high mountain heather-bilberry dwarf shrublands. In this paper we will centre on medium mountain heathlands co-dominated by different heather species (mainly *Erica umbellata*, *Erica cinerea*, *Calluna vulgaris*) and western gorse (*Ulex gallii*), a thorny woody legume. The soils are generally shallow, acidic and with low nutrient contents, especially calcium, magnesium and phosphorus.

Heathland vegetation is characterized by its low nutritive value for grazing animals (Table 1). The current year green shoots of common heather species present low contents of crude protein (50-100 g CP/kg DM) and high contents of neutral and acid detergent fibre (480-690 g NDF/kg DM, 380-530 g ADF/kg DM). The green shoots of gorse present higher protein contents, particularly during spring (175-220 g CP/kg DM), but thereafter, as its thorns develop and become more lignified, such contents decrease to 90-125 g CP/kg DM. Acid detergent lignin contents are very high in these woody plants, ranging from 230 to 420 g ADL/kg DM in heather and from 130 to 300 g ADL/kg DM in gorse, and generally increase as season advances. Herbaceous plants are mostly grasses such as *Pseudarrhenatherum longifolium*, *Agrostis curtisii* and *Avenula sulcata*, that present rather coarse leaves. Their lignin contents are lower by far than those of shrubs, ranging from 25 to 60 g ADL/kg DM, but protein contents are also low, ranging from 100 to 150 g CP/kg DM during spring and decreasing to 75-110 and to 55-90 g CP/kg DM in summer and autumn, respectively. These grasses are characterized by their high fibre contents, particularly of NDF (650-800 g NDF/kg DM), reflecting the high fraction of cell wall content in leaf tissues.

Table 1. Chemical composition (g/kg DM ranges) of the main plant components of Cantabrian heathlands

| Component | Season | CP | NDF | ADF | ADL |
|-----------|---------------|---------|---------|---------|---------|
| Heather | spring | 70-105 | 480-575 | 380-515 | 230-410 |
| | summer-autumn | 50-80 | 500-690 | 430-540 | 250-420 |
| Gorse | spring | 175-220 | 560-640 | 360-480 | 130-210 |
| | summer-autumn | 90-125 | 630-725 | 460-570 | 200-300 |
| Grass | spring | 100-150 | 645-735 | 310-375 | 20-35 |
| | summer-autumn | 55-110 | 690-800 | 370-470 | 35-60 |

CP: crude protein; NDF: neutral detergent fibre; ADF: acid detergent fibre; ADL: acid detergent lignin.

Animal performance and foraging behaviour in heathlands

The main implication of the low nutritive quality of heathland vegetation is the low animal performance of domestic herbivores. In general, all species (cattle, sheep, goats and horses) present poor productive responses, being more negatively affected those animals with higher absolute nutritional requirements, i.e. cattle compared to small ruminants or suckler dams compared to non-lactating animals. The first consequence is the difficulty in maintaining productive herds with lactating animals and their offspring into a sustainable grazing system for meat production when available surface is mostly occupied by heathlands. The second one is the short length of the grazing season, which can extend to around five months for small ruminants and three months or little more for cattle and horses.

Comparing large herbivore species grazing together during summer at low stocking rates (0.25 animals/ha), it was observed that mares achieved more favourable live-weight (LW) changes than cows (Celaya et al., 2011). Mares selected proportionally more herbaceous plants (mostly grasses) and less heather than did cows, particularly in early summer (0.85 vs. 0.65 herbage proportion in July; 0.63 vs. 0.55 in September). Thus, horses seem to be more able to search for and gather grasses, having an advantage over cattle to maintain a good nutritional status. Lactating state affected more to cows' LW changes than to mares' ones. Regarding the offspring, LW percentage gains (relative to initial LW) between June and August were similar in calves and foals (0.83 and 0.90%/day, respectively), but thereafter calves achieved higher gains than foals (0.37 vs. 0.16%/day). Thus, cows seemed to maintain milk production by mobilizing body reserves, contributing to maintain good calf growth rates, whereas lactating mares showed better performances than lactating cows at the expense of reducing their milk production, negatively affecting foal LW gains.

Among small ruminants, goats in general achieved better performances than sheep in different heath-related shrublands, although differences between both species depended on the type of vegetation regarding the dominant plant species. Managing non-lactating adult females, goats showed better productive responses (changes in LW and body condition score) than sheep in both grass-rich and heather-dominated shrublands, whilst the reverse occurred in gorse-dominated ones, mainly because of higher ewes' gains during spring (Osoro et al., unpublished). Averaging the three types of shrubland, sheep and goats gained LW similarly in spring, lost it in summer (sheep more than goats), and lost it similarly in autumn. Across the five years studied, sheep showed better performance than goats during the first two years, but the opposite occurred during the following three years. Apart from the possible climatic differences between years, this trend reversal was related to changes in the botanical composition of the shrublands. Goats in general selected more woody plants, both heather and gorse, and less herbaceous plants than sheep (Osoro et al., unpublished). In consequence, goats controlled shrub encroachment, phytomass accumulation, and canopy height more than sheep in either grass-, gorse- and heather-dominated shrublands, promoting a higher increase of herbaceous species (Jáuregui et al., 2009). Thus, as gorse dominance steadily increased across years under sheep grazing, ewes' performance was worsening, whereas goats thrived better than sheep since they had more herbage available besides their ability to use woody plants.

In heather-gorse communities dominated by *Erica umbellata* with sparse presence of tall heath scrubs (*Erica australis* subsp. *aragonensis* and *Erica arborea*), differences between goat breeds were also observed in animal performance and diet selection. Local Celtiberic goats (44 kg LW average) and smaller Cashmere goats (33 kg LW) were managed at equivalent high stocking rates (11.7 and 15 goats/ha, respectively, around 500 kg LW/ha). Over four grazing seasons, Cashmere goats presented more favourable LW changes than Celtiberic goats (-1 vs. -30 g/day), owing to the lower nutrient requirements of the smaller breed (Osoro et al., 2007b). Celtiberic goats browsed more intensively on heather plants, particularly on isolated tall scrubs, than Cashmere ones, opening more gaps in the canopy and promoting greater herbaceous cover (Celaya et al., 2010b). Although Cashmere goats tended to browse more on gorse than Celtiberic goats, there were no differences in gorse cover changes between breeds across four grazing years. Despite the greater presence of herbaceous plants could benefit the subsequent animal performance in the Celtiberic breed, goat performance was worsening over time as the availability of green foliage of heather was progressively depleting. In addition, the defoliation of tall heathers resulted in the lack of shelters against inclement weather, with additional negative effects on animal welfare and subsequent performance. Besides the higher performance of Cashmere compared to Celtiberic goats in terms of LW change, the production of good quality fibre of the former adds extra output to these livestock systems.

Within the Cashmere breed, stocking rate (15 vs. 6.7 goats/ha) neither affected goat LW changes nor the productivity/ha., indicating that the nutritive quality of heathland vegetation is limiting animal performance more than available phytomass quantity (Osoro et al., 2007b).

Overall these results reveal the limitations of heathlands for the development of sustainable grazing systems, and the need for integrating such heathlands with other plant communities with better nutritive value. Otherwise, supplementary feeding would be necessary during most of the year, increasing production costs and reducing profitability.

PARTIALLY IMPROVED HEATHLANDS

Areas of improved pasture are established in relatively level terrains by mechanical clearing of heath vegetation, soil ploughing, fertilization with lime and NPK, and sowing perennial ryegrass (*Lolium perenne*) and white clover (*Trifolium repens*). This allows to meet animal requirements and to extend grazing season from early or mid spring to mid or late autumn, depending on altitude and climatic conditions. The surface percentage to be improved depends on the herbivore species managed: at equivalent stocking rates in a livestock unit (LU) basis, cattle needs more pasture surface available while small ruminants can thrive with only 20-25% of improved pasture, because sheep and particularly goats use heathlands more efficiently, being able to select the most nutritious plant parts. Apart from the animal production, these improved pastures are also beneficial from the environmental point of view, as they contribute to

landscape diversification and may act as fire-breaks with no needs of costly mechanical clearings since they are maintained under proper grazing management.

Foraging behaviour in partially improved heathlands

When animals have access to improved pasture areas within heathlands, there are clear differences between species in their foraging behaviour and productive responses. In heathlands with 20-25% surface of ryegrass-clover pasture, goats spent longer times grazing on heathlands than cattle, sheep and horses, which preferentially utilize the improved pastures. Although there are seasonal switches in the proportional use of one or other type of vegetation depending on the herbage allowance (sward height) in the improved area, goats spent 35-70% of their daily grazing time on heathland, frequently over 50% from spring onwards. On the contrary, cows and ewes in general did not exceed 30% of grazing time on heathland (Celaya et al., 2008). Although sheep were more willing to use heathland vegetation than cattle because of their higher selective ability, they also have a higher capacity than cattle to stay grazing on short swards (< 4-5 cm). Thus, higher grazing times on heathland by sheep early in the grazing season (high herbage allowance) were compensated with higher grazing times on heathland by cattle later in the season (low herbage allowance). Mares generally spent longer times grazing than ruminants. This stems from the different digestive and foraging strategy of horses, relying on faster food passage through the digestive tract and higher intake capacity, compensating their lower fibre digestive efficiency compared with ruminants. In addition, horses are well adapted to utilize short grassy swards thanks to the tenure of both upper and lower incisors. Therefore, horses compete with cattle to consume the preferred pasture, although they more readily switch to heathland vegetation later in the season once the sward height in the improved area is reduced below 4 cm (Osoro et al., 2005).

Greatly reflecting the grazing times in each type of vegetation, cattle, sheep and horses preferentially selected herbaceous plants, mostly from the improved pasture area, accounting for 90-100% of the diet in spring, when herbage allowance was plentiful (Celaya et al., 2007b, 2008; Osoro et al., 2008). By contrast, goats consumed 25-50% of woody plants, including both heather and gorse, even in spring, increasing those percentages to 50-85% as season advanced. As sward height in the pasture area was decreasing, shrub percentages in general also increased in the diets of the other three herbivore species, but always below those attained by goats. Shrub percentages in cattle diets were below 20-25%, consisting mostly of heather, whereas 30% of gorse was recorded in horse diet at the end of the grazing season (Osoro et al., 2008). Sheep consumed 6-20% gorse before thorn hardening occurred in summer, and increased heather percentages in their diet to 35-50% in late-summer-autumn. In general, goats showed a lower dietary overlap and hence a higher complementarity with the other herbivore species (Celaya et al., 2007b, 2008).

In mechanically cleared heathland areas with one third of improved ryegrass-clover pasture, goats grazed longer on gorse-dominated shrubland (41-81% of daily grazing time) than sheep (24-48%) and cattle (2-32%). The proportional times in each type of vegetation also varied according to the type of flock. The time spent by cattle and sheep on improved pasture was slightly higher in monospecific than in mixed herds (84 vs. 78% in cattle, 67 vs. 64% in sheep), while the difference was especially noted in goats (50 vs. 30%). Mean gorse percentage accounted for 28% in goat diet, while it accounted for 7% in sheep and 2% in cattle diets (Benavides et al., 2009).

Animal performance in partially improved heathlands

When improved pastures are associated to heathlands, animal performance is conditioned by the balance between the needs for maintenance and production of each livestock species and the available food at each season, mainly determined by the preferred herbage allowance in the improved area, but also by the changes in nutritive quality of pasture and heathland vegetation. In partially (20-25%) improved heathlands, cattle have good productive responses during spring, and both non-lactating and suckler cows gain LW when mean sward height in the pasture area is over 6-7 cm, while calves show acceptable growth rates. Nevertheless, these LW changes depend on the calving season as it is related to cow physiological state and calf developmental stage. Autumn-calving cows presented higher LW recoveries than spring-calving cows due to the more advanced lactation stage in the former and thus lower nutritional requirements for milk production. On the other hand, autumn-born calves showed higher gains than younger spring-born ones, due to the higher pasture intake capacity of the former (Celaya et al., 2008). Under

the same conditions, LW changes of mares and their foals during spring were similar to those observed in cattle (Table 2).

During summer, once available quantity and quality of the improved pasture are reduced, cows and mares generally lose LW in a similar way, and the LW gains of calves and foals are also reduced. Ewes and goats, after the weaning of their offspring, show better performances than large herbivores. In this period, there is high variability between years in the LW changes of all species, depending on climatic conditions, mainly rainfall, and subsequent balance between pasture growth and senescence. Although LW losses can be ameliorated during autumn because of pasture regrowth, the productive responses of large herbivores worsen as season advances, and particularly during winter, cows lose much LW and body condition due to pasture shortage and adverse climatic conditions. These heavy losses will negatively affect subsequent reproductive performance (extended anestrus cycle and decreased conception rate) and thus cattle productivity.

Overall, taking into account both mothers and their offspring, sheep is the species with the best daily LW changes per livestock unit (1 LU = 1 cow = 1 mare = 7 ewes = 7 goats) because of the higher LW gains of lambs compared to calves, foals and kids. Horses and goats show similar absolute gains per LU, whilst cattle is the species that present the worst productive responses due to the great LW losses of cows rather than to calf growth rates (Table 2).

Table 2. Daily live-weight (LW) changes per livestock unit (LU) of cattle, horses, sheep and goats grazing together on a heathland area with 25% of improved pasture

| Herbivore species | Cattle | Horse | Sheep | Goat | | |
|-----------------------------|---------------|--------------|--------------|--------------|---------------|--------------|
| Suckler dams | Cows | Mares | Ewes | Goats | s.e.m. | Sign. |
| Initial LW (kg) | 479 | 350 | 41 | 37 | 8.6 | *** |
| Initial LW per LU (kg/LU) | 479 | 350 | 283 | 256 | 25.1 | *** |
| LW change per LU (g/day/LU) | | | | | | |
| Spring | 859 | 842 | 377 | 308 | 103.0 | *** |
| Summer | -345 | -317 | 20 | -125 | 95.7 | *** |
| Autumn | -32 | -71 | 237 | -19 | 65.0 | *** |
| Winter | -1878 | -604 | -290 | 41 | 121.7 | *** |
| Overall | -170 | 63 | 64 | 76 | 55.9 | ** |
| Offspring | Calves | Foals | Lambs | Kids | s.e.m. | Sign. |
| Initial date | 3 May | 18 June | 3 May | 3 May | | |
| Weaning date | 20 Sept. | 27 Nov. | 24 July | 24 July | | |
| Initial LW (kg) | 149 | 43 | 11 | 8 | 3.9 | *** |
| LW at weaning (kg) | 261 | 170 | 24 | 17 | 8.4 | *** |
| LW change per LU (g/day/LU) | 804 | 770 | 1113 | 721 | 91.5 | *** |

s.e.m. maximum standard error of mean; ** $P < 0.01$; *** $P < 0.001$.

ANIMAL HEALTH

In humid areas, parasitic infections by gastrointestinal nematodes are a major threat to the development of efficient and sustainable extensive grazing systems, particularly in the case of small ruminants, due to their negative impact on animal health and therefore on both production and product quality. Increasing social concerns over safe food and pesticide residues and the development of resistances to anthelmintic drugs in several nematode strains make necessary alternative grazing, food and sanitary management strategies to control these infections in livestock. The use of bioactive plants as nutraceuticals, specifically those containing condensed tannins, has been regarded as an efficient method for controlling these worm diseases. Heather plants (both *Calluna vulgaris* and *Erica* spp.) present low to moderate concentrations of tannins in their green shoots (60-100 g tannin acid equivalents/kg DM), and therefore, their potential use as anthelmintic was studied in several experiments with goats, as this species, being browser, is known to have evolved lower immunity level than sheep or cattle, which are mainly grazers (grass-roughage eaters).

In pastures consisting mostly of perennial ryegrass, common bent (*Agrostis capillaris*) and white clover, reductions of 30-75% in faecal nematode egg excretion were observed in goats supplemented with heather (freshly cut plants offered every 3 days) compared with non-supplemented goats (Osoro et al., 2007a,c; Frutos et al., 2008; Celaya et al., 2010a). This reduction in parasitism level enhanced animal performance, so heather-supplemented goats

had more favourable LW changes and body condition score than those feeding only on pasture. Both *in vivo* and *in vitro* experiments showed that tannin consumption was not associated to clear anti-nutritional effects that could counteract the beneficial anthelmintic effect of heather. Greater concentrations of volatile fatty acids were observed in the ruminal fluid of supplemented goats, suggesting an improved efficiency of ruminal fermentation in these animals compared to those fed on pasture (Osoro et al., 2007c; Frutos et al., 2008).

Parasite burden may also be affected by the grazing management. Goats at high stocking rate (38 goats/ha) showed higher nematode egg excretions than at lower stocking rate (24 goats/ha). Worm counts in abomasum and small intestine also tended to be higher at high stocking rate, particularly in the case of *Trichostrongylus* spp. (Osoro et al., 2009). In this trial, faecal egg counts were not significantly affected by heather supplementation, presumably because of an anomalous dry year that lowered parasite burdens. However, within high stocking rate treatment, *Teladorsagia circumcincta* in abomasum and *Chabertia ovina* in large intestine were significantly more numerous in non-supplemented than in supplemented goats. Independently of stocking rate, goat LW changes were positively affected by heather supplementation.

Combining tannin-containing heather and energy (oats, *Avena sativa*) supplementation, additive positive effects were observed in reduced faecal egg excretion and enhanced goat performance (Celaya et al., 2010a). In this trial, heather-supplemented goats consumed 21-35% heather while total intake was similar to non-supplemented goats. Thus, goats chose to feed on heather instead of grazing only pasture, which was better in nutritional terms (higher protein and lower lignin contents), and sacrificed nutrient intake in the interests of health, which ultimately improved their productive response. These results suggest that goats self-medicate through the pharmacological use of heather to enhance their fitness.

In partially improved heathlands, goats shed more nematode eggs in faeces, ranging from 110 to 200 eggs/g from September onwards, than cattle (10-20) and sheep (30-90) (Celaya et al., 2008). Nevertheless, these counts in goats were much lower than those observed at pasture with no available heather (2500-8600 eggs/g). Thus, the presence of heathlands, in spite of their low nutritive value, is beneficial when they are integrated with improved pastures, at least for goats. In addition to its anthelmintic effect, heather may provide minerals, trace elements and fibre, improving ruminal processes, animal nutrition and health.

GRAZING EFFECTS ON HEATHLAND VEGETATION AND BIODIVERSITY

Heathland vegetation is affected by grazing management, i.e. herbivore species and breed, stocking rate, type of flock, etc., as well as by other management practices such as burning or cutting, which in turn may affect local fauna. Both burning and mechanical clearing favours gorse regrowth, becoming dominant in a few years (Celaya et al., 2007a; Jáuregui et al., 2007; Benavides et al., 2009). In previously burnt heathlands, gorse biomass accumulation is reduced under grazing, being such reduction higher with goats than with sheep (Jáuregui et al., 2007, 2009). Therefore, higher herbaceous cover developed under goat grazing. In undisturbed heather-dominated shrublands, goats reduced heather cover more than sheep, again promoting a higher herbaceous cover, although the differences between grazer species were less important in this case than in previously burnt grass-rich heathlands. Thus, grazing effects also depend on the initial vegetation stage and previous management (Jáuregui et al., 2009).

Looking at ground-dwelling arthropod fauna, higher abundances and diversity (considering families of Araneae, Opiliones, Isopoda, Julida, Microcoryphia, Hemiptera, Coleoptera and Hymenoptera) were recorded in heather-dominated shrublands, although certain species were more numerous in grass-rich heathlands (Rosa et al., 2010b). In general, effects of the grazer species were lower than those exerted by the shrubland type, although some groups like sheet weavers (money spiders, Linyphiidae, Araneae) and jumping bristletails (Microcoryphia), or species such as the wolf spider *Pardosa pullata*, which prefer a higher presence of herbs, were favoured by goat grazing.

Regarding the effects of goat breed, higher plant species richness was recorded under local Celtiberic goat grazing than under Cashmere goat grazing, owing to the more open heathland generated in the former treatment, allowing more herbaceous species to settle. However,

floristic diversity index and evenness were reduced because of increasing dominance of the two most abundant grasses, *Agrostis curtisii* and *Pseudarrhenatherum longifolium* (Celaya et al., 2010b). Although it has been assumed that traditional breeds may enhance overall biodiversity, the present study found no significant differences for arthropod fauna (Jauregui et al., 2008; Rosa et al., 2009a).

Within the Cashmere breed, the higher herbaceous cover and lower shrub cover generated under the higher stocking rate (15 goats/ha) was not accompanied by differences in floristic diversity compared with the lower stocking rate (6.7 goats/ha) (Celaya et al., 2010b). The lower stocking rate did not enhance overall arthropod diversity or abundance, although harvestmen (Opiliones) were favoured, whereas abundance and species richness of carabids, and abundance of lycosids like *Pardosa pullata*, were higher under the higher stocking rate (Rosa et al., 2009a). As well, total grasshopper density was increased under high stocking rate, but this was attained almost exclusively by one species, the graminivorous *Stenobothrus stigmaticus*, while the other eight orthopteran species tended to be favoured by the lower grazing intensity (Jauregui et al., 2008). After two years of grazing cessation in these heathlands, ground dwelling arthropod community composition varied significantly. Whereas the abundance of some species such as the opilionid *Odiellus spinosus* increased, the abundance of the opilionid *Nemastoma hankiewiczii* was reduced. Nevertheless, previous grazing effects remained on both vegetation and fauna two years after grazing cessation (Rosa et al., 2009b).

In mechanically cleared heathlands, higher increments of gorse cover, height and phytomass were observed under single cattle or sheep grazing than under mixed grazing with goats (Benavides et al., 2009). More arthropod groups favoured the patchier areas with higher herbaceous biomass generated by mixed herds with goats (Rosa et al., 2010a). Compared to adjacent grasslands, these gorse-dominated shrublands held higher abundances of Opiliones, Julida, Lithobiomorpha, Microcoryphia and Carabidae, while the reverse was observed for Linyphiidae, Lycosidae and Hemiptera (Rosa et al., 2010a, 2011).

Overall, these results indicate that the responses of arthropod fauna to grazing management, and hence to different vegetation structures and composition, are species specific. Thus, a patchier habitat generated under different grazing regimes and integrating different plant communities would promote a greater variety of arthropod species in a given area. In the case of fauna directly linked to resources originated by livestock, such as dung beetles, a greater diversity is to be hoped under mixed grazing.

ECONOMIC PROFITABILITY OF DIFFERENT GRAZING SYSTEMS IN PARTIALLY IMPROVED HEATHLANDS

The negative LW changes in cattle as grazing season advances and during winter, relative to small ruminants, mean in practice earlier and higher needs of food supplementation in cows (from summer until the following spring). The supplementation for ewes and goats is normally restricted to winter, coinciding with lambing and kidding periods. This significantly affects the economic balance of the farm depending on the available improved pasture area and the livestock species managed. In heathlands with 30% area improved, the annual difference per LU between the incomes from animal sales (calves, lambs or kids) and the food purchase costs is clearly lower for cattle (51 €/LU) than for sheep and goats (288 and 323 €/LU, respectively). Besides the lower production costs in small ruminants, it is partly due to the higher prices for kid and lamb meat compared to beef (applied prices of 2009: 2.10, 2.16 and 2.85 €/kg LW for calves, lambs and kids, respectively). In addition, small ruminants are more prolific than cattle (applied birth rates per female: 0.7, 1.1 and 1.2 for cattle, sheep and goats, respectively). Adding the subsidies for animal husbandry per LU, those differences between cattle and small ruminants are somewhat reduced (370, 474 and 482 €/LU for cattle, sheep and goats).

Considering mixed grazing systems in these partially improved heathlands, the profitability of two types of flock managed in a 22.5 ha paddock was compared, one consisting of cattle, sheep and goats (CSG: 6 cows, 42 ewes and 42 goats with their offspring; 0.27, 1.87 and 1.87 breeding females/ha, respectively) and another consisting of only sheep and goats (SG: 150 ewes and 75 goats with their offspring; 6.67 and 3.33 breeding females/ha, respectively). The difference between sale incomes and feeding costs per unit area was higher in SG (449 €/ha) than in CSG flock (181 €/ha) (Fig. 1).

Apart from the animal production aspects, the investments in infrastructures (closures, establishment of improved pastures, drinking troughs, etc.) should be considered. Applying a cost of 1191 €/ha for initial infrastructure and adding CAP subsidies for animal husbandry per unit area (204 and 285 €/ha for CSG and SG, respectively) plus the aids for infrastructure improvements (596 €/ha), the economic balance in the first year is negative for CSG (-211 €/ha) and positive for SG (138 €/ha). In the following years (with no infrastructure investment), the balances are positive for both types of flock, 385 €/ha in CSG and 734 €/ha in SG, the difference showing a clearly higher profitability when the flock is composed only of small ruminants.

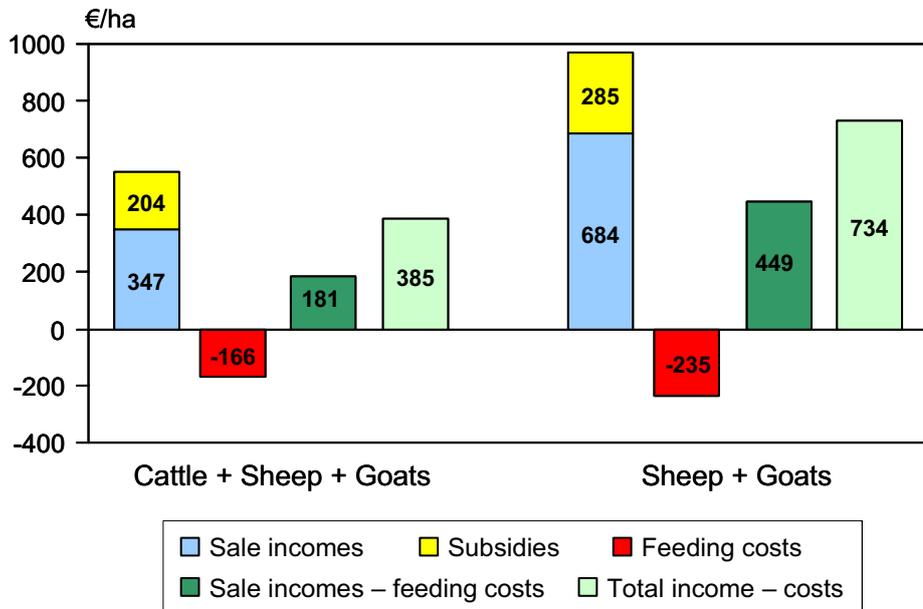


Fig.1. Sale incomes, subsidy payments for animal husbandry, feeding costs and differences incomes-costs in an area basis in a flock composed of cattle, sheep and goats and other composed of only sheep and goats grazing in a partially improved heathland area (30% improved ryegrass-clover pasture).

CONCLUSIVE REMARKS

From the productive point of view, cattle show lower performances than other herbivore species and a negative balance during most of the grazing season, although they present the highest productivity during spring. Thereby, the needs for external or preserved food are greater for cattle, increasing yearly costs. Small ruminants are more suitable to develop sustainable grazing systems in heathland territories. They have a positive balance during most of the year and their offspring are weaned and sold in summer before the reduction in available quality pasture. Sheep is the most productive species in partially improved heathlands. Goats, because of their mixed feeding behaviour (grazer-browser), complement well with sheep and cattle, and contribute to improve the utilization efficiency of heathland resources. In addition, goats reduce shrub dominance and generate higher biodiversity indexes, reducing fire risk. Horses have a high intake capacity and compete with other grazers, especially with cattle which show a low ability for heathland utilization. Preferably, horses should be sequentially managed after ruminants to consume their refusals, maintaining a better quality pasture. Nevertheless, when herbaceous availability is scarce, horse performance is also negatively affected.

Interspersed open and close heathlands mixed with grasslands could keep higher faunistic diversity. Mixed grazing with small ruminants seem the most appropriate to increase both economic and environmental value of these marginal areas. Nevertheless, grazing pressure should be monitored to conserve heathland-grassland associations in good condition in order to enhance biodiversity and animals' sanitary and nutritional status. The profitability of extensive grazing systems in heathland areas is supported by the distinguishable product quality, in addition to an efficient utilization of these underused resources, which contributes to enhance biodiversity and to maintain sustainable production systems.

Acknowledgements

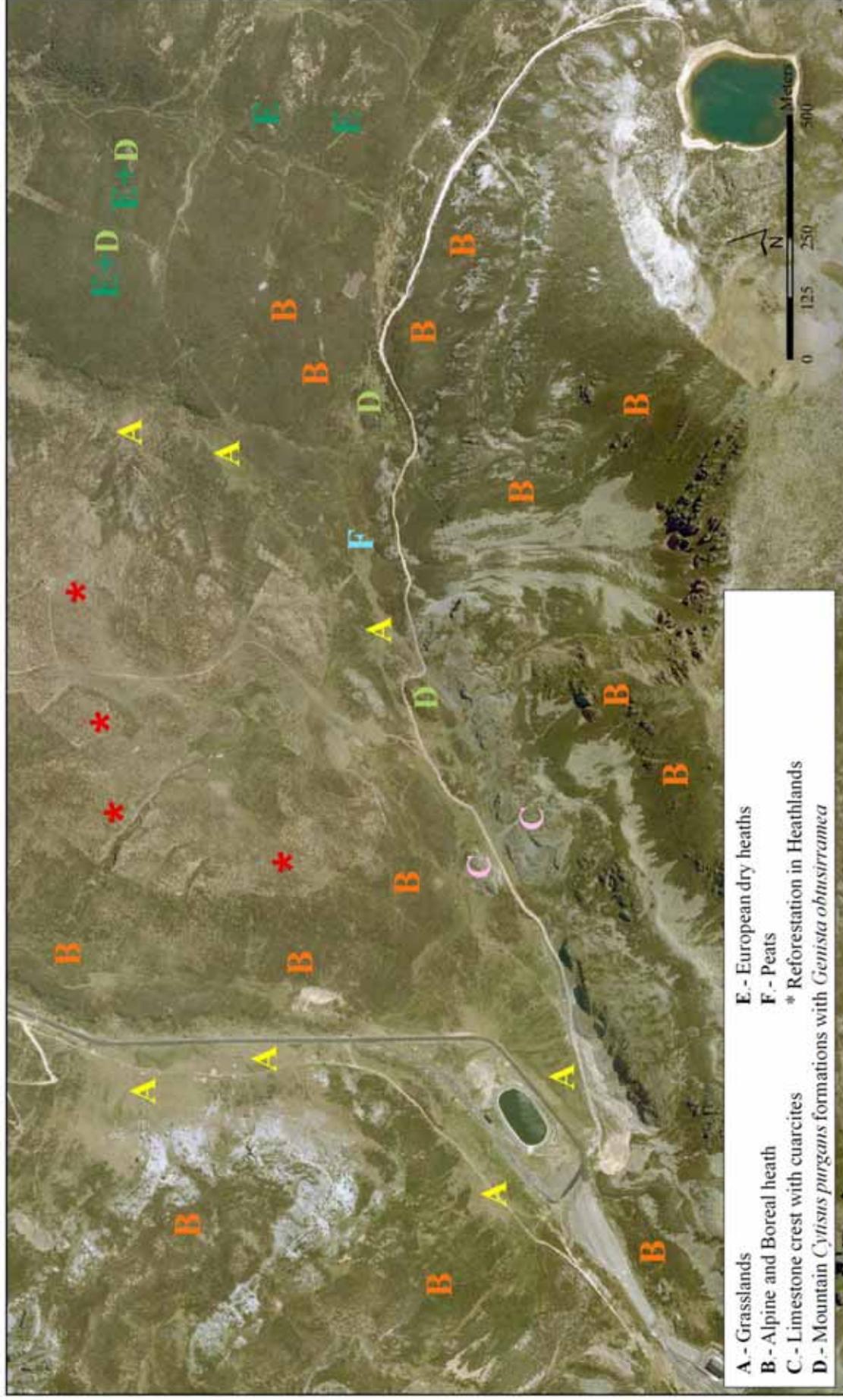
We thank the staff of the experimental farm for their work in livestock management, upkeep of the pastures, paddocks, stables, warehouses and other infrastructures, and assistance in samplings and measurements. We also acknowledge financial support of several research projects from INIA (Spanish National Institute for Agrarian and Food Research and Technology), CICYT (Spanish Interministerial Commission of Science and Technology), FICYT (Foundation for the Promotion of Applied Scientific Research and Technology in Asturias) and EU Framework Programme.

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Field trip: Experimental plots University of León.
 San Isidro (León). 13th of June, 2011.

VEGETATION AND HABITATS OF SPECIAL INTEREST



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Site of community importance “Picos de Europa en Castilla y León”, Spain

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1. NATURAL HABITAT TYPES OF COMMUNITY INTEREST

Freshwater habitats

3150 Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition* —type vegetation.

3220 Alpine rivers and the herbaceous vegetation along their banks.

3260 Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitriche-Batrachion* vegetation.

Temperate heath and shrub

4020 Temperate Atlantic wet heaths with *Erica ciliaris* and *Erica tetralix*. In the visiting area they correspond to heath formations dominated by *E. tetralix* growing over wet soils with low drainage, usually linked to peat soils.

4030 European dry heaths. They are heaths of medium size and high cover dominated by *Erica* sp. They are very homogeneous and therefore they have a low species richness. They occur on acid soils and usually in areas with high recurrence of fires. Within the visiting area, they mainly correspond with heath patches dominated by *Erica australis* subsp. *aragonensis*, with presence of *Erica arborea*.

4060 Alpine and Boreal heath. In the Cantabrian Mountains, the sub-alpine shrub vegetation growing over limestones is *Arctostaphylos uvaursi* and *Juniperus communis* subsp. *alpina* with *Daphne laureola*, *Rosa pendulina*, etc; on the other hand, when the substrate is of a siliceous character, the dominant species are *Juniperus communis* subsp. *alpina*, together with *Vaccinium myrtillus* and other acid-like species as *Calluna vulgaris*.

4090 Endemic oro-Mediterranean heaths with gorse. They correspond, within the visiting area, with formations of cushion shrub dominated by *Genista hispanica* subsp. *occidentalis*, which occur mainly linked to limestones substrate.

Sclerophylus scrub

5120 Mountain *Cytisus purgans* formations. Shrub formations dominated by *Cytisus oromediterraneus* (*Cytisus purgans*) occurring within siliceous soils, which frequently occur together with another endemic *Genista* sp. (*Genista obtusiramea* in the case of the visiting area). Some fauna associated to these formations are some other species of high conservation interest as the bluethroat (*Luscinia svecica*), the grey partridge (*Perdix perdix hispaniensis*) and the broom hare *Lepus castroviejoi* (endemic to northern Spain).

Natural and semi-natural grasslands formations

6140 Siliceous Pyrenean *Festuca eskia* grasslands. They are alpine pastures dominated by *Festuca eskia* in which we can find species like *Polygala edmundi*, *Trifolium thalii*, *Trifolium alpinum*, *Luzula caespitosa*, *Oreochloa blanka* or *Juncus trifidus*. There is a high proportion of endemic species in these grasslands.

6160 Oro-Iberian *Festuca indigesta* grasslands.

6170 Alpine and subalpine calcareous grasslands.

6210 Semi-natural dry grasslands and scrubland facies on calcareous substrates (*Festuco-Brometalia*) (* important orchid sites). They occur on fresh, calcareous and not very deep soils. They have an extreme species richness. Some of the characteristic species: *Carex caryophyllea*, *Bromus erectus*, *Potentilla crantzii*, *Achillea odorata*, *Ononis cristata*, *Linus catharticum*, *Anthyllis vulneraria*, *Carex flacca*, *Coronilla minima* subsp. *minima*, etc. Sometimes there are populations of orchids linked to these grasslands (*Ophrys* sp., *Orchis* sp., *Dactylorhiza* sp., etc.), which convert them in priority habitats.

6220 Pseudo-steppe with grasses and annuals of the *Thero-Brachypodieta*.

6230 Species-rich *Nardus* grasslands, on silicious substrates in mountain areas (and submountain areas in Continental Europe).

6420 Mediterranean tall humid grasslands of the *Molinio-Holoschoenion*.

Communities growing on every type of substrate with a preference for soils rich in nutrients. They require an underground water supply running near the surface. This kind of communities is commonly found in depressed terrains that accumulate water in the raining seasons, as well as in the riparian zone of rivers and streams. They are evergreen dense

grasslands, where the two dominant families are Ciperaceae and Juncaceae. The most characteristic species are: *Scirpoides holoschoenus* (dominant species), *Cirsium mospessulanum*, *Festuca arundinacea* subsp. *fenas*, *Schoenus nigricans*, *Mentha longifolia*, *Agrostis castellana*, *A. stolonifera*, *Deschampsia media* or *Lysimachia ephemerum*.

6430 Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels.

Raised bogs and mires and fens

7110 Active raised bogs.

7140 Transition mires and quaking bogs.

7220 Petrifying springs with tufa formation (*Cratoneurion*).

7230 Alkaline fens.

Rocky habitats and caves

8130 Western Mediterranean and thermophilous scree.

8210 Calcareous rocky slopes with chasmophytic vegetation.

8220 Siliceous rocky slopes with chasmophytic vegetation.

8230 Siliceous rock with pioneer vegetation of the *Sedo-Scleranthion* or of the *Sedo albi-Veronicion dillenii*.

8310 Caves not open to the public.

Forest

9120 Atlantic acidophilous beech forests with *Ilex* and sometimes also *Taxus* in the shrublayer (*Quercion robori-petraeae* or *Ilici-Fagenion*).

9150 Medio-European limestone beech forests of the *Cephalanthero-Fagion*.

9230 Galicio-Portuguese oak woods with *Quercus robur* and *Quercus pirenaica*.

92A0 *Salix alba* and *Populus alba* galleries.

9340 *Quercus ilex* and *Quercus rotundifolia* forests.

9380 Forests of *Ilex aquifolium*

9560 Endemic forests with *Juniperus* spp.

9580 Mediterranean *Taxus baccata* woods

2. FAUNA AND FLORA OF COMMUNITY INTEREST (Habitats Directive, 92/43/EEC)

Mammals: *Galemys pyrenaicu*, *Rhinolophus hipposideros*, *R. ferrum-equinum*, *R. euryale*, *Barbastella barbastellus*, *Miniopterus schreibersi*, *Myotis emarginatus*, *M. bechsteini*, *M. myotis*, *Ursus arctos*, *Lutra lutra*.

Birds: *Ciconia ciconia*, *Pernis apivorus*, *Milvus migrans*, *M. milvus*, *Neophron percnopterus*, *Gyps fulvus*, *Circaetus gallicus*, *C. cyaneus*, *Circus pygargus*, *Accipiter nisus*, *Aquila chrysaetos*, *Hieraaetus pennatus*, *Falco columbarius*, *F. subbuteo*, *F. peregrinus*, *Tetrao urogallus*, *Charadrius morinellus*, *Scolopax rusticola*, *Bubo bubo*, *Caprimulgus europaeus*, *Apus melba*, *Alcedo atthis*, *Dryocopus martius*, *Dendrocopos medius*, *D. minor*, *Lullula arborea*, *Anthus campestris*, *Luscinia svecica*, *Phoenicurus phoenicurus*, *Monticola saxatilis*, *Sylvia undata*, *Lanius collurio*, *Pyrrhocorax pyrrhocorax*, *Emberiza hortulana* and *Perdix perdix hispaniensis*.

Amphibians and reptiles: *Lacerta monticola* and *Lacerta schreiberi*.

Invertebrates: *Austropotamobius pallipes*, *Rosalia alpina*, *Elona quimperiana*, *Geomalacus maculosus*, *Maculinea nausithous*, *Euphydryas aurinia*, *Lucanus cervus* and *Cerambyx cerdo*.

Flora: *Narcissus pseudonarcissus nobilis* and *Narcissus asturiensis*.

3. SOME MORE ECOLOGICAL/CULTURAL TIPS

- The area we are going to visit during our field trip to San Isidro belongs to the National Hunting Reserve of Mampodre (declared in 1966).
- This SCI partially overlaps with the National Park of Picos de Europa.
- Although this area has traditionally been important for transhumance, this activity has almost disappeared nowadays. Pastures are used for grazing by cows and horses from the neighbouring municipalities.
- The main threats to this Site of Community Importance are urban development, construction of linear infrastructures (electric and phone lines, chairlift and skylift), the increasing transit of vehicles and people through forest ways and paths, and poaching of protected species.
- At the beginning of the 1970s the Regional Administration inaugurated a sky resort in this area, which nowadays is one of the most visited in the Cantabrian Mountains.

List of plants in San Isidro field trip (Asturias, León; NW Spain)

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Alchemilla plicatula
Alchemilla xantholora
Anthyllis vulneraria
Aquilegia vulgaris
Arenaria montana
Asplenium trichomanes
Asplenium viride
Astrantia major
Avena pratensis subsp. *iberica*
Avena sulfata
Avenula lodunensis (= *Avena sulcata*)
Berberis vulgaris
Biscutella laevigata
Calamintha alpina
Calluna vulgaris
Caltha palustris,
Campanula glomerata
Campanula rotundifolia
Carduus nutans
Chaenorhinum origanifolium
Criptograma crispa
Cytisus oromediterraneus
Daboecia cantabrica
Dactylorhiza maculata
Daphne laureola
Deschampsia flexuosa
Dianthus monspesulanus
Doronicum grandiflorum
Dryopteris dilatata
Dryopteris gr.affinis
Erica arborea
Erica tetralix
Erodium glandulosum
Erythronium dens canis
Festuca burnatti (Cantabrian Endemism)
Festuca ovina
Festuca rubra
Gagea lutea
Genista obtusiramea
Gentiana lutea
Geum rivale
Globularia nudicaulis
Globularia repens
Helianthemum croceum
Helleborus viridis
Hieracium bombycinum
Hieracium pilsella
Homogyne alpina
Horminium pyrenaicum
Hypericum reicheri subsp. *burseri*
Jasione laevis
Juncus conglomeratus
Juncus glomeratus
Juncus squarrosus
Juniperus alpina
Juniperus communis subsp. *alpina*
Koeleria vallesiana
Leontodon pyrenaicus subsp. *cantabricus*
Linaria supina
Lotus corniculatus
Luzula caespitosa
Luzula multiflora
Melampyrum pratense
Meum athamanticum
Nardus stricta
Narthecium ossifragum
Polygonum bistorta
Polystichum aculeatum
Polystichum lonchitis
Potentilla erecta
Ranunculus aconitifolius
Rhamnus alpina
Rosa pendulina
Rumex acetosella
Rumex scutatus
Sanguisorba minor
Saxifraga conifera (Cantabrian Endemism)
Saxifraga canaliculata (Cantabrian Endemism)
Saxifraga paniculada
Scabiosa columbaria
Sedum acre
Sedum album
Sedum brevifolium
Sedum forsteranum
Sempervivum cantabricum
Senecio doronicum
Senecio jacobea
Silene ciliata
Silene nutans
Sphagnum
Teesdaliopsis conferta
Thymelaea dendrobrium
Thymus praecox
Trichophorum caespitosum subsp. *germanicum*
Vaccinium myrtillus
Vaccinium uliginosum
Veronica officinalis

Long term survey of heathlands in San Isidro pass, Cantabrian Mountains (NW Spain)

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Within the fragmented distribution of *Calluna vulgaris* heathlands in NW Spain (Fig. 1), San Isidro Pass represents one of the biggest patches. During summer, this mountain pass was traditionally used for raising flocks of sheep and goats, cows and horses from the nearby villages in León and Asturias. Summer grazing was basically developed by sheep guided by a shepherd and, to a lesser extent, by cows and horses grazing alone. At present, two important changes in the traditional management practices in the area can be highlighted: in the first place, the number of livestock in the mountain passes has strongly decreased and, secondly, the type of livestock grazing has evolved. There has been an increase in the number of cows and horses in detriment of sheep and this has caused significant changes in vegetation physiognomy.

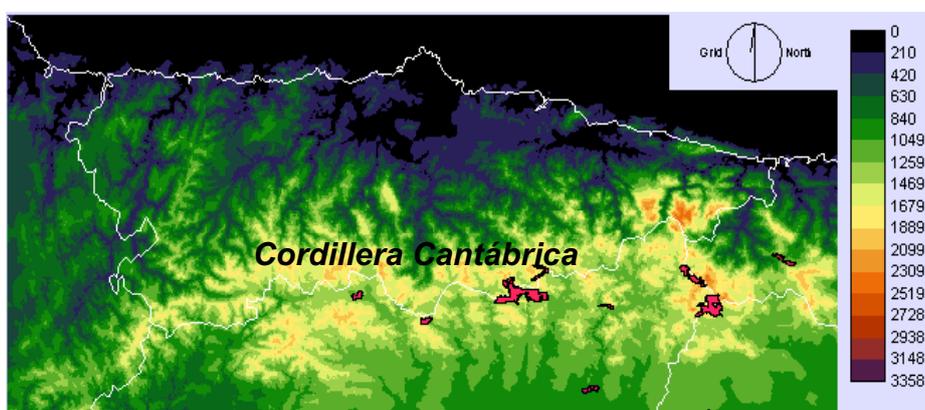


Fig. 1. Heathland dominated by *Calluna vulgaris* in the Cantabrian Mountains (red colour). Source: Cartography Habitat Directive 92/43/CEE (1:50000) Ministerio de Medio Ambiente

The traditional livestock grazing in these heathlands has been associated with burning or cutting to create pastureland and improve forage. Besides, in lowland areas, ploughing of the woody species represents another widespread traditional human practice in these heathland communities. However, currently these management activities have been practically abandoned due to an important decrease in the human population of the montane villages, associated with two big migrations. The first migration occurred between 1875-1920, in which more than 100,000 inhabitants migrated from León province to America. This process was related to the adverse situation in the rural areas and the low production of the fields. The second migration occurred during the 1960s associated with the developmental plans of Franco's government for the rural areas that favoured the migration to the cities. During this period, 40,000 inhabitants of León province migrated to Barcelona, Madrid and the Basque Country and, in some cases, to Oviedo. Moreover, approximately 50,000 inhabitants went to Central Europe. Agrarian policies changed, and, as a consequence, these montane farming areas were abandoned in the 1970s, starting a secondary succession process towards heath communities. Recently, due to the decline of traditional management activities, heaths have begun to be considered marginal lands. Indeed, some of these upland heathlands have been turned into forest plantations as it can be observed very close to the experimental plots in San Isidro Pass (see photograph).

The San Isidro mountain pass is situated at 1600 m altitude, and on a site with no appreciable slope. From a geological viewpoint, the area is characterised by polygenic forms that determine a complex lithology involving Cantabrian Area Palaeozoic materials. They include mountain limestone, massive quartzite and slate with levels of sandstone, limestone and conglomerates.



Pinus afforestation on heathlands. Author: L. Calvo

Regarding its current climatic and vegetation characteristics, the area is part of the Eurosiberian Region and is included in the subalpine bioclimatic stage. The climate is typical continental, characterised by a lack of an aridity period or, if one occurs, it is shorter than two months and always during the warm season. Mean annual temperature on the site is 5.5 °C. The length of winter in this area is very important because of its limiting effects on plant growth. The winter is cold, with a mean temperature of –3.5 °C in the coldest month. Mean annual precipitation is 1319 mm, but the distribution of rain is irregular throughout the year, decreasing significantly during the summer. The biological activity period is reduced to eight months or less.

This area is occupied by a humid heath, with a dominance of *Calluna vulgaris* (mean cover > 80%) and also presence of *Erica tetralix*, *Vaccinium myrtillus* and *Vaccinium uliginosum* (mean cover < 10%). None of these species is over 50 cm in height and they form a cover of homogeneous appearance. Another woody species occurring in the area is *Erica australis* (mean cover < 2%). Herbaceous species are not very abundant. Some of the herbaceous species present in this area are: *Deschampsia flexuosa*, *Aira caryophyllea*, *Festuca rubra*, *Carex pilulifera*, *Nardus stricta*, *Juncus squarrosus*, *Jasione montana*, *Potentilla erecta*, *Scilla verna*, *Galium saxatile*.

Studies in the *Calluna vulgaris* heathlands of San Isidro started in 1985, with the PhD of L. Calvo, supervised by E. de Luis and R. Tárrega. This study was addressed to perform a comparative analysis of the responses showed by these heathlands against burning, ploughing and cutting, which represent the main impacts on these heathlands in NW León Province. At the same time, we compared the behaviour of *Erica australis* shrublands with *Calluna vulgaris* heathlands after perturbations.

Within the area uniformly occupied by heath, three 10 m x 10 m plots were randomly selected. One plot was burned in summer 1986. No aboveground biomass survived the burning. In the second plot, all the woody aboveground biomass was cut to ground level in summer 1985. The third plot was ploughed by mechanical means in summer 1986 (with a tractor, ploughing depth was 50 cm). All the vegetation stumps were eliminated by this treatment in order to avoid vegetative resprouting. We monitored the secondary succession for 20 years and the main results showed that after burning and ploughing there was good regeneration of the vegetation and that more than 20 years are needed to achieve a similar situation to the original. However, after cutting the community dominated by *Calluna vulgaris* in the original situation was transformed into a heathland dominated by *Erica tetralix*. So, **from these results, we address the following question: Is cutting a correct tool to manage these *Calluna* heathlands in order to conserve them?**

In 1998, new experiments were carried out, simulating the effects of cutting and nitrogen deposition in experimental plots in this area. The objectives of this new application were to increase the knowledge on those subjects, but also to include new simulations on the effects of climate change. In this new project the research group was integrated by E. de Luis, R. Tárrega,

L. Calvo, L. Valbuena, E. Marcos and I. Alonso. The incorporation of new members facilitated the extension of our initial studies on the changes in vegetation composition and structure during secondary succession to the new approach on the changes in soil characteristics and soil seed bank. The results of this project showed that fertilization allowed vegetation biodiversity to increase over time within a medium time scale (5 years). This increase was considerably greater after cutting plus fertilization than after cutting or after fertilization alone. The increase in global richness was fundamentally based on an increase in the number of perennial herbs. The rise in perennial herb richness also corresponded to an increase in cover values. Besides, we observed that *Calluna vulgaris* showed regeneration problems in comparison to *Erica tetralix*. So, cutting could be a good management tool to increase the vegetal biodiversity but it was not the best tool to conserve the *Calluna* heathlands. From this moment, we targeted a new question: **Could burning be used as a management tool to preserve this ecosystem in the new scenario of increased nitrogen deposition?**

In 2005 we started a new project with the incorporation of S. Suárez-Seoane to the research team, who helped us to initiate the study of the historical variation of the landscape in the south part of the Catabrian Mountain, focusing on heathland changes. Likewise, during this period, people from the Animal Biology Department, A. Taboada and J. M. Salgado, joined the team and collaborated via the entomological characterization of these heathlands. Another innovative aspect was that two members of our Faculty, L. Saenz de Miera and G. Ansola, participated in the project and developed a new technique to characterize the soil microbial community.

This multidisciplinary group started an integrated project to study the functioning of the Heathlands after burning in the scenario of nitrogen deposition. To achieve this objective we fixed four plots of 20 m x 20 m. One plot was the control, the second was burnt in June 2005, the third plot was monthly fertilized (from May to October every year from 2005 till now) with ammonium nitrate and the fourth plot was burnt in June 2005 and monthly fertilized.

Associated with this project three PhD students are developing their research studies: A. Morán-Ordóñez is analysing the landscape changes in this region, D. Cuesta-Segura is studying the effects of perturbations on the edaphic fauna of ground beetles, leaf beetles and true bugs and C. Villalón is investigating the nutrient changes after perturbation. The main results of this project will be explained in the field during the Workshop excursions by some of the members of the team.

In 2009 we started another project in which we will try to understand the dynamics of the nitrogen in these ecosystems, using the technology of the stable isotope ¹⁵N. The experimental design and more information about this project will be also explained in the field during the Workshop.

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Burning and nitrogen deposition effects on soil characteristics in heathlands. Nitrogen cycle in Cantabrian heathlands

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Heathlands occur on nutrient-poor acidic soils and are adapted to low availability of nutrients. Soils where *Calluna* heathlands appear in the Cantabrian Mountains are sandy (75-90% in sand), acidic (pH around 4), with low content in nitrogen (0.1-0.2%) and phosphorus (2-9 ppm), high organic matter content (20%) and often suffer a podsolitization process. Soil temperature is low most of the year and the water content is high for 5 or 6 months. These abiotic conditions result in slow cycling of N and low availability of N in suitable forms for plant uptake. In North and Central European heathlands, N deposition has a large impact on the structure and functioning of the ecosystem. However, we do not know how the southernmost heathlands will respond to these high depositions. For this reason, we have studied the changes in soil and vegetation nutrient status after fertilization (simulating nitrogen deposition) and the interaction with other perturbations such as burning and cutting (simulating land management).

The results showed that after fertilization and cutting no changes in soil chemistry were produced. However, an increase in the nitrogen content of the shoots of *Calluna vulgaris* and *Erica tetralix* was observed due to the treatments. Also, cutting one of the two species studied favours the accumulation of nitrogen in the other. When burning, fertilization and burning plus fertilization were carried out, the results in soil chemistry were different according to the treatments. Fertilization had no effect on soil nutrients. A significant increase in NH_4^+ content was detected in burning plots as a result of more favourable soil environmental conditions. Nitrogen shoot content in *Calluna* was significantly increased by nitrogen addition. This increase reached its maximum value three years after the treatments. Five years later, nitrogen content was higher in fertilization and burning plus fertilization plots than in burning plots. In the case of P, an important increase was observed after three years in all treatments. In the fifth year the highest content appeared in both burning plots.

If we analyze the percentage of nitrogen retention in the experimental plots, we always observe higher retention in fertilized (about 98%) than in non-fertilized plots (35%). However, this retention is not sufficiently reflected in plants and soil. For this reason, we intend to study N allocation patterns using a ^{15}N tracer. We selected two study areas in the Cantabrian Mountains (La Majua and San Isidro). In each area, we established two plots to study N allocation in biomass, microorganisms and soil. Each plot had two subplots (2 x 1 m): one subplot will receive ^{15}N tracer and the other will be used as a control. To calculate leaching losses, we established another two plots per area. Two lysimeters were installed per plot: one will receive ^{15}N tracer and the other will be the control. All the plots were fenced off to prevent grazing.

These studies were financed by the research projects: JCYL LE021A08, JCYL LE039A09.

The importance of seed germination in the regeneration of the Cantabrian heathlands after burning and nitrogen deposition

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The San Isidro mountain pass is situated at 1600 m altitude, and it is characterised by a complex lithology involving Cantabrian Area Palaeozoic materials. They include mountain limestone, massive quartzite and slate with levels of sandstone, limestone and conglomerates. Regarding its current climatic and vegetation characteristics, this area is part of the Eurosiberian Region and it is included in the subalpine bioclimatic belt. The climate is typically continental, being characterised by a lack of an aridity period or, if one occurs, it is shorter than two months and always during the warm season. Mean annual temperature is 5.5 °C. The length of winter in this area is very important because of its limiting effects on plant growth. The winter is cold, with a mean temperature of -3.5 °C in the coldest month. Mean annual precipitation is 1319 mm, but the distribution of rain is irregular throughout the year, decreasing significantly during summer. The biological activity period is reduced to eight months or less. This area is occupied by a humid heath, dominated by *Calluna vulgaris* (average cover values > 80%) with also presence of *Erica tetralix*, *Vaccinium myrtillus* and *Vaccinium uliginosum* (average cover values < 10%).

In 2005, we started to develop a project aimed to study the functioning of these heathlands after burning processes, within a scenario of increased nitrogen deposition. To achieve this objective we fixed four plots of 20 x 20 m (three replicates): (1) Control plot; (2) Burned plot (it was burned in June 2005); (3) Fertilized plot. This has same characteristics than the control plot but it has been monthly fertilized with ammonium nitrate during the period May-October, every year since 2005; (4) Burned plus fertilized plot. This was burnt in June 2005 and fertilized afterwards following the same criteria than the fertilized plot. In our study we aimed to analyze the regeneration capacity of *Calluna vulgaris* and *Erica tetralix* heaths from seeds after burning perturbations, within a scenario of increased nitrogen deposition. Thus, in each one of the four field plots mentioned above, we established 10 sampling units where we counted the number of *Calluna vulgaris* and *Erica tetralix* seedlings found through time (1m² each). One year after the treatments, we started to observe seedlings from both species. Four years later, we found an average density of 8.5 *Calluna vulgaris* seedlings/m² in the burned plots, and an average of nine seedlings/m² in burned and fertilized plots. This density was lower in the case of *Erica tetralix*: 0.76 seedlings/m² in plots burned and fertilized. *Erica tetralix* disappeared in burned plots 4 years later. In these heath communities, the use of fire as a management tool clearly favours *Calluna vulgaris* communities' persistence when compared to those of *Erica tetralix*.



Seedlings of *C. vulgaris* and *E. tetralix* one year after burning and fertilization. Author: L. Valbuena

These studies were financed by the research projects: JCYL LE021A08, JCYL LE039A09, MCYT CGL2006-10998-C02-01/BOS.

Entomological research in *Calluna*-heathlands of NW Spain

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The aim of this study was to determine the effects of experimental burning, nitrogen addition and burning plus nitrogen addition, at short- (first year) and medium-term (second and third years), on three groups of insects (ground beetles -Coleoptera: Carabidae-, leaf beetles -Coleoptera: Chrysomelidae- and true bugs -Hemiptera: Heteroptera-) inhabiting *Calluna vulgaris* heathlands of NW Spain. We selected three sites dominated by *C. vulgaris* between 1560-1660 m a.s.l. and at least 2.5 km apart. In each site four permanent 20x20 m plots were established: 1) burned plot, experimentally burned in June 2005; 2) fertilized plot, monthly fertilized with ordinary granules of ammonium nitrate, from June to October each year; 3) burned plus fertilized plot; and 4) control plot. Six pitfall traps partly filled with 25% propylene glycol and covered by 11x11 cm roofs were placed in each plot in order to capture the insects. Traps were sampled every 20 days from July to October in 2005 and from June to October in 2006 and 2007. A total of 5686 individuals of ground beetles belonging to 50 species, 3435 individuals (8 species) of leaf beetles and 1787 individuals (30 species) of true bugs were captured. At the group level, the fire was the most important factor affecting the three groups of insects. Ground beetles showed a positive response to fire (burned and burned plus fertilized plots), increasing in abundance and species richness at short- and medium-term. Leaf beetle abundance was negatively affected by fire and highly increased in fertilized plots, especially during the third year. The number of leaf beetle species was low, but positively influenced by fire. True bug abundance increased in burned and burned plus fertilized plots at short-term but decreased at the medium-term, while species richness showed no clear pattern.

At the species level, a variety of responses was observed in the three insect groups. For ground beetles, *Calathus asturiensis* and *Cryobius cantabricus* were the most abundant species. The abundance of a high number of ground beetle species was positively affected by fire, like *C. asturiensis* and several species of the genera *Bembidion*, *Cicindela*, *Poecilus* and *Zabrus*. The abundance of other species such as *C. cantabricus* and *Carabus macrocephalus* increased in fertilized plots and decreased in the burned ones. Leaf beetles mainly belonged to *Lochmaea suturalis* and were benefited by nitrogen fertilization. *Macrodema microtera* was the most abundant true bug species captured. This species and the nymphs of Lygaeidae followed the group's pattern; whereas the fire negatively affected the abundance of *Nabis ericetorum*, *Orthotylus ericetorum* and *Stygnocoris fuliginus* at short- and medium-term, and positively influenced *Coranus subapterus* and the nymphs of Aradidae.



Cryobius cantabricus. Author: D. Cuesta-Segura



Lochmaea suturalis. Author A. Taboada

These studies were financed by the research projects: JCYL LE021A08, JCYL LE039A09; MCYT CGL2006-10998-C02-01/BOS

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Plant diversity in the Cantabrian range is characterized by a mixed influence of Atlantic, Mediterranean and Alpine flora. As a result of such influences, distinct vegetation types can be found along the northern and southern slopes of the central axis of these mountains. In acid bedrocks, this effect is especially marked above the tree-line, where northern exposures are dominated by Atlantic heathlands (*Calluno-Ullicetea*) and southern slopes are covered by shrublands (*Cysetetea-Scopario striati*) and grasslands (*Festuco-Indigestea*) of Mediterranean influence. In the highest summits (> 1800 m) it is possible to find relict vegetation with (sub)alpine dwarf-shrubs (*Vaccinio-Picetea*) dominated by *Juniperus communis* subsp. *alpina* and *Vaccinium uliginosum*. This vegetation is especially frequent in the area of San Isidro (Asturias and León), a particular case of the Cantabrian Mountains because of the high impact of the pleistocene glaciations, nowadays substituted by active periglacial processes. The climatic conditions of San Isidro have permitted the survival of relict populations of boreo-alpine species in northern exposures of the highest summits, in some cases (es. *Empetrum nigrum* subsp. *nigrum* and *Callianthemum coriandrifolium*) their unique refuges in the Iberian Peninsula. Since many of these species are extremely rare, they are included in the IUCN Spanish red list, and considered of high conservation concern at both regional and national level. Furthermore, the area of San Isidro and the whole Cantabrian range provide an optimal scenario to assess the ecological niche of boreo-alpine species and vegetation on their distribution limit, and the effects of global change on their future development.

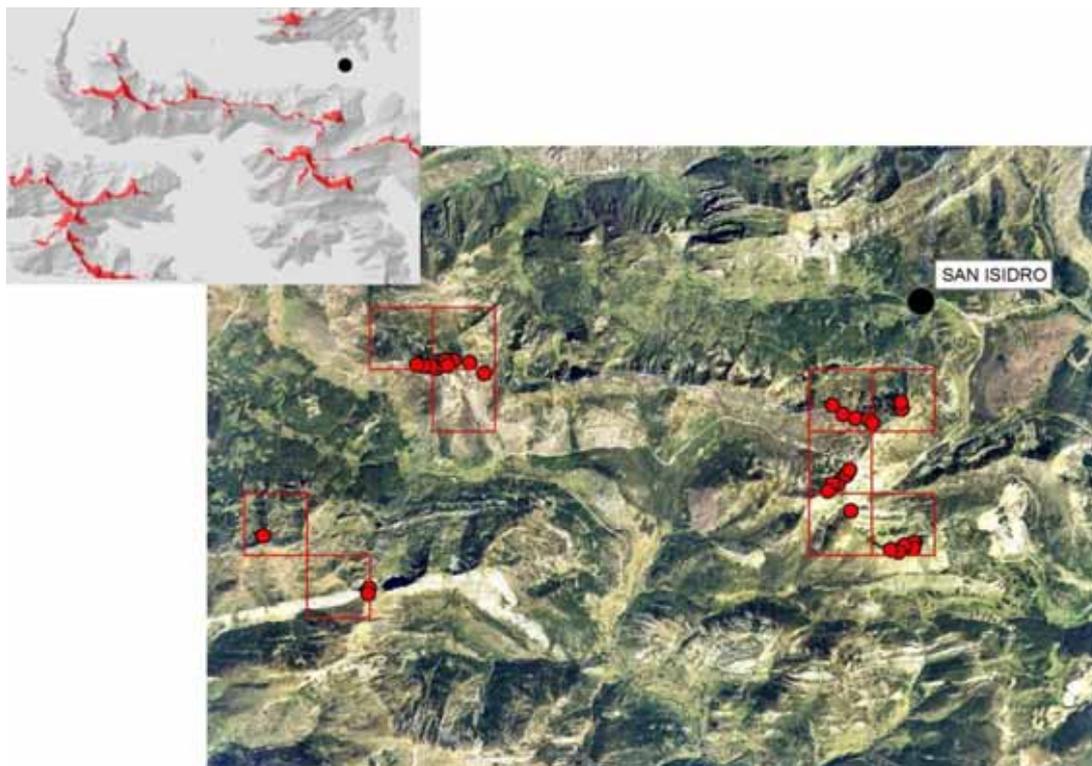


Fig.1. Local distribution of *Empetrum nigrum* in the area of San Isidro. The species was firstly reported by M.L. Vera (University of Oviedo) in 1980. Red points indicate the populations currently known, which are distributed along 10 grids of 1x1 km² (red squares). The upper figure shows the potential distribution of the species according to a habitat suitability model (in red) performed above the 1600 meters of altitude (dark grey), closely related to shady snow-beds between 1900 and 2100 m.

Field trip 3: BABIA

Spanish juniper (*Juniperus thurifera* L.) in the Cantabrian Mountains

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INTRODUCTION

Spanish juniper (*Juniperus thurifera* L.) is a dioecious, masting and very old species in evolutionary terms (its origin was in Tertiary). It is native to the mountains of the western Mediterranean region, from southern France across eastern and central Spain to Morocco and, locally, it is present in northern Algeria. This species woodland occupies more than 600,000 ha in Spain, half of them being pure or juniper-dominated mixed stands.

The climatic habitat occupied nowadays by *J. thurifera* is more similar to Submediterranean environments rather than the genuine Mediterranean one. Therefore, its strategy to compete with faster-growing species (*Pinus*, *Quercus*) lies in inhabiting on the worst soils, either due to the high stoniness, low or very high permeability or extremely high pH. The European Community has classified forests of this species as priority habitat (code 9560).

The Spanish juniper formation in the Cantabrian Mountains represents the most occidental in the Iberian Peninsula (Fig. 1). It is located in the southern slope of the Cantabrian Mountains, at an elevation between 1150 and 1300 metres. They occupy the south aspect with high slopes and in soils with low development. The rocks upon it live are mostly limestone. The presence of this species in the area is outstanding, as thousands of hectares of abandoned marginal agricultural lands have been encroached by *Juniperus*.

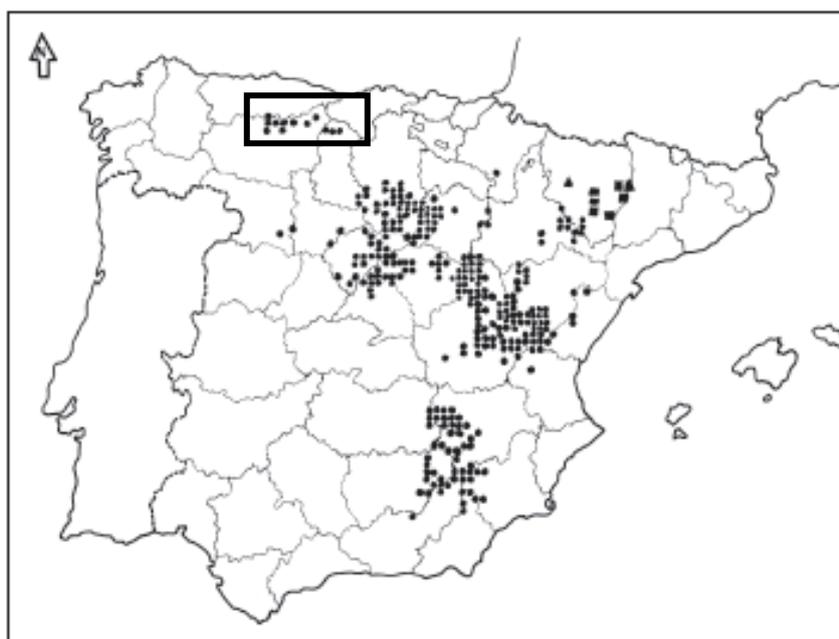


Fig. 1. Distribution of the juniper (*Juniperus thurifera* L.) in the Iberian Peninsula (Fernández 2003)

HISTORY

The past land use is one of the main factors to contribute to form ecosystems. In the Cantabrian Mountains the traditional management, repeated burnings, extended croplands and intense grazing, gave us an open landscape, mostly dominated by pastures and shrublands. The short interval among severe disturbances caused the local extinction of most no-resprouting trees species. This disturbances regime provided suitable conditions to the best resprouters, in particular to *Quercus pyrenaica*. Most of coniferous species were disappeared all over the entire range, as *Picea abies*, *Pinus uncinata* or *Pinus nigra*. Even some resprouters like *Tilia* spp. and *Acer* spp. as they are not very resistant to fire and heavy grazing, they were eliminated over vast areas. Nevertheless, the particular habitat of *Juniperus thurifera*, with preference for bare soil, rocky, land not able to farm and fireproof slopes, has prevented from extinction this slow-growing and not sprouting species.

In the 60's, the traditional relationship between man and territory has broke down. Young people gave up the rural areas and the entire socioeconomic system collapsed. The pressure for natural resources dropped abruptly and, as consequence, the ecosystem dynamics changes radically. The scarce *Juniperus thurifera* left by traditional uses have now their opportunity to regenerate and became more abundant.

DYNAMICS

The current habitat of *J. thurifera* in the Cantabrian Mountains, relegated to geographically isolated patches, must be the result of a compromise between high environmental stress and low presence of others competitive species. The main traits of *J. thurifera* slow growing, shade-intolerant; give this species more success than other tree species typical from this area. So, in areas where forest had been cleared for agriculture or livestock purposes, this species had an opportunity of colonization and rapid spread, because their mechanisms of regeneration and establishment are very effective in these conditions.



Juniperus thurifera spreading as a pioneer tree in ancient crop lands (Miñera de Luna, León). Author: F. Sevilla



In 1935, the socioeconomic context of poverty and the subsistence economy led to an extremely intensive use of the territory. Here, due to livestock grazing, cuttings for firewood, and wildfires when and where shrubs expand, the bare limestone rock appeared only with scattered trees, mostly spanish juniper. Traditional exploitation caused heavy deforestation, but also generates suitable conditions for *Juniperus thurifera* spread when the pressure decreased. Recent dynamics (photo taken in 2002) favours tree progress in general: not only Spanish juniper expands, but also deciduous trees, mainly Portuguese oak (*Quercus faginea*). In the future, the cover of oaks will prevent Spanish juniper regeneration and the forest of this species will decrease (Mallo de Luna, León). *Authors: Servicio de Medio Ambiente de la Junta de Castilla y León and J. Ezquerro, respectively*

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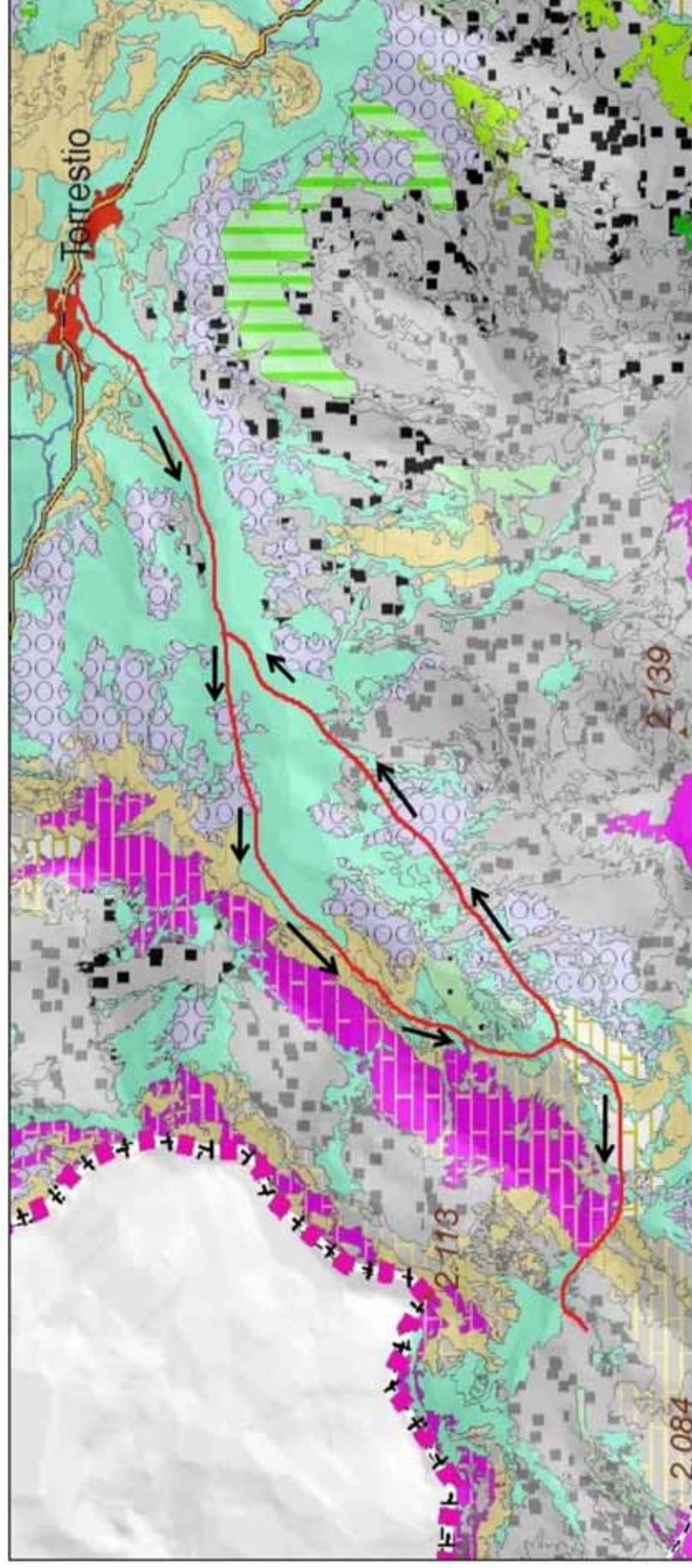
Field trip: Heathlands and transhumance in the Cantabrian Mountains. Babia (León). 15th of June, 2011.

Talks:

Dr. Ángela Taboada (University of Lüneburg - University of León)
Mr. Manuel Rodríguez (CSIC) Mr. Ignacio Prieto (University of León)
Dr. Patricia Matco (IE University) Mr. Javier Ezquerro (JCyL)
Dr. Pedro P. Olea (IE University) Mr. Froilán Sevilla (JCyL)



Field trip: Heathlands and transhumance in the Cantabrian Mountains, Babia (León). 15th of June, 2011. VEGETATION AND HABITATS OF SPECIAL INTEREST.



-  *Juniperus communis* subsp. *alpina* shrubs (basic substrate). Alpine and boreal heaths.
-  *Juniperus communis* subsp. *alpina* shrubs (siliceous). Alpine and boreal heaths.
-  *Genista hispanica* subsp. *occidentalis* cushion shrubs. Endemic oro-Mediterranean heaths.
-  *Erica australis* subsp. *aragonensis* heathlands. European dry heaths.
-  Shrublands of *Genista florida* and *Cytisus scoparius*.
-  *Calluna vulgaris* heathlands. Alpine and boreal heaths.
-  Cantabrian shrubs of *Genista obtusiframca* and *Cytisus nuregans*. Mountain *Cytisus nuregans* formations.

-  Reforestation
-  Cryoturbated basic grasslands
-  Mesophilous grasslands
-  Siliceous grasslands
-  Limestone crests
-  Birch forest

Site of community importance “Valle de San Emiliano” (León, NW Spain)

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1. NATURAL HABITAT TYPES OF COMMUNITY INTEREST

Freshwater habitats

3150 Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition* —type vegetation.

3220 Alpine rivers and the herbaceous vegetation along their banks.

3260 Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation.

Temperate heath and shrub

4020 Temperate Atlantic wet heaths with *Erica ciliaris* and *Erica tetralix*. In the visiting area they correspond to heath formations dominated by *E. tetralix* growing over wet soils with low drainage, usually linked to peat soils.

4030 European dry heaths. They are heaths of medium size and high cover dominated by *Erica* sp. They are very homogeneous and therefore they have a low species richness. They occur on acid soils and usually in areas with high recurrence of fires. Within the visiting area, they mainly correspond with heath patches dominated by *Erica australis* subsp. *aragonensis*, with presence of *Erica arborea*.

4060 Alpine and Boreal heath. In the Cantabrian Mountains, the sub-alpine shrub vegetation growing over limestones is *Arctostaphylos uvaursi* and *Juniperus communis* subsp. *alpina* with *Daphne laureola*, *Rosa pendulina*, etc; on the other hand, when the substrate is of a siliceous character, the dominant species are *Juniperus communis* subsp. *alpina*, together with *Vaccinium myrtillus* and other acid-like species as *Calluna vulgaris*.

4090 Endemic oro-Mediterranean heaths with gorse. They correspond, within the visiting area, with formations of cushion shrub dominated by *Genista hispanica* subsp. *occidentalis*, which occur mainly linked to limestones substrate.

Sclerophylus scrub

5120 Mountain *Cytisus purgans* formations. Shrub formations dominated by *Cytisus oromediterraneus* (*Cytisus purgans*) occurring within siliceous soils, which frequently occur together with another endemic *Genista* sp. (*Genista obtusiramea* in the case of the visiting area). Some fauna associated to these formations are some other species of high conservation interest as the bluethroat (*Luscinia svecica*), the grey partridge (*Perdix perdix hispaniensis*) and the broom hare *Lepus castroviejo* (endemic to northern Spain).

Natural and semi-natural grasslands formations

6140 Siliceous Pyrenean *Festuca eskia* grasslands. They are alpine pastures dominated by *Festuca eskia* in which we can find species like *Polygala edmundi*, *Trifolium thalii*, *Trifolium alpinum*, *Luzula caespitosa*, *Oreochloa blanka* or *Juncus trifidus*. There is a high proportion of endemic species in these grasslands.

6160 Oro-Iberian *Festuca indigesta* grasslands.

6170 Alpine and subalpine calcareous grasslands.

6210 Semi-natural dry grasslands and scrubland facies on calcareous substrates (*Festuco-Brometalia*) (* important orchid sites). They occur on fresh, calcareous and not very deep soils. They have an extreme species richness. Some of the characteristic species: *Carex caryophyllea*, *Bromus erectus*, *Potentilla crantzii*, *Achillea odorata*, *Ononis cristata*, *Linus catharticum*, *Anthyllis vulneraria*, *Carex flacca*, *Coronilla minima* subsp. *minima*, etc. Sometimes there are populations of orchids linked to these grasslands (*Ophrys* sp., *Orchis* sp., *Dactylorrhiza* sp., etc.), which convert them in priority habitats.

6220 Pseudo-steppe with grasses and annuals of the *Thero-Brachypodietea*.

6230 Species-rich *Nardus* grasslands, on siliceous substrates in mountain areas (and submountain areas in Continental Europe).

6430 Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels.

Raised bogs and mires and fens

7110 Active raised bogs.

7140 Transition mires and quaking bogs.

- 7150 Depressions on peat substrates of the *Rhynchosporion*.
- 7220 Petrifying springs with tufa formation (*Cratoneurion*).
- 7230 Alkaline fens.

Rocky habitats and caves

- 8130 Western Mediterranean and thermophilous scree.
- 8210 Calcareous rocky slopes with chasmophytic vegetation.
- 8220 Siliceous rocky slopes with chasmophytic vegetation.
- 8230 Siliceous rock with pioneer vegetation of the *Sedo-Scleranthion* or of the *Sedo albi-Veronicion dillenii*.
- 8310 Caves not open to the public.

Forest

- 9120 Atlantic acidophilous beech forests with *Ilex* and sometimes also *Taxus* in the shrublayer (*Quercion robori-petraeae* or *Ilici-Fagenion*).
- 9150 Medio-European limestone beech forests of the *Cephalanthero-Fagion*.
- 9230 Galicio-Portuguese oak woods with *Quercus robur* and *Quercus pirenaica*.
- 92A0 *Salix alba* and *Populus alba* galleries.
- 9560 Endemic forests with *Juniperus* spp.

2. FAUNA AND FLORA OF COMMUNITY INTEREST (Habitats Directive, 92/43/EEC)

Mammals: *Galemys pyrenaicus*, *Rhinolophus hipposideros*, *Rhinolophus ferrum-equinum*, *Rhinolophus euryale*, *Miniopterus schreibersi*, *Myotis myotis*, *Ursus arcto* and *Lutra lutra*.

Birds: The populations of Egyptian vulture (*Neophron percnopterus*), Hen harrier (*Circus cyaneus*), Grey partridge (*Perdix perdix hispaniensis*), Honey buzzard (*Pernis apivorus*), Short-toed eagle (*Circaetus gallicus*), within this area have importance to national to international level. It is remarkable the breeding community of alpine species: Alpine accentor (*Prunella collaris*), Rufous tailed Rock Thrush (*Monticola saxatilis*), Bluethroat (*Luscinia svecica*), Wallcreeper (*Tichodroma muraria*), Alpine chough (*Pyrrhocorax graculus*) and the Snow finch (*Montifringilla nivalis*), some of them with important populations in this area.

Amphibians and reptiles: *Discoglossus galganoi*, *Lacerta monticola* and *Lacerta schreiberi*

Invertebrates: *Elona quimperiana*, *Euphydryas aurinia* and *Lucanus cervus*.

Flora: *Centaurium somedanum*, *Narcissus pseudonarcissus nobilis*, *Narcissus asturiensis* and *Festuca elegans*.

3. SOME MORE ECOLOGICAL/CULTURAL TIPS

- It shelters high flora richness thanks to the complex lithology and the fact that it lies on the boundary between the Atlantic/EuroSiberian and Mediterranean biogeographical regions.
- It represents the western-most distribution in Europe of *Juniperus thurifera*.
- Good conservation status of the deciduous forest, although it is scarcely represented in this site of community importance.
- Sporadic presence of brown bear (*Ursus arctos*) on their movements between the Eastern and Western Cantabrian Mountains sub-populations.
- It shelters some of the most important populations of the heath tiger beetle (*Cicindela sylvatica*) in Europe.
- Good simple/representation of the alpine biome with its correspondent ornithological cohort.
- High cultural richness due to the fact that this area was a game reserve for kings and counts of León during centuries, and also because it has been one of the most important regions in northern Spain receiving flocks of merina sheep linked to transhumance movements.
- Transhumance has represented one of the most important economic activities for the population of this region for centuries. Some of the villages remained empty during winter while full occupied in summer, because of seasonal movements of its inhabitants looking for the best weather conditions for them and their livestock. Thus, they used to spent the winter in the coastal zones of Asturias (mild winter), and in June, they used to come back to the mountain's villages looking for the fresh and green mountain pastures their flock will use until the end of October. Torrestío, the village we will visit in our field trip is one of these examples. In this village we can find elements of the Asturias traditional architecture called "horreos". They are small constructions separated from the ground by 4 or 6 pillars which use to be placed nearby the familiar house. Families used them to store their food and the products they harvest from their small orchards (potatoes, onions, etc.), to keep them fresh and out of rodent reach.

Plants and vegetation of Babia (León, NW Iberian Peninsula)

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The vegetation of our area has been profoundly affected by human historical uses, mainly recurrent fires and cattle grazing. Original forests are gone and only remnants can be observed in nearby areas, in which we may find oaks (*Quercus pyrenaica*, *Quercus petraea*), birch tree (*Betula alba*), hazel nut trees (*Corylus avellana*) or beech tree (*Fagus sylvatica*). On humid soils by the streams a community of ashes (*Fraxinus excelsior*), maple tree (*Acer pseudoplatanus*) occur, although the most frequent community is dominated by willows (*Salix cantabrica*, *S. atrocinnerea*, *S. alba* and others).

Heathlands dominate the landscape, dwarf shrubs with *Pterospartum tridentatum*, *Ulex gallii*, *Halimium alyssoides*, *Erica cinerea*, *Erica australis* or *Daboecia cantabrica* are dominant on acid soils, while the basophylous community has *Genista occidentalis*, *Arctostaphylos uva-ursi* and in some places *Erica vagans* is present. Humid heathlands appear where moist soils never get dry and the water moves slowly forming mountain peatlands, with *Erica tetralix*, *Calluna vulgaris*, *Genista anglica*, *Carex echinata* and several species with high requires of water.

Brooms also form a widely distributed community that occurs where the soils have a higher depth and as a higher community on natural succession. *Cytisus scoparius* and *Genista florida* subsp. *polygaliphylla* are its dominant species, while *Genista obtusiramea* takes place in higher altitudes. The tree heath (*Erica arborea*) and *Pteridium aquilinum* are frequent.

Meadows and grasslands are the last stages on plant succession, here formed by different grass species such as *Cynosurus cristatus*, *Phleum pratense*, *Agrostis stolonifera*, *A. capillaris*, *Dactylis glomerata*, *Avenula sulcata* or *Cynosurus cristatus*. Other species also occur such as *Hypochoeris radicata*, *Anthyllis vulneraria*, *Thymus praecox* and *Lotus corniculatus*.

Chasmophytic vegetation associated to rock surfaces and very shallow soils occur mostly on limestone areas, where *Bromus erectus*, *Sideritis hissiopifolia* or *Koeleria vallesiana* are frequent, but also on acid rocks in which *Sedum anglicum*, *Dianthus langeanus* or *Agrostis durieui* occur.



Digitalis parviflora Jacq. Author: J. Fagúndez

To know more

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Eryngium bougartii Gouan. Author: J. Fagúndez

Torrestío: an example of territory use in the Babia district (León)

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Torrestío is a small place in the municipal area of San Emiliano (previously known as Babia de Suso). It covers 2,398.4 ha and is physiographically characterised by the duality existing between the reduced space occupied by the quaternary sedimentation valley (situated at heights of over 1,300 metres) and the mountains over 2,000 metres high surrounding it. The landscape is the result of traditional land use, mainly livestock farming. In the past severe deforestation produced the surface area occupied by pasture. Biodiversity maintenance at present depends on maintaining the traditional activities which are clearly declining. Torrestío has historically been a district of very intense human activity, particularly linked to extensive livestock farming. This has produced a complex landscape of great cultural and ecological value. In the last few decades the factors acting on this territory have been substantially modified: the growing demographic weakness, the abandonment of lands or the decadence of extensive livestock farming activity paint a new scenario which endangers the maintenance of the cultural and ecological features of the district. From the human viewpoint the place is characterised by a very marked economic and sociodemographic regression; the depopulation trend and population ageing are significant at the same time as the agricultural-livestock activities are in considerable decline not compensated for, as yet, by the timid increase in tertiary activities linked to tourism. As regards the characteristic relief of the district, it can be stated that 1% of the geographical area is at over 2,000 metres, 18% between 1,000 and 1,500 m and 81% between 1,500 and 2,000 m. The highest point of the district is *Moronegro* (2,151 m). In general, the zones with flat or gentle slopes cover 2%. The zones with a moderate or steep slope cover 25% of the district. These zones are used to grow cereal crops. Finally 73% of the surface area is characterised by the presence of over 30% slopes which can only be used for extensive livestock farming. From the geological point of view the place is situated in the Iberian Massif (or Hesperian Massif). The valley zones through which the rivers flow are the result of Quaternary erosive processes; however, the rugged zones, characterised by steep slopes, are the result of the Alpine Orogeny finally modelled by fluvial, glacial, periglacial and karstic dynamic processes. Lithologically it presents limestone, sandstone and palaeozoic slate. The climate is characterised by annual precipitations of over 1,100 mm, falling irregularly during the year, with maximums from October to February and minimums in July and August. Snowfall depends greatly on the altitude, and its permanence is closely linked to orientation. Mean annual temperature is 8°; the fact that mean temperatures equal to or below 0° are recorded in every month of the year is worth mentioning, which means that there is a risk of frost throughout the year. This conditions the development of vegetable crops to a great extent. Absolute minimum temperatures exceed -20° in the lower zones, reaching even more extreme values in the peak areas. Vegetal potential of the district consists of three great types of vegetation:

- 1.- In the lowest zones of the area, as well as on all the slopes up to 1,800 m there are birch stands; this type of wood is established above 1,500 m, fixing the limit of the forested terrain. The birch tree (*Betula celtiberica*), adapted to very extreme thermal conditions, forms less dense woods than the beech.
- 2.- The river and stream valleys present *riverbank groves*: among the most common the *ash groves*, consisting of ash (*Fraxinus excelsior*), elm (*Ulmus minor*), poplar (*Populus nigra*) and various types of willow, stand out. The headwaters of the streams present willow groves dominated by endemic willow trees (*Salix cantabrica*).
- 3.- Above 1,800 m the creeping *juniper* (*Juniperus nana*) dominates in these climate conditions and with a substrate of this nature with barely developed soils.

Diverse actions linked to agricultural and livestock farming uses (cutting, burning, grazing, crop growing) have meant that at present the forests are limited in size; however, meadows and grasslands dominate with very few crops and extensive shrub areas.

From a socioeconomic perspective the main economy of Babia was a subsistence economy with self sufficiency, characterized by the insignificance of commercial trade, until the 20th century. So, on the one hand, we can identify cereal production lands (wheat and rye), harvesting hay for winter feed of livestock and growing vegetable crops (potatoes, pulses, cabbages). On the other hand the grazing activities, classified as two types:

- 1.- “*Vecera*” or communal care of neighbours’ livestock (bovine, ovine, caprine, mules) in turns or “*velanda*” according to the number of animals.
- 2.- “*Transterminance*” or “*transhumance*”, that is, grazing outside livestock which come from the riverbanks of León or from Extremadura, respectively. This grazing is done by professionals who move with their herds and flocks following a seasonal pattern.

Another way of maximising resources characterised by their seasonality encroaches on these livestock farming uses: “*alzada*” which consists of an annual migration to the coast (council areas in Asturias close to the coast where they stay from October to Mayo approximately) and in which the whole family is involved, as well as their livestock and all their household belongings. These people have been known as “*vaqueiros de alzada*” since ancient times. The organisation of the area is shown in Fig.1.

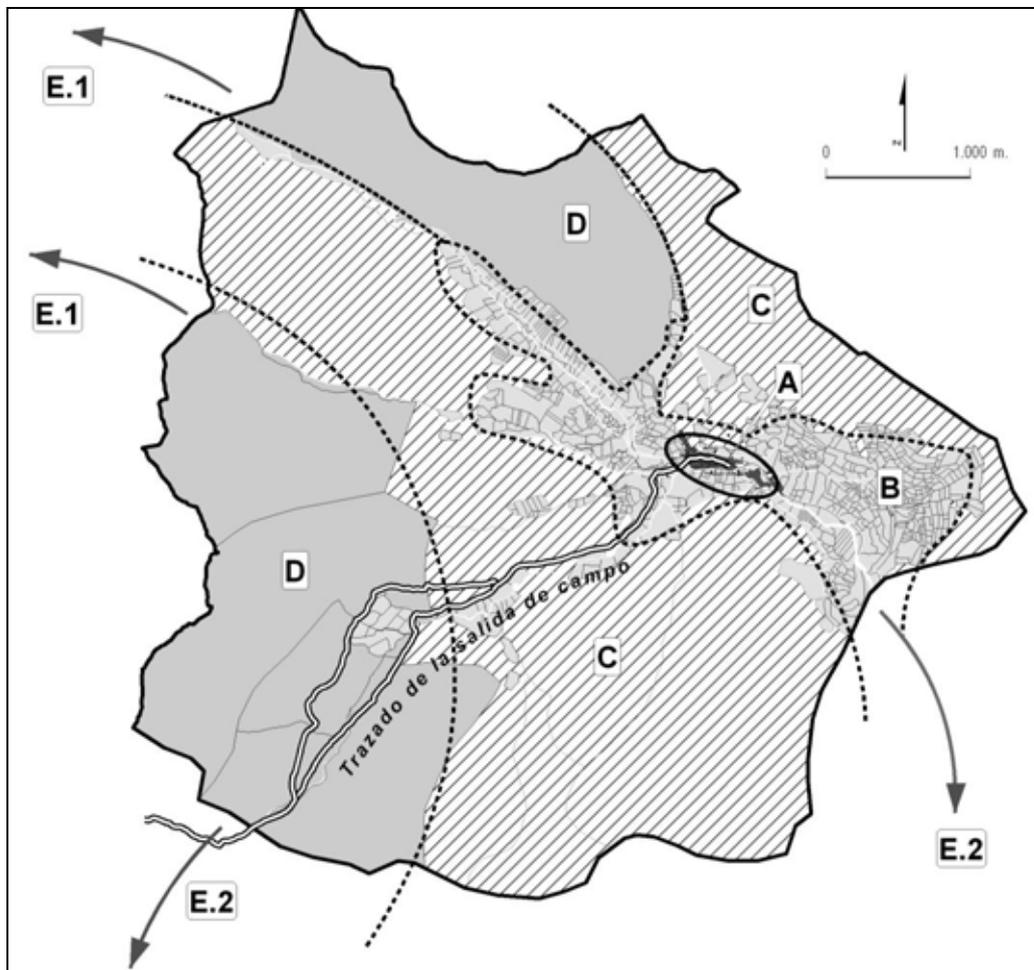


Fig. 1. Organisation of the area: (A) The settlement is located on the banks of the river Torrestío; it is long and there are plots of land used for vegetable crops within it. (B) The riverbank area and some adjoining slopes were used for growing cereals and as meadows for mowing. It is a smallholder zone from which the first use mentioned has disappeared, now replaced by rain-fed meadows or “*pacaderos*”. (C) Most of the district is occupied by communal property for maintaining the local livestock (ovine, bovine and equine), both those that remain there all year (“*estante*”) and those that do the “*alzada*”, grazing using the “*vecera*” system. A progression of shrubland caused by infragrazing can be seen in these areas (E1). (D) The Pyrenaic-type mountain passes are used by transhumant or transterminant merino sheep and rent is paid to the settlement. This money is used to cover expenses such as doctors, teachers, purchasing firewood, church taxes, etc.). Each mountain pass has cabins for the shepherds built of stone and vegetal materials (E2).

The future NATURAL PARK OF BABIA AND LUNA

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The Valleys of Omaña and Luna and San Emiliano were both designated Biosphere Reserves by UNESCO in 2005. In a very near future most of this area will be designated as “Natural Park of Babia and Luna” by the environmental authority. The area is located in the autonomous region of Castile and León, in the northwest of the province of León. It includes the municipalities of Sena de Luna, Barrios de Luna, San Emiliano and Cabrillanes. This high-altitude area is surrounded by mountains reaching even 2.400 m a.s.l., which mark the frontier between the northern and southern slopes of the Cantabrian range (at the north) and between the latter and the León Mountains, at the south. This Natural Park is an excellent example of a mountain ecosystem in the Cantabrian Mountains. This area has also been declared ZEPA and LIC within the Natura 2000 network. From the climatic point of view, the Cantabrian Mountains prevent the movement of wet fronts from the Atlantic, so rainfall and temperature conditions are more extreme in this area than in the northern side of the range. Climatic conditions in this area are: average temperatures 18°C, the warmest month and 1 °C in the coldest month, and high number of days with snow and freeze. The amount of precipitation decreases as you go to south, leaving the Atlantic part, and varies between 1.600 and 900 l/m² per year. The Mountainous landscape of Babia and Luna is determined by its altitude (about 50% of the area exceeds 1,500 m), reaching its peak in the 2,417 m of the massive limestone of the Peña Ubiña. The terrain is generally quite pronounced except in the valleys of the major rivers. Preserved in many parts of the area several glacial morphological features, mainly cirques, lateral and frontal moraines.

Babia and Luna is an area of great environmental value, that include many species of fauna, several of which have their southern distribution limit in the region, such as the brown bear (*Ursus arctos*) and a few remnant capercaillies (*Tetrao urogallus*). Other interesting species include Cantabrian endemic species such as the broom hare (*Lepus castroviejoi*) and Iberian endemic species such as the Pyrenean desman (*Galemys pyrenaicus*). The flora of the region includes many endemic Iberian species. There are typical deciduous forests like, birch forests and oak forest. The main feature of the vegetation of the area is given by the border area between the Atlantic and Mediterranean vegetation. Within the zone, there are good examples of both types of vegetation, because the vegetation of the North Atlantic typically contrasts with that of the southern valleys, in which shows a certain degree of Mediterranean influence, as evidenced by the presence of *Juniperus thurifera* and other Mediterranean species on sunny limestone rocky slopes. The existence of the juniper is the most peculiar feature of the area. The dominant tree species in the south aspect of this area are *Quercus petraea*, *Q. robur* and *Q. pyrenaica* and in the northern exposures *Betula pubescens* and *Fagus sylvatica*. Likewise, there are important pastures that have been used by livestock since ancient times. These livestock came and still come annually from other area of Castilla y León and mainly Extremadura. This activity affects the landscape of the area, which currently dominates the grassland and scrub. There are important number of endemic species.

The diversity and conservation status of the landscape is a direct result of traditional land uses, mainly farming. The continuity of these applications will have much to do with the maintenance and preservation of much of this diversity, because as has been observed in recent times, the abandonment of grazing cattle in the mountain passes in the area, brings disappearance of the rich grasslands of the territory being invaded by shrub communities. Past traditional economic activities include extensive livestock raising, subsistence agriculture and coal mining. These activities have shaped the landscape and the natural environment. The coal mining has stopped today and the livestock raising has diminished in the last decades, although it remains the main economic activity in the region. The region has a rich architectural heritage and different representations of indigenous art. More than hundred ancient religious buildings are dispersed in the region.

Transhumance in the Cantabrian mountain range: from wool to environmental conservation

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Although long range transhumance has been practised in the Iberian Peninsula since ancient times, it was not effectively developed until the late 12th century, as the “Reconquista” gradually left large, liberated territories in the south. Its basic purpose was to use livestock to communicate two distant and complementary resources: the mountain pastures bordering the Duero river basin in the north, *the sierras (mountain ranges)*, and the warm “dehesa” grasslands south of the Tagus and Guadiana rivers (500-600 km away), the so-called *extremes* or Extremadura.

Aware that they could only defend their interests if they were united, the shepherds of the León mountain range formed a group with those of Soria, Segovia and Cuenca, and convinced Alfonso X to legitimise the formation of the “Honrado Concejo de La Mesta” (Honoured Council of the Mesta agricultural union) in 1273. Once royal protection guaranteed travel, certain privileges when using grazing lands and feed for the livestock throughout the year, the shepherds addressed a still more difficult task: the selection of Merino sheep. The aim was successfully achieved during the 14th century and for at least 500 years, until the early 19th century, their fine, white, silky wool would flood and monopolise the best international markets, becoming the main source of foreign currency earnings for Spain. This world monopoly brought prosperity to the villages of the León mountain range, as its mountain passes (over 400 excellent quality ones) were the most highly valued; and the councils obtained a substantial income by leasing out these *properties*, with which they paid all the community expenses.

However, the political, economic and social transformations of the 19th century, like the war of independence, with the previously prohibited removal of Merino sheep to other countries, the loss of the wool monopoly and the fall in the price of wool, jeopardised the Mesta and its privileges and it was legally dissolved in 1836. Since then there has been a constant decrease in transhumance.

Nowadays there are approximately 10,000 head of sheep out of the 135,000 that moved to the León mountains in the early 20th century. Nevertheless, this marked decrease in ovines is compensated for by the 700-800 cattle in 2010 which still follow the transhumance route from León to Extremadura, in addition to 50,000 sheep which did the short transhumance or *trasterminance* route (80-100 km over 3-4 days’ walk) in the same year, from the mountains (above all in the Babia, Luna and La Tercia districts) to the south of the province to take advantage of the winter pasture and stubble.

Throughout its long history transhumance has left a lasting mark on our culture in the form of empirical knowledge, livestock practices, vocabulary, place names, pastoral architecture, craft, folklore and gastronomy. However, the most important legacy is the Merino sheep, born in the mountains of the north due to the efforts of anonymous shepherds and now present throughout the world from Australia and New Zealand to the Argentine Patagonia (over 300 million head) and the main provider of quality wool on the international market.

The landscapes which these activities have generated over the centuries because of the careful interaction of shepherds and flocks on the environment merit special consideration. Transhumance has enhanced the maintenance of ecosystems of great interest like the “dehesa” grasslands in Extremadura and the mountain pastures (*Merino mountain passes*) in the Cantabrian mountain range, as well as an endless range of natural sites of enormous ecological and environmental value. In the last few decades it has been clearly appreciated that, as professional shepherds disappear, transhumant flocks and extensive mountain livestock farming with a diversity of domesticated species spread fires and erosion everywhere, loss of quality of pastures and produce losses in biodiversity and quality landscapes.

Nor must we forget the heritage of the 125,000 km of livestock rights of way, a unique legacy in Europe. Three great Royal Rights of Way came into being in the León mountain range because of

their significance in livestock farming: the La Vizana or La Plata (Silver right of way) (500 km long), the Leonesa Occidental (Western León) (650 km) and the Leonesa Oriental (Eastern León) (760 km). This huge network of livestock routes (León has 2,320 km), in addition to its primary livestock uses, has offered enormous possibilities for the development of nature tourism (hiking, biking or horseriding routes) which are revitalising the economy of the villages located along it.

Over the last few decades these activities have been badly affected due to high production costs (pasture leasing, salaries, dried feed,...) and low prices for lamb (wool barely covers the cost of shearing). Only EU subsidies help them to maintain a difficult balance between tradition and modernity. We are very aware that transhumance will never again be that great river of wool that it was in the past, but at least it is still a small, natural stream which comes down from the mountains to the plains and serves as a channel for maintaining an ancestral cultural tradition, valuable landscapes and a rich, varied heritage under dignified conditions.

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“Cañada” of León. Author: M. Rodríguez



"Dehesa" of Cáceres. Author: M. Rodríguez



Mountain pass of Las Verdes- Babia. Author: M. Rodríguez

The role of transhumance in the conservation of the upland ecosystems of the Cantabrian Mountains: a case study with vultures

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Many semi-natural ecosystems have resulted from a dynamic equilibrium between wildlife and human activities that have shaped one another over the centuries. In fact, around half of the European Natura 2000 sites are farmed habitats that support a wider range of species than those found in purely natural habitats. However, the rapid changes experienced by agrarian practices (i.e. intensification, mechanization, abandonment) in the last decades are threatening biodiversity, thereby, potentially altering the composition, structure and function of ecosystems.

Transhumance is a traditional farming practice based on the movement of livestock between winter and summer pastures, maximizing resource exploitation through grazing. Many mountain areas in Europe where transhumant livestock spend most of the year have developed cultural landscapes with diverse ecosystems. However, transhumance is today experiencing a sharp decrease across Europe. The importance of transhumance for the conservation of natural ecosystems and their biodiversity has rarely been analyzed and, to our knowledge, no works have described the importance that transhumant activity could have on vertebrate conservation, particularly at the top of the ecosystem, i.e., scavengers. This is an ecologically key guild that efficiently contributes to accelerate nutrient return and limit diseases spread from decomposing carcasses.

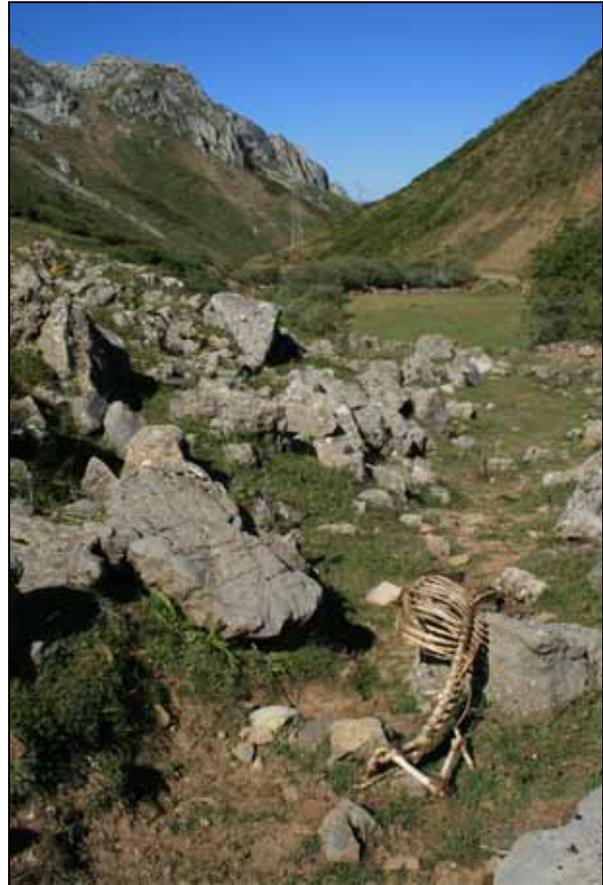
We explored the influence of transhumance at the top of the upland ecosystems of the Cantabrian Mountains, a region with a long transhumance tradition. This was done by looking at the relationship between transhumant livestock and scavenging birds (i.e. griffon vultures *Gyps fulvus*), analyzing the spatiotemporal patterns of use of highland summer pastures by transhumant livestock and vultures, and examining how one adjusts the other. We also took advantage of a natural experiment where recent and rapid changes in the use of some mountain pastures by livestock enabled us to see how vultures respond to livestock presence.

Our results provided strong evidence of a close relationship between vultures and transhumance. Vultures moved far away from their breeding colonies to occupy roosting sites very close to the summer pastures and often consumed livestock carcasses. As a result, there was a strong spatiotemporal adjustment in the use of these mountain areas by transhumant livestock, especially sheep, and vultures. In fact, the number of transhumant sheep and cows within 10–12.5 km around the roosts were the best predictors of vulture occurrence and abundance, respectively, according to statistical models. Finally, sharp and rapid changes in the space use of summer pastures by transhumant sheep, but not by cows, were followed by similar spatial changes by vultures. Our estimates of potentially available food from livestock carcasses for vultures indicated that our study area can maintain important griffon vulture populations (~700 vultures during half a year) through a system based on traditional livestock farming including transhumance.

Transhumance is thus able to influence the top of the ecosystem (i.e. scavengers) and could enable the sustainable management of vulture populations. In the Cantabrian Mountains, transhumant sheep were reduced by 62% in the last 15 years and only ~20% of summer pastures are now occupied by this type of livestock. The potential impact that the ongoing loss of transhumant activity could have on mountain ecosystem conservation should be further studied and assessed, as well as taken into account by the new European Common Agricultural Policy.



Griffon vultures *Gyps fulvus* in the Cantabrian Mountains. Author: P. Pérez Olea



The rocky cliffs existing in these pastures are frequently used as roosts by the Griffon vulture *Gyps fulvus* coinciding with the stay period of this type of livestock. The vultures feed on the livestock carcasses available in these summer pastures. Authors: P. Pérez Olea and P. Mateo-Tomás

Fossils along the path between La Majúa and Torrestío (Babia, N León)

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GEOLOGICAL CONTEXT

From a geological viewpoint the district of Babia is situated in the Iberian Massif, specifically in the Cantabrian Zone and, within this, in the Somiedo Unit Region of Folds and Buckled Strata. The **Iberian Massif** is an enormous outcrop of Pre-Cambrian and Palaeozoic rocks which covers most of the best of the Iberian Peninsula, although there are smaller outcrops of these rocks in other regions (Fig. 1). It is formed by igneous, metamorphic and sedimentary rocks with a common history: all of them were affected or generated during a great continental collision which occurred during the Carboniferous and so-called Variscan Orogeny (previously called Hercynian). Within the Iberian Massif, the **Cantabrian Zone (CZ)** is characterised by rocks which were located far away from the Variscan Orogeny collision front. In this orogeny a continent formed by the present-day North America and Eurasia collided against another one formed by southern lands (Gondwana: consisting of present-day Africa, South America, Australia and India amongst others, and on whose northern edge was the embryo Iberian Peninsula). This collision occurred in Galicia (situated about 150 km to the west of its present-day location), in such a way that rocks at a distance from this front (like those outcrops now in the north of León) were only superficially affected by the orogeny. The result is that the CZ is formed by sedimentary (not metamorphosed) rocks, with barely any igneous ones, and deformation is very superficial, consisting, above all, of fractures (faults and buckled strata) and by loose folds.

THE INTEREST OF THE CANTABRIAN ZONE

It has been stated that the CZ is formed by sedimentary rocks, not modified by metamorphism. This type of rock comes from the sediment deposit in different environments (lake shore, shallow marine, shelf marine, deep marine, deltaic...). Studying slight variations in their composition and in the sediment size, analysing different sedimentary structures which they contain (marks of waves, raindrops, desiccation...) and studying the fossils, these rocks tell us about the **environment successions** that there were in the past. *The environment changes in a specific zone are basically studied by analysing the variations in sea level, which are a consequence of climatic and geological changes.* In the CZ there is a **very complete series of sedimentary rocks from the Cambrian to the late Carboniferous** (that is, all the Palaeozoic except the Permian, between approximately 500 and 300 millennia ago). These were deposited in **marine environments until the early Carboniferous, and in swampy and deltaic environments during the late Carboniferous** (once the Variscan Orogeny raised the marine depths "transforming them into mountains) (Fig. 2).

Note: People usually ask how old the Cantabrian mountain range is or when it was formed; for example, when the mountains of the Babia district were generated. It has been stated that they were affected by the Variscan Orogeny which formed the great Variscan mountain range (higher than the present-day Himalayas and extremely long). However, this mountain range was completely eroded during the Mesozoic and only its roots remained. What produced the rising of the present-day mountains is the Alpine Orogeny, specifically the collision of the African plate against the European plate about 35 millennia ago. This approximation reactivated old faults and generated new ones which raised the roots of the Variscan mountain range. Therefore, the **present-day reliefs in the north of León are of the Cenozoic age and are the result of the present-day Alpine Orogeny**, although its rocks and basic structure are older.

THE CANTABRIAN ZONE DEVONIAN

The rocks with fossils observed on this trip belong to the La Vid Group Valporquero Formation and are early Devonian. In the Devonian the embryo of the present-day Iberian Peninsula was on the north coast of the great continent of Gondwana in the southern tropics about 8000 km from our current position. At that time the planet was going through one of its *greenhouse* moments with mean temperatures of 25°C (as opposed to the present-day 12°C). Obviously there was no ice at

the poles and the sea level was very high, so large parts of low continents were under water.

Against this backdrop, a large shallow marine platform, the sediments (silt, clay and, above all, magnesium and calcium carbonate), which form the La Vid Group rocks, were deposited:

- Shale (also called slate) originating in silt and clay; in dark hues
- Limestone originating in CO_3Ca precipitation; in grey hues
- Dolomite originating in CO_3CaMg precipitation; externally ochre rocks
- Marl, which is a mixture of very fine-grained limestone and silt and which are reddish or greenish in these facies

An environment like this, with warm waters, moderate terrigenous sediment content, some water upheaval, oxygen and plentiful light is propitious for the establishment of various communities of benthic invertebrate organisms. We can see two of them among the rocks of the La Vid Group as we pass.

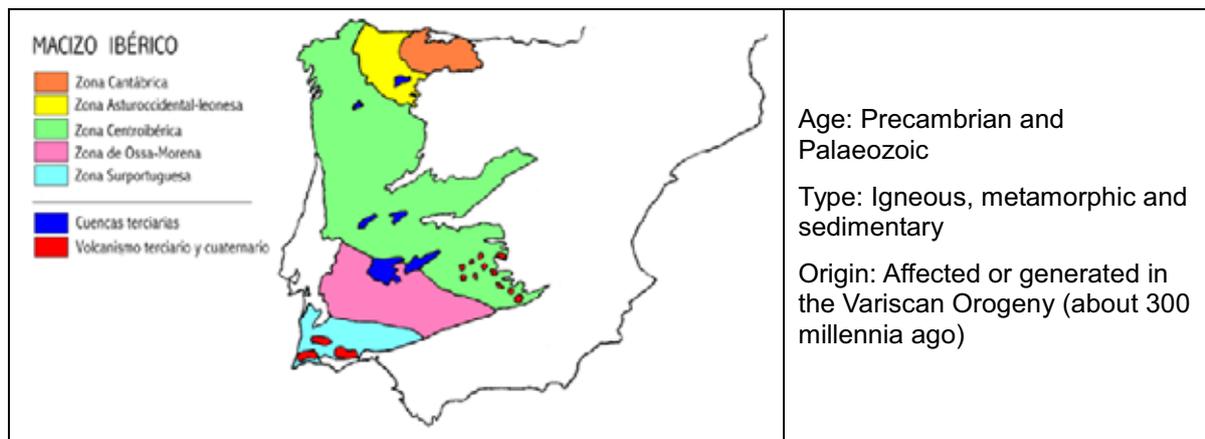


Fig. 1. Iberian Massif

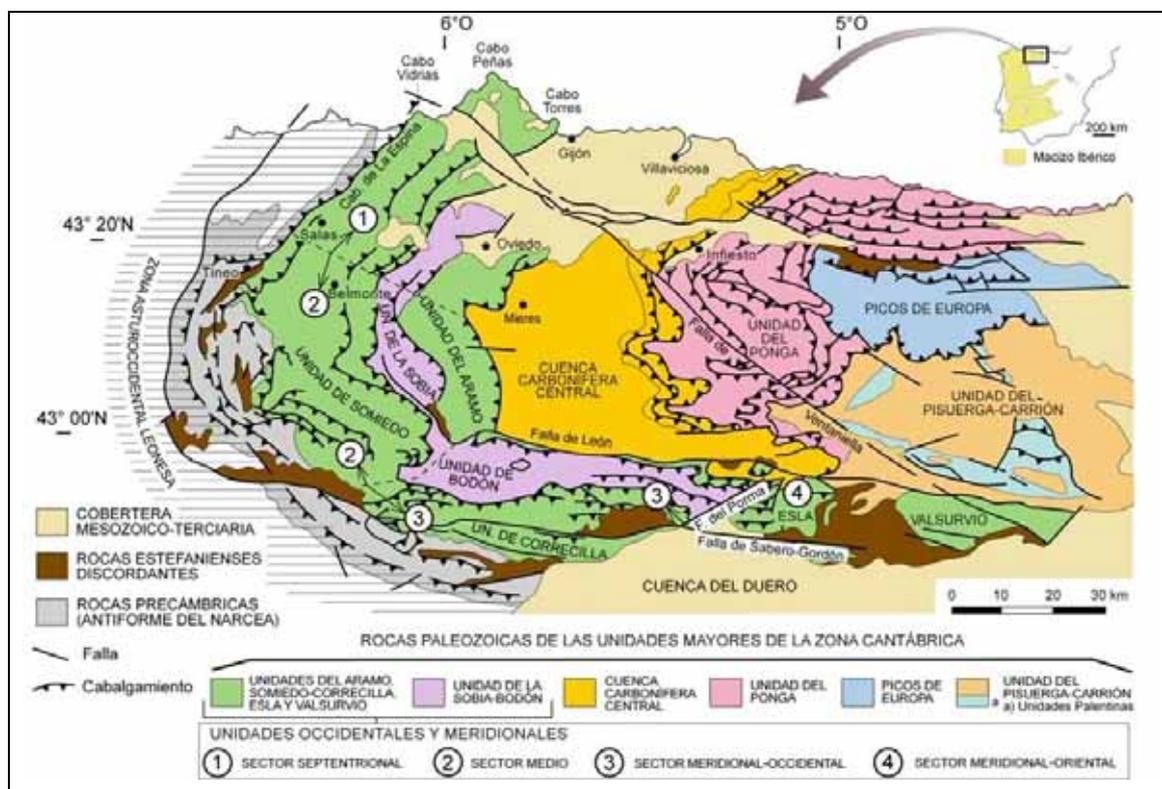


Fig. 2. Cantabrian Zone and its different units. The huge quantity of folded, buckled strata (lines with small peaks), which are the distinguishing mark of this geological zone, can be seen.

OCHRE FACIES: CRINOID MEADOWS

Ochre rocks are bioclastic limestone, that is, limestone mainly formed by remains of organic skeletons. To be specific, these rocks are formed by remains of the skeletons of crinoid type echinoderms (sea lilies) (Fig. 3) and are called “**encrinites**”.

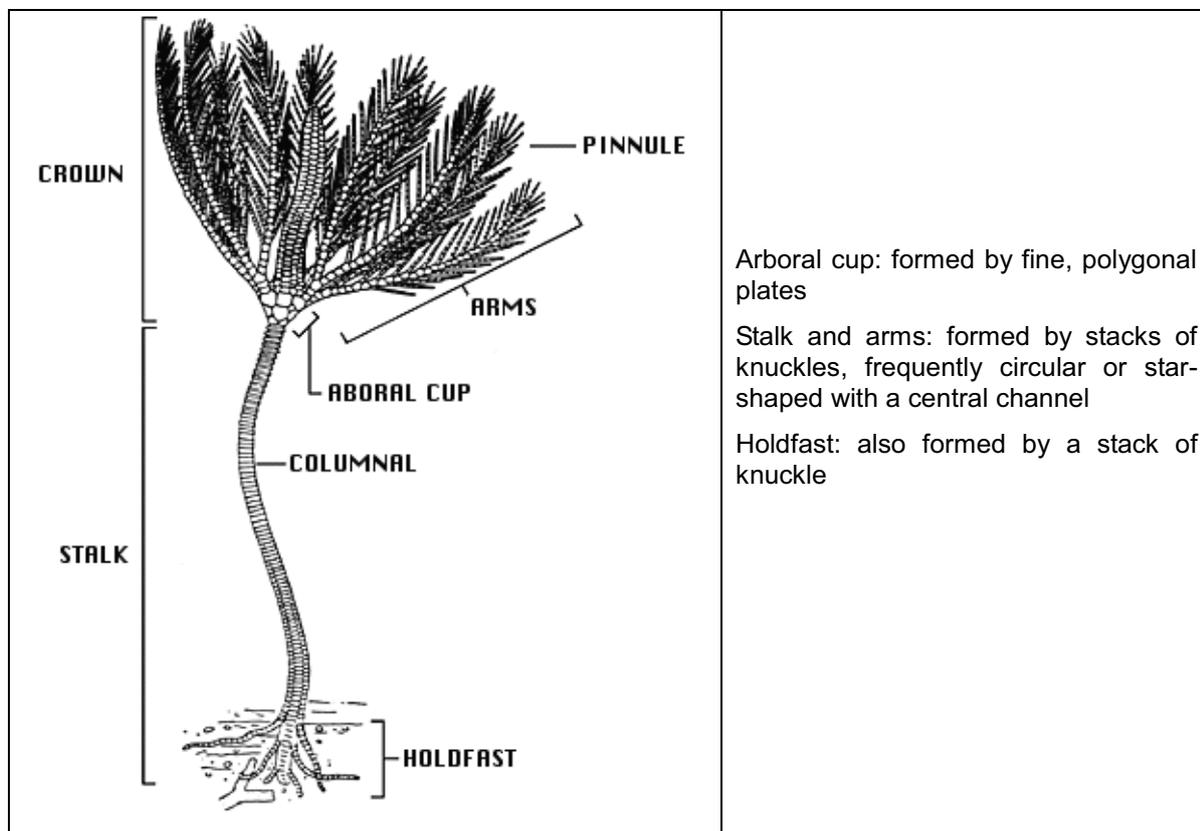


Fig. 3. Drawing of a crinoid with different parts

Crinoids are echinoderms with peduncles and arms formed by stacks of calcite plates (knuckle). On dying the skeleton disarticulates rapidly into tens and hundreds of pieces whose accumulation produces these rocks. Among the knuckles the matrix is very fine-grain limestone or marly limestone (mixed sedimentary rock formed by limestone mixed with silt). More or less complete remains of peduncles, holdfast roots, theca plates, etc.... can be found among the fossils.

All these fossils are the result of the death of crinoids which formed large meadows together with a mass of organisms which took shelter among the stalks or grew around them in the early Devonian. These biological associations were produced in shallow marine depths, usually below the normal wave base, but above the storm wave base, so storms (in fact, hurricanes, typhoons... typical of tropical zones) caused death frequently and the consequent formation of deposits of these bioclasts.

REDDISH OR GREENISH-RED FACIES: MOUNDS OF MIRE

The more reddish-hued rocks which look as though they contain a clay matrix with very smooth, shiny surfaces are deposits corresponding to mounds of mud (Figs. 4 and 7). They are materials produced on deeper marine sea beds than those of the previous association, in zones situated below the action of storm waves. These sea beds have a great diversity of benthic invertebrate organisms: brachyopoda, small corals, different types of bryozoa, small crinoids and other extinct echinoderms... all of them can be found in fossilised form, although it is difficult at times to distinguish them among the fragments into which the rock decomposes.

Microbial communities rich in Fe oxidising microbials lived together with these, though not fossilised. The activity of these bacteria gave these rocks their reddish hue.



La Vid Group rocks. These rocks were deposited during the Early Devonian on a shallow marine platform in the photic zone with variations in sea level. *Author: L. Calvo*



Rock formed by remains of crinoids: encrinite. The circular knuckles with a central channel, sometimes forming stacks, can be seen. Most correspond to stalk or peduncle fragments. *Author: L. Calvo*



Red facies corresponding to deposits linked to the action of Fe bacteria. In front, a close-up of ochre facies rich in crinoids. Both rocks appear together due to weathering and alteration of fragments, but are originally products of different environments and of different biotic communities. *Author: L. Calvo*

Although these materials are difficult for non-experts to recognise, they consist of small mounds (1-1.5 m high), among which there are rocks similar in appearance and composition, but which did not form peaks on the sea bed. In fact this is a special type of reef, occurring very frequently in the past but practically unknown nowadays, and in which the activity of the microorganisms is responsible for calcite nucleation and for water nutrient richness.

THE BIOTIC AND THE ABIOTIC

Life builds rocks

Both deposits are a good example of how life builds rocks, not only the macroscopic metazoa (crinoids in this case), which harness the water CO_2 to form their skeleton, storing it for millions of years. Microscopic life which favours mineral nucleation and traps the smallest sediment particles is also capable of generating typical rocks. These rocky deposits that we see now would not exist without the intervention of living beings.

The abiotic rules life

Both deposits are also an example of how the abiotic factors determine the type of communities, which settle in a zone, on a geological scale. The ochre facies were deposited on a shallow seabed; the sea level rose and, as a result of this, the seabed became deeper and another type of biotic community settled in.

But what caused this rise in sea level? Present-day studies consider that it is a high frequency deepening, of the 5th order, often linked to the lower frequency Milankovitch cycles (terrestrial orbit eccentricity cycles, of about 100,000 years). This means that, at least in this case, the variations of our solar system are ultimately responsible for the development of some biological communities or others.

BRIEF ADDENDUM ABOUT THE PALAEOLOGICAL HERITAGE

Since **Law 42/2007** was passed, fossils are officially part of our **geological heritage**, which is part of our natural heritage.

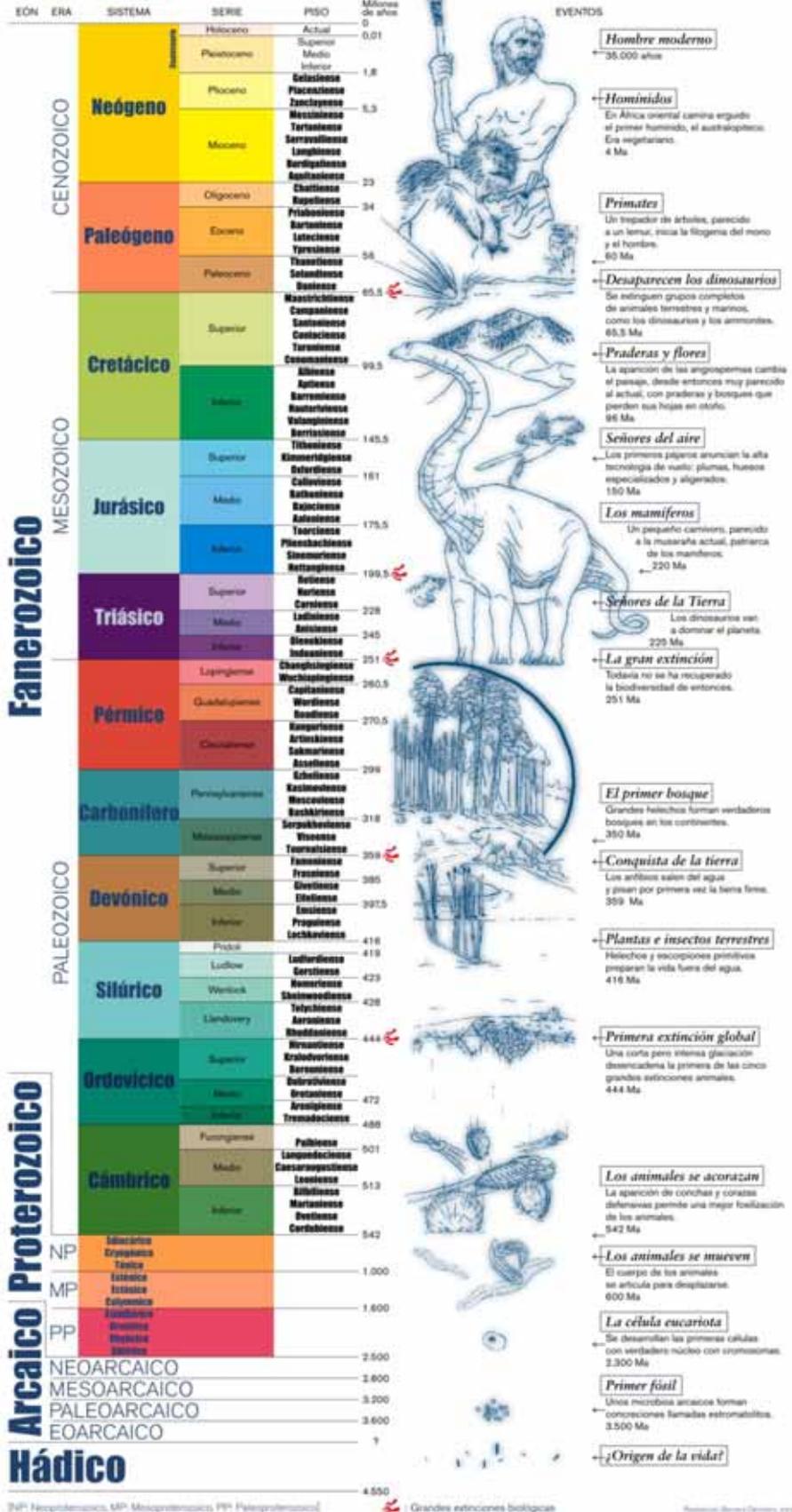
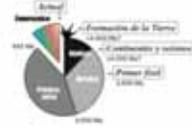
In **Castile and León** this legislation is being developed at regional government level. Today fossils are nominally protected by the Spanish Cultural Heritage Legislation (dated 1985) and its regional application (especially the Decree on Archaeological and Palaeontological Excavations). However, in practice, fossils are completely unprotected elements. This, together with their appeal, vulnerability and non-renewable character (there are no seeds or bulbs which allow us to reproduce them) results in frequently irreparable damage.

However, fossils are elements essential to uncovering the history of the Earth and are the only existing memory of the history of life on our planet. Without them **living beings would have no past**. Preserving them and publicising their value should be one of the priorities of all those working in territory administration.

Note: I have taken the liberty of using this term in its geological sense because it is really very useful. Facies is a synonym for environment and is the set of features which becomes a fossilised environment, thus allowing us to define it. When I say facies, I am not speaking of the type of rock or the organisms, or the colour or the environment... but rather of how all this has been preserved providing an image of a specific environment.

el tiempo geológico

Tabla cronoestratigráfica



Iberian massif:
Precambrian and Palaeozoic

Cantabrian zone:
Late Precambrian and Cambrian to Carboniferous (no Permian materials present)

La Vid group: Early Devonian

[NP: Neoproterozoico, MP: Mesoproterozoico, PP: Paleoproterozoico] Grandes extinciones biológicas. Fuente: www.mge.es, 2012.

Past, present and future of transhumance in the Cantabrian range

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Climatic and orographic conditions of the Cantabrian mountain range have conditioned the chances and ways of use of its natural resources from ancient times. In terms of stockbreeding, its highlands offer a good chance in summer times, as then its short vegetative period allows the growing of rich pastures when those of lower lands have dried. This has been known by man just from Neolithic times, but extents use for cattle increased exponentially in some historical periods (kelts invasion, Roman domination and high-density occupation after Arabs) and became absolute in certain areas during flourishing late-mediaeval centuries when the most important European markets were regulated by the value of Spanish wool.

Obviously, this fact had several consequences in landscape level: extents coniferous and deciduous forests were burnt and substituted by grasslands and shrubs communities, which still dominate nowadays. Some of these formations are considered of high value today, have been identified as habitats of importance for the European Union and sustain a high variety of endangered species, as the blue throat, the grey partridge, or the broom hare, and even some species are directly linked with sheep grazing, as Egyptian vulture.

So the maintenance of transhumance practices with sheep is a key factor in terms of biodiversity conservation in large areas of Cantabrian range. Nevertheless, socioeconomic reasons have caused the abandonment of this kind of grazing in recent decades, and its substitution by others as cows or mares livestock, but effects of this cattle in terms of conservation are very different and poorer. Several actions are being implemented these years trying to avoid the disappearance of transhumant ecosystems.

Habitat modelling for the conservation of the endangered and endemic heath tiger beetle *Cicindela sylvatica rubescens* in northern Spain

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The heath tiger beetle, *Cicindela sylvatica* Linnaeus, 1758 (Coleoptera, Carabidae), inhabits mainly dry, sandy and sun-exposed areas with bare soils or very light vegetation in heathlands dominated by *Calluna vulgaris*. The species thrives primarily on the ground, where cylindrical larval burrows can be found and where the adult beetle, diurnally active, typically runs in short but fast spurts interspersed with brief stops, often along paths, or flies low over bare areas. When disturbed, adults usually fly to adjacent patches of taller heather, where they may also get shelter for overwintering and protection from natural enemies and adverse climatic conditions. Both adults and larvae hunt surface-active invertebrate preys such as ants, lepidopteran larvae and wasps. Larvae are thought to take two years to develop, while the adult beetle may have a two year life cycle with two overlapping generations.

The heath tiger beetle is a conservation priority species occurring in north, central and north-west Europe, with isolated populations in northern Spain (Cantabrian mountain range and Sistema Ibérico Norte). These populations form the endemic subspecies *Cicindela sylvatica rubescens* Jeanne, 1967. This rear edge, or low-latitude margin of the species' distribution range, is expected to be critically important for the long-term survival of the species, as well as in determining the species responses to global changes. These populations, most likely at high risk of becoming extinct, inhabit quite small habitat patches in subalpine areas or isolated mountainous valleys, between which individual exchange seems unlikely and population sizes are estimated to be fairly limited (i.e., up to 50 reproductive adults coexisting in time and space). Therefore, conservation efforts should aim at maintaining as many heath tiger beetle populations as possible at the regional level to protect the genetic variability of the species.

The species seems to decrease in its entire distribution range. Possible factors causing disappearance or diminution of populations include the loss of heathland habitat where the species lives, and the afforestation and invasion of open heaths by shrubs and grasses due to inappropriate management practices. Particularly, it is expected that increasing temperature and drought due to climate change may negatively affect the geographically restricted populations of this beetle in northern Spain, by causing the extinction of *Calluna*-heathlands in the region and promoting their expansion to higher latitudes. Even these uphill shifts seem to be limited due to the high altitudinal occurrences of the beetles.

Currently, the ecological requirements of the heath tiger beetle are not completely understood and need to be more thoroughly investigated to conduct appropriate conservation management work. We present the main objectives, methodologies and first developments of a starting 2-year research project aimed at describing and evaluating the relative importance of the environmental parameters which coincide with the occurrence of the species, by constructing habitat suitability models. Habitat models will allow us to investigate the realised niche and habitat use of the species at different spatial scales, to evaluate the habitat quality of the surroundings of populations of special concern, to predict the effect of environmental changes on the species' occurrence, and to determine suitable conservation measures. We intend to assess the robustness, validity and predictive power of the significant models by their spatial transferability [i.e., cross-validation between populations within the Cantabrian mountain range and between countries, especially Spain (rear edge of distribution) and Germany (central area)].



Cicindela sylvatica larva and cylindrical larval burrow (20-40 cm depth). Author: A. Taboada



Adult *Cicindela sylvatica* beetle (15-20 mm length). Author: A. Taboada

Field trip 4: PENEDA GERÊS

The National Park of Peneda-Gerês

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The National Park was established in 1971. It covers a mountainous and border region of about 70.000 ha. The proximity of the ocean, the diversity of landscapes and the elevation range created a wide range of microclimates and promoted biodiversity. The geology is dominated by old hercynian granites which are 310 million years old and recent hercynian granites which are 290 millions years old. A lot older are the schist-meta-sediments which are 430 millions years old. The climatic forests of oaks (*Quercus pyrenaica* at higher elevations and *Quercus robur* at the lower elevations) associated with holly, strawberry tree, yew, cork-oak, juniper, birch and Gerês iris give this region a high botanical value. Nowadays the majority of the forest is fragmented, due to centuries of human deforestation. Grazing and the associated fire regime have instead promoted the expansion of scrubland of heaths, brooms and gorse. Scots pine forest is also native to the region, but most of the existing patches were planted during the last century. Peats bogs and wet heathlands are particularly vulnerable habitats where we can find unique species such as the sundew and the butterwort. The landscape around villages is composed by a mosaic of wet pastures ("lameiro") and dry pastures ("prados de feno") created by man, where we can find a diverse flora, including orchids and daffodils.

**Field trip: National Park Peneda-Gerês
Pitões das Júnias (Portugal). 17th of June, 2011.**

Dr. Herminio da Silva (University of Trás-os-Montes e Alto Douro)

Ms. Lucia Jorge (Secretariado dos Baldios de Trás-os-Montes e Alto Douro)



Author: A Morán-Ordóñez

Associated with this botanical richness there is a diverse and important fauna. Although several species became extinct in the past, such as a bear, the ibex (recently reintroduced), the lynx and the red-deer, we can still find today wolves, roe-deers, wild boards, badges, otters, Pyrenean desmans, Iberian adders, golden eagles, among others. There is also a small group of Garrano horses, the last individuals of this luso-galician breed living in the wild. The National park also holds a rich geological patrimony: glacial cirques and valleys, geological faults, huge granite domes, and unique rock formations.

The human occupation of this territory dates back at least to the Neolithic. This long occupation left several monuments, including large megalithic necropolises, medieval castles and monasteries. Living testimony from those times are the archaic communities dispersed in the mountains such as “brandas” (summer villages) and the “inverneiras” (winter village), or yet the corncribs (“espigueiros”) and the communitarian stone yards for drying and trashing corn (“eiras”), relics from the introduction of corn in the XVII century. These communities, isolated in the hostile environments of the mountains, developed an agro-pastoral activity for their subsistence, and were able to maintain an identity and a communitarian culture whose origins are lost in time.



Landscape of the National Park. *Author: L. Calvo*



“Espigueiros”. *Author: L. Calvo*



Heathlands in Peneda-Gerês. *Author: L. Calvo*

Symposium Guide



Author: S. Suárez-Seoane

SESSION 1

ORAL PRESENTATIONS

Heathlands: Anthropogenic Landscapes

Chairman: Werner Haerdtle

POSTER PRESENTATIONS

Heathlands: Anthropogenic Landscapes

Chairman: Peter Kaland



Author: S. Suárez-Seoane

Landscape ecology of the Cantabrian Mountains: natural history, evolution and climatic change effects

de Luis E.

Lecture

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The Cantabrian mountain range is situated in the north of the Iberian Peninsula, parallel to the Cantabrian seacoast. Although its peaks barely rise above 2500 metres, it constitutes one of the most important mountain ranges due to its singular location and distinctive configuration. Indeed, the spectacular landscape of this mountain range varies remarkably in altitude and is characterised by huge contrasts of climatic conditions and great variety of vegetation communities. This outstanding landscape can be noticed from the northern coastline, from where its steep slopes are enhanced, as well as from the much higher central Iberian plateau at its southern part, from where the outstanding contrasts of climate and vegetation types are easily noticed. The name itself refers to the fact that it is a vantage point and a fortress: from the pre-Roman root word *kant*, which means stone, rock or mountain, and *briga* which means a wall. Its highest peaks are to be found in the Picos de Europa mountains but it also extends to the west as far as the Ancares and Laurel in Galicia, and to the east as far as Urbasa and Andía in Navarre. Different sectors of great morphological and structural complexity can be distinguished geologically. The western section consists of pre-Cambrian and Palaeozoic rocks which form part of the 600-million-year-old Iberian or Hesperian massif. They were formed in a marine sediment environment, folded and fractured in the Carboniferous age 300 million years ago during the Hercynian orogeny, then becoming plutonic, metamorphic rocks. A highly complex anticline structure formed in other palaeographic environments and of very different tectonic evolution can be seen in the east. The Picos de Europa limestone predominates here. The Alpine orogeny of 35 million years ago modelled today's Cantabrian. The rivers of the north start close to the sea and are short but with a lot of water due to the high rainfall and highly erosive. However, the eroding power of the rivers is far less in the south because of the lesser difference in water level and lower rainfall. The general climate is defined by the latitudinal situation and general atmospheric dynamics on the one hand, and the nearby oceanic and mountain masses on the other. During winter it is constantly affected by Atlantic squalls and in summer by the Azores anticyclones. They bring warm air which cools as it rises over the mountains, so the thermal contrast is very marked. The thermal values produced by altitude also become continental as they advance towards the centre of the peninsula, so the southern slopes have to put up with severe winters. The moisture-charged air reaching the coast becomes saturated as it rises, producing rain of varying intensity which can exceed 2000 mm in the highest zones. Once the air has risen over the peaks, it descends rapidly, heats up and dries, thus decreasing rainfall on the southern slopes. But local microclimates also abound as a result of the complicated orography.

All of this has maintained the great diversity of flora and fauna by providing shelter for a considerable number of endemic species in its abrupt and heterogeneous landscape. Natural Cantabrian communities are among the most complete and best conserved in Spain, and even in western Europe. But, in spite of difficult access and its relative isolation, both history and traditions have left their mark. Increased grazing, protected and supported by several centuries of livestock transhumance increased the herbs communities surface in detriment to trees and, in many cases, introduced shrub elimination by fire. The consequences of overexploitation and the resulting soil degradation with significantly reduced animal production gradually brought about the end of the transhumant system: this led to a natural secondary succession under conditions which, in most cases, has slowed down in the currently widespread heathland community.

The effects of climate change have now modified the general pattern of biological communities. The southern slopes have become more and more Mediterranean with increasing temperatures, which follow the latitudinal trajectory in the northern hemisphere together with the effect of altitudinal change: all this is producing one of the greatest climate change effects on the south slopes of the Cantabrian mountain range which have been recognised at world level.

The forest fires problem in the Cantabrian range. Implications for management

Torre M.

Lecture

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1. Forest fires are a worldwide problem, every year they burn between 300 and 400 million ha (FAO 2003). In the European Mediterranean basin, in average, 50.000 wildfires happen every year burning half a million hectares. In Spain 20.000 wildfires spread over 160.000 hectares per year.

2. The wildfires causes are quite well known even though they still remain hidden to the urban societies (FAO 2006) and the media. In the world "The list of human-induced causes includes land clearing, specially for shifting cultivation and other agriculture activities, maintenance of grasslands for livestock management, extraction of non wood forest products, industrial development, resettlement, hunting negligence (such as careless disposal of cigarettes) and arson" (FAO, 2006). Essentially, the problem of forest fire lies on a very old culture, deeply rooted and widespread all over the world: the use of fire as a vegetation management tool by farmers and overall stock breeders. European colonizers have been using fire for ages to get and maintain lands free of shrubs for grazing or agriculture everywhere since the Neolithic. In the Mediterranean area: "An important source of fires is shepherds who ignite forest and grasslands to promote new flushes of flow for grazing animals. Farmers also use fires to eliminate crop stubble and invasive torn plants and to push back the forest to make room agricultural expansion" (FAO, 2006). The last decade analysis in Castile y León shows the same trend. Around 75% of wild fires come from shepherds and farmers and the majority of the rest can be considered as accidents. This rate is about the same in other parts of Spain.

3. The current vegetation is in a phase of very unfavorable development for traditional uses from rural abandonment and changing production model of the last half century. Now we are going through an unstable succession situation that is changing very fast. The pastures are being transformed into bushes and they will become woods at the end. At this moment we have a lot of young stands with shrubs growing under them and continuous bushes on their side. On the other hand, the load of fine fraction of biomass in these ecosystems is very high and if we consider the vertical and horizontal continuity of the fuel, we should realize that the stands are as dangerous as gunpowder barrels.

4. As a consequence, the nowadays state of the vegetation maintains and reinforces the need for traditional use of fire. Still remaining rural population wants to control the vegetation to maintain grassland or lands free of scrubs, and they have great need for doing so. The people are still using fire as a primary form of clearance, as they have always done. As a result the number of fires is very high.

5. On the other hand, it causes an increasing risk of disasters, because the high amount of fine materials, its huge extension and continuity leads to a great difficulty to stop any fire in windy summer days. For this reason, wildfire suppression is getting worse every year because of the amount of energy that a fire may emit in a windy day in summer. That makes firefighters unable to work close to the flames, so the fires spread out of control.

6. In short: the current state of evolution of the Mediterranean is closely connected with the number of fires and with their severity. It is the central point of the forest fire issue. Neither the number nor the severity of the fires can be understood without understanding the actual state of vegetation.

7. The evolution of the vegetation has been very quick since the seventies when people immigrated to cities from countryside villages. Forest surface of León County has grown from 317.900 ha to 526.000 ha, (a rise of 65%). Nevertheless a big amount of not wooden area, 475.000 ha, still remains from the initial 526.000 ha. Most of this area is covered with heathlands or leguminous plants like *Cytisus* sp, *Genista* sp. We have no data of heathlands

cover in the seventies but we can suppose without a big inaccuracy, looking at the old pictures, that grassland was dominant in the Cantabrian range landscape, heather lands nowadays being bigger than any other time.

8. But we know that a change is possible. We have got the experience that a tree-based economy is the permanent solution. Where this type of economy takes place there is not fire anymore. ¡Even there is not fire accidents! This is the case of Urbion Forest Model County, located in the Duero river springs, where a transformation had happened since the early twenty century when large fires where common until the sixties when the forestry economy became important and the fires disappear at last. One thing we have learned about this process is that stock breeders had needed to assume that economic forestry could be important and can go together with livestock.

9. The solution key is to modify the current forestry structure. Or we accelerate their development or we will keep the problem of forest fires over many decades. So we must manage the vegetation structure in order to make ourselves able to control catastrophic wild fires. This is urgent and we should do it in a landscape scale. The structure management effect will open in addition the chance to some economical value of the forest and so it will lead steadily to the solution.

10. Meanwhile and at the same time we should work in order to change the tradition of using fire. The PLAN 42 is a program for reducing the number of forest fires that aims to change the habit of using fire. It is located in the counties with more fires: 154 municipalities (7% of the total) that suffer 50% of the fires of Castile and Leon. Its methodology consists on working directly with users of fire to implement alternative tools for vegetation management. It also aims to train rural people in activities to promote forestry development since that is not part of his experience and neither of their tradition. The forest economy has a positive impact on the severity of the fires because it creates much less dangerous structures. Furthermore, the population has no need to use fire for two reasons: because forest does not require it (counterproductive) and because the structure produced allows the livestock activities without need of thicket control.

Management policies for heathland conservation included in the Habitat 2000- Rural development in the south of the Cantabrian mountain range

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Lecture

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Thanks to a lot of palaeoecological and historical research, life history of vegetation along the southern slopes of the Cantabrian mountain range during the last 20,000 years is well known nowadays. Anthropogenic effects are particularly important for the understanding of the landscape configuration although they are sometimes difficult to separate from the effects of other ecological factors, as they interact. Within a general cattle management framework, burnings have been extensively used as a tool during the last two millennia to open the previous forests and then to prevent succession toward forested stages. Herbaceous pastures and heathlands, although could be naturally present in rocky soils and at the mountain ridges, have been widely favoured by this activities and dominate landscape in wide high areas, commonly mixed with fertile pastures and remnant forested patches. More than 70% of the range area has been protected under the requirements of the Habitats Directive from the European Union, because of its high biodiversity values. Despite of the huge surface they cover, their anthropogenic origin and their scarce conservation problems, most of Cantabrian shrublands (dry heathlands being the most important and widespread) have been identified as natural habitats types of community interest whose conservation is needed in designed areas. Nevertheless, main conservation values in the range are those related to forests, and abandonment of cultural practices (burning and grazing, but also agriculture) during the last decades is allowing just now the recovery of forested lands, while non-controlled fires are perhaps the main threat for Cantabrian wildlife and traditional use of heathlands and pastures has become unsustainable. Crossroads related to this fact and the management policies for conservation must be analysed from the long view.

Heathlands in Finland: distribution, threats and management

Poster

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There is about 1000 ha of heathlands in Finland, representing four different habitat types. Three of the types occur solely in the coastal areas: low herb dwarf shrub heaths, graminoid dwarf shrub heaths and dwarf shrub heaths. They have developed and are still partly maintained through traditional management such as grazing and burning. All these types are included in the EU habitats directive as European dry heaths (4030). In Lapland, in the northernmost part of Finland, the fourth type, frost influenced heaths, occur. This type is considered to be maintained through climatic conditions and is not dependent of management actions.

In all of the heathland types shrubs such as crowberry (*Empetrum nigrum*), heather (*Calluna vulgaris*) and lingonberry (*Vaccinium vitis-idaea*) occur, as well as grasses such as wavy hair-grass (*Deschampsia flexuosa*) or sheep's fescue (*Festuca ovina*) and common bent (*Agrostis capillaris*). The amount of juniper (*Juniperus communis*) as well as tree coverage is considered as an indication of overgrowing.

The three coastal types of heathlands were classified as endangered in the Finnish assessment of endangered habitat types published in 2008. Low herb and graminoid dwarf shrub heaths were classified as critically endangered (CR) and dwarf shrub heaths as endangered (EN). The main cause of threat is ceasing of traditional management, a majority of the coastal heathlands are considered to be in a stage of overgrowing. Other threats for the coastal heathlands are: forestry actions, eutrophication of water bodies, construction and erosion.

The need for management of the Finnish heathlands is urgent. Most of the coastal heathlands occur in protected areas. Presently, only a small area is managed, mainly through clearing and grazing. Only a few heathlands have been burned during the last decade although being a traditional management method. The management actions are carried out both by managers of the protected areas, i.e. Metsähallitus Natural Heritage Services, in many cases in cooperation with local farmers. Most of the management actions are work-intensive and therefore often dependent of project funding. Metsähallitus has applied for an EU Life+ project where, if accepted, also heathlands will be managed during the five next years.

Spatial inventory of heathlands in north-western part of Poland and Torun surroundings

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Poster

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Spatial distribution of heathlands in Pomerania (the north-western part of Poland) was described based on the results of questionnaires sent out to the registered offices of all forest divisions (96), national (4) and landscape (15) parks of this area. According to the inventory, heathlands occur in 28 forest divisions and 3 national and landscape parks. The frequency of occurrence and the area covered by heathlands were determined. All the data were compiled in the form of a spatial database with the use of Geographic Information Systems. The poster also contains the geographical distribution of heath habitats in the area of Pomerania according to particular syntaxa. Additionally, the content of the database CORINE Land Cover was analysed at the third level for the area of Pomerania, completed for the years of 2000 and 2006. The area and the number of patches were described according to three land cover categories: heaths (code 322), conflagration sites (code 334) and peat bogs (code 412). The obtained results increase our knowledge on heaths in Pomerania. Moreover, there are the results of territorial listing of heathlands in Torun. This is a rare situation when this category of land cover exists in the area administratively belonging to the urban territory. At present this interesting plant formation is rather disappearing as a result of economical activity of man especially because of creating new areas to build houses.

The research presented as a poster was performed within the framework of the research grants by the Ministry of Science and Higher Education, the Republic of Poland, No. N N304 220835.

Traditional uses of the shrubland ecosystems of the NW Iberian Peninsula

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Poster

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In 2004, the students taking Earth Ecology in the 5th Course of Biology at the University of Santiago de Compostela polled the uses of shrubland in Galicia.

The poll was carried out using 72 persons, more than fifty years old, resident in 20 councils that cover an important representative biogeographic and ecological area of both the coastal and interior zone of Galicia.

The information received was concentrated in 4 shrubland ecosystems preponderant in Galicia and whose use was long established: Shrubland of *Ulex*, shrubland of *Cytisus*, heathland of *Erica-Calluna* and heathland of *Erica ciliaris-E. tetralix*.

There was a notable difference in the ecological and economic value and degree of conservation assigned by the students and by the farmers to each ecosystem.

Diverse management practices in the shrublands were detected and various types of exploitation of the products were discovered, ranging from their use as feed to their use as fertilisers, fuel, medicines, or their use as construction materials. Some of these practices were frequent in the area, whilst others had fewer applications.

The traditional uses decreased in intensity in the Seventies, principally through the lack of inhabitants in the rural areas due to the effects of migration and the appearance of other products and agroforestral techniques.

Dynamics of Atlantic shrubland after traditional managements

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The shrubland ecosystems in Galicia have been intervened by human action from time immemorial and the types of traditional use have partially determined the composition and structure of its vegetal community. Moreover, some LIC communities require adequate measures for their sustainable management.

In this work, three LIC zone shrubland communities that were subjected to traditional uses: fire, cutting and grazing, were studied. The changes produced in the horizontal structure of the vegetation, after each treatment, were monitored and ecological groupings of the variables were made.

The results manifest the important differences between the plant species, depending on their taxonomic group and the regenerative habit acquired. Likewise, the three traditional uses that were tested induce different dynamics in the families and in the regenerative groups of species.

Lastly, the role of each of the practices in the intensity of the regeneration of the shrubland and the applicability of these results for the management of shrub ecosystems, are discussed.

Shrub regeneration after cutting in the Sanabria region, Spain

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Poster

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20 years ago, my research group thought about the possibility of using shrubs as renewable source of energy, and the Sanabria region was considered as pilot experimental area because of its climatic characteristics. There was information on post-fire regeneration of some plant species dominating this area, but their response after cutting was much less known.

Therefore, we proposed a study to explore the after cutting regeneration capacity of those dominant plant species (regeneration mechanisms, percentage of mortality, etc.), and to test whether it differed according to the age of cut plants. The studied plant species were: *Cytisus multiflorus*, *Adenocarpus complicatus*, *Halimium alyssoides*, *Chamaespartium tridentatum*, *Erica umbellata* y *Calluna vulgaris*. Nevertheless, we mainly studied the first three ones that preferably occupied old fields and lands with low slope and easy access, which were the main areas considered for the sustainable exploitation project of shrubs.

We identified different sites according to their shrub species composition, proportion and height. In each one, aerial biomass included in 5mx5m quadrats was cut and quantified (in dry weight). One year later, the regenerative response of shrub formation was assessed within the nine central quadrats (1mx1m) of every 5mx5m cut quadrat. The number of plants of each shrub species, differing between resprouts and seedlings, as well as the number of cut plants that resprouted were quantified. For each plant, dry weight by drying to constant weight in a forced-air oven at 80 °C for 24 h was estimated.

Among results, it is important to mention that dominant species continued contributing with more biomass one year after cutting, but the proportion of contributing species varied since some species such as *Chamaespartium* and *Halimium* showed a faster early-response than *Erica* and *Cytisus*. With respect to the regeneration mechanisms, all species except for *Calluna*, regenerated after cutting by means of resprout as well as by seed. In density, the importance of each regenerative way differed according to the shrub species and age of plants before cutting. However, the vegetative way always was the most important in biomass. Most plants resprouted after cutting, although notably differences were found for some species as *C. multiflorus* according to the age of cut plants, being the mortality higher in the extreme age categories (young plants and elder ones).

Ecological consequences of heathland afforestation in Pomerania, north-western Poland

Poster

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In the mid-19th century, the sheep industry played a considerable part in sheep breeding in Pomerania. Livestock grazing took place on extensive heathlands developed as a result of land deforestation, performed in the 17th and 18th century, as well as during and after Napoleonic wars. Sheep industry and accompanying textile craft developed until the 1990s, when the Prussian government, after the period of excessive forest exploitation, began their restoration. The decline of sheep industry was significantly accelerated by import of wool from Australia and Argentina to Prussia, which started during that period.

This paper aims at determining how the aforementioned economic processes affected the environmental transformations in Pomerania, particularly including the region of Tuchola Forest and the existing, present-day landscape parks – Zaborski and Wdzydzki. Based on a few examples, the following changes were presented:

- the areas of heaths and the range of forests,
- species composition and species diversity of forest plant communities restored on heathlands, by comparing the temporal series of relevés,
- plant standing crop and carbon stock contained in this biomass on the landscape level,
- pattern of landscape described by indices of its spatial structure, calculated on the basis of historical and contemporary topographic maps,
- actual spatial variation of NDVI defined based on the analysis of satellite images,
- energy flows between ecosystems and the society affecting the income of the local human community.

Methods of numerical taxonomy, the GIS and RS technology, as well as methods of energy analysis were applied in order to evaluate and to present the extent of transformations. The research presented as a poster was performed partly within the framework of the research grants by the Ministry of Science and Higher Education, the Republic of Poland, No. N N304 220835 and No. N N305 336834.

Long-term development of woodland on cattle grazed and un-grazed heathland

Poster

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Anthropogenic heathland is generally subject to natural afforestation. Woodland building often takes decades and depends on many factors: Local climate, amount of seedbed, seed sources and management of the heathland. In Denmark we have studied a cattle grazed and un-grazed heathland for close to three decades. The heathland have a common management prehistory of grazing from the mid-fifties till the mid-sixties followed by a decade of abandonment until cattle grazing was initiated on part of the heathland in 1975. At that time only few trees and bushes were present, and of these a limited number were out of reach of browsing by roe deer and cattle.

The development of woodland follows different pathway in the grazed and un-grazed heath. In the period 1984 to 2010 the density of all woody species rose from 5 to 25 individuals per 100m² on the grazed heath and from 10 to 40 on the un-grazed heath. In both areas the density of trees above 2m in height is 5 individuals per 100m² in 2010, but whereas half of the density is contributed by woodland canopy forming species in the un-grazed heath, the density of these in the grazed area is only 0.03 individual per 100m². The speed of woodland development is significantly higher without cattle grazing.

The sapling population on the cattle grazed heathland is mainly comprised of cattle spread or propagated woody species, *Crataegus* spp., *Juniperus communis*, *Malus sylvestris* and *Rosa* spp. Depending on the grazing management (season of grazing, stocking rate) these species have a high rate of establishment success and irrespective of the named preconditions will eventually build up protected scrub for climax and birds spread woody species, the latter once perches are available for the birds. The scrub development is widespread, but clustered where mainly juniper established with success in the period of abandonment.

In contrast to this the initial sapling population on the un-grazed heathland is largely comprised of *Quercus robur* propagated by forgotten pigeon, jay and mouse winter-storage. As bird perches with growth of the trees become available, the sapling population becomes increasingly dominated by bird spread woody species, *Prunus* spp., *Sambucus nigra* and *Sorbus* spp. The woodland formation starts in clusters round the initial trees on the heathland, which largely established the period of grazing prehistory.

Cattle grazing and deer browsing cannot control woodland development and periodic supportive management is necessary to maintain the heathland open. On the grazed area a strategy aimed at limiting the amount of grazing protected space should be applied, thus leaving woodland fragments to support the over-all diversity, but preventing new fragments in developing. As a supplementary measure mature wind-spread species should be controlled in heathland perimeter and potentially invasive species cut down on sight.

Control of woodland development on heathland by goat grazing

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Poster

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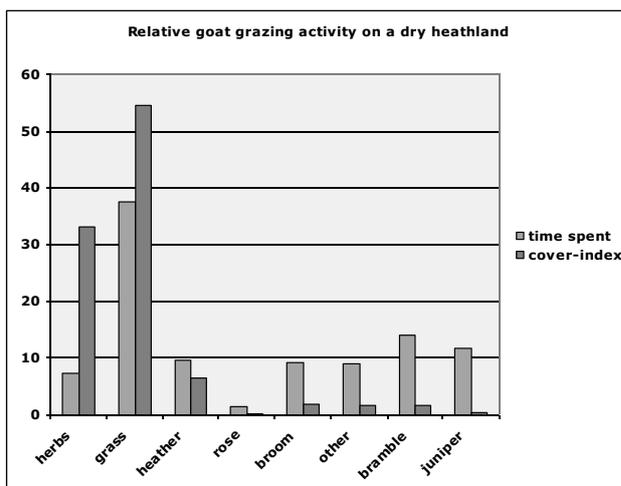
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In 2007 we started grazing in summer with 200 young milk goats on 40 ha dry heathland. Until then, and since 1987, the heathland was grazed by cattle in summer and autumn. Woodland development had accelerated during the latest few years and development of closed woodland was foreseeable within a few decades. Mainly thickets of *Cytisus scoparius*, *Prunus spinosa* and *Rubus fruticosus* coll. were providing shelter for widespread woodland development. The grazing prehistory on the site showed that cattle could not control the woodland development. On other sites, previous studies of control of *Cytisus scoparius* by sheep grazing were not successful.

The goats browse by preference. Thus seek woody species out selectively and de-leaf trees and bushes within reach, i.e. browsing standing erect on hind legs. In the field layer herbs and grass are grazed less than indicated by their cover, while dwarf shrubs are grazed more. All woody species are grazed much more than indicated by their cover (Fig. 1).

We analysed some important nutritive contents of different woody species. In general the woody species have a significantly higher content of crude protein, *Juniperus communis* being an exception, than the herbaceous plants and dwarf shrub (*Calluna vulgaris*) of the field layer. Similarly, there is a lower content of fibre and a higher and above sufficiency-level content of many minerals in the woody species.

There is heavy to very heavy browse on all woody species but *Ulex europeaus* and *Rosa rubiginosa*. There is a slight decrease in the population of most woody species, and, more apparent, a reduction in the size of the individuals. The population of *Cytisus scoparius* does not decrease, but the lead shoots of solitary individuals are browsed heavily and flowering is controlled. The denser stands are also browsed heavily, but there is a small recruitment of new individuals in the dense stands. Flowering is sparse in the dense stands.



We conclude that there is a significant increase in the relative browsing pressure when goat grazing is introduced. In general the woody species are shaped into densely twigged individuals and, dependent on the species, many individuals will die after some years of goat grazing. Large or dense populations of species with a high re-growth potential respond slower, but seeding is to a large extent hindered from the start. The low grazing pressure on herbs allows an appreciably high inflorescence and seeding – this is contrary to our results with sheep grazing on similar heathland.

SESSION 2

ORAL PRESENTATIONS

The future of heathlands under global change

Chairman: Nigel Webb

POSTER PRESENTATIONS

The future of heathlands under global change

Chairman: Inger Kappel Schmidt



Author: S. Suárez-Seoane

Bioindicators of nitrogen deposition impacts on heathland ecosystems

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Lecture

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Nitrogen deposition rates currently exceed critical loads for many sensitive ecosystems across Europe. Evidence suggests that exposure to elevated levels of nitrogen deposition will result in loss of biodiversity, changes in the structure and functioning of ecosystems and negative consequences for habitat integrity. Bioindicators have been extensively used as tools for monitoring N-driven changes in ecosystems and provide an opportunity for wide scale assessment of ecological change as a result of exposure to differing levels of pollutant inputs. Findings from several heathland manipulation experiments involving N addition indicate that a number of plant and microbial parameters (e.g. *Calluna* shoot growth, lower plant abundance, soil and litter enzyme activity, foliar N content) respond in a predictable way to elevated rates of N deposition. The robustness of these indicators of N impacts has been investigated within non-experimental, spatial surveys of heathland systems across the UK, along an N deposition gradient. Results from several earlier surveys of grassland and heathland habitats indicated a relationship between N deposition rates and plant species richness and cover. This relationship has been investigated in detail in a survey of 25 upland heath and 27 lowland heathland sites across the UK, taking into account variation in other potential drivers of vegetation change, such as climate (annual rainfall, temperature), site attributes (aspect, altitude, soil pH) and habitat management.

Preliminary results show a relationship between N deposition and changes in plant functional groups. Grass abundance is positively related to increasing N deposition levels ($r^2=0.159$). Conversely, lichen cover was found to decline with increasing levels of N ($r^2=0.492$). Across both lowland and upland sites, decline in plant species richness (vascular and non-vascular) negatively correlated to increasing rates of N deposition ($r^2=0.4$). Sites exposed to higher levels of N were also seen to support a greater abundance of the nitrophilous moss *Brachythecium rutabulum*, a species more commonly associated with eutrophic habitats. For soil parameters, non-significant trends were seen between total N deposition and soil C:N ratio ($r^2=0.063$), total soil N ($r^2=0.071$) and C ($r^2=0.066$) contents. A relationship between extractable concentrations of NO_3 ($r^2=0.2$) and NH_4 ($r^2=0.4$) with N deposition was evident in the upland sites, in addition to increased activity of the enzymes responsible for phosphate transformation ($r^2=0.2$) and litter decomposition ($r^2=0.2$). Analysis to date indicates that the functional diversity of heathland systems is being affected by ambient rates of N deposition. Lichens and grasses appear to be the most robust indicators of N driven change in vegetation; available soil nutrients and enzyme indicators vary inconsistently across habitat type, reflecting the generally higher temporal variability of these variables.

Fate of airborne nitrogen in heathland ecosystems – results of a ^{15}N tracer study

Lecture

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In this talk results of a study will be presented in which we analyze the fate of airborne nitrogen in a dry heathland ecosystem in NW Germany by means of a ^{15}N tracer experiment. Our objective was to quantify N sequestration and N allocation patterns in an ecosystem that is naturally limited by N, but that has been exposed to airborne N inputs exceeding critical loads for more than 3 decades. We hypothesized that the system has a tendency towards N saturation, which should be indicated by low N sequestration and high N leaching. We analyzed ^{15}N partitioning (aboveground biomass and soil horizons) and investigated ^{15}N leaching over 2 years following a ^{15}N tracer pulse addition.

^{15}N tracer recovery was 90% and 76% in the first and second year, respectively. Contrary to our expectations, more than 99% of the tracer recovered was sequestered in the biomass and soil, while leaching losses were $< 0.05\%$ after 2 years. Mosses were the most important short-term sink for ^{15}N (64% recovery in the first year), followed by the organic layer. In the second year, the moss layer developed from a sink to a source (23% losses), and soil compartments were the most important sink (gains of 11.2% in 2008). Low ^{15}N tracer recovery in the current year's shoots of *Calluna vulgaris* ($< 2\%$) indicated minor availability of ^{15}N tracer sequestered in the organic layer.

N partitioning patterns showed that the investigated heaths still have conservative N cycling, even after several decades of high N loads. This finding is mainly attributable to the high immobilization capacities for N of podzols in soil compartments. In the long term, the podzol-A- and B-horizons (i.e. albic and spodic horizons) in particular may immobilize considerable amounts of incoming N. Since N compounds of these horizons are not readily bio-available, podzols have a high potential to withdraw airborne N from the system's N cycle.

Competitive superiority of *Molinia caerulea* in *Calluna*-heathlands under high N availability

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Lecture

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Airborne N loads are considered a major threat to the biodiversity of nutrient-poor ecosystems typical of NW Europe. In heathlands, biodiversity loss is often related to encroachment of grasses (such as *Molinia caerulea*), a process which takes place in both dry and wet heaths; for dry heaths, however, underlying mechanisms are poorly understood. We hypothesise that the pioneer phase of a heath is the crucial tipping point at which a dwarf shrub dominated heath may become dominated by grasses. In a greenhouse experiment (simulating a heath's pioneer phase) we analysed growth strategies (biomass allocation, nutrient sequestration and allocation) of *Calluna vulgaris* and *M. caerulea* seedlings in monocultures and mixtures in relation to N, P, and N+P fertilisation.

In monocultures, N fertilisation increased the total biomass of *C. vulgaris* and *M. caerulea* by a factor of 1.2 and 4.8, respectively. N treatments halved the relative belowground allocation of *C. vulgaris*, resulting in high shoot-root ratios (4.3 vs. 1.6 in the control). By contrast, *M. caerulea* showed a high belowground allocation (shoot-root ratios between 0.5 and 1.0). In mixtures, *M. caerulea* seedlings exhibited much stronger responses to N fertilisation than those known from previous experiments with older plants (ninefold increase of the total biomass), and they sequestered about 65% of the N applied. This caused an N shortage of *C. vulgaris* seedlings, resulting in a halving of their total biomass. Thus, in mixture only *M. caerulea* seedlings will benefit from airborne N loads, and competition will become increasingly asymmetric with increasing N availability.

Our results indicate that the heath's pioneer phase is the crucial tipping point at which the competitive vigour of *M. caerulea* seedlings induces a shift to dominance of grasses under increased N availability. *M. caerulea* seedlings responded extremely positively to N fertilisation accompanied by a high belowground allocation, an efficient use of belowground resources, and shortened reproductive cycles (one year). *C. vulgaris* seedlings, by contrast, almost tripled their shoot-root ratio as a result of N fertilisation. This may entail a higher susceptibility to drought events and thus higher seedling mortality under shifting climatic conditions.

Modern pollen deposition in heathlands and neighbouring forest phytocoenoses

Poster

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Differences were investigated between modern pollen deposition in three types of phytocoenoses in two regions, i.e. Tuchola Forest and the Toruń Valley, which is covered with Bydgoszcz Forest. Those were heaths, young pine-birch growths and mature pine tree stands, which form a temporal sequence and spatial mosaic in the landscape. An increase in the concentration of pollen grains was found in samples collected from stems of moss growing on the same soil surface in a series of plant communities, arranged from non-forest through young growths to mature forests. In this series, also the percentage contribution of pine pollen grains increased, as well as the total contribution of arboreal pollen AP. The increase in the percentage contribution of arboreal pollen is accompanied by the decrease in the contribution of non-arboreal pollen NAP, including the pollen of *Calluna* and the family Ericaceae. In the studied series, the number of taxa increases insignificantly, but due to the increased pine domination in the pollen spectra, both the taxonomic diversity, expressed by the Shannon-Wiener index, and the equitability decreased. However, with this trend in arithmetic means of parameters describing the pollen spectra from three types of plant communities, there is a high similarity of pollen samples from different phytocoenoses. Because in dendrograms compiled with numerical taxonomy methods, pollen samples from different types of communities form common clusters. Larger differences occurred in the analyses, in which the percentage contribution of taxa constituted attributes of samples, whereas smaller differences - when these attributes were concentration of taxa. Blurring of differences between samples was probably strongly influenced by an import of pollen from outside a phytocoenosis, in which a given sample was collected, i.e. other communities of the landscape, as well as extremely strong domination of pine in the vegetation of both regions.

Spatial distribution of Opiliones in four shrublands of the Cantabrian mountain range, NW Iberian Peninsula. The importance of vegetation structure

Poster

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The historically managed Cantabrian mountain range constitutes a mosaic landscape of agricultural and pastoral lands, highly fragmented natural forests, recently established conifer plantations and extensive shrubland areas. Among the main shrubland communities, heathlands dominated by *Calluna vulgaris* stand out as a conservation priority, as stated in the 92/43/CEE Regulation. In this area, recent studies on shrublands, particularly on *Calluna* heathlands, have provided abundant information on vegetation ecology. However, relatively fewer studies have focused on the great diversity and relevant functional roles of the arthropod fauna inhabiting these communities. In the shrubland landscape of the Cantabrian mountain range harvestmen (Arachnida: Opiliones) represent one of the arthropod groups with the largest epiedaphic biomass. In addition, harvestmen play an important role within the ecosystem food webs, generally exhibit limited dispersal abilities, show preferences for specific habitat types and strongly respond to environmental gradients. This way, harvestmen have been suggested as suitable arthropod model group in ecological studies.

Thus, the aim of this study is to: (1) investigate the spatial distribution patterns of harvestmen in the shrubland mosaic landscape of the southern Cantabrian mountain range by studying four extensive communities: *Erica australis* and *C. vulgaris* heathlands, *Genista hispanica* and *G. florida* shrublands; (2) determine the actual singularity of the harvestman assemblage inhabiting the *Calluna* heathlands; and (3) analyze the effect of environmental variables on the spatial occurrence of harvestman species in the studied shrubland types.

We selected five sites per shrubland type and captured harvestmen by pitfall trapping during June-October 2008. We defined 5 leg-length categories and 4 habitat-preference categories to sort the captured harvestmen. We also measured vegetation structure parameters, soil characteristics and general site descriptors. Harvestman total abundance and species richness did not differ significantly among shrubland types. *C. vulgaris* heathlands presented a singular harvestman assemblage composition, mainly due to the presence of *Phalangium opilio*, *Odiellus ruentalis* and *Mitopus morio*, and great percentage of generalist individuals. Besides, *G. florida* shrublands, the structurally most complex community, had the most even harvestman assemblage, characterized by the highest proportion of short-legged and forest specialist individuals. Vegetation cover percentage between 50 and 100 cm and the height of the first branch of the dominant woody species were the major factors influencing the spatial distribution of harvestmen in the studied shrublands.

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Heathlands in the Cantabrian Mountains (North Spain) under a climate change scenario

Vera M.L.

Poster

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There is increasing evidence of climate change in Asturias and the Cantabrian Mountains. The average annual air temperature has increased in recent decades, being more pronounced in the spring and summer. Climate models predict an even greater temperature increase. Some locations show a decrease in precipitation and it seems that, during this century, the trend will be a more marked reduction of precipitation.

The Cantabrian Mountains present heathlands distributed over a wide altitudinal range, providing natural scenarios to analyse the plant responses to environmental changes and the potential effects of global change. Altitudinal variation in flowering and seed development of heathland woody species suggests phenological and reproductive efficiency changes due to global warming. Changes in temperature and precipitation in the last decades are affecting the phenology, development and reproductive aspects of the Cantabrian Mountain heaths. Comparison of recent and previous decades (interval 1979-2010) phenological data showed a trend towards earlier flowering in heaths. The decrease in precipitation might be already affecting the development of several heathland woody species. Indeed, *Erica arborea*, *Calluna vulgaris*, *Vaccinium myrtillus*, *V. uliginosum* and *Empetrum nigrum* populations, growing in soils with low water retention, showed a withered state in the years with a remarkable decrease in precipitation. *Juniperus communis* subsp. *alpina* was another species that seems to be negatively affected by the shortage of snow and rainfall. The flower and seed production in *Calluna vulgaris* and *Daboecia cantabrica* decreased significantly in the years with hot summer and low precipitation. What would happen if the years with higher temperatures and decreased precipitation were more frequent? Probably it could affect the survival of certain heathlands in the north of Spain. Also, the risk of fires could increase, affecting the conservation of woody species.

More favourable temperatures could improve the establishment of heaths at the edge of their altitudinal limit and expand their distribution to higher elevations. But a reduction of precipitation could limit their expansion, mainly in sandy soils developed on quartzite rocks where water retention is scarce.

In the last two decades, studies on *Calluna vulgaris* and *Daboecia cantabrica* populations in the S. Isidro mountain Pass (about 2050 m altitude) have characterised the production of ripe seeds by these species (*C. vulgaris* mean: 190699-319080 seeds/m² depending on the conditions; *D. cantabrica* mean: 105123 seeds/m²), and have concluded that their seed banks have long-term viability and high germination capacity (*Daboecia* seeds collected at 2010 m altitude in 1999 and placed under laboratory conditions had germination capacity at least during 12 years, reaching 78% germination; *Calluna* seeds from 2090 m altitude reached the 88% germination 20 months after sowing). But, in spite of this, the germination and establishment of seedlings is practically non-existent at high mountains with harsh environmental conditions. However, in favourable conditions, the germination and seedling establishment could be possible, since seeds from soil samples collected at 2010 m altitude have germinated in a greenhouse (emerging 7360 seedlings/m² from the seed bank under *Daboecia* canopy during 2 years, and 715 seedlings/m² under *Calluna* canopy during 6 months). Relict populations of *Empetrum nigrum* are restricted to small areas in the central part of the Cantabrian Mountains, being very sensitive to environmental changes. The *E. nigrum* regeneration is mainly vegetative, although it produces ripe seeds. Prostrate stems may root in contact with the ground. Studies on the growth of *E. nigrum* during 1990-2009 showed that an increase in temperature seemed to benefit its growth, as long as water is available, since the species requires high humidity for its development. Reduction in snow cover, precipitation, and vegetal cover could affect the survival of *E. nigrum* populations.

Plant community responses to climate change: Results from the FACE experiment CLIMAITE

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Poster

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The climate is changing, and Northern Europe will see milder winters, longer growth season and altered precipitation patterns, including longer summer drought periods, within the next century.

Dry heathlands as a habitat, are already under stress from anthropogenic activities, including primarily altered land use and increased nitrogen deposition, and climate change is expected to interact with these stressors. So, how will climate changes affect heathland ecosystems and should changes lead to reconsiderations of the existing management strategies of dry heathlands in Northern Europe.

Since 2004 the FACE experiment CLIMAITE (www.climaite.dk) has investigated the effects of *in situ* exposure to elevated atmospheric CO₂ (510 ppm), increased temperature (1-2°C) and prolonged drought periods on ecosystems patterns and processes in a dry heathland in Denmark.

During the first five years, species specific responses to drought were evident for the two dominant heathland species *Deschampsia flexuosa* and *Calluna vulgaris*. Increased summer drought had a significant negative effect on the biomass production for both species during the drought period. However, the magnitude of the effect was dependent on the precipitation pattern within the season. *Deschampsia flexuosa* showed response to the drought treatment most years, whereas *C. vulgaris* only responded in years where the summer drought was more severe because it followed a naturally dry spring. Also, the post-drought recovery depended on the precipitation patterns and was species specific: *Deschampsia flexuosa* already recovered a month after the end of the drought period, if the autumn water supply was sufficient, whereas recovery for *C. vulgaris* was much slower. We explain this difference in recovery by (1) the two different life forms and strategies of the two species and (2) the different ability of the two species to compete for nutrients released by re-wetting following the drought period.

Elevated CO₂ was not found to affect biomass production, but instead stimulated the reproductive success of *D. flexuosa*. Also, warming did not influence biomass production, but had an effect on grass phenology, including earlier leaf appearance and flowering time.

The species specific responses of the two dominant species, found in this study, suggest a future change in species composition. We hypothesise that climate change, in time, will favour the ecophysiologicaly more dynamic grasses, in this case *D. flexuosa*, but that the change will depend on the inter-annual variation in precipitation patterns. We therefore expect climate change to enhance the ongoing invasion of grasses into dry heathlands

Long term impacts of N deposition and interactions with climate stress

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Poster

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Long term field experiments can provide novel insight into the consequences of global change for the diversity and functioning of semi-natural ecosystems, and the mechanisms underpinning observed change. The long term nitrogen (N) addition experiment at Thursley Common (Surrey, UK), now in its thirteenth year, has yielded major advances in our understanding of ecosystem response to both increases in N deposition and associated rates of recovery when additions are suspended. Long-term data collection and analysis make it possible to identify persistent responses to N additions as well as interactions with both habitat management and naturally occurring variations in climate, including drought stress.

Annual *Calluna* shoot growth increments (and by association, canopy height) correlate with precipitation rates; particularly dry years are associated with decreased plant growth, reduced flowering and, on occasion, visible drought injury in either the same or the following year. These effects were significantly exacerbated by N inputs with, for example, substantially higher levels of drought damage to *Calluna* shoots in plots receiving additional N ($30 \text{ kg ha}^{-1} \text{ yr}^{-1}$) compared to control plots in 2009 (45 % more damage in N addition plots: $F = 43.49$, $P < 0.001$). The same plots were reassessed the following summer (July 2010) in order to determine the persistence and magnitude of carry over effects from the previous year; the proportion of dead plants was greater in the nitrogen addition plots (58 %) compared to control plots (37.4 %) ($F = 16.37$, $P < 0.001$). Interestingly, differences in the level of drought injury were also observed in plots which had not received N additions for the past 14 years, compared to their controls (the Thursley “recovery” study). This indicates that, even over long timescales, the effects of N on climate sensitivity persist, and that ecosystem recovery from earlier nutrient loading is a slow process. Interactions between N deposition and drought also had an impact on *Calluna* phenology. On its own, N addition has resulted in significantly higher levels of *Calluna* flowering throughout the 13 years of the current experiment, compared to plots receiving ambient N deposition inputs. However, interactions between N and drought conditions in 2004 and 2009 were found, with a marked decrease in flowering in the N addition plots, compared to controls. Taken together, these findings demonstrate significant impacts of N and climate stress on the productivity of *Calluna*, as well as for plant-pollinator interactions, seed ripening and seed rain abundance, all of which can have long term implications for the structure and functioning of heathlands across Europe, and for the valuable services that these ecosystems provide.

Effects of experimental summer drought and nitrogen addition on vitality and productivity of *Calluna vulgaris* from four different provenances

Meyer-Grünefeldt M., Belz K., Härdtle W., von Oheimb G.

Poster

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Climate change scenarios predict an increase of summer drought events in Europe which could influence the vitality and productivity of heathlands. Additionally, atmospheric nitrogen (N) deposition already led to changes in European heathlands. To protect this cultural landscape it is important to investigate synergistic effects caused by the simultaneous presence of summer drought and nitrogen deposition.

A greenhouse pot experiment is carried out to analyse the combined effects of drought events and N-addition on the vitality and productivity of *Calluna vulgaris* considering a potential provenance effect. Four different seed provenances covering a climatic gradient (Province of León, ES; Saxony-Anhalt, DE; Lüneburger Heide and Nemitzer Heide in Lower Saxony, DE) were used. The impact of drought and N-addition are studied through a two-factorial design over two growth periods (June 2010 – October 2011). In 2010 two summer drought events were implemented which reduced the total amount of watering by 14 %. Nitrogen deposition was imitated by fertilization with ammonium nitrate (equal to 35 kg N ha⁻¹ a⁻¹). The experiment runs with 10 replicates per provenance. We measured leaf area-related net photosynthetic rates at light saturation and at different CO₂ concentrations after the two drought events. We also determined the following parameters: dry weight of above- and below-ground biomass, C-, N-, and P-content in above and below-ground biomass, and leaf carbon isotope ratio ($\delta^{13}\text{C}$).

We hypothesize that nitrogen fertilization causes a shift from below- to aboveground biomass in plants which thus are more exposed to drought stress. As a consequence, we expect changes in plant growth and productivity. We assume a strong correlation between net photosynthetic rates and drought events in terms of reduced photosynthetic activity during drought stress. We expect less pronounced drought effects regarding the plants from drier provenances.

The experiment will result in recommendations for future nature management strategies for heathland ecosystems.

SESSION 3

ORAL PRESENTATIONS

The future of heathlands under global change

Chairman: Sally A. Power

POSTER PRESENTATIONS

***Heathland management and restoration: a key
to maintain biodiversity***

Chairman: Geert de Blust



Author: S. Suárez-Seoane

Increased nitrogen deposition lowers food quality for fauna in heathlands, through a shift in nitrogen to phosphorus stoichiometry

Vogels J., van den Burg A., Remke E., Siepel H.

Lecture

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Nitrogen deposition levels in the Netherlands are among the highest levels encountered in Europe. From the early 1970's onward, annual deposition levels are typically ten to twenty times higher than natural background deposition levels. Heathland ecosystems are nutrient poor, mainly N-limited and therefore very susceptible for additional N-input from external sources. Past research has shown that increased nitrogen deposition leads to a shift in dominance of dwarf shrubs such as *Calluna vulgaris* and *Erica tetralix* towards a dominance of tall grasses, mainly *Molinia caerulea* and *Deschampsia flexuosa*. Effects on the fauna are less well documented.

Until now, the effects of nitrogen deposition on fauna communities in heathlands focused mainly on indirect effects of increased N-deposition, for instance the effects of alterations in vegetation structure due to grass-encroachment by *Molinia caerulea*. Until now, research focused on the effects of N-deposition on biochemical processes that affect fauna communities in a more direct way, received much less attention.

In this talk we will present another approach and focus on the effects of altered nutritional status of heathland vegetation. It will be shown that decades of increased nitrogen deposition have lead to major shifts in macronutrient stoichiometry, in particular in nitrogen to phosphorus ratio's in plant tissue. N:P ratio's of vegetation in Dutch heathlands shifted towards levels between 20 and 30 (mass percentage ratio). In Dutch heathlands, P-availability in relation to nitrogen availability is nowadays the best predictor for both fauna densities and species richness of heathland fauna communities. These effects are found among several trophic levels. This indicates that the shift towards higher plant N:P ratio's in Dutch heathlands initiates a cascading effect on the faunal community structure of heathland fauna communities. This implies a major overall effect of N:P shifts on fauna biodiversity of heathland landscapes.

Conclusions from 50 years of permanent plot analysis in Dutch heathlands

Remke E., Vogels J., de Smidt J.

Lecture

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From the mid 1950's until the begin of the 21st century permanent plots in dry and wet heathlands were visited each year. In each plot (44 plots in 7 Dutch heathland regions) a detailed vegetation relevee was done, management measures and other important information noted (e.g. high density of heather beetles).

The effects of atmospheric pollution in combination with management measures in dry and wet heathlands could be magnificently analysed with this time row of nearly 50 years of permanent plot surveys. It gives the unique opportunity to test the following hypotheses:

1. With increased atmospheric pollution (nitrogen and sulphur) heathlands lose their specialists and increase in generalists, species from ruderal habitats. Today's red list species are the first to be lost.
2. During these 5 decades functional diversity (diversity of plant functional traits and also tactics) has decreased and heathlands became more uniform.
3. Lichens are the first to be diminished at increasing levels of atmospheric pollution. At field sites with less well buffered soils, the effects are the most severe, especially on lichens growing with most of their thalli flat on the soil.
4. Management measures can work against this increased nutrient inputs, but turnover times for managements is shorter with higher nutrient loads and increases succession speed. Thus species adapted to a slow recovery, slow succession, are lost in the system.

First results of the analysis of this dataset will be shown and answers given to the hypotheses.

Trends in Danish Atlantic heath vegetation during the last decades

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Lecture

During the last decades, studies have revealed changes in species composition and various threats causing deterioration of Atlantic heath vegetation along the west coast of Jutland and at the Kattegat islands.

The studies were part of the EU-LIFE programme (Hulsig (north Jutland), Anholt (island in Kattegat) and latest the regional LIFE study covering several of the Danish coastal heaths along the west coast of Jutland), the ecological investigations (intensive monitoring) of which were undertaken by University of Copenhagen.

The species composition changes include loss of ice age relicts among epigeic lichens (*Flavocetraria nivalis*, *Cladonia stellaris*, *Ochrolechia frigida*, *Alectoria sarmentosa* var *vexillifera*), as well as a general reduction in occurrence of *Cladonia* spp.

Threats to the Atlantic coastal heath ecosystem are bio invasion (*Pinus mugo*, *Campylopus introflexus*, *Rosa rugosa*), and climate change resulting in stronger wind erosion of the dunes close to the coast line and increasing precipitation probably increasing the atmospheric N-deposition. This latter effect may be the reason for increasing cover of grass species (*Deschampsia flexuosa*, *Molinia caerulea*), also seen in the inland heaths of Jutland.

The recent observations are being presented and discussed, hopefully inspiring to define mitigating actions to be taken.

Vulnerability of *Calluna vulgaris* in response to long-term climate manipulation and ecosystem disturbances

Lecture

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Most studies of climate impact on heathland vegetation have been performed on mature vegetation. The critical period for the key species *Calluna vulgaris* may, however, be during the regenerative phase where the species is more susceptible to altered climate. We examined two consecutive attacks of the heather beetle on *Calluna* growth and regeneration in a Danish heathland subjected to field scale manipulation of climate. The treatments were non-intrusive night-time warming and prolonged summer drought from 1999 to 2010. The *Calluna* vegetation was totally destructed by the beetles in 1999. We cut the vegetation as the normal management option to create suitable gaps for *Calluna* seed germination and seedling growth. We measured climate impact on plant growth and vegetation composition during 12 years. Further, we monitored the intensity of the grazing of the beetles and impact on *Calluna*. We calculated mortality rate and recruitment after the 1999 attack and the survival rate after the 2009 beetle outbreak where most plants survived.

The beetles grazed 40-50 % more on shoots of *C. vulgaris* exposed to drought and warming compared to the control plots in 1999 and 74% and 54% more in the drought and warmed plots, respectively. The recovery of the *Calluna* vegetation was high in the control plots and plots subjected to warming, whereas few plants established in the plots exposed to prolonged drought indicating that the future climate scenarios for Denmark with prolonged summer drought will change the distribution range of the heathlands.

From molecular genetics to landscape ecology: New insights from invertebrates for a comprehensive approach in the conservation biology of heathlands

Lecture

Assmann T., Drees C., Eggers B., Eggers J., Krause H., Renken A., Schäfer K., Schuldt A.

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During the Middle Ages and early modern times heathlands covered very large areas across north-western Europe. Due to changes in land use the remnants of these heathlands today are highly fragmented and show a reduced habitat quality (e.g. overaged heather). As one of the consequences of these changes many of the characteristic heathland animals show a strong decline and they are listed in red lists. This is also true for some species-rich taxa like Carabidae, Araneae, and Lycaenidae which have numerous stenotopic species in heathlands. We use these model taxa to study the impacts of the large-scale landscape changes on several population biological levels and to develop action plans for stopping (or at least reducing) the loss of biodiversity in heathlands. A central focus of the contribution is given to (1) a new corridor concept and (2) heathland management to conserve the diversity of stenotopic invertebrate species which decline even in large heathland complexes.

To (1): Molecular studies reveal genetic erosion in stenotopic ground beetle species, even in relatively large populations. The progressive loss of genetic variability within populations and the loss of whole populations seem to be triggered by metapopulation dynamics of the given species. One approach to reduce the extinction probability is the conservation and/or development of very large heathland areas. If this is not possible the chance of (re-) colonization of empty patches would increase with the establishment of corridors. For example, heathland corridors connect patches of heathland, and alternatively hedgerows and woodland stripes connect patches of woodland. Nevertheless, these corridors themselves also break up previously connected patches of their surrounding habitat and in so doing fragment another type of habitat (heathland corridors fragment woodlands and woodland strips or hedgerows fragment heathlands). To overcome this challenge we propose the establishment of semi-open habitats (a mixture of heathland and woodland vegetation) as conservation corridors to enable dispersal of both stenotopic heathland and woodland species. Our first field results support this concept developed to overcome fragmentation effects for both heathland and woodland species.

To (2): Habitat suitability models and further studies reveal that some highly endangered (and partly charismatic) species like the ladybird spider *Eresus kollari*, the tiger beetle *Cicindela sylvatica* or the ground beetle *Carabus nitens* prefer specific stages in the *Calluna vulgaris* cycle or other habitat prerequisites. The ant butterfly *Maculinea alcon* prefers wet heathlands with spaced stocks of its feeding plant *Gentiana pneumonanthe* and higher densities of its host ant. All these species-specific microsite conditions can be best conserved by a heterogenic heathland management at small scales. This approach takes the cycles of plants (*C. vulgaris*, *G. pneumonanthe*) into account and results in a temporal and spatial heterogeneity of the heathlands. Our results regarding the power of dispersal of some species give reasons to believe that heterogenous heathlands with numerous differing microsites are essential for the (re-) establishment of local populations in ephemeral patches.

All in all large heathlands, semi-open corridors and heterogenous heathland management on small scales are prerequisites for the long-term conservation of endangered stenotopic heathland invertebrates.

This talk bases *inter alia* upon the following contributions:

Assmann T. & Janssen J. 1999. *Journal of Insect Conservation* 3: 107-116

Drees C., de Vries H., Härdtle W., Matern A., Persigehl M. & Assmann T. in press. *Conservation Genetics*, doi: 10.1007/s10592-10009-19994-x.

Eggers B., Matern A., Drees C., Eggers J., Härdtle W. & Assmann T. 2010. *Conservation Biology* 24: 256-266

Habel J.C., Schmitt J., Härdtle W., Lütkepohl M. & Assmann T. 2007. *Ecological Entomology* 32: 1-8

The role of transhumance on the supply of services in a highly diverse landscape: heathlands. A case of study in the Cantabrian Mountains (NW Spain)

Lecture

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Heathlands are cultural landscapes, whose occurrence in the Cantabrian Mountains has been historically linked to transhumance pastoral systems (i.e. grazing, cutting and burning). Flocks of sheep coming from the south of Spain have traditionally used the pastures above the treeline during summer (called “*puertos*”), favouring the maintenance of a highly diverse heterogeneous mosaic of environments during centuries: pasture, heath, shrub, bare ground, rocks, etc. This diversity provides a wide range of goods and services. However, the abandonment of rural areas and the decline of the transhumance system (particularly since the 1960s) have determined deep changes on the heath-pasture landscape: heath and shrub encroachment of the open pasture areas and evolution of those heath formations towards senescent stages.

In this study we analyze the changes experienced by the heath-pasture landscape mosaic in the Cantabrian Mountains during the period 1956-2006, and their consequences on the provision of ecosystem services. We chose 14 *puertos* as case studies, equally distributed between two regions: *Babia*, where transhumance is still active even though the number of sheep has decreased during the last decades, and *Argüellos*, where activity has almost ceased and sheep have been replaced by cows. We used aerial photography (1956) and ortophotographs (2006) to analyze changes in heathlands' landscape composition and structure (fragmentation and connectivity).

Preliminary results show a general trend of heath and shrub expansion in both regions, with the consequent increase in their connectivity, to the detriment of pastures which in some cases have been reduced to isolated patches. During the last 60 years, these changes have led to the decrease and loss of some services, mainly those related to the provision of goods (timber, fertilizers, grazing, etc.), while others have been strengthened, for example the provision of habitat for species of high conservation or recreational interest (i.e. game species). However, the lack of proper land management of some heath communities (such as prescribed fires) can lead to their progressive loss due to large-scale replacement by more competitive grasses (e.g. *C.vulgaris* communities), shrub or woodlands. Therefore, to ensure future provision of ecosystem services it is necessary to design and implement management strategies aimed to maintain these communities at a building state and keep a diverse heath-pasture landscape mosaic, since most of the services provided by this mosaic are related with its spatial structure.

These studies were financed by the research projects: JCYL LE021A08, JCYL LE039A09, MCYT CGL2006-10998-C02-01/BOS.

How to reconstruct past grazing regimes of heathlands?

Baker A.

Poster

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Grazing is fundamental to maintaining the integrity of heathland structure and diversity and has been a major use of heathlands for centuries. However, knowledge regarding the influence of herbivory on the original development of heathland vegetation is not vast, and consequently little is known about how these interactions operated in the past. As a consequence, management measures aiming at biodiversity often rely on either historical information (which can be difficult to access) or direct experience acquired from sites of differing in nature. The use of pollen analysis in palaeoecology, has been used as an alternative method which allows the reconstruction of past vegetation at time scales varying between annual and millennial. The nature of vegetation at a particular place is the historical result of multiple factors, including climate, pedology, fire regimes, wild herbivory, and human activities. For this reason, the reconstruction of those past factors using pollen solely can be difficult. In fact, those factors often act and interact in complex ways and cannot be tracked using a single line of evidence.

Our research aims to improve the reconstruction of past grazing regimes in heathland and other habitats. In particular, we are developing the use of fossils from dung fungi to reconstruct the past abundance of large herbivores, in conjunction with pollen analysis.

Samples of modern sediments from the New Forest, UK, and Oostvaardersplassen nature reserve, The Netherlands, were collected with this aim in view. We compared large herbivore densities at the sampled sites with the fungal spores contained in the samples. The result of which was then compared to each samples' pollen composition with the purpose of linking vegetation structure with grazing regimes.

The result is a positive relationship between the dung fungal remains large herbivore density, validating the use of this type of fossil as a line of evidence for past animal densities. In contrast, the pollen alone does not give such a clear indication of grazing regimes in heathlands.

Two types of explanation can be advanced in regard to this apparent lack of a direct link between grazing regimes and vegetation structure. Firstly, grazing may not be a major driving force shaping vegetation at the time scale investigated by this experiment. Secondly, the behaviour inherent to large herbivores may provide a twofold explanation. On the one hand, the impact of large herbivores on vegetation goes beyond biomass removal, with the notable effect of trampling and the positive but localised effect of fertilisation. On the other hand, large herbivores have specific usage requirements of various habitats (i.e grazing, latrine, etc.), therefore impacting different places in various ways. Thus pollen may track vegetation variation at a scale at which the effect of large herbivores is heterogeneous and thus difficult to decipher. The addition of dung fungi as a line of evidence for the presence of large herbivores is thus necessary for the reconstruction of the past grazing-vegetation interaction.

The conjoined reconstruction of past animal abundance and the consequent variations in vegetation, represent the key to understanding the short and long-term effects of grazing. This understanding in turn will inform appropriate long-sighted management measures. This poster is therefore a call for further integration of palaeoecology in the management planning of heathlands. This includes both site specific investigation to understand the historical contingencies that lead to the existing vegetation, and a deeper understanding of the interaction between vegetation and grazing, in general.

Heathland farming as a boost for biodiversity conservation: ideas for the Netherlands

Frazaõ J., van den Burg A., Vogels J., Remke E., Lenders R.

Poster

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Biodiversity of Dutch heathlands has sharply decreased in recent decennia. Anthropogenic nitrogen deposition contributed strongly to this decline. To counteract nitrogen soil enrichment, nutrient removal (e.g. by sod-cutting) has been the prime action in heathland management. As a result of – often large-scale – nutrient removal measures, present day heathlands are very poor in all plant nutrients, and homogenous on a large scale. Consequently, (bio)diversity of heathlands as landscapes decreased further.

Recent research on the restoration ecology of heathland landscapes in the Netherlands indicates that rebalancing the nutrients in soil is necessary to restore and maintain soil quality and fauna biodiversity. Semi-natural ecosystems like heathland landscapes can best be brought to full biological diversity if their management builds on historical ways of exploitation, thus doing justice to both their biodiversity potentials and their cultural-historical assets. Crop-farming may be such a historical way of exploitation of heathland systems. By crop-farming, a range of nutrients is first added to the system to increase soil quality and later partly removed again by harvesting. Including periods of nutrient depletion during fallowing, crop-farming practices create nutrient dynamics, which we expect to be a key-factor to support heathland biodiversity. There are already some indications that reinstalling heathland crop-farming systems is a way to recreate soil nutrient dynamics and to restore heathland biodiversity. However, little is known about the link between heathland crop-farming and biodiversity, specifically what are the mechanisms responsible for the biodiversity boost. Before introducing heathland crop farming in nature management, this knowledge gap needs to be bridged.

In this project we aim to provide scientific answers to the following questions: 1) what are the mechanisms that link soil nutrient dynamics to biodiversity, 2) what traditional ways of heathland crop-farming may contribute to our goals, and 3) what are the best farming practices for biodiversity conservation, that restore nutrient balance in soil for heathland ecosystem restoration? To solve these problems, we propose to study heathland crop-farming systems and their relationships with soil quality and biodiversity in Serra da Estrela (Portugal) where extensive traditional farming systems still exist and where there is no inheritance of accumulated acidification and nitrogen deposition. A field-based comparative research approach will be adopted to study biodiversity differences between heathlands, farmed and fallowed fields and to collect evidence of the underlying mechanisms regarding soil processes, vegetation, and plant quality for herbivores. This will be complemented by field and laboratory experiments to determine the causality of correlative relationships, involving decomposers and nutrient cycles and plant quality for herbivores. Next to this, using a historical approach, the Portuguese and Dutch heathland crop-farming systems will be compared. Combining these datasets, we will integrate and apply our findings in the management of experimentally reinstalled Dutch heathland farming sites.

Reintroduction of Old Norwegian Sheep for restoring heathland in Flekkefjord Protected landscape, Vest-Agder, Norway

Vikøyr B., Thele S., Danielsen T., Haraldstad Ø.

Poster

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Heathland in southern Norway is a result of continuously grazing from domestic animals since 4 000 years. In southern part of Norway the Old Norwegian Sheep was the dominating grazer in coastal heathland up to 1800. Domestic breeds took over and dominated grazing from 1850-2000.

Grazing in coastal heathland generally diminished in Norway after 1950. The total winter stock of domestic sheep breeds in Hidra parish 70 km² (includes/coincides Flekkefjord Protected Landscape area) was reduced from 1258 in 1907 to 209 in 2005. The number of cows was reduced from 570 in 1907, to 9 in 1988. 2005 was a historical minimum for grazing in the area.

Because of a general awareness of the value of historical cultivated landscapes, there was established governmental support from the Norwegian Ministry of Agriculture in 1994. A program named Regional Environmental Program for Agriculture in Vest-Agder offered dedicated financial support to farmers that reintroduced moderate grazing on islands and some other heathlands of high value from 2005.

Parallel to this there was a special focus on the values of Coastal Heathland in the management plan for Flekkefjord Protected Landscape from 2003. This plan focused on stimulating restoration of recently overgrown heathland. All the 330 private landowners in Flekkefjord Protected Landscape was invited to take action to increase grazing activity in 2007.

There are 499 sheep (362 Old Norwegian Sheep and 137 Norwegian White Sheep (domestic)) in Hidra parish (Flekkefjord Protected Landscape) in 2011. There are concrete plans to increase the stock of Old N. Sheep in 2011 and the following years.

Conclusions:

1. The number of sheep in Hidra parish (Flekkefjord Protected Landscape) is 499 in 2011. This is about 65 % of the stock in 1808 and about 40 % compared to the first half of the 20th century.
2. The number of cows was in the same period reduced from 570 to 9.
3. The number of sheep should be at least doubled in Flekkefjord Protected Landscape within 2015.
4. This is necessary to reach the goal of 18 km² of coastal heathland in Flekkefjord Protected Landscape in 2020.

“Feral sheep” in coastal heaths – developing a sustainable local industry in vulnerable cultural landscapes

Poster

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Coastal heathlands found along the Norwegian coast where the climate is oceanic and mild, are ecosystems of high conservation value. These semi-natural ecosystems were created by year-round grazing by Old Norse sheep (*Ovis brachyura borealis*) and goats, in combination with summer grazing by cattle and heath burning. They covered large areas, but as a result of land use changes and abandonment, the coastal heathlands are now greatly endangered, and the pasture quality of several heath areas is reduced. To maintain coastal heathlands, researchers on landscape ecology, animal health, agronomy and agricultural economy have joined forces in an interdisciplinary project (2007-2011) to develop Old Norse sheep farming into sustainable agriculture. The idea of the project is that a combination of innovation and management will be a cost-effective tool for preservation of coastal heathlands and the natural and cultural heritage they represent.

The project has three main packages; (1) sheep holding, production and animal welfare, (2) the effect of management on the coastal heathland vegetation, and (3) economy and development of local industry. Activities involve studies of post-fire vegetation development, vegetation mapping, examination of selected plants on defined locations for digestibility, nutritional value, macro-minerals and trace elements, studies of plant and vegetation preferences (in June, August, October and February/March) by microhistological analyses of faeces, as well as marketing research and statistics from abattoirs. Sheep from 10 areas are being weighed 2-3 times a year, and blood and faeces sampled so that blood serum parameters can be examined and parasitic egg counts (EGP) can be performed. Vegetation mapping has been performed in 10 study areas, and floristic data from the post-fire succession have been recorded in permanent plots in 5 main locations.

The project is in its last year. So far we have revealed low lamb weight gains in certain areas, while quite satisfactory in others. The growth rate and carcass weight increase with increasing content of grass in the vegetation. The growth rate of lambs from spring to slaughtering in September-October differs greatly between localities along the coastline. This may be caused by several factors, such as differences between the localities with regard to the content of protein, minerals and energy in winter and summer fodder. Preliminary results of the microhistological analyses reveal different grazing preferences among both localities and seasons. Heather is not only an important winter grazing species but is grazed all year round and mostly in October. In addition it is revealed that *Carex* spp. first and foremost is grazed during the winter. The studies of post-fire vegetation development and succession after experimental fires emphasise the importance of burning as part of the management regime. Management and climate strongly influence the revegetation dynamics. Continuance in burning practises should be preferred as it reduces implications concerning the post-fire substrate of mosses and litter, but results have also demonstrated that old heaths develop characteristic heathland vegetation and structure after fire, despite lower successional rates.

These and other results from the different work packages will be presented and discussed at the conference. In our opinion, the wide angled approach to key issues of our project is fundamental for throwing light on factors important for further development of Old Norse sheep farming into modern sustainable agriculture.

Productive performance and foraging behaviour of cattle and horses grazing in Cantabrian heathlands

Poster

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Cantabrian (N Spain) less-favoured areas are occupied in a large extent by heathland communities, and are mostly utilized for cattle grazing, as small ruminants (i.e. sheep and goats) have practically disappeared since the last century. However, the number of horses is steadily increasing but little is known about the productive performance and utilization of these herbivores grazing on this nutritionally poor vegetation. The objective of this work was to study and compare diet selection and performance of crossbred horses and beef cattle (Asturiana de los Valles breed) grazing together on Cantabrian heathlands during the summer.

The study was carried out in the experimental farm of SERIDA located at 900 m a.s.l. in Illano (western Asturias). A total of 20 cows (seven lactating their calves and 13 dry) and 20 mares (eight lactating their foals and 12 dry) were managed during three consecutive years (2006-2008) on a heathland area from June to September-October. The experimental paddock (59 ha) was dominated by heather species (68% cover), mostly *Erica umbellata* (31%) and *Erica cinerea* (23%), followed by *Calluna vulgaris* (10%), *Erica australis* subsp. *aragonensis* (3%), *Daboecia cantabrica* (1%), *Erica tetralix* (0.4%) and *Erica arborea* (0.1%). Other shrubs (*Genistella tridentata*, *Ulex gallii*, *Halimium alyssoides*, *Lithodora prostrata*) accounted for 25% cover, while herbaceous plants did for only 7%. Diet composition (percentages of grasses and heather) of cows and mares was estimated in two occasions (July and September) each year using alkane markers. All animals were weighed at the beginning, middle and end of the summer grazing season.

Mares selected grasses and rejected heather species more than did cows ($p < 0.001$), particularly in early summer (85% grasses in diet vs. 65% in July; 63% vs. 55% in September). Lactating state did not affect the diet composition of mares and cows. Mares achieved more favourable ($p < 0.001$) body weight (BW) changes than cows, but there were interactions with season and lactating state. From June to August, daily BW losses were greater ($p < 0.05$) in lactating than in dry cows (-759 vs. -254 g/d), whereas the BW gains of mares were not affected by lactating state (mean 428 g/d). From August to October, both lactating cows and mares lost more BW ($p < 0.05$) than their non-lactating counterparts (-970 vs. -529 g/d in cows; -457 vs. -173 g/d in mares).

Regarding the offspring, BW gains between June and August were closely similar in calves and foals (647 and 643 g/d, respectively), but thereafter calves achieved higher ($p < 0.01$) BW gains (421 vs. 157 g/d). These results indicate that lactating cows were able to maintain milk production at the expense of mobilizing body reserves, thus buffering calf growth rates. However, lactating mares, in spite of showing worse performances than dry mares but better than lactating cows, seemed to reduce their milk production, thus affecting negatively to foal gains during the second half of the grazing season.

It is concluded that the low nutritive quality of these heathlands restricts both cattle and horse performance, even during short summer grazing season, being the lactating cows more penalized. Although calves were able to maintain acceptable growth rates, foals showed reduced ones. In practice, other plant communities with better nutritive quality should be provided to assure replenishment of body reserves in dams, and enhance offspring gains to maintain sustainable grazing systems with productive herds of cattle and horses in these heathland areas.

Financial support from INIA (project RTA2010-00136-00-00) to continue this research line is acknowledged.

Horse performance grazing on heather- or gorse-dominated shrublands

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Rodrigues² M.A.M., Osoro¹ K.

Poster

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Horse presence in heath-dominated mountain landscapes of northern Spain has increased during the last years because of the easier management compared with other livestock and other social causes. This study aimed to compare the productive responses of horses grazing on different types of heath-related shrublands (*Calluno-Ulicetea*) regarding the existing dominant species.

A preliminary study was carried out in the experimental farm of SERIDA located at 850-1000 m a.s.l. in Illano (western Asturias). Six paddocks (0.6 ha each) were established in 2008: two with heather-dominated vegetation (heathlands strictly speaking: 56% cover of heather species, mainly *Erica cinerea*, *Erica umbellata* and *Calluna vulgaris*; 19% gorse *Ulex gallii*; 18% herbs), two dominated by gorse (81%), and two co-dominated by herbs (53%, mainly grasses such as *Agrostis curtisii* and *Pseudarrhenatherum longifolium*) and gorse (36%). The dominance of gorse and grasses was a consequence of a previous burning in 2001. Two mares (320 ± 15 kg) with their foals (132 ± 8 kg) grazed in each paddock during the autumn of 2008, and their body weight changes were recorded. In 2009, the number of paddocks was doubled, so there were four paddocks per type of shrubland, although in this case the existing differences between the paddocks dominated by gorse and those co-dominated by grasses and gorse were lower. Two mares (268 ± 14 kg) per paddock grazed during the spring-summer season. Differences in daily body weight changes among types of shrubland were analysed using ANOVA and Tukey test for comparisons of means.

The results obtained in both years showed better horse performance in gorse- and grass-gorse-dominated shrublands than in heathlands. There were no differences between paddocks dominated by gorse and those co-dominated by grasses and gorse (further on named as gorse-grass shrublands). During the autumn grazing, mares lost 1446 g/d in heathlands, almost twice as much as in gorse-grass shrublands (-790 g/d; $p < 0.05$). In fact, animals stayed grazing during only 5 weeks in heathlands and they had to be taken out the paddocks because of their very poor body condition, while the horses in gorse-grass shrublands remained grazing during 7 weeks. Differences in body weight changes of foals between shrubland types followed a similar pattern to those observed in the dams. In gorse-grass shrublands the foals gained 233 g/d, whereas those in heathlands lost 394 g/d ($p < 0.05$). Like in the preceding autumn, in 2009 the mares grazing in heathlands had to be taken out before the planned dates (two paddocks in late July and the other two in late August) to prevent starvation. In gorse-grass shrublands mares grazed until late September. During the first month of the season (i.e. June) mares in heathlands were able to gain weight (129 g/d) although less than those grazing in gorse-grass shrublands (614 g/d; $p < 0.01$). After that, mares in heathlands lost weight (-214 g/d until the end of July) whereas those in gorse-grass shrublands mares continued gaining weight (302 g/d; $p < 0.001$). During August, the mares grazing on gorse-grass shrublands lost weight (-222 g/d) but less than those in heathlands (-863 g/d in the two paddocks where mares went on grazing; $p < 0.01$). In late summer (September) the mares grazing in gorse-grass shrublands lost 606 g/d.

In conclusion, gorse-dominated shrublands seem to be more beneficial for horse nutrition than heather-dominated ones. Horses could be an efficient tool to control excessive gorse encroachment and reduce combustible material liable to burn. However, the stocking rates applied in this study (3.3 mares/ha) were too high to maintain horses grazing during most of the year. Horses are usually managed as free-ranging, being able to search for the most palatable plants and thus attaining better productive responses. Further studies in course will provide information about horse performance at lower stocking rates in order to assess the potential of different plant communities to achieve sustainable horse production systems.

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An overview of the northern heathers (Ericaceae, Ericaceae)

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Poster

From Scandinavia to the Southern Mediterranean coasts, from the Canary Islands to the Black sea, as part of the Atlantic heaths, laurel forests, mountain shrublands or mediterranean maquis, from sea level to above 3000 metres in the Alps or Taurus mountains, the Ericaceae (*Erica*, *Calluna* and *Daboecia*) are an essential component of European and Mediterranean flora and vegetation landscapes. About twenty species of *Erica* species occur in this area, just a scarce representation of a genus that has around 860 species mostly from South Africa, but also from the mountains of Eastern Africa, Madagascar and the Mascarenes and the gulf of Guinea. Together with *Calluna vulgaris* and *Daboecia cantabrica*, the northern *Erica* species have a high importance as main components of the structure of several vegetation types. Adaptations to perturbation in different environments such as fire-recovery scenarios show the important ecological role of the species. Uses of heathers go from gardening to honey production, wood manufacture or medical uses.

Despite of its importance, the systematics of the genus is still unresolved and Bentham's classification from the nineteenth century remains as the only overall systematic frame for the taxonomic relationships between heathers. In recent times, new data has been obtained from morphological, anatomical and molecular analyses and a new natural approach to the systematics of the genus *Erica* is now closer.

Can mother shrub age have an influence on germination characteristics and on seed response to fire?

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Poster

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It is well known that Mediterranean areas are commonly affected by fire, thus a great number of studies have analyzed the response of different shrub species to this perturbation. According with it researchers have established three shrub categories: obligate seeders, resprouters and facultative resprouters.

In previous studies, some facultative resprouter species have shown different responses after fire according to burnt plant age. In genera *Cytisus* some species in elderly shrublands regenerate in a minor number of sprouts and more seedlings.

In this study we aim to ascertain plant age effects on seed germination, and whether their post-fire response is affected as well. We didn't find any references about this topic for shrub species. We focused on *Cytisus multiflorus* (L'Hér.) Sweet, a leguminous matorral shrub native to the NW Iberian Peninsula, which behaves as a facultative resprouter. The selected plants of this species were close to each other, in the W of the province of Salamanca (Spain).

We divided them into 4 categories based on morphology but consistent with plant age:

- (1) Young shrubs (height = 80-100 cm), primary producers;
- (2) Middle-aged shrubs (height = 130-150 cm), rounded shape with thin fractions and green biomass along every branch;
- (3) Old shrubs (height = 170-220 cm), with a vertical structure (a conic shape), no buds or thin fractions, green biomass just at the top of branches; and
- (4) Elderly shrubs (height = 170-240 cm) with similar structure to the previous categorie but with $\geq 50\%$ of dead branches.

Then, the seeds from these plants were collected and kept in dark storage for 5 years. In this study, those seeds were sown in Petri dishes and placed in a controlled environment cabinet in order to keep controlling temperature and light (20°C 14h light/ 15°C 10h dark). For thermal shock, we selected 5 temperatures (50°, 75°, 100°, 125°, 150°C) and we heat them for 1, 4, 8 or 16 minutes. We separated a batch of seeds not subjected to thermal treatment to be used as control group. We analyzed statistically the final percentage of germination in different stages and the speed.

It is important to mention that seed viability, after 5 years in storage, is not different from data of previous research carried out on freshly collected seeds. It should be pointed out that a great variability is found among extreme categories (Young and Elderly shrubs). In addition, we obtain some differences in the final percentage of germination and speed in both control and treated seeds.

Heathland as a “Selected habitat-type” in Norway – the first action plan and the new law for nature-biodiversity

Østebrot A.

Poster

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In 2010 an action plan for the Norwegian heathlands were made. This came about after the focus of the European Heathland Network Workshop in Norway 2007 had upon Norwegian authorities concerning nature management (Directorate for nature management) and the status for heathlands in Norway. The threats to the heathlands in Norway are mainly overgrowing because of abandonments and no use.

In 2009 a new law for nature-biodiversity was established in Norway:

“The purpose of this Act is to protect biological, geological and landscape diversity and ecological processes through conservation and sustainable use, and in such a way that the environment provides a basis for human activity, culture, health and well-being, now and in the future, including a basis for Sami culture.”

Chapter VI of the Act on selected habitat types is intended to safeguard endangered and vulnerable habitats through sustainable use. These provisions are of crucial importance for compliance with international obligations and for achieving the national target of halting the loss of biological diversity.

In order to promote the objective set out in section 4, the King in Council may make regulations designating specific habitat types as selected throughout or in parts of the country.

In deciding whether to designate a habitat type as selected, particular importance shall be attached to whether:

- a) trends for or the status of the habitat type are contrary to the objective set out in section 4
- b) the habitat type is important for one or more priority species,
- c) a significant proportion of the natural range of the habitat type is found in Norway, or
- d) international obligations apply to the habitat type

When there is documentation to show that the status of or trends for a habitat type based on scientific criteria are significantly contrary to the objective set out in section 4, the competent authorities under this Act shall – of their own initiative or at the request of an organization or another person who has a legal interest in the matter – assess whether regulations should be made under the first paragraph.

When a habitat type is selected for which active management or other types of measures are essential to the maintenance of the habitat type, the state shall present an action plan to safeguard the habitat type.

In 2010 there is a proposal for heathlands to become a “selected habitat-type” and an action plan is made and will be started up in all the 10 counties with heathlands along the coast in Norway. The action plan suggests areas for references, about 23 localities with different types of heathlands, here among also some protected areas. About 500 localities, heathland-habitats, has been mapped during the last year and about 200 of them of value “very important for biodiversity”, these last ones will be a part of the new act and selected habitat types.

The municipalities have an important role in keeping the habitats. The agricultural and environmental sectors cooperate in the management of the localities. The management is based on long term voluntary contracts with landowners, not classic conservation.

SESSION 4

ORAL PRESENTATIONS

Heathland management and restoration: a key to maintain biodiversity

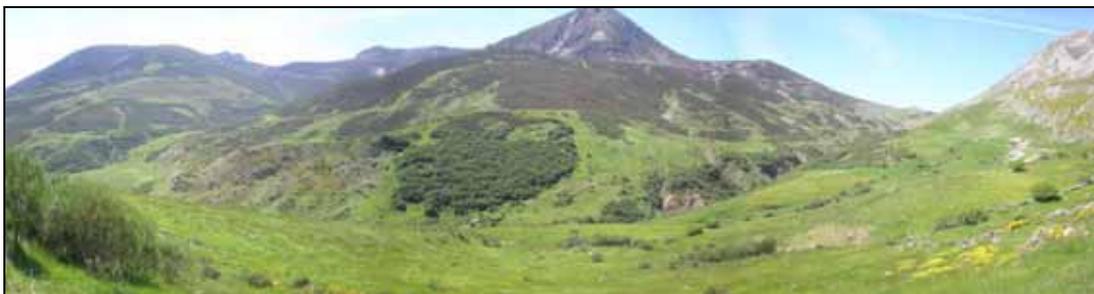
Chairman: Hermínio da Silva Botelho

POSTER PRESENTATIONS

Heathland management and restoration: a key to maintain biodiversity

Burning-effective heathland management tool?

Chairman: Mieczyslaw Kunz



Author: S. Suárez-Seoane

One century of heathlands dynamics in mountain pastures of central Pyrenees (France): the case of the valleys of Luchon

Métailié J.P., de Munnik N.

Lecture

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In the central and oriental French Pyrenees, *Calluna* heathlands represent a great part of summer pastures, which extend from 1300 up to 2300 meters in altitude. This landscape is associated to a still very active pastoralism : 6000 pastoral farms exist in the mountain region, with a total of 84 000 cattle and 490 000 sheep. In spite of this important stock farming, it does not exist neither a precise inventory of *Calluna* heathlands at the scale of the pyrenean range, nor a survey of the contemporary dynamics. Although the Pyrenees suffered during the 20th century a strong decrease of rural population and increase of land abandonment, pastoral economy has been renewed since 30 years, thanks to development of policies supporting mountain agriculture and pastoralism. As a consequence of these contradictory evolutions, the mountains can show abandoned pastures close to very exploited.

The dynamics of *Calluna* heathlands were studied in the Luchon valleys (department of Haute-Garonne) where they cover very large surfaces. Deforestation is almost complete on these slopes, between 1200 and 2200 meters in altitude, where the first remains of peopling (cromlechs, habitat sites) date from the Bronze Age. Historical sources are numerous for the contemporary period since 1850: forest archives of the Mountain Restoration Service (1860-1910), pastoral archives, archives photographs since 1860, botanical inventories, aerial photographs since 1942, research programs on pastoralism during the years 1970'-80', etc. They allowed a precise reconstitution of heathlands evolutions since 19th century.

In 1880, foresters claimed that the pastures on the mountain of Espiau were highly degraded by sheep breeding and that reforestation was an absolute necessity to prevent hazards and soil erosion. But historical sources and vegetation survey show on the contrary a great stability of pastoral landscapes from the 19th century, in spite of the variations of pastoral pressure (strong decrease during the years 50'-60' and increase after the 70'). The use of fire remained the principal way of pasture management, but practices changed during the last decades, with generalization of fences separating the communal pastures, construction of pastoral tracks and installations, and some forest plantations. The clearest evolution is the appearance during the last 30 years of a phenomenon of *Calluna* decline on the lower sunny slopes (1300-1500 m), where *Calluna* is replaced by *Brachypodium pinnatum* grasslands. On northern cold slopes, *Vaccinium myrtillus* and *Rhododendron ferrugineum* are also eliminating the old *Calluna* heathlands. The causes of this decline are not today clearly identified: changes of pastoral pressure and practices, climate change, atmospheric pollutions, etc. But the phenomenon is very widespread in the Pyrenees and the Luchon valleys were selected as one of the study sites within the framework of a research program on *Calluna* dynamics in all the range.

Long term management policies to protect European heathlands from urban pressures - Lessons from the heathlands of Dorset, UK

Tidball H., Sterling P.

Lecture

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Dorset has approximately 7000Ha of Lowland heathland supporting many rare and endangered species. The vast majority of these heaths are designated as nationally-important Sites of Special Scientific Interest, variously included within Natura 2000 sites (SPA, SAC) and internationally-important wetlands (Ramsar sites). Many of these Natura 2000 heaths are embedded in or immediately adjacent to the urban areas of the Poole/Bournemouth conurbation, one of the largest urban areas in south west England. As the Principal Urban Area in Dorset, supporting a population of just under ½ million, it is the focus for much of the housing development planned in Dorset in the next 20 years.

Research has demonstrated links between quality and condition of heathland habitats and species and the proximity of residential development. The diverse effects that people and urban living have on the heaths have become known as 'urban pressures'. These effects can, either directly or indirectly, adversely affect the wildlife value of the heathlands. In south east Dorset these effects meant that in 2001 the conservation status of the Natura 2000 heathlands embedded in, or immediately adjacent to, the Bournemouth/Poole conurbation was 'unfavourable' or 'unfavourable and deteriorating'.

Since 2001 a partnership of landowners and managers and the police and fire services have worked together to combat the effects of urban pressures on the Dorset heaths particularly those in and close to the conurbation – the "urban heaths". Initially the partnership's work concentrated on the most pressing problem, arson, and then expanded to include motor vehicle trespass, disturbance from visitors and fly tipping. The work to combat the urban pressures includes 6 inter-related strands: wardening and policing; education and awareness raising; fire risk management; access management; projects to divert users to other less sensitive sites; and monitoring. By 2005 the deterioration in condition of the urban heaths included in the original project had been halted and some sites were showing signs of recovery. This trend has continued up to the present.

Evidence has been gathered on the adverse effects of urban pressures on the lowland heathlands of the UK throughout the first decade of the 21st century. By 2007 it had become obvious that no proposals for residential development close to the N2000 Dorset heaths would pass appropriate assessment under the Habitats Directive which is translated into UK law by the Habitats Regulations 2010. Regulation 61 of the Habitats Regulations restricts the granting of planning permission for development that is likely to significantly affect a European site by requiring that an appropriate assessment is carried out of the implications of the development for the site's conservation objectives. The planning authority must ascertain that the plan or project will not have an adverse effect on the integrity of the site, alone or in combination with other plans or projects, either directly or indirectly, taking account of any conditions or restrictions that would help ensure no adverse effect, before granting permission. The Regulation thus enshrines the precautionary principle in law, preventing consent, other than in closely-defined circumstances, unless the authority is certain of no adverse effect. The continuing work of the partnership now helps provide the mitigation package that allows residential development within 5km of the protected sites but not within 400m. Contributions from the developers help fund the work of the partnership.

Objective controlled management in heathland, Berge, Flekkerøy, Oksøy-Ryvingen Protected landscape, Vest-Agder, Norway

Vikøyr B., Gunnarsli K.S., Haraldstad Ø., Kilander C.E., Lie A., Danielsen T.

Lecture

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Heathland is a result of continuously grazing from domestic animals for centuries. Berge, a peninsula of one square kilometer (100 hectare), was grazed by cows and domestic sheep up to 1940. There was no grazing and no public access to Berge between 1940 and 2000. Berge was heavily overgrown with trees up to an age of 55 years old in year 2000. The outer part of Berge was heathland in senile phase dominated by *Calluna vulgaris*. The Heathland was partly heavily natural invaded by *Juniperus vulgaris* as well as broadleaved trees such as *Betula pubescens*, *Sorbus aucuparia*. It was also partly planted by *Picea sitchensis*. Because of a general awareness of the value of historical cultivated landscapes, there was established governmental support from the Norwegian Ministry of Agriculture. A program named Regional Environmental Program for Agriculture in Vest-Agder offered dedicated financial support to farmers that reintroduced moderate grazing on islands and some other heathlands of high value from 2005. Parallel to this there was a special focus on the values of Coastal Heathland in the conservation plan for Oksøy-Ryvingen Protected Landscape from 2003. The plan asked for restoration of recently overgrown heathland. Oksøy-Ryvingen Protected Landscape was established by the National Government in 2005. Berge became a public recreational area owned by Directorate for Nature Management in 2004. A process for making a management plan for Oksøy-Ryvingen Protected Landscape started in 2006. Berge was focused as a pioneer management project with the objective to restore the heathland. A plan for Heathland burning was made in 2006. The following actions were taken: Chopping trees and remove the biomass from the high priority fields started in 2007, fencing including dividing the area in two 2007-08, introduce Old Norwegian Sheep in 2008, lenient burning from 2009.

The Directorate for Nature Management started a national program in 2009. Restoring Heathland on Berge became one of three ecological projects in the program, and the only one that focused on Heathland. The program included:

- Establishing conservation objectives
- Making a management plan
- Systematic registrations, focus on vegetation
- Putting management plan into action
- Annual monitoring and evaluation

The objectives for the project period 2009-2011 are:

1. At least 5 % (1.5 hectare) of the project area shall have *Calluna vulgaris* in pioneer phase (0-6 yoa).
2. *Dactylorhiza maculata*, *Polygala vulgaris*, *Pedicularis sylvatica*, *Potentilla anserina*, *Scleranthus annuus* and *Veronica arvensis* shall have a larger population than in 2009.
3. *Crambe maritima* og *Carex punctata* shall maintain its population from 2007-08.
4. There shall be no trees of *pinus* and *picea* at the end of 2011.

Results:

- A. The landscape is more open.
- B. Regeneration of *Calluna vulgaris* is good.
- C. Overgrowing is stopped.
- D. The flora is dramatically changed, especially the seashore meadow.
- E. *Rhodiola rosea* and *Carex punctata* is dramatically reduced in flowering number.

The management strategy will continue in 2011. Increased effort will be taken to vitalize the inner/central area by burning and cutting trees and shrubs, to reduce grazing intensity on seashore meadows. The area burned per year will be increased from 2012 to shorten the restoration period and increase the grazing value in general. The management is positive to introduce 10 traditional goats, but wants to supervise the consequences for the threatened species *Sorbus meinichii* and *Malus sylvestris*.

A ground-breeding heathland bird negatively affected by grazing sheep

Vermeersch G., Jollyn F.T., de Bruyn L., **de Blust G.**

Lecture

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Extensive sheep grazing is a well known measure in heathland management. It is often demonstrated that it prevents heathlands to become overgrown by shrubs and trees, it increases the complexity of vegetation structure and facilitates the dispersion of diaspores. However, controversy remains regarding its effect on ground-breeding birds. Therefore a detailed study on the impact of grazing sheep on the breeding success of a typical heathland bird of high conservation concern, the Woodlark (*Lullula arborea*), was done in the trans-boundary heathland reserve 'De Zoom - Kalmthoutse Heide' (Belgium - The Netherlands, province of Antwerp).

In 2010, six plots of approx. 250ha were selected, each with a comparable area of suitable Woodlark habitat. At the beginning of the breeding season (late March) none of these plots were grazed. Later in the breeding season, i.e. from the 1st of May on during the second brood period, three plots were grazed (1 sheep/ha). Nests were recorded and revisited regularly to monitor breeding success.

75 nests were found. During the period with no grazing, the first brood, no significant differences in nest success and offspring survival were found between the plots. Success of the second brood however, was significantly and clearly lower in the grazed plots compared with the ungrazed sites.

The processes that cause these remarkable differences are studied in 2011. Last year, evidence of direct nest trampling by sheep was only found in two occasions. Therefore, disturbance of the breeding birds will be studied now, yielding insights in patterns of cooling of the clutches and eventually increased predation rates.

The results of the study will be discussed in the context of optimized grazing management of heathland.

LIFE Liereman: preparation, restoration and communication

Poster

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From 2004 until 2010 the NGO Natuurpunt carried out a nature restoration project in the nature reserve “the Liereman Landscape”. The Liereman Landscape is located in the northern part of Belgium in the Campine area, a sandy region between the Rivers Scheldt and Meuse.

At the Liereman Landscape heathlands strongly declined from the years 1950's onwards. The classical extensive forms of land-use could not compete with modern agricultural techniques. The landscape changed dramatically, boggy marshes were abandoned, which resulted in vegetation encroachment. The inland dunes were abandoned or planted with pines and small bungalows appeared throughout the landscape. Whenever possible, the heathlands were exploited on a large scale by means of drainage, surface leveling and fertilization.

The main target of LIFE Liereman was the large scale restoration of heathlands, which consisted of different European target habitats: dune heaths (2310), dune grasslands (2330), oligotrophic waters (3110), oligotrophic to mesotrophic waters (3130), wet heaths (4010), dry heaths (4030), *Nardus* grasslands (6230+), calcareous fens (7120), depressions on peat substrates (7150), old acidophilus oak woods (9190), bog woodlands (91D0) and alluvial forests (91E0+). These habitats host many rare plants and animals such as Marsh Gentian (*Gentiana pneumonanthe*), Bog Asphodel (*Narthecium ossifragum*), Green Hairstreak (*Callophrys rubi*), European Nightjar (*Caprimulgus europaeus*), Black woodpecker (*Dryocopus martius*), Spotted crane (*Porzana porzana*), Moor frog (*Rana arvalis*) and Natterjack Toad (*Bufo calamita*).

Within the framework of LIFE Liereman several preparatory studies were executed:

- The groundwater infiltration and seepage areas were mapped by an engineering office. Also, hydrological bottlenecks were examined and mitigating measures were suggested.
- Soil profile analyses were made to determine the best locations for the restoration of heaths and inland dune habitats.
- The soil profiles of former fens were analyzed to prepare fen restoration.
- Olsen phosphate analyses were made on former agriculture lands to prepare the restoration of dry grasslands.
- A general management plan was made for the whole perimeter of the nature reserve.

Based on the preparatory studies 8 restoration actions were executed for the one-off restoration of the target habitats. Following these actions mowing and grazing management were started to be continued after the LIFE-project by farmers, and volunteers and professional field workers of Natuurpunt.

In total 43 ha dune heaths and dune grasslands, 25 ha wet heaths, dry heaths and depressions on peat substrates, 60 ha *Nardus* grasslands, 6 fens and 54 ha forests were qualitatively restored. The habitat restoration had a good effect for the populations of the species mentioned before.

Because large scale nature restoration raises many questions, pro-active communication is the most practicable. Preceding every step of the project, informative walks were organized, information signs were installed, information brochures were distributed and articles written in local magazines and newspapers.

To widen the public awareness of the Liereman Landscape, a conceptual plan concerning the opening of the nature reserve and the visitor centre was part of the general management plan. The concept focused on maximizing nature experience, yet minimizing habitat disturbance.

Heath for Everybody: the experiences of a volunteer-based NGO in the conservation of heathlands

Rotsaert R.

Poster

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With a population density of 462 inhabitants per km², Flanders is one of the most densely populated regions in the world. This of course results in a tremendous pressure on the remaining open space. A large part of Flanders was historically managed as heathland. Unfortunately, since intensive agricultural methods and forestry practices took over, most of these heathlands have been lost or were decimated.

In this framework it is the merit of the volunteer-based NGO, Natuurpunt, not only to preserve and restore an ever-growing network of nature reserves (thus bringing nature closer to the people), but also to continuously bring the people closer to nature, creating a bigger public awareness and involvement towards nature and the problem of biodiversity-loss. Though being guided by a professional staff, the real strength of Natuurpunt are its volunteers. So far Natuurpunt has managed to preserve and restore 1.2 % of the Flemish territory, including a good share of heathland habitats.

Natuurpunt has been committed to heathland conservation ever since its founding in the 1950's. The format of a volunteer-based organization has proved to be a very useful one in this respect. It's a bottom-up system where the local knowledge and hard work of many thousands of dedicated people, is translated in actual in-field results for nature conservation. Through a small scale approach several heathland relicts are conserved and hundreds of hectares of degraded heathland were restored to their former glory.

By doing so, a great deal of practical knowledge has been built up within the organization, for instance in the fields of preliminary studies, restoration through sod-cutting, monitoring and heathland management through grazing. During the last two decades this culminated in bigger restoration projects with bigger funding, most importantly European funding through several LIFE-projects. With these LIFE-projects Natuurpunt has become a key player in strengthening the Natura 2000 network.

How our volunteers manage to achieve all this? We will gladly clarify this with our poster presentation.

Post-fire successions along a 390 km latitudinal gradient in Northern *Calluna* heathlands

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Poster

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The coastal heathlands of Norway are distributed along a geographical gradient from southernmost Norway to Lofoten in north. The coastal heathlands are semi-natural, and their existence depends on burning and grazing as part of the farming regime. Today, the heathlands are classified as greatly endangered, and abandonment of traditional heathland farming is a major threat.

In this study we quantify the effect of geography on post-fire successions after experimental fires set in five coastal heaths along a north-south gradient. The 390 km latitudinal gradient span from Lygra in south at 60° 42' N, 5° 4' E to Tarva in north at 63° 47' N, 9° 22' E. We assess whether the post-fire succession differs between sites along the gradient, and questions how habitat (wet/dry) influences the post-fire development along the gradient.

A repeated measurements design was used, with floristic data recorded in wet and dry heath in permanent plots in the post-fire succession (n = 20) over a 3-year period. The data were analysed using multivariate ordination techniques and mixed effects models.

Our study demonstrates that geography strongly influenced the post-fire succession; geography alone explained 27.4% of the total floristic variation in the dataset. The post-fire successional trend explained 17.4%, and out of this the geography-specific fire responses explained 6.5% of the variation.

The regeneration rate in the south appeared faster than in north, which might be explained by species composition and productivity related to climate. The wet habitats also showed a faster regeneration towards the pre-burned community than the dry habitats along the entire geographic gradient. This is probably linked to early-successional dry heaths harbouring a higher diversity and abundance of pioneer grasses and herbs than the wet habitats.

In a conservation perspective, this study illustrates that heathlands vary geographically, not only in species compositions but also in post-fire successional trends and dynamics. This study points to the importance of conservation of a geographically diverse set of sites, as well as the development of site-specific management plans.

Fire effects on soil and *Pinus radiata* germination in a heathland of NW of Iberian Peninsula

Poster

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This work supposes a new point of view in the study of the ecological effects of the fire on the heathlands, because the calorimetry of the soil and the reproductive behavior of an arboreal specie are joined the same study.

A soil of Atlantic heath located in Meira (Lugo), with a *P. radiata* forest plantation and affected by a fire in March, 2010 was selected for this analysis. Samples of burnt and unburnt soils (2 cm depth) were picked up.

A Differential Scanning Calorimeter (DSC Q100 TA Instruments) was used to determine de heat of combustion of the organic matter and the ignition temperature of samples of burnt and unburnt soils. From these data the reduction of SOM as a consequence of the fire was determined. These results showed a lower impact in the soil, indicating that the temperature raised in the soil surface was lower than the ignition temperature of the unburnt soil (240°C approximately).

On the other hand, samples of unburnt soil were heated in a laboratory oven to temperatures of 150°C and 200°C during 5 and 10 min. The DSC curves of these samples were also done to clarify the impact of the fire from the comparison with that of burnt soil, resulting that the fire in the soil have been similar to the caused one in the soil heated in the laboratory to 150°C during 10 min.

To verify the effects of the fire (heat and smoke) on the germination of two origins of *P. radiata* 12 treatments were carried out: Control, 80°C-5min, 80°C-10min, 110°C-5min, 110°C-10min, 150°C-5min, 150°C- 10min, .Smoke-5min, smoke-10min and Smoke -15min.

These factors presented different effects on *P. radiata* and their intensity dependent with the origin of the species: the heating at the highest temperatures and times of exposition inhibited partially or totally the germination of the studied species, and the smoke, on the other hand, does not affected significantly to the germination.

From the obtained results, the conclusion of this work is that the fire of Meira in 2010 reached a temperature in soil able to inhibit the germination of *P. radiata* due to the lethal effects of the heat.

SESSION 5

ORAL PRESENTATIONS

Burning - effective heathland management tool?

Chairman: John Underhill-Day

SESSION 6

ORAL PRESENTATIONS

Heathland ecosystem services

Chairman: Estanislao de Luis



Author: S. Suárez-Seoane

Resilience of heathland habitats after severe summer fires: results from a long-term survey

Clément B.

Lecture

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Controlled burning is frequently used as a standard heathland management tool instead of mowing or grazing. Loss of traditional management increases the probability of causing severe humus fires in relation with fuel accumulation. Such severe fires generally occurred after a long hot and dry season. In summer 1976, humus fires took place in North York Moors (England), Brittany (France). More recently, in 1990, 2009, some severe fires occurred again in Brittany.

We aimed at describing the main changes of plant populations and communities at the habitat scale and evaluating the resilience of the ecosystem. We analysed plants and ecosystems responses linked with different fire intensities and their consequences through diachronic surveys.

We demonstrated through a long-term survey that four major successional trajectories have been occurring since 1976 in Brittany. They were function of fuel accumulation, ash accumulation or erosion, and persistence or not of an active seed bank. These scenarios were:

A – High and quick resilience of heathland occurred where there was no accumulation of fuel (biomass + litter). B – Medium and late resilience occurred after an erosion of ash. Space re-colonisation depended on the distance from the source and the type of diaspores. C – No resilience of heathland occurred in areas with more than 2cm deep ash accumulation. In these areas, *Polytrichum* populations and later *Molinia caerulea* populations inhibited the succession process. D – Slow and local resilience of heathland plants occurred in areas with particular micro-topography and ash erosion process. The main example was the top of ridges where high constraints of soil (low water availability and high oligotrophy) limited growth of bryophytes and then, gave place for late colonisation by heathland plant species.

Scenario A corresponded to the response of heathland communities associated with controlled burning. Biodiversity was lowly affected (mainly animals!) in these communities. In scenarios B and D, the major functions of heathland ecosystem were restored partially but all geophytes populations did not recover even 30 years later.

Restoration of management tools in dwarf shrub ecosystems could prevent from alteration of biodiversity. This will be necessary in the global change framework.

Smoke-induced germination in coastal *Calluna* heathlands - a case of management-induced evolution?

Vandvik V., Daws M.I., Kaland P.E., Måren I.E., Spindelböck J.P., Velle L.G.

Lecture

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Smoke-induced germination responses have been shown to play an important role in post-fire revegetation responses and in the population dynamics of many species characteristic of naturally fire-prone habitats world wide. Fire is also ecologically important in the coastal heathlands of north-west Europe, but here fire is a culturally induced phenomenon, dating back only a few thousand years. In this study we ask (i) if smoke-induced germination responses also operate in this culturally fire-prone system, and (ii) if such responses are unique to heathland populations of the wide-spread species *Calluna vulgaris*, suggesting that the response may be affected by local selection pressures.

We test for and quantify smoke-induced germination responses in coastal heathland seedbanks, and in *Calluna* populations sampled along parallel climate gradients in and outside the coastal heathland region of Norway (south – north and lowland – alpine, respectively).

Smoke treatment significantly increases germination in coastal heathland seedbanks. Smoke-induced germination responses were also detected in fresh *Calluna vulgaris* seeds, and these responses were constant along a south-to-north climate gradient within coastal heathlands in Norway (58°N- 69°N, mean annual temperature 7.3°C – 2.7°C). In contrast, smoke responses gradually decreased along a climatically parallel gradient from the traditionally fire-managed heathlands at the coast to alpine heathlands with no history of fire management (1 – 1020 metres above sea level, mean annual temperature 7.3°C – -0.6°C). This suggests that the historical fire regime may have had evolutionary consequences for germination responses of species of *Calluna* heathlands.

In a conservation perspective, this points to the importance of conserving not only a geographically diverse set of sites but also the historic management regimes of this cultural landscape to conserve the ecological and genetic diversity of coastal heathlands.

Can old degraded Northern *Calluna* heathlands be restored through reintroduction of fire?

Lecture

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Coastal heathlands of Norway are classified as greatly endangered. Burning has traditionally been used as a management tool, and burning rotations of 10-20 years were common. Abandonment of traditional heathland farming generally results in decreased fire frequencies. The high conservation value of coastal heathlands calls not only for the conservation of existing managed heaths, but also for the assessment of restoration potential of abandoned and degenerated heaths.

The aims of this study is to quantify the effect of fire on vegetation composition after experimental fires set in young (8 years since last fire) and old (> 50 years since last fire) heath. We assess whether, and how fast, *Calluna* is able to regain its position as a temporal dominant species after fire when there is absence of vegetative regeneration in both young and old heaths, and evaluate the role of prescribed burning as part of future management in such sites. The revegetation dynamics were followed in the Tarva archipelago, central Norway. A repeated measurements design was used, with floristic data recorded in permanent plots in the post-fire succession (n = 12) over a 7-year period. The data were analysed using multivariate ordination techniques and mixed effects models.

Our study demonstrates that fire interval strongly influenced post-fire successions. Despite lower successional rates, old stands do develop characteristic heathland vegetation and structure after fire, and while potential invasives into the system such as trees and rhizomatous species are present, they do not impair *Calluna* regeneration or vegetation development. Despite no vegetative regeneration of *Calluna*, the species still re-established as the dominating species within 5-7 years in both young and old stands. Regeneration dynamics was also affected by habitat conditions.

The young heath showed a faster and more uniform succession toward the pre-burned community composition, which could be linked to lower litter cover early in succession. However, young heath had less pronounced overall effect of fire than old heath. Further, our young stands are only in their second fire rotation after restoration; suggesting that the characteristic dynamics of managed heathlands are able to re-establish relatively rapidly. Site-specific considerations are also needed, however. We conclude that there can be restoration potential in old heaths, despite slow dynamics in the first rotation.

Calluna dynamics related to grazing and prescribed burning in the Pyrenees

Faerber J.

Lecture

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Heathlands dominated by *Calluna vulgaris* cover a large part of Pyrenean rangelands. Even in the Eastern, Mediterranean part of the Pyrenees, about 20 % of mountain pastures are made up of *Calluna*. In most cases, these communities correspond to a transitory stage during progressive or regressive successions. The analysis of historic photographs shows that grazing or specific management techniques may confer certain stability to *Calluna* heath. However, during the past decades, changes of land use involved a decreasing of heather. Therefore, it had seemed necessary to better evaluate the impact of grazing and burning, in order to design conservation strategies for these European priority habitats (92/43/CEE Regulation).

Several *Calluna vulgaris* heathlands have been studied since 1991 on experimental plots located in the central and Eastern Pyrenees. Qualitative and quantitative recording has been carried out on permanent transect lines before and, periodically, after prescribed burning. The impact of fire and grazing was studied in terms of specific composition, abundance and pastoral value.

The results show that *Calluna* dynamics depend on various parameters such as composition of the chamaephytic layer, age of the heath, intensity of burning and subsequent grazing.

In the majority of cases, fire contributes to the internal stability of the heath (*Calluna* remained dominant, no significant modification of the floristic composition) and ensures the long-term maintenance of *Calluna* heathlands, by blocking re-colonisation by trees (*Pinus uncinata* and *Pinus sylvestris*). The pastoral value of the heathlands is increasing significantly.

However, in some cases, burning may contribute to heathland regression. In mixed stands, fire can disturb the fragile balance which exists between the chamaephytic species of the heath, favour quick resprouters and involve the forming of a dense *Ulex*- or *Vaccinium*-dominated heath. On the other hand, strong grazing after burning favours the replacement of *Calluna* heath by grassland. The effect is particularly important after intense burning of old heathlands and in case of dry summers after burning.

The results strengthen that *Calluna* heathlands are clearly linked to extensive land use. The current evolution implying abandon of some mountain pastures and a more intensive use of others endangers heathlands dominated by *Calluna vulgaris*. Conservation strategies should take into account this problem.

Nature, culture and the fate of the heaths: the relationship between cultural service delivery and heathland conservation

Kirkpatrick A.H.

Lecture

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The Millennium Ecosystem Assessment grouped ecosystem services (the benefits people get from nature) into four categories, provisioning, regulating, cultural and supporting services. Cultural services are defined as the non-material benefits that are obtained from ecosystems. While such services are often not valued in the market, some commentators have suggested that they represent one of the strongest incentives for people to get involved in conservation. As cultural landscapes created by centuries of interaction between people, their livestock and fire, heathlands exist at an interface between nature and culture and thus one might anticipate popular support for their retention within landscapes. This paper will examine how heathlands have accumulated (or lost) value in relation to cultural services and the extent to which cultural drivers have contributed to their protection. Consideration will be given to the nature of the trade-offs between cultural services and other ecosystem services in present management strategies. The paper will also discuss whether an expansion in the supply of cultural services could lead to economic benefits for a region.

Heathland management on a military domain: A unique combination of partners and tools as a key to success

Dictus C.

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Lecture

The 'Vallei van de Zwarte Beek' ('Valley of the Black Stream'), covering 1500 hectares, is the largest nature reserve managed by Natuurpunt in Flanders. It started however in the late seventies as a small enterprise of a few local volunteers who saw the nature in their neighbourhood threatened by reformplans of the government. These same volunteers of Natuurpunt were also affected by the nearby military domain where unique boglands and heathland on a large scale were still present. The nature conservation organisation tried to obtain permission for the restoration of important parts of heathland, amongst other habitats through restoring hydrology in its original state, and succeeded in launching a grazing project with Aberdeen angus and a sheep herd.

Later on a cooperation with the Flemish government and federal government resulted in an extensive LIFE project in a number of military domains in Flanders which became known as the Danah-project. Heathland restoration on a large scale through different means became possible. The new challenge now lies in maintaining the present open landscape in a sustainable way with respect for its biodiversity.

The presentation will further focus on how this cooperation between the different government, nature conservation organization generates a variety of tools for heathland management that give possibilities for grazing, mowing, burning, sod cutting and fen conservation and how this helps to achieve the goals of the management plan.

The example of a few species, like Alcon blue (*Maculinea alcon*), Nightjar (*Caprimulgus europaeus*) or Bog asphodel (*Narthecium ossifragum*), that benefited from this management can illustrate how this approach can be a key to success.

Ecosystem service provision in dynamic lowland heathlands

Cordingley¹ J.E., Newton¹ A.C., Clarke¹ R.T., Bullock² J.M.

Lecture

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It is now widely recognised that natural environments provide ecosystem services to humans. When considering ecosystem service provision one key issue, which has received relatively little research attention to date, is that ecosystems are dynamic. The provision of ecosystem services is therefore likely to vary over both time and space. This is especially relevant under conditions of environmental change which may alter community composition, which in turn may affect ecosystem functioning and so potentially ecosystem service provision. The Dorset lowland heathlands are a fragmented habitat where changes in management practices have meant that succession from heathland to woodland is now widespread. This research used a thirty year data set to analyse transitions between vegetation communities on the Dorset heathlands over time and link these changes to the spatial characteristics of individual heaths. Carbon storage in different heathland communities was then quantified in the field and the links between landscape fragmentation, community change and ecosystem service provision (carbon storage) examined. The results are presented in light of potential trade-offs which may exist between biodiversity conservation objectives and ecosystem service provision.

Carbon consequences of heathland management and restoration

Alonso I.

Lecture

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Human activities, including land management choices, are changing directly and indirectly the rate of global CO₂ exchange and the amount of stocks. Land use change, such as deforestation and agricultural conversion, is a major source of global emissions (about 1.8 Gt C yr⁻¹) (IPCC, 2007). There is also increasing evidence that degraded peatlands and other wetlands are a significant source of CO₂ emissions. The UK has signed the United Nations Framework Convention on Climate Change and has to submit annually data including greenhouse gas (GHG) emissions and sequestration from land use, land use change and forestry. Some practices, such as drainage, cultivation, deforestation and habitat destruction, result in emissions. Others, such as afforestation, conversion of croplands into grasslands and the restoration of degraded land, result in sequestration (Dawson & Smith, 2007). By restoring some habitats such as grasslands or bogs, but also to a lesser extent heathlands, land managers could help mitigate the causes of climate change by directly reducing GHG emissions, safeguarding carbon stores and possibly re-starting sequestration (Thompson 2008). The sustainable management of habitats important for carbon storage can therefore potentially contribute to meeting national targets for GHG emission reductions. However, in some cases, habitat restoration or management may pose a dilemma between increasing carbon sequestration and increasing biodiversity (e.g. removal of trees to restore lowland heathland) and land managers will need all the available information to underpin their decisions.

Natural England carried out a review in 2010 to find out available information and identify knowledge gaps on carbon stocks for important terrestrial habitats in England and to determine how different management options may impact the sequestration or emission of carbon by habitat. One of the habitats considered was "Dwarf shrub Heath". Most of the carbon stock associated with heathlands is in the soils, which vary depending on the parent material, including wind deposited sand and loess, glacial and fluvial deposits and peat. Milne & Brown (1997) suggested that podzols contain about 10% of England and Wales soil carbon, equating to approximately 175-211 tC ha⁻¹, which is relatively high for non-peat soils. On the other hand, brown sands, the most likely result of agricultural improvement of sandy heathland soils, contain approximately 93 tC ha⁻¹. The UK BAP targets seek the restoration of 10,500 ha lowland heath by 2020 much of which will be on agricultural and forested land. As at November 2010, 11.5 % of the upland heathlands were in favourable condition, whereas 86.3% were in unfavourable recovering condition. The figures for lowland heathlands are 27.6% and 65.3% respectively. The main reasons for heathland sites being in unfavourable condition were: inappropriate grazing levels, moor burning/arson fires, inappropriate scrub control, drainage, inappropriate cutting/mowing and inappropriate ditch control. Hawley et al. (2008) reviewed the impact of commonly used heathland restoration or re-creation techniques on soils (including the carbon stock) and archaeology. The impact of these techniques on carbon storage seems to depend not so much on the objective (e.g. removing trees), as on the way it is performed. For instance, whereas there could be a significant loss of carbon from rapid clear felling, carbon stocks could be maintained with a more gradual felling cycle (Broadmeadow & Matthews, 2003). As a broad principle, those heathland restoration techniques which rely on soil removal or disturbance are more likely to cause carbon emissions than those which rely only on vegetation changes (Broadmeadow & Matthews, 2003). However, they also tend to be more effective (Hawley et al., 2008). Re-creating heathlands from arable land and/or restoring the hydrology would result in increased carbon sequestration, both in the vegetation (e.g. peat forming mosses) and in soils. This would go some way to redress the potential loss from tree clearances (Milne & Brown, 1997). As with other open habitats, the management and restoration of heathlands can result in carbon emissions. However, these habitats are important for biodiversity and the cultural ecosystem services they provide. Further work is needed to obtain better figures of carbon emissions under different management options to help with the decision making.

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Thanks for coming!

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