5th EUROPEAN HEATHLAND WORKSHOP

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Erica umbellata L.

Area de Ecologia
University of Santiago de Compostela

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Session I: *Atlantic heathlands from North to South*

Invited Lecturer Prof. J. Izco

ATLANTIC HEATHLANDS FROM NORTH TO SOUTH

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The concept of "heathland" includes the shrub formations of the Ericaceae. In the European Atlantic coastal belt, such communities show remarkable diversity: they occupy sites of very varied environmental characteristics, and likewise vary very considerably in terms of companion species composition.

These heathlands of the Atlantic coastal belt extend from the Eurosiberian Region down through into the Mediterranean Region. They may occur close to sea level, and up to altitudes as high as 2000 m. Generally, these communities are seral, developing following disturbance of woodland communities (whether deciduous, or broad-leaved, or needle-leaved or evergreen); in high mountain areas, however, heathlands may constitute climax communities, and are often more or less permanent.

Ericacea diversity shows a clear north-south gradient, with species richness higher in southern territories. Similarly, the principal companion species of heathland-most notably, species of the Cistaceae and the Genisteae- show increasing diversity from north to south. Heathland communities are thus typically richest in southern Europe. Currently, most of these communities are listed under the European Union's Habitat Directive, as vegetation types to be included within the Nature 2000 network of nature reserves.

ORAL COMMUNICATIONS

HEATHS OF THE NORTHERN HEMISPHERE: A PERSPECTIVE FROM QUANTITATIVE BIOGEOGRAPHY

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In this study a quantitative biogeographic analysis of the species of the subfamily Ericoideae (heaths) through Europe and the Mediterranean Basin is carried out. This area is considered to be a secondary centre of diversity within the subfamily (20 species) and it has traditionally been associated with temperate heathlands. The Cape floristic region is the primary centre of diversity (over 600 species) and their heath species are mostly present in a Mediterranean-type climate. Three main questions are addresed:

1. What are the geographic elements which heath species may be grouped into, and what ecogeographic variables are correlated with these elements?
2. How is the species diversity within this group distributed in the study area?
3. What are the biological correlates of the geographic elements? If these represent areas with very different environmental conditions, some biological features of these plants should vary accordingly

Three matrices (species x areas, species x ecogeographic variables, and species x biological characteristics) were assembled and multivariate techniques of classification (TWINSPAN) and ordination (DCA, DCCA) were performed on them.

The 20 species were grouped into seven geographic elements and the 47 geographic units considered formed six floristic regions. The elements are: Eastern Mediterranean-Balkanic, Western Mediterranean, Subatlanctic, Oceanic, Circumpolar, and two monospecific elements (*Erica arborea* element and *E. herbacea* element). The highest diversity of heath species is found in Western Mediterranean areas (15 spp in Spain, 11 spp in France, 10 spp in Portugal, and 8 spp in Morocco).

Correspondence analysis of species x areas and areas x ecogeographic variables clearly ordered Mediterranean species against boreal species along the first axis. This separation was correlated with frost risk, minimum temperature and water stress. A second axis ordered atlantic species against continental species and this axis was correlated with annual temperature range and oceanic influence.

LOWLAND HEATH IN BELGIUM

EVOLUTION AND PRESENT STATUS

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In this contribution we will describe the former and the present distribution of lowland heath in Belgium. The first complete historical data are derived from the map of De Ferraris, drawn in the late 18th century. Figures of the present distribution are based on the Biological Valuation Map of Belgium and on regional field surveys.

The Biological Valuation Map provides a lot of details concerning the type, the area and the spatial position of the heathland sites. For the main heathland region, the results of a GIS analysis will be presented.

The species composition of the heathland vegetations, based on phytosociological relevés, will be discussed for the period before and after 1965. General trends that come out of the analysis are compared with the results of a detailed study of relevés, made at exactly the same places in 1955 and 1994.

We will conclude with an overview of the present level of protection of lowland heath in Belgium.

POSTERS

SOME CONTRIBUTIONS TO THE ORIGIN, DISTRIBUTION AND CHARACTERISATION OF HEATHLANDS IN THE NORTHERN GALICIAN MOUNTAINS (NW SPAIN)

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Data from paleobotanical and paleoclimatic studies have established the existence of heathlands in this area since the Final Pleistocene. As a result of the development of forests during the Initial Holocene, heathlands were restricted to the highest areas. During the last 3000 years, human activities in the countryside have caused the beginning of a new expansion phase of these communities to the detriment of oakwoods.

Nowadays, in the Northern Galician Mountains, climatic, topographic and soil conditions, as well as human activities, are responsible for the existence of shrublands in the landscape.

Two main groups of heathlands may be established according to their physiognomic and floristical appearance.

Low-appearance heathland stands, under more or less moist conditions, composed of a low or dwarf canopy of heaths, which constitute a mosaic of different communities.

The landscape is dominated by a community characterised by a dense to mid-dense grouping of *Calluna vulgaris* (L.) Hull. and *Erica mackaiana* Bab., which spreads above 700 m, under a moisture regime described as "hyper-humid", on hydromorphic and peat soils (Histosols), growing on slopes and some flat levels at the top of hills below 850 m. Bogs maintained by the moisture regime are widespread above this altitude.

Although dominated by *Calluna vulgaris* (L.) Hull. and *Erica mackaiana* Bab., this shrubland changes gradually from wet peat conditions, with *Sphagnum* and Cyperaceae, into dryer-heathlands with *Gentiana pneumonanthe* L. (*Gentiano pneumonanthe-Ericetum mackaianae*).

Other heathlands of less importance in the area are characterised by the presence of *Erica ciliaris* L., *Ulex galli* Planchon, *Cirsium filipendulum* Lange *(Cirsio filipenduli-Ericetum ciliaris* and *Ulici europei-Ericetum cinereae), Genista berberidea* Lange and *Erica mackaiana* Bab. *(Genisto berberideae-Ericetum mackaianae),* which develop under gradually drier moisture regimes.

High-appearance heathland stands, related to forest stand dynamics, are composed of *Erica australis* L., *Erica arborea* L., *Vaccinium myrtillus* L. ..., growing on very steep hillsides, and spreading from 600 up to 800 m above sea level.

STRUCTURAL AND ENERGETIC CARACTERIZATION OF HEATHLANDS IN LEON PROVINCE (NW SPAIN)

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Seventeen heathlands, nine in the Mediterranean region and eight in the Eurosiberian region, all of them located in León province in Spain (NW Iberian Peninsula) have been studied.

Cover and biomass of ligneous species in the communities have been evaluated starting from the average of ten 1 m^2 unit plots for cover results and three for biomass results. Other structural parameters, such as species diversity and differential heterogeneity, were calculated. These data were related to chemical and physical soil properties and energetic values of species, evaluated in a calorimetric bomb taking into account the values obtained for different parts of the plant.

The most frequent species was *Erica australis* subsp. *aragonensis,* appearing in fouteen of the heathlands studied, and *Chamaespartium tridentatum* in thirteen. The greatest value of biomass (2760 g/m^2) was observed in a wet heathland, dominated by *Calluna vulgaris,* the smallest (467 g/m^2) corresponding to a shrubland dominated by *Erica umbellata.* Richness of shrub species ranged from 3 to 9, and diversity (calculated by Shannon index) from 0.45 to 2.03, being the less diverse community also the less heterogeneous one, with *Erica umbellata* covering 65% and only two other ligneous species, *Halimium alyssoides* and *Halimium umbellatum,* with a cover lesser than 6%. The most diverse shrubland was also dominated by *Erica umbellata,* but other ligneous species, such as *Erica australis, Chamaespartium tridentatum, Halimium umbellatum,* etc, were also abundant. Both parameters, species diversity and heterogeneity were not related to location in the Mediterranean or Eurosiberian regions.

All the heathlands were compared using an affinity analysis and a factorial analysis of principal components. It was possible to differentiate three groups: communities dominated by *Chamaespartium tridentatum* and *Erica australis* subsp. *aragonensis,* communities dominated by *Erica umbellata* and communities with *Calluna vulgaris.* These groups were not clearly associated to given soil conditions.

EXPERIMENT IN DECOMPOSITION HEATHER (*Erica australis* L.) UNDER LABORATORY CONDITIONS.

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Leaf litter decomposition is the main process of nutrient soil reincorporation. This study shows *Erica australis* L. leaf decomposition data under laboratory conditions. To carry this out, two processes have been differentiated: solution and decomposition.

Erica australis leaves were collected in November 1995 in a *Quercus pyrenaica* forest in Fontanos de Torio, in the province of León (NW of Spain).

Solution was studied placing the leaves in distilled water and measuring the fresh and dry weights at different times, and analyzing the solution water after nine days. With this information, the soluble substances loss and leaf permeability have been estimated.

Decomposition was studied by placing the samples in microcosms (15 cm height and 16 cm dimeter pots, containing 800 g of soil) which were kept ventilated and had drainage facilities, at a constant temperature (24°C) and humidity (60-80%). Periodically, samples were extracted and fresh weight, dry weight, ADF, lignine, N, C, P, Na, K, Ca and Mg were measured. The loss by decomposition was estimated by comparing the differences with regard to the initial values.

Changes in soil parameters as a consequence of heather leaf decomposition were also analyzed, comparing soil control samples with soil samples from the microcosms after three months of experimentation.

THERMOPHILIC HEATHLAND AND HEATHER COMMUNITIES IN WESTERN CENTRAL FRANCE : FLORAL SPECIES AND SYSTEMATIC

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The western border of the Massif Central of France profits from climatic conditions which are favourable to penetration of many thermophilic plant species issued from southern regions. A number of them exist in heathlands and even contribute to their definition.

The authors present the different natural environments where the following species are found :

* *Erica scoparia* :

- *Ulici minoris - Ericetum scopariae*, mesophilic heathland with a thermo-atlantic influence,
- *Erico scopariae - Spiraetum obovati*, in a particular situation near the forest mantle,,
- heathers with *Erica scoparia* and *Ulex europaeus*.

* *Erica vagans* :

- a community with *Erica vagans* and *Pseudarrhenatherum longifolium*.
- *Rubio peregrinae - Ericetum vagantis*, community composed of chamephytes and present in forest hem,
- special cases in serpentine outcrops.

Finally the exceptional presence of other heath species (*Erica erigena*, *Erica lusitanica*) and species of Cistaceae (*Halimium umbellatum*, *Helianthemum alyssoïdes*) is observed.

Habitat Requirements of the Ladybird Spider (*Eresus niger*) in North Germany

(Poster)

Gunnar Brehm und Kuno Brehm**

The Ladybird Spider (*Eresus niger*) has its northernmost range in Jutland (Denmark and North Germany). There are only very few places left where this species can still live. The spider needs open dune heathland with a warm climate. Plant succession which is favoured by fertilizing immissions and missing landscape management are the most severe factors which will lead to extinction of the spider within the next years. Investigations have to be done in order to find out the essentials for survival of this mediterranean spider in northern central Europe.

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LONG-TERM SUCCESSIONAL PATTERNS ON NØRHOLM HEATH

INVESTIGATIONS ON PERMANENT PLOTS 1921-1995.

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Nørholm Heath is situated in the south-western part of Jutland, Denmark. The heath, covering 350 ha, is geologically based on fluvioglacial sand with a layer of old shifting sand on top of it. Cultivation has ocurred in at least three periods from early Medieval to 1870. From 1895 and onwards no cultivation or domestic-animal grazing has taken place on the heath. In 1913 the owner imposed an easement on the property, stating that no human activities were ever allowed again. Having been left untouched by man for a 100 years and systematically investigated for 70 years, Nørholm heath constitutes a rare reference-area for long-term successional patterns on heath lands.

In 1921 a permanent square-net was established, making it possible to follow the immigration of trees and bushes. Besides the main-net 20 test-sites were established in different areas to follow the plant succession after the grazing had ceased. Fieldwork was carried out in 1921, 1926, 1931, 1937, 1942, 1949, 1959, 1974 and 1994. More fieldwork will take place summer 1995. Data from the preceding years have been summarized and displayed graphically to show the varying aspects of succession and the overall development. This material and a

NORWEGIAN HEATHLANDS - PAST, PRESENT, AND FUTURE

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Age

The vegetation history of the lowland heaths of Western Norway, started ca 4300 - 5100 years before present on the outermost islands west of Bergen at 60° N and at the costal fringe in the region of Rogaland, 58-59°N, where the earliest evidenses of *Calluna* heaths are found. Going inland, the age of continous heaths decrease. The heathland area reaches its maximum in the 16. th and 17. th Century.

In Rogaland *Molinia* heaths started to develop 1900 years before present and have since then increased in area. This prove that "natural" *Molinia* heaths along the coast of Norway have existed far in advance of the present enhanced level of N deposition around the North sea basin.

Extent

The lowland Norwegian heaths are at the northeastern extreme of the west Europaean heath region. At present the Norwegian coastal heathlands extend from the outermost skerries in the southeast(58°30'N, 9°E) to Lofoten,69°N, in Northern Norway. Especially in southeast the heathland area has diminished. Here there are only rudimentary heaths on islands in the outer Oslofjord.

Heathlands have its largest exstent in width in the area between Flekkefjord 58° and Sognefjorden 61°N. The heathlands extending c. 1800 km north to south, are accompanyed by floristic and vegetational changes. Going north, an increasing number of species with a northerly distribution, notably

HEATHLANDS VEGETATION OF NORTH-WEST RUSSIA

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Heathlands vegetation and habitats are usually widely distributed but they don't grow on the large fields of vegetation covering the European Russia area. Boreal coniferous and mixed broad-leaved-coniferous forests are the mainland vegetations of the North-West Russia. This is, for example, the taiga region near Baltic Sea and Ladoga Lake with its post-glacial sand and clay moraine plains as well as small granite rocks of Karelia. The heathlands which named in Russian scientific translation as "poostoushe" is the term for vegetation communities with low shrubs from the family _Ericaceae_ or in some cases short grasses especially from the family _Poaceae_. They are situated on acid or neutral soils with low moisture (rarely with other moisture conditions), somewhere in combinations with open woodlands containing _Juniperus communis L._ or dwarf form of _Pinus sylvestris L._". The classic grassland "poostoushe" is a community with _Nardus stricta L. (Poaceae)_. Some authors suppose the such community is natural, initial vegetation of poor acid soils but others assume that is secondary vegetation in the territories with acid soils where extensive pasture or hay-meadows was happened during 19-20 centuries. Hence, classic "poostoushe" is original vegetation of poor acid soils or some result of vegetation under the conditions of the soil anthropogenous degradation. Cetrainly, this is one of the stages of the succession process. There are also some kinds of low shrubs and grasses communities with _Vaccinium vitis-idaea L._, _Ledum palustre L._, _Arctostaphylos uva-ursi (L.) Spreng._, _Calluna vulgaris (L.) Hull_. They represent usually the heathland vegetation of the North-West Russia. It is important and interesting that all above 4 species require poor acid soils. In Russian scientific tradition, _Calluna vulgaris_ is named as "heath" and shrubs of genera _Erica_ are named as "heath". There are no shrubs of genera _Erica_ habitated in the North-West of Russia and the special name "heathland" is given traditionally for _Calluna vulgaris_ vegetation.

Sometimes, some vegetation communities of either low grasses or small shrubs of _Juniperus communis_ or dwarf (5-8 M high) trees of _Pinus sylvestris_ may be met. The such communities are the "poostoushe" too. Some authors in Russia use in the such cases the name "grass heathlands" meaning "lowgrass meadows on poor acid soils". They use also "Ericaceae heathlands" meaning "subshrub bog" (high moisture type) or "heathland" (low moisture type). Another not traditional view exists also that "heathland" or "poostoushe" is non-forest vegetation of poor low moisture acid soils (especially on sand soils), and that "heathland-like vegetation" is "any vegetation (forest and non-forest) with both dominance low grass and dwarf shrubs species which are typical for heathlands". Those can be, for example, inter alia, open pine forests, alvares and alvare-kind communities, some types of oligotrophic subshrub bogs, some types of maritime marsches on sand low moisture soils, some types of post-agriculture steppe-like communities on sand low moisture soils.

Session II: *Use and management of heathland*

Invited Lecturer Prof. B. Clément

USE AND MANAGEMENT OF HEATHLANDS

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Lowland heathlands can be divided in two categories - Natural heathlands on maritime cliffs and decalcified dunes, excluding coastal plateau - Semi-natural heathlands and moorland on other areas.

Semi-natural heathlands were the consequences of over exploitation of forest on poor substrata. If before deforestation, heathlands coexist with forest in clearing areas, human perturbations during last ten centuries have induced a new open landscape, in which heathlands were dominant. Persistence of heathlands was linked with recurrent use and management which maintain ecological functions of these ecosystems. Most heathlands owe their origin and continued existence to traditional forms of land use and management. They are potentially unstable and liable to successional change when management is abandoned or changed.

Traditional land use and management are controlled burning - turf-cutting or sod-cutting - cutting and harvesting - temporary cropping - grazing, mainly range grazing.

Conservation management may involue the reinstatement of traditional practices or certain other options.

Now, grazing is the most important management of heathlands for conservation (see next communications, session II), like in wetlands! Controlled burning, in Scotland, is always used for managed Red Grouse habitat.

Mowing and harvesting is used somewhere with a recent dynamics linked with financial assistance by European and National Communities. Other uses, mechanical turf-cutting, forage harvesters, take place for smaller areas managed by trust, nature institutions.

In most of the case, the strategy is to conserve landscape value, habitat diversity, rare or threatened species and those features could only be reached by maintaining or emphasizing oligotrophic characteritics of these ecosystems. Conservation management of heathlands needs to ensure continued, or periodic, nutrient depletion, as was the case with most of the traditional management practices (GIMINGHAM, 1992).

GIMINGHAM C.H., 1992 - The lowland heathland management handbook. *English Nature Science* , n°8.

ORAL COMMUNICATIONS

LOWLAND HEATH IN BELGIUM

MANAGEMENT PRACTICES

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With a survey, we determined the main threats lowland heath reserves in Flanders have to deal with. The different management techniques practiced, are evaluated for their effectiveness to maintain the typical heathland ecosystems.

As far as area is concerned, grazing is the most important management technique. In the larger and older state nature reserves sheeps are used, while in the smaller private reserves, cattle and ponies are the grazing animals.

For the heathland reserve of the Kalmthoutse Heide (1000 ha), we will analyse the sheep grazing project. Details of the management plan, the flock, the diet, the consumption, the production of the vegetation and the effect upon species composition and abundance, will be presented.

A SURVEY OF HEATHLAND MANAGEMENT IN SOUTHERN ENGLAND

James M. Bullock

Institute of Terrestrial Ecology

A wide variety of management types are carried out on British lowland heathland. Management to maintain heathland involves burning, grazing and mowing and combinations of these. There is also restoration management to allow regeneration of heathland vegetation on sites where scrub or bracken (*Pteridium aquilinum*) have invaded or forestry has been planted. There has been little monitoring of the consequences and effectiveness of each management type for the conservation of heathland vegetation and species. I report a survey of heathland management carried out on nature reserves throughout southern England, from Devon in the west to Sussex in the east. Within each nature reserve a range of heathland types were surveyed, including wet, humid and dry heaths and valley mires. Types of maintenance management used were: grazing by cattle, ponies or sheep; burning; mowing or cutting; mowing followed by burning; and burning or mowing followed by grazing. Restoration management included: cutting or spraying of bracken with or without litter scraping or ploughing; felling of forestry with or without litter removal; and scrub cutting. Effects of management were assessed by surveys of adjacent plots with different mangement histories. Burning or mowing of heaths tended to maintain vigourous stands of dwarf shrubs and controlled scrub and bracken invasion. Grazing had a greater effect, allowing a variety of low-growing species to establish among the dwarf shrubs (e.g. *Narthecium ossifragum* in wet heaths and *Pedicularis sylvatica* in dryer heaths), and burning or mowing before introducing grazing enhanced this process. The restoration mangements had varying success, but if the undesirable species was controlled exposure of the seedbank allowed rapid regeneration of heathland vegetation.

THE AGRICULTURAL USE OF DANISH HEATHLAND IN THE PAST.

Torben Riis-Nielsen

University of Copenhagen, Botanical Institute, Department of Plant Ecology, Øster Farimagsgade 2D, DK-1353 Copenhagen K, Denmark.

Heaths have existed in Denmark in 4000 years, and have dominated the vegetation in western Jutland during the last 1000 years. The basic features of the agricultural system in the 18th and 19th century are supposed to have existed since the early middle age (1100 A.C.).

The ancient agricultural system in Denmark, like in The Netherlands and Germany, was based on the nutrient flow from meadows and heaths to maintain the fertility of the arable land. Sods were cut in the heath in huge amounts and mixed with dung to fertilize the fields. Sheep were pastured on the heaths and their faeces collected. Heather was mown to serve as winter fodder for the sheep. Losses of nitrogen due to cutting sods are estimated to 5 $kg*ha^{-1}*yr^{-1}$ while losses due to cutting heather and to sheep grazing only amount to 0,8 $kg*ha^{-1}*yr^{-1}$.

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In contrast to the agricultural system of The Netherlands and Germany, the fields in Denmark were utilized in a more extensive manner. Fields were cultivated four years and then lain fallow for six years. Fallows were covered by grasses and heather. During this 10 years cycle the fields was only fertilized once. A minor part of the fields - the "heath-fields" - were left to heath for 20-30 years after a few years of cultivation.

The heather on the fallows was burned before ploughing, and "heath fields" were often fertilized by ashes from sods burned on the fields or in the heath. Unintended fires originating from these activities often ravaged great heath areas. Regular burning of heaths to ensure young nutrient rich fodder for the sheep did not take place - at least in the last centuries.

Maps are presented to show the landscape and the pattern of biotopes connected to the old agricultural system, including the zone of sod-cutting activity. The distribution of some conspicuous and rare plant species in relation to ancient biotopes is discussed as well as implications to modern heathland management.

Traditional land use methods in the coastal heathland of Norway. How can we encourage the farmers to maintain the tradition within a modern society?

Professor Peter Emil Kaland
Botanical institute, University of Bergen, Norway.

The *Calluna* heathland is the most characteristic landscape type along the west Norwegian coast up to the Polar circle. Together with stretches of bog and bare rock this kind of vegetation forms a 20-40 km broad belt in from the sea. Thanks to the influence of the Gulf stream, the mean temperature of January at the Norwegian coast is relatively high, +1 - +2^{0}C, up to about the Polar circle.

The traditional landuse in the heaths of Norway follows the system found further south and west in Europe: In the mild oceanic climate it has been possible for suitable breeds of sheep to graze all the year round. The cattle, however, was kept inside during the winter. The farmers provided heather fodder for the cattle by mowing heather with scythe or sickle. In the last century the heather accounted for approximately 1/3 of their winter-fodder. The heaths were burnt from time to time, dependent on the grazing pressure. Because of the lack of trees the coastal farmers had to cut peat, and over large areas the soil surface has been more or less removed by this work. The blanket mires of the coast were famous for their peat quality. Dried, crumbled peat (mould) was also used in the fertilising system of the fields after similar principles as described as «Plaggen wirtschaft» on the Continent. The fields were used every year with no fallow periods. During the last century the crops alternated annually between oat/barley and potatoes. The plough did not come into use before towards the end of the last century. The soil was worked with spades, and was heavily fertilised. The adding of soil from the outfields, seaweed, all thinkable refuse like ash, fish entrails etc. lead to a gradually increase in the thickness of the fields. The remaining part of the infields was utilised for hay production.

In the heath district of Norway the population has always combined farming with fishing and sea hunting for birds, seals, and whales. The high diversity of resources available at the coast has given the population a high degree of security in its fight to survive.

The Norwegian coast is difficult to cultivate by modern agricultural methods. This fact has forced the farmers to continue with traditional methods longer towards modern times than most areas further south. Up to the end of the last world war most farmers practised the traditional land use methods. Even if modern techniques later has been taken into use, most farmers older than 50 years have practised heath burning, heather cutting, peat cutting, and the traditional system for fertilising. The new generation of farmers has, however, left the traditional land use methods, and the knowledge will soon disappear.

How can we encourage the farmers to maintain the tradition within a modern society with all its demands for a high and efficient agricultural production? As one attempt to maintain the

30B knowledge University of Bergen is now co-operating with the County Council of Hordaland and the Ministries of Agriculture and Environment to establish a Heathland Centre 40 km. North of the city of Bergen. 5 farmers are now reactivating the traditional land use both for the outfield and the infield area. The traditional sheep and cattle breeds are now reintroduced to the farms. The land area cover approximately 2 km^2. The farmers wishes to utilise their knowledge in tourism during the summer months and for teaching school children during the rest of the year.

POSTERS

MOORLAND AUDIT AND MANAGEMENT IN ORKNEY AND SHETLAND

A.H. Kirkpatrick, I.A. Simpson, L. Scott, N. Hanley, A. Watson, D.A. Davidson (University of Stirling) and A.J. Macdonald (Scottish Natural Heritage).

The moorland habitat of Orkney and Shetland is of outstanding natural heritage value. It supports a range of arctic and northern vegetation types with oceanic and continental characteristics in close juxtaposition. There is a rich bird population including hen harrier, short-eared owl, whimbrel and red-throated diver. In Orkney there have been substantial losses of both upland and coastal heath this century. In Shetland there was extensive turf stripping until the last century and there has been unexplained dieback of heather at a number of sites. This poster paper gives an account of a study commissioned by Scottish Natural Heritage to provide an assessment of the extent, condition and present management of heather moorland in Orkney and Shetland and the economic importance of these areas within present farming systems.

Session III: *Present disturbances affecting heathland ecosystems*

Invited Lecturer Prof. J. de Smidt

19 The Imminent Destruction of Northwest European Heaths Due to Atmospheric Nitrogen Deposition

J. T. de Smidt

Summary

1. Heathland ecosystems in the lowlands of Europe are endangered by loss of their species.

2. In the major part of the geographical area of these heaths the annual atmospheric deposition is more than 15 kg nitrogen per hectare, which is beyond the ecological tolerance of most heathland species.

3. Accordingly, heath species can survive in Europe only in Galicia, in parts of the middle European mountain ranges (e.g. the Vosges, Schwarzwald, Auvergne, Appenines, west Norway), and in parts of the British Isles, particularly in Scotland.

4. This limited tolerance to nitrogen-input has become clear from empirical field observations and from fertilizer experiments in The Netherlands.

19.1 Introduction

This chapter considers aspects of the demise of north west European heaths, most notably in relation to pollution in the Netherlands.

Empirical observations of the demise of north west European heaths go back to the late 1970s, when an increase in the abundance of grass was observed in heathland. Two grass species were responsible: *Deschampsia flexuosa* in the dry heaths and *Molinia caerulea* in the wet heaths. There has been some hesitation among heathland ecologists to recognise the increased dominance by grasses as a trend rather than as a fluctuation.

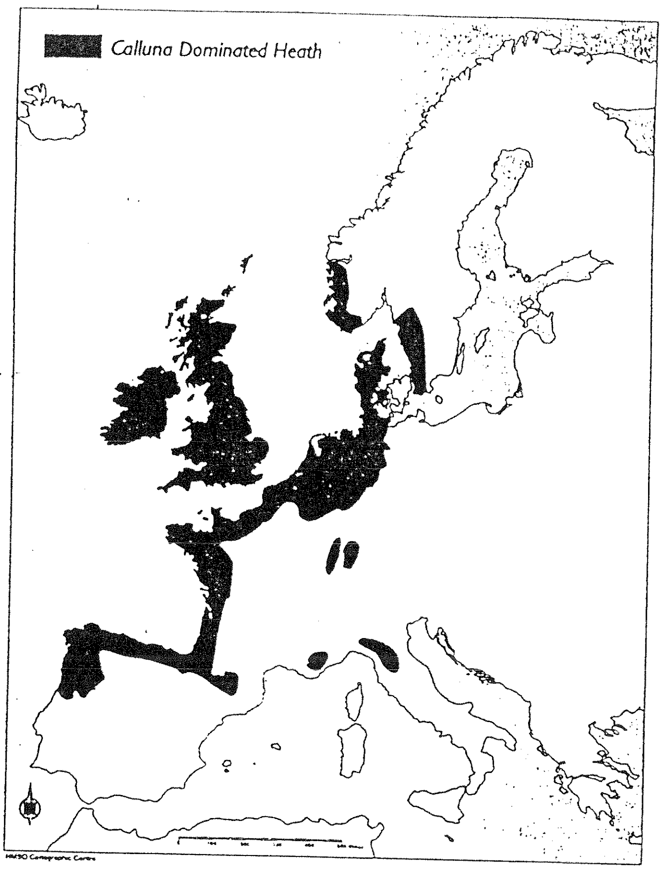

Figure 19.1. Geographical area of present-day occurrence of *Calluna*-dominated heathland.

19.2 Species changes in Netherlands heathlands: the spread of *Deschampsia*

Grasses were traditionally known in the Netherlands as temporary dominants of heathland after disturbance, such as fire, mowing or an attack by the heather beetle (*Lochmaea suturalis*) (de Smidt, 1977a). However, this dominance lasted no more than two or three years, until *Calluna vulgaris* or *Erica tetralix* regained their dominant position, and the temporary grassy aspect occurring during the pioneer phase of *Calluna* had no negative consequences for the heathland ecosystem.

Many characteristic heathland species flowered and produced seeds, thus renewing the seedbank and spreading to new locations. Amongst these are a number of relatively rare species in the lowland heath such as *Arnica montana*, *Antennaria dioica*, *Scorzonera humilis* and *Lycopodium complanatum*. These species co-existed with grasses very well, since the grasses covered no more than 20 % of the ground. The frequent heathland grasses were *Festuca tenuifolia*, *Sieglingia decumbens*, *Nardus stricta* and *Agrostis vinealis* (but not *Deschampsia* spp) (de Smidt, 1977b). These grasses rarely dominated the heaths, for they would have needed a relatively rich loamy soil and permanent suppression of the dwarf shrubs, as happens along tracks or around sheep folds. *Deschampsia* was a woodland species, growing on the raw humus and in the shaded and damp microclimate of pinewood.

In the pre-nitrogen era *Deschampsia* was a consistent member only in the *Vaccinium*-rich heathland communities. This *Vaccinio-Callunetum* is a boreal-montane heathland community where the cool and damp macroclimate resembles that of the woodland microclimate in lowland areas (e.g. Gimingham, this volume). This behaviour of *Deschampsia* in the British Isles is clearly described by Rodwell (1991). From the Midlands of England to northern Scotland it is a frequent heathland species. In the context of *Deschampsia* as an indicator of air pollution, it is interesting that Shimwell (1973) had already explained the floristic composition of the *Calluna vulgaris – Deschampsia flexuosa* heath as occurring under the combined effects of a cool and wet climate, frequent burning and grazing, and heavy atmospheric pollution around the industrial conurbations of the Midlands and northern England.

This brings us close to the explanation of the success of *Deschampsia* in Dutch heathlands. The annual atmospheric input of 40 kg nitrogen per hectare has both an acidifying and fertilizing effect. Nitrification of nitrogen-oxides and of ammonia creates pH values of 3 and lower. The resulting nitrate is an important nutrient. Such low pH values explain the loss of herbs like *Arnica montana, Antennaria dioica, Scorzonera humilis, Campanula rotundifolia, Hypochaeris radicata* and of the lycopods (van Dobben, 1991). Indeed, these species of sub-neutral soil decreased rapidly between 1970 and 1980. The weakly buffered heathland soils of the moderpodzol type easily lose their cations, calcium and potassium, through acid deposition. Below pH 3 even aluminium is released from the soil complex, thus poisoning the habitat for many species (van der Aart *et al.*, 1988). *Deschampsia*, however, can withstand such low pH values.

These findings do not explain, however, why *Deschampsia* should have reached dominance, since *Calluna* also thrives in acid conditions. Both benefit from nitrate when it is available in great quantity, so *Calluna* ought to keep its dominant position. But *Calluna* undergoes important physiological changes. The high nitrogen uptake raises considerably the nutritive value of the *Calluna* leaves for herbivores. This enables the heather beetle (*Lochmaea suturalis*) to build up a dense population much more rapidly than it did before the atmospheric deposition of nitrogen became so high (Brunsting and Heil, 1985). Indeed, the frequency of heather beetle outbreaks rose from once in ten years in the first half of the 20th century to every 3–5 years after 1970 (de Smidt, 1977a; Berdowski, 1987; Aerts and Heil, 1993). Other effects of the physiological changes resulting from nitrogen uptake are higher sensitivity to frost and to drought (Heil, 1984).

19.3 The loss of biodiversity: pre- and post-1980

Until about 1980 the damage, as described above, to the *Calluna* canopy was temporary (*Calluna* regenerated from the seed bank within a few years). In the meantime, the sub-dominant herbs, the dwarf shrubs *Genista anglica* and *Genista pilosa*, and lycopods had an opportunity to enlarge their populations. Such damaged

Calluna stands were also the best location for lichen formation: a great variety of *Cladonia* species developed rapidly in such open places.

After 1980, however, the death of *Calluna* meant virtually the end of the heathland ecosystem. Before this, *Deschampsia* had been confined to the canopy layer, unable to compete with *Calluna*. After the death of *Calluna*, *Deschampsia* was able to grow fast, produce seedlings in the surrounding areas and then close canopy before *Calluna* could regenerate. *Calluna* was then 'trapped' by its inherent, inflexible slow growth rate, whereas *Deschampsia* had flexibility – growing slowly and staying small, or growing fast and becoming tall. In the dense sward of *Deschampsia*, insufficient space was left for seedlings of dwarf shrubs, for herbs or for cryptogams.

It was not the loss of beauty that was distressing, however, for a *Deschampsia* prairie has its own beauty! In any case there is no great antipathy against *Deschampsia*, for it is an indigenous species. Rather, it was the drastic loss of the characteristic heathland ecosystem that concerned ecologists in the Netherlands. An ecosystem and a habitat for one of the most characteristic suite of species that contributes to the biodiversity of Atlantic and sub-Atlantic Europe was being lost.

Empirical evidence for the loss of many sub-dominants, in the first instance, and eventually of the total ecosystem, including insects, reptiles and birds, came from permanent plots, remote sensing and repeated vegetation surveys.

Permanent plots, that were started between 1950 and 1960, showed a decrease of cryptogams during the 1960s and 1970s and, from the mid 1970s onwards, a

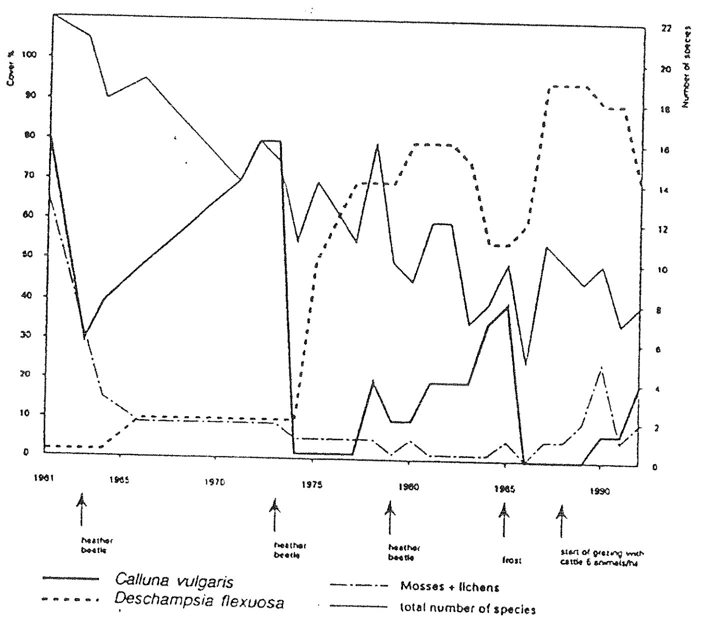

Figure 19.2. The change from *Calluna*-dominance to *Deschampsia* and the decrease of number of species in a permanent plot on the Veluwe (Netherlands). The loss of cryptogams occurred 10 years earlier than the shift to grass, both as effects of atmospheric nitrogen deposition.

dramatic increase of *Deschampsia* after damage to *Calluna* by the heather beetle or frost (Figure 19.2) (de Smidt, unpublished).

Remote sensing made it possible to make accurate estimates of the cover of heather versus grass over large areas. This showed the dramatic increase of grass cover in most heathland areas after the death of *Calluna* (Moen *et al.*, 1991).

Another opportunity to study this process was offered by a study in the 1970s of plant communities on heathlands of the Veluwe, Netherlands. Re-sampling of the same areas in 1988 showed an increase of grasses and a decrease of sub-dominants (van Ree and Meertens, 1989; de Smidt and van Ree, 1991) (Figure

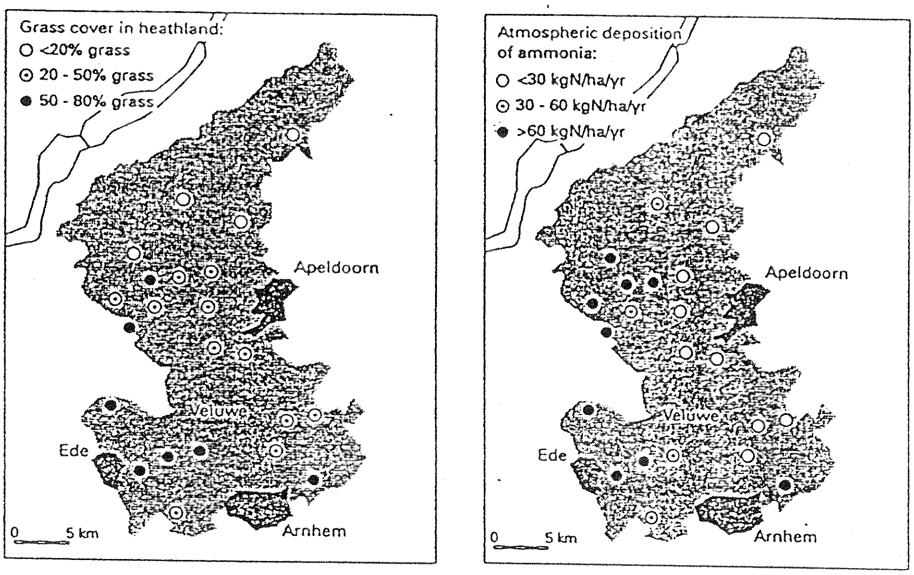

Figure 19.3. Relationship between increase in grass cover and deposition of nitrogen in the Veluwe (Van Ree and Meertens, 1989).

19.3). The decrease of the subdominants could only be recorded from the permanent plots, as they could not be detected using remote sensing. This study on the Veluwe also gave the opportunity to demonstrate the correlation between the increase of grass and the input of nitrogen (Figure 19.3). In the southern Veluwe grass increased more than in the northern part, coinciding with a higher nitrogen input in the southern part, because of intensive bio-industry (chicken, veal and pig) in the Gelderse Vallei, compared with the north and east (van Ree and Meertens, 1989). This comparative inventory also revealed that the first response of the heathland ecosystem to nitrogen input is the loss of sub-dominants, and the next is the shift to grassland. This is demonstrated in the northern Veluwe, where the increase of grass is moderate, but the cryptogams have been strongly reduced.

In twenty years between the two records, 25 cryptogams show a drastic decrease or a total loss (Table 19.1). The most common heathland mosses *Hypnum* *jutlandicum* and *Dicranum scoparium* are still frequently present but have suffered a strong quantitative reduction. The total cover of the moss layer was reduced from around 50–60 % to 2–10 %. Six *Cladonia* species (*C. bacillaris, C. macilenta, C. floerkeana, C. chorophaea, C. portentosa, C. coccifera*) manage to survive at low abundance. One cryptogam shows the opposite response: *Campylopus introflexus*. Since the first establishment of this Southern Hemisphere moss some twenty years ago, it spread rapidly in Dutch heathlands. Its abundance increased explosively after the rapid loss of indigenous species. It has become the most frequent species and usually covers more ground than all the other cryptogams together (see also Equihua and Usher, 1993). The effect on the vegetation of the loss of so many characteristic species is the extinction of six sub-associations out of the total of ten that had been described in 1977 (de Smidt, 1977b) (Table 19.2).

Table 19.1 Cryptogams that strongly decreased or disappeared after 1980 from heathland on the Veluwe (Van Ree and Meertens, 1989

Lichens	*Hepatics*
Cladonia uncialis	*Ptilidium ciliara*
Cladonia squamosa	*Calypogeia fissa*
Cladonia arbuscula	*Gymnocolea inflata*
Cladonia gracilis	*Lophozia ventricosa*
Cladonia glauca	*Kurzia pauciflora*
Cladonia destricta	*Odontoschisma sphagni*
Cladonia foliacea	*Cephalozia bicuspidata*
Cladonia strepsilis	*Lophocolea bidentata*
Cladonia subulata	*Barbilophozia attenuata*
Cladonia verticillata	*Barbilophozia barbata*
Cornicularia aculeata	*Scapania nemorosa*
Hypogymnia physodes	*Cephaloziella divaricata*

Table 19.2 Associations and sub-associations of dry inland heath in 1975. Six of these (*) disappeared between 1980 and 1988.

Asociation Genisto-Callunetum (G-C)	
Sub-associations	G.-C. sieglingietosum
	G.-C. typicum
	*G.-C. cladonietosum uncialis
	*G.-C. cladonietosum bacillaris
	*G.-C. lophozietosum
	*G.-C. bazzanietosum
Association Vaccinio-Callunetum (V-C)	
Sub-associations	V.-C. potentilletosum
	V.-C. typicum
	*V.-C. cladonietosum
	*V.-C. bazzanietosum

Table 19.3 Critical nitrogen loads (kg N $ha^{-1}yr^{-1}$) to semi-natural terrestrial vegetation (adapted from Heil and Bobbink, 1993)

	Critical load	*Indication*
Acidic (managed) coniferous forest	15–20	Changes in ground flora and fungal fruit bodies
Acidic (managed) deciduous forest	<15–20	Changes in ground flora
Calcareous forests	Unknown	Unknown
Lowland dry heathland	15–20	Transition from heather to grass
Lowland wet heathland	17–22	Transition from heather to grass
Species-rich lowland heaths/acid grassland	<20	Decline in sensitive species
Arctic and alpine heaths	<15–20	Increase in grasses
Calcareous species-rich grassland	14–25	Increase in tall grass
Neutral-acid species-rich grassland	20–30	Increase in tall grass
Montane-subalpine grassland	10–15	Increase in tall graminoids, decline in diversity
Shallow soft-water bodies	<20	Decline in isoetid species
Fens	20–35	Increase in tall graminoids, decline in diversity
Ombrotrophic bogs	10–15	Decrease in typical mosses, increase in tall graminoids

19.4 Conditions under high N levels

Some experimental evidence for high nitrogen input being the causal factor has been collected from 1981 onwards. Fertilizer experiments were carried out in the Hoorneboeg heathland reserve with a mix containing 14 % N, 16 % P and 18 % K. Lichens disappeared first, followed by the bryophytes. The more fertilizer that was applied annually, the more rapid this process became (Figure 19.4a). An unexpected observation in this experiment was the disappearance of lichens in the untreated plots between 1983 and 1988 (Figure 19.4b). This effect was ascribed to nitrogen deposition from the atmosphere. From the third to the fifth year *Deschampsia* increased explosively in the fertilized plots (Figure 19.4c). A small number of bryophytes survived, but in very low abundance, with a cover of not more than 1 %. Furthermore, some new mosses appeared in the fertilized plots (*Brachythecium rutabulum, Ceratodon purpureus, Funaria hygrometrica* and *Eurhynchium praelongum*), together with some 'weedy' angiosperms of nitrogen-rich disturbed habitats (*Agrostis stolonifera, Poa pratensis* and *Rubus fruticosus*) (Figure 19.4a,d). These data indicate that the loss of cryptogams was a direct effect of added fertilizers, and not an indirect effect because of the dense grass sward. The direct effect hypothesis is supported by the observation that lichens vanished from the fertilized plots two to three years before the grass became dominant.

19.5 Survival strategies and safe refugia

Field and laboratory experiments by Heil and Diemont (1983), Heil (1984), Heil and Bruggink (1987) and Aerts (1989) confirmed the importance of nutrients, especially

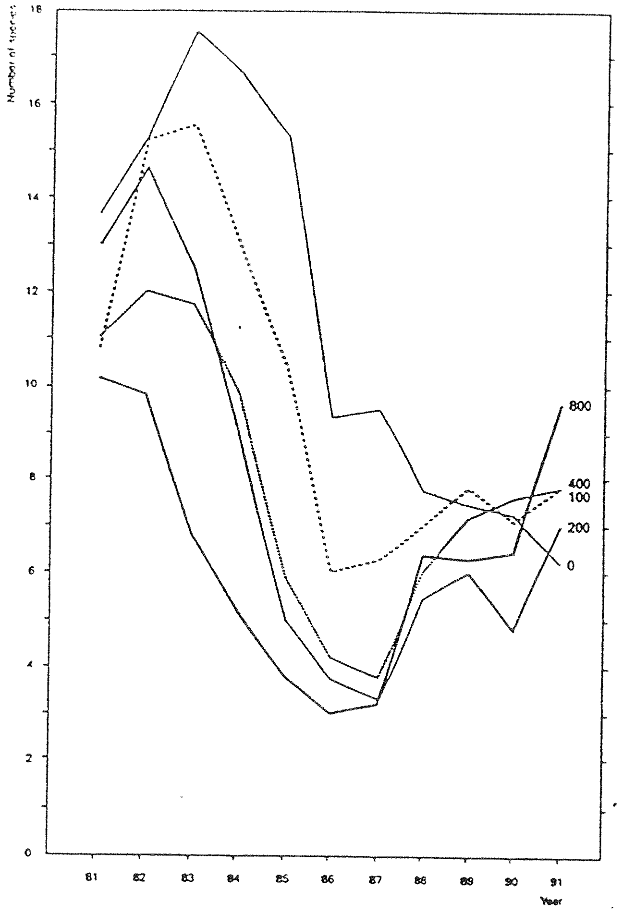

Figure 19.4a. Decrease of total number of species (mainly cryptogams) in *Calluna* heath turning into grass. Fertilized from 1981–1987 with 0, 100, 200, 400, 800 kg NPK $ha^{-1}yr^{-1}$).

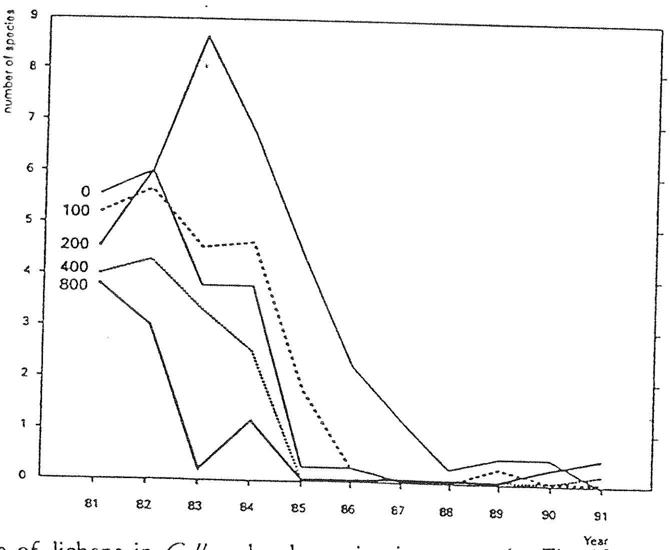

Figure 19.4b. Decrease of lichens in *Calluna* heath turning into grass (as Fig. 19.4 a) above). The reference plots (0 kg) also lost their lichens as an effect of atmospheric deposition of nitrogen, becoming manifest in those years.

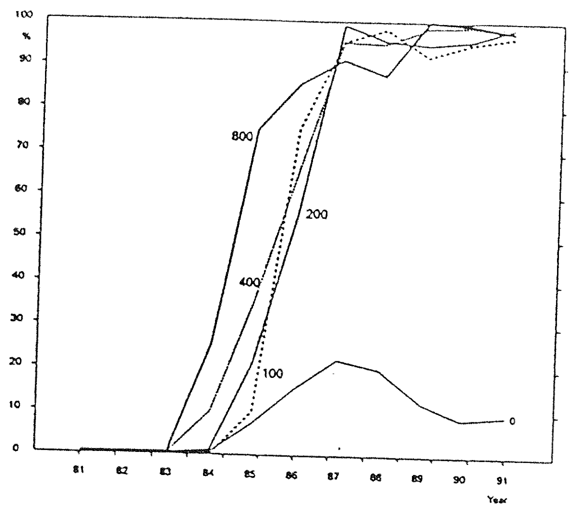

Figure 19.4c. Establishment and increase of *Deschampsia* in *Calluna* heath (as Fig. 19.4a above).

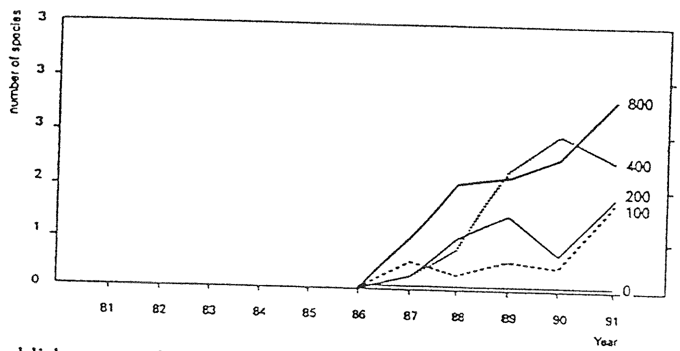

Figure 19.4d. Establishment and increase of eutraphent species in heathland after the change into Deschampsia vegetation (as Figure 19.4a above).

of nitrogen, in the shift from heathlands to grassland. Heil and Bobbink (1993) used the data of these experiments to construct a model predicting the interaction between *Calluna, Molinia, Deschampsia* and the heather beetle at different input levels of nitrogen (Figure 19.5a,b). At an input of more than 15 kg N ha^{-1} yr^{-1} *Calluna* lost its dominance. The sub-dominants disappeared as well, as demonstrated by the permanent plots.

This result contributes to a strong plea for a drastic reduction of nitrogen emissions. The loss of the heathland ecosystem is in itself already an important factor in arguments for such a reduction. But the fate of the heathland species is mirrored by a great number of other indigenous species (Heil and Bobbink, 1993). A drastic reduction of nitrogen emissions from agriculture, traffic and industry will take at least several decades. 'Survival' programmes for endangered species therefore need to be developed as a matter of urgency.

Some relief comes through land management. One can have intensified removal of accumulated nutrients by cutting and removing sods. The low nutrient levels in the underlying bare ground offer both *Calluna* and *Erica* an opportunity to regen-

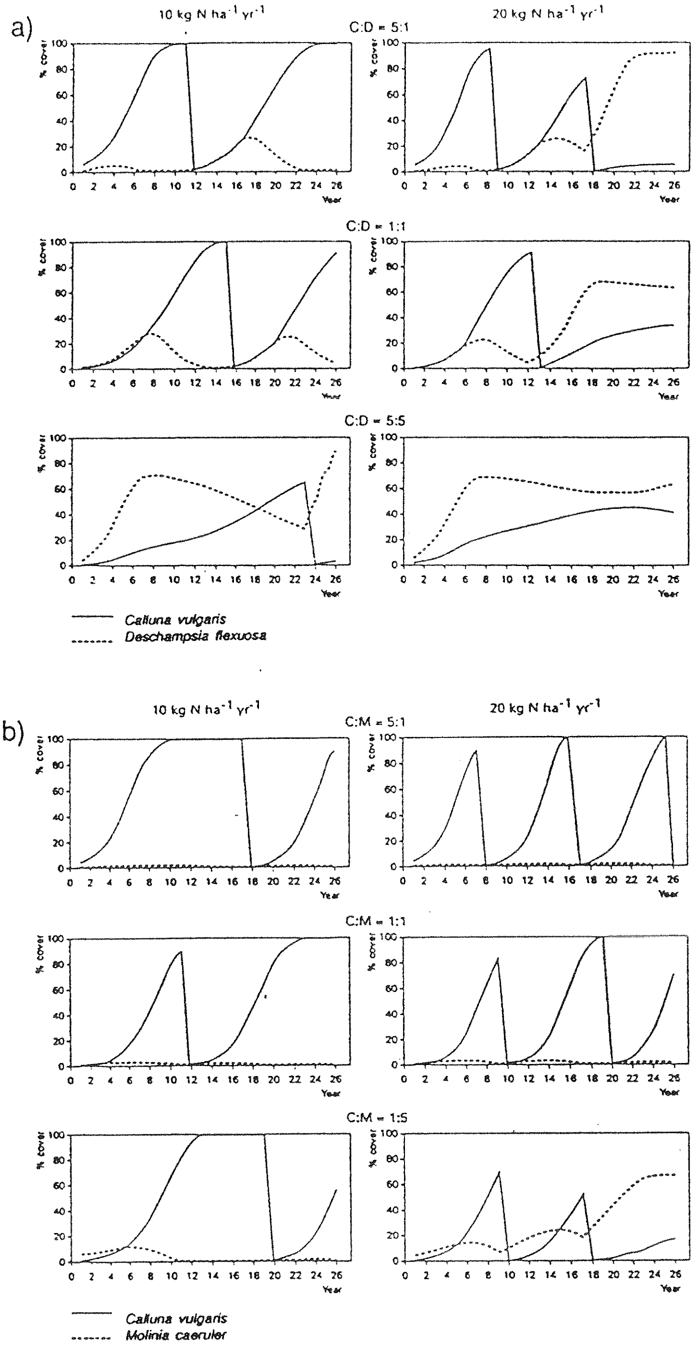

Figure 19.5. Model results of interaction between a) *Calluna vulgaris* and *Deschampsia flexuosa* at two levels of atmospheric nitrogen deposition and different initial ratios between *Calluna* (C) and *Deschampsia* (D). C:D = ratio between *Calluna* and *Deschampsia* at the beginning of the simulation. The sudden reduction of *Calluna* cover is due to stochastic heather beetle attacks. At the level of 20 kg N $ha^{-1}yr^{1}$ *Deschampsia* will always become dominant after one or two disturbance events. b) *Calluna vulgaris* and *Molina caerulea* at two levels of atmospheric nitrogen deposition and different initial ratios between *Calluna* and *Molinia* (details as in a).

erate from the seed bank, to dominate the grasses for a short while and to produce more seed. However, time seems to be too short for the cryptogams to establish and the pH is too low for the sub-dominants to return. A helpful additional means of management is cattle grazing. These large grazing animals keep the vegetation sufficiently low and open for a number of cryptogams to return. Experiments are still at too early a stage, however, to conclude for which species cattle grazing offers major opportunities for survival.

An important conclusion is that safe refugia are only found in areas with sufficiently clean air. These are on the fringes of the heathland geographical area, of which Scotland is one of the more important parts (Hetteling *et al.*, 1991, Figure 19.6).

Acknowledgements

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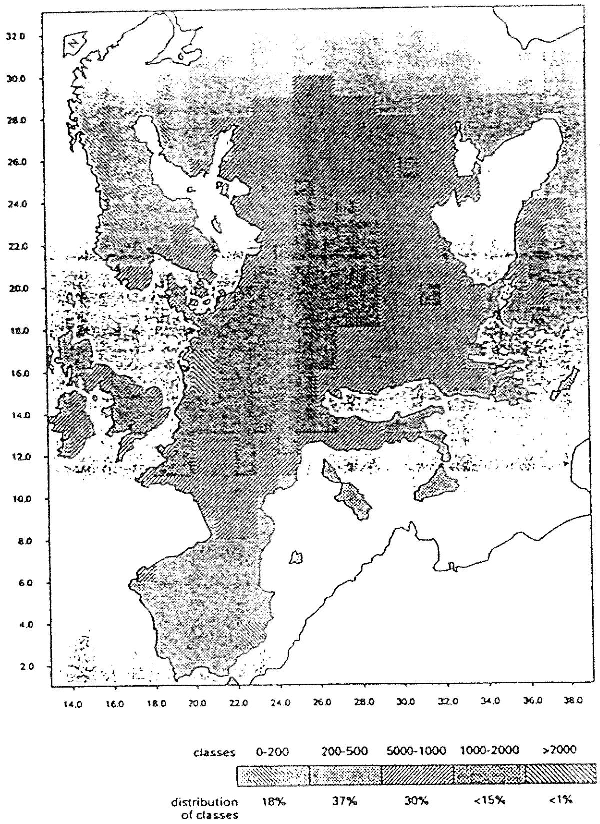

Figure 19.6. Present load computation of nitrogen (NO_X+NH_X) expressed in $mol_c\ ha^{-1}yr^{-1}$ mapped in five load classes. Only the load classes 0–200 and 200–500 offer safe refugia for heathland; these are found in west Norway, Scotland, west Ireland, north Spain and north Portugal (Hetteling *et al.*, 1991).

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Heaths and Moorland: Cultural Landscapes

Edited by
D. B. A. THOMPSON, ALISON J. HESTER and
MICHAEL B. USHER

With a Foreword by
Magnus Magnusson

SCOTTISH NATURAL HERITAGE

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ORAL COMMUNICATIONS

TEMPERATURES IN MANAGEMENT FIRES ON LOWLAND DRY HEATH

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Controlled burning is used to manage heathland as a means of breaking up stands of even-aged heather and to prevent invasion by undesirable species such as bracken and trees.

Fire temperatures may affect regeneration from rootstock and from seed. In this paper I report a study in which different fire temperatures were generated by manipulating the fuel load in areas of both building-mature and degenerate growth forms of heather (*Calluna vulgaris*) at two sites in southern England. This forms the basis of continuing work on the demography of the regenerating shrubs.

Temperatures of these experimental fires were measured using pyrometers made from floor tiles with temperature-sensitive paints in vertical strips. Temperatures were variable within individual fires and replicates, but were highest in the building-mature sites at both reserves.

A follow-up experiment to acquire more temperature data and to assess the accuracy of the temperature sensitive paints was performed last spring. In this study, thermistors and data loggers were used to measure temperatures just below the litter surface and in the canopy of building-mature heather. Preliminary analyses of these data suggest that the soil surface is well insulated by the litter layer since there is very little change in temperature recorded by the ground level thermistors. Canopy temperatures are variable, but the temperatures recorded are higher than those reached by the tiles. Reasons for this are suggested.

Abstract

SURVIVAL OF DUTCH HEATHLANDS

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Heathlands in the Netherlands have been subject to encroachment of woody species and grasses. Results of sequential aerial photointerpretation for various heathlands in the Netherlands are presented. The results indicate that seral changes including encroachment of grasses have only occurred in heathlands without periodic management. Other causes of change such as increased levels of atmospheric N are discussed. I conclude from the data presented and the literature that lack of periodic management is the main cause of changes in Dutch heathlands. Only in part of the Dutch heathlands where brown podzolic soils occur, increased atmopheric N levels have increased the rate of transformation to grass heath. Future management needs in Dutch heathlands are indicated. It is postulated that the old practice of plaggen (turf cutting) is not only a historical fact, but also an ecological need for Dutch heathlands to survive.

REGENERATION OF GIBRALTAR STRAIT HEATHLANDS AFTER SLASH AND BURN

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Fire is a frequent disturbance affecting Mediterranean heathlands during the warm and dry summers. Additionally, sylviculture practices in the cork oak woodlands include slash and burn of the heathland understorey. The present structure of heathland communities reflects the past history of disturbance events and the regenerative capabilities of the component species.

We present in this paper two cases of study documenting the regeneration after disturbance of Mediterranean heathland communities in Southern Spain.

Site 1. *Sierra del Niño*. We have studied for three years the regeneration of a heathland community after a wild fire in Sierra del Niño (680 m altitude). In a permanent transect of 50 m we have documented the emergence of woody plant seedlings: *Calluna vulgaris, Cistus populifolius* and *Genista triacanthos* showed the highest numbers. In the third postfire year the community cover was co-dominated by vigorous sprouters such as *Quercus lusitanica* (a dwarf shrubby oak), *Genista triacanthos* and *Stauracanthus boivinii*, and by the seeder *Cistus populifolius*.

Site 2. *Sierra de la Luna*. An experimental plot of 60 x 40 m has been marked and fenced in Sierra de la Luna (710 m altitude). In half of the plot surface, heathland was slashed and burned, simulating traditional practices. We are documenting the emergence of woody plant seedlings and canopy recovery in three transects, in control, slashed and burned conditions respectively.

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POSTERS

Poster abstract

SHORT TERM IMMOBILIZATION/FIXATION OF MINERAL NITROGEN IN *CALLUNA* RAW HUMUS.

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The increase in atmospheric nitrogen deposition is reported to change heathlands into grasslands in several European countries. The nitrogen accumulates in the soil-plant system and influences the carbon and nitrogen cycles of the ecosystem.
The HEATH project is an ecosystem research project, where the effect of increased nitrogen deposition on Danish heathlands is studied and critical loads for the ecosystems are estimated. A *Calluna* heathland has been fertilized six times a year since 1993 with ammonium nitrate in water solution. Nitrogen levels are comparable to deposition levels in Europe (15-70 kg N ha^{-1} yr^{-1}). No changes in biomass production were recorded in 1994 after which an attack of the heather beetle (*Lochmaea suturalis*) destroyed the *Calluna* vegetation. The soil water content of mineral nitrogen in 10 cm depth remains low (<1 mg N/l). This indicates a continous immobilization/fixation of added nitrogen in the mor-layer.

Several studies show the immobilization of nitrogen by microorganisms in a wide range of organic materials. Also, a chemical fixation of ammonium is reported under alkaline conditions in organic matter. Yet there is still a lack of knowledge about the capacity of nitrogen immobilization/fixation and change of mineralization processes when nitrogen is continously added in small doses to acid raw humus. Preliminary results of HEATH laboratory experiments have shown that ammonium is non-extractable in 1 M KCl after 15 minutes of incubation with *Calluna* raw humus.

The present study represents ongoing research on the immobilization/fixation of newly added ammonium and nitrate in the mor-layer of the HEATH experimental sites. The mor-layer is characterized as regards the capacity and rate of immobilization/fixation within 24 h. The influence of pH and biological activity in the raw humus is studied as well. Intact soil cores are used in the study as microbial processes is related to the vertical structure of organic top soils.

VEGETATION DYNAMICS IN DANISH LICHEN RICH HEATHLAND

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Heathland vegetation in Denmark is prone to change due to reduced management and increased nitrogen deposition, and severe injuries have been observed in reindeer lichens in recent years. To monitor the rate and direction of changes 252 permanent plots were established in heathland rich in reindeer lichens at 15 localities in Denmark and Northwest Germany. The vegetation on the plots was photographically recorded annually through five years (1990-95).

During the five years there was an increase in the cover of Calluna, which was significantly correlated to the calculated deposition of ammonia and ammonium and to the total deposition of nitrogen. A significant decrease in the cover of reindeer lichens was not significantly correlated to nitrogen depostion. Total nitrogen concentration of reindeer lichens was not correlated to calculated deposition of nitrogen.

GROWTH OF DOMINANT SPECIES IN HEATHLAND COMMUNITIES AFTER EXPERIMENTAL DISTURBANCES

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The main purpose of this paper is to study shrub species recovery in heathlands after they have been subjected to different experimental disturbances (burning, cutting and uprooting). Experimental treatments were carried out in two neighboring areas, in León province (NW Spain), both dominated by *Erica australis* subsp. *aragonensis,* althought in one of them other shrub species, such as *Arctostaphylos uva ursi, Erica umbellata, Calluna vulgaris, Chamaespartium tridentatum,* etc., were also abundant.

Three square plots, measuring 100 m^2, were established in each sampling area and they were subjected to burning, cutting of woody biomass and uprooting, respectively. Treatments were carried out in July 1985, except for the uprooting of one area, which was in July 1986. The other area was burnt by a wildfire (which had nothing to do with the experiment) in September 1985; so in this area the superimposition of the effect of this second fire on that of the treatments carried out (mainly in the cut plot) is studied.

Before the disturbances, cover of shrub species was estimated in the 100 inventories of 1 m^2 in each plot. Post-disturbances regeneration was evaluated in the following years in the same way.

Recovery was similar after burning and cutting, being slower in the uprooted plots because resprouting was not possible. *Erica australis* was the species with the best recovery response after all treatments. It increased its cover to the fourth or fifth year, stabilizing afterwards. *Erica umbellata* and *Calluna vulgaris* reproduced mainly by seeds in the study areas and they were at a disadvantage compared with vegetative resprouting species. *Halimium alyssoides, Halimium umbellatum* and *Chamaespartium tridentatum,* on the contrary, enlarged their cover in the few first years, taking advantage in the bare space. *Arctostaphylos uva-ursi* reappeared quickly in the burnt plot, but not in the cut plot that was burned by the wildfire.

Poster abstract

MODELLING DANISH HEATHLAND DYNAMICS IN RELATION TO NITROGEN DEPOSITION AND MANAGEMENT.

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Danish heathlands are cultural landscapes with a need for periodic management. This reflects the former cultivation systems to keep heathlands in function as a dynamic ecosystem. Management is a prerequisite for the existence of inland heaths, whereas increased nitrogen depositions, changed land use patterns and expected future climate changes might impose major threats towards this sensitive ecosystem in Western Europe. Heathlands are found in many variants within the region. Structurally and functionally they have common features, whereas gradients in temperature and precipitation as well as variation in soil substrate and local traditional management give each heathland type its unique characteristics. *Calluna vulgaris* is often the dominant species with different co-dominant or characteristic species, e.g. *Empetrum nigrum* and *Vaccinium spp.*

The airborne nitrogen deposition has been increasing in western Europe and it is well documented that this has induced structural and functional changes in Dutch heathlands. The critical load for Dutch heathlands have been estimated to be 17-22 kg N $ha^{-1}yr^{-1}$. Such changes have not yet been documented for Danish heathlands with present nitrogen deposition of about 15-20 kg N $ha^{-1}yr^{-1}$ although it seems likely that they will occur at present or slightly increased deposition levels. In this context, modelling of the vegetation in relation to nitrogen deposition and management strategy will be an important tool for making realistic vegetation scenarios.

The aim of this work is to combine data for soil geochemistry and vegetation parameters using existing dynamic models to calculate critical loads for the Danish heathland ecosystem and to simulate vegetation succession patterns according to nitrogen deposition scenarios. This demands the combined use of geochemical, hydrological and vegetation models as fully integrated models are not available.

The model development will be undertaken in a European framework of research groups with specific experiences from different approaches to models (CALLUNA, CALGIS, SAFE and HILL GRAZING MODEL) and heathland management regimes. This will give an ideal basis for the combination of locally adapted models into an integrated heathland model, which also will be capable of assessing the effects of environmental changes and changed land use patterns on European heathland ecosystems.

COMPARISON OF BIOMASS POST-FIRE RECOVERY IN HEATHLANDS

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The aim of this paper is to compare the temporary dynamic of green material and non green material in a burnt heathland. This study was carry out on a heathland situated in the North of León province (NW Spain) in an area whose climax is a *Quercus pyrenaica* forest. Three plots, located beside each other, were selected on a south facing slope which differed for the period of time elapsed since undergoing the fire: the first and second plots were burnt one (1993) and three (1991) years ago, respectively. The third had not been burnt for over 15 years and was used as a control plot.

In September 1994, the aboveground biomass was cut from three samples per plot, randomly selected, of 1 m^2 each. Then, the shrub species green material and non green (woody) material were separated in the laboratory and were oven dryed at 100° C for 12 hours, together with herbaceous species in order to be weighed.

The results show that the proportion between green and woody material inverts in the course of succession. The green material is very abundant in first plot and very sparse in the third plot. The contrary ocurred in the non green material. The individual species studied show the same results (Table I). Data were compared by an analysis of variance (ANOVA) between the three plots and significant differences were found.

Table I. Mean biomass, as dry weight (g/m^2), and percentage of green material of each shrub species and total herbaceous species in the three plots studied.

	PLOT 1 (burnt 1993)		**PLOT 2** (burnt 1991)		**PLOT 3** (control)	
	Total Weight	**% Green material**	**Total Weight**	**% Green material**	**Total Weight**	**% Green material**
Erica australis	12,6	66	500.9	46	982.0	18
Halimium alyssoides	6.7	74	26.1	44	13.3	34
Arctostaphylos uva-ursi	1.7	81	187.6	72	246.2	47
Erica umbellata					19.7	16
Calluna vulgaris					432.8	18
Chamaespartium tridentatum					65.8	41
Cytisus scoparius					34.7	33
Lithodora diffusa					0.1	38
Herbaceous species	46.5	100	2.2	100	6.2	100
Total Biomass	67.5	89	716.8	53	1800.8	25

PRESCRIBED BURNING EFFECT ON THE SOIL SEED BANK IN A HEATHLAND ECOSYSTEM

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The object of this study is to find out the effects of fire on seed buried in the soil by comparing the soil seed bank before and after a prescribed burning, as well as the importance of soil seed bank in the recovery of a burnt shrubland. That is why a homogeneous heathland, with species such as *Erica australis* subsp. *aragonensis*, *Arctostaphylos uva-ursi*, *Calluna vulgaris*, etc., was chosen. Four square plots, measuring 10 x 18 m, were established and they were subjected to prescribed burning. Temperatures reached in the litter layer, soil surface and 1, 2, and 3 cm deep during the fire were registered.

Before and after prescribed burning, four soil samples from each plot were collected in 20 x 25 cm subplots, 5 cm deep. Depth was divided in two layers at the moment of sampling: 0-2 cm and 2-5 cm. Total number of samples taken into account were 64 (16 from each layer before and after fire). The indirect method was used to know the soil seed bank. This consists of displaying soil samples in trays in controled environment for germination in the laboratory and counting the seedlings which appeared.

A total of 3768 seedlings appeared in the year of study, with more seedling abundance in the samples taken before than after the fire, and more in the 0-2 cm layer than in the 2-5 cm, in both cases. The estimated number of living seeds in the soil before the burning was of 2638 seeds/m^2 and 2071 seeds/m^2 afterwards. Most of the seedlings (90%) were from *Erica australis* subsp. *aragonensis* and *Calluna vulgaris*, the first species being more abundant in the samples taken before the fire, while *Calluna vulgaris* increased germination after the fire.

Results obtained of soil seed bank were compared with plant inventories carried out on the site before and 10 months after the fire. A similarity analysis, using Sorensen index, was performed, only taking into account qualitative data (presence of species). Two groups clearly appeared on the dendrogram, distingishing samples of soil seed bank and field inventories. The highest value of similarity corresponded to the soil samples, with 100% of common species among burnt samples from 0-2 and 2-5 cm layers, and 85% between the two layers of unburnt samples, with an overall similarity among seed bank samples of 74%. The similarity between field prefire conditions and plant inventories 10 month afterwards was 51%. The differences between the results from soil samples and field observations, with only 22% of similarity, could be due to the different temperature and humidity conditions. *Calluna vulgaris*, very abundant in the burnt soil samples, did not appear in the field 10 months after the fire. The majority of plants in this community reappearing in the field after burning were from species preexisting the fire and regenerating vegetatively by sprouts from subterranean survival organs.

Session IV: *Heathland restoration and conservation*

Invited Lecturer Prof. N.R. Webb

HEATHLAND CONSERVATION AND RESTORATION

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Rather than review the whole subject, this paper will consider recent trends in conservation and management of heathlands and the changes in ecological science with which they are associated. Currently, there is trend away from a site-based approach to a landscape approach. Previously, conservation management was planned and executed on a site-by-site basis. This approach was underpinned by theories of species-area relationships and island biogeography. The pursuit of these theories focused attention on the within-site interactions at the expense of the between site interactions. In so doing there was a failure to recognise the dynamics of the systems to be conserved and there was an emphasis on biodiversity. The attainment of high diversity was considered to be an indicator of success as was the presence and survival of endangered species. Heathlands, in common with many other biotopes, were seen more as the habitats of a suite endangered species and less as communities in their own right. The composition of the species assemblages was considered of more importance than community structure and ecosystem function. This approach to conservation was particularly a feature of conservation practice in the UK where species and sites were central to conservation thinking. However, in other countries, for example the Netherlands attempts have been made to re-establish former landscapes and to practice species conservation within this policy: a top-down approach in contrast to a bottom-up approach.

The large scale or landscape approach starts with the recognition that the patchwork of biotopes and managed land which forms the countryside is a mosaic of interacting patches and thus recognises the dynamics which exist between the various patches. Like the site-based approach, the landscape approach has gained impetus from developments in ecological theory and in particular from metapopulation theory. This has emphasised the between patch dynamics rather than the within patch dynamics. Allied to this has been the interest in scaling problems in ecology and the development of technologies (eg Geographical Information Systems) which enable spatially referenced data to be analysed easily.

A further impetus has been gained from changes in land use policies. In previous decades we have seen continuing loss of the countryside and the expansion and intensification of agriculture. Suddenly, as a result of over production, farmland is no longer needed. A few years ago we would not have believed that set-aside, and related schemes would shape the countryside but now we are faced with the problem of converting land into biotopes of conservation value and of integrating it with the existing patches which we have conserved. Thus, we are faced with not only with the problem of how to restore and manage these new areas, but more importantly where to locate them. Likewise, in planning conservation management it is important to consider where it is to be carried out. The problem of "where" has a firm context within current ecological theory.

Once created the network of patches needs management and here one may look to the concept of the cultural landscape. In some countries, eg Norway, Spain and eastern Europe intimate management of the land has created biotopes of conservation value. Heathland ecology has always recognised the close link between human activity and the maintenance of the biotope and this approach offerers an alternative to complement that of intensive site-based management and restoration practices.

ORAL COMMUNICATIONS

LOWLAND HEATHS AND FORESTRY IN GREAT BRITAIN

Fred Currie

The Forestry Authority

The Forestry Authority is part of the Forestry Commission is responsible for implementing the Government's forestry policy through (1) advice, including setting standards, (2) incentives, including grant-aid, and (3) regulation, including tree-felling controls.

The Forestry Authority's guidelines on heathland conservation and restoration will be presented.

Restoration of lowland heaths, by clearance of trees, is supported where it will result in significant conservation gains provided other land-use aspects such as good landscape design, timber production, recreation and concerns of local communities, have been taken into account. The Forestry Authority will also discourage, and not grant-aid, tree planting on or close to remaining lowland heaths.

Within heath forests, forest management which favours heathland habitats and species will be encouraged. This includes diversification of crop age class structure to ensure recently felled areas are present at all times, for rare mobile species, such as woodlark and nightjar and the creation and maintenance of permanent heathland open areas, linked where possible by a wide ride network. Operations which could cause enrichment, such as sewage sludge or fertiliser application and planting of inappropriate tree species, will be discouraged. Appropriate recreational use within heath forest is encouraged, particularly where it will help reduce pressures on adjacent and sensitive lowland heath.

THE SIGNIFICANCE OF DISTURBANCE FOR THE RESTORATION OF HEATHLANDS

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Historically disturbance has been an important factor in maintaining lowland heath in a state of recurrent early succession. Disturbance created a mosaic of patches ranging from bare mineral substrate through early colonisation phases to later successional stages in which dwarf shrubs dominated. Many traditional rural activities which included turf cutting, peat cutting, cutting furze and young trees for fuel, cutting and gathering bracken and extensive grazing by domestic stock all contributed to removal of mineral nutrients from surface soil horizons and exposure of bare substrate. This provided a continuous supply of germination and establishment microsites for indigenous species, particularly heathers. No doubt fire also contributed to the process.

How do these historical practices relate to present-day problems of re-creating and managing lowland heath ?

Severe physical disturbance resulting from mineral extraction or civil engineering works or severe accidental fire may create environments that disrupt the existing soil profile and soil seed populations to such an extent that natural processes of colonisation are ineffective and therefore active intervention is required to re-create heathland. This is essentially a process of restoration which has now been well documented for a wide variety of sites. Our talk will touch on this restoration approach and subsequent aftercare management.

The main emphasis of the talk will be to consider the utilisation of removal of turves for the re-creation of degraded heathland where trees, shrubs and bracken have colonised extensively and here heathland species are in decline and also the maintenance of a mosaic patchwork of early successional heath utilising the traditional rural practice of turf-cutting. Evidence will be presented from recent experimental work undertaken by Catherine Traynor (research for PhD) as part of the programme of collaborative research between the Institute of Terrestrial Ecology (Nigel Webb and Richard Pywell, R.S.P.B. (Martin Auld) and Liverpool University (Philip Putwain).

SOME EFFECTS OF ACIDIFYING ARABLE SOIL WITH REFERENCE TO HEATHLAND CREATION ON SET-ASIDE FARMLAND IN NORTH-EAST SCOTLAND

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Recent reforms in European agricultural policy and the change in emphasis to one of production control has provided the opportunity to recreate habitats of conservation interest on surplus agricultural land (e.g. Set-aside). In particular, there has been interest in the possibility of recreating areas of lowland heath on former farmland.

The extent of lowland heath in Scotland has been much reduced and it has been estimated that only 18,800 ha now remains. The surviving heath is fragmented and vulnerable to further deterioration.

This paper will describe a series of experiments on heathland creation on land withdrawn from agricultural production.

Thus far, heathland vegetation has very rarely developed spontaneously on Scottish Set-aside. In most cases the vegetation which does develop comprises only coarse weedy species.

Heathlands characteristically occur on nutrient-poor acid soils, in contrast to the 'improved' soils of farmland, where the pH has been raised by liming and nutrients have been added in fertilisers. The conversion of former farmland to heath may, therefore, depend on a reduction in soil nutrient availability and pH.

In our experiments, an approach based on soil modification with sulphur has been adopted. The addition of sulphur to three arable soils has been found to lower the soil pH and extractable nutrients to levels similar to those of heathland soils. In a pot experiment using arable soil, competition from the volunteer weed flora was found to increase the mortality of heather transplants. Soil acidification has been found to inhibit the growth of arable weeds on an ex-arable soil and may thus favour the growth of heather. We conclude that the addition of sulphur to the soil appears to offer a practical solution to the recreation of heathland vegetation on Set-aside farmland.

HEATHLAND / ACID GRASSLAND CREATION ON ARABLE LAND AT MINSMERE RSPB RESERVE, SUFFOLK, ENGLAND

*Ceri Evans**, *Rob Marrs & Kathy Owen*+

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The RSPB is intending to create heathland/acid grassland on 158 ha of arable land at Minsmere RSPB reserve, mainly to benefit rare breeding birds such as stone curlew *Burhinus oedicnemus* and woodlark *Lullula arborea*.

The main problem of heathland / acid grassland creation on former arable land is that of high residual soil fertility. A baseline soil survey prior to any management showed that the arable soils had higher levels of exchangeable calcium and hence soil pH than the existing heathland soils, as a result of past liming, and also higher levels of extractable phosphorus, from fertiliser additions.

The primary objective of management in the initial stages was to reduce soil fertility. This was done by cropping the land with cereals and linseed in an attempt to deplete 'nutrients'. Although initially encouraging, soil 'nutrient' levels have not significantly decreased in the arable soils after four years of cropping.

Other experimental techniques have proved to be more promising. Soil acidification of the arable soils to heathland levels was achieved by the addition of sulphur and bracken litter. Propagules of acid grassland species have been sown onto the acidified plots, and establishment is being monitored.

Half of the arable area will be taken out of cropping in autumn 1995. Soil acidification using sulphur and bracken litter will be trialled on a field scale, and the effects on invertebrates will be monitored. Other fields will be grazed by sheep and 'topped', with the aim of recolonisation by acid grassland species, over a longer timescale, from the seed-rain.

1 June 1995

TITLE: Restoration of Heathland in Jersey, Channel Islands

AUTHOR: Penny Anderson

INSTITUTION: Penny Anderson Associates
Consultant Ecologists

SUMMARY:

An area of dense *Ulex europaeus* just inland from a narrow dune system was once heathland and still contains pockets of wet and dry heath. In 1987 and 1988, 3 plots were cleared, in addition one was burnt to remove litter, and in a second the litter was raked off. The resultant regrowth has been monitored in the 3 plots and a control plot intermittently to 1994. Limited heathland species colonised in the first years (eg. *Erica cinerea*), but subsequently disappeared due either to drought or rabbit grazing or both. A rabbit exclusion cage placed on one plot showed the dramatic inhibitory effects of rabbit grazing. After 7 years, the plots are beginning to return to a *Ulex* community, and heathland has not been achieved.

The Restoration of an Isolated Inland Dune Heathland in North Germany and the Consequences for Plants and Arthropods

Kuno Brehm *

The northernmost part of Germany (Schleswig-Holstein; 1,5 Mio ha of size) is the link between the Baltic Sea and the North Sea. In former times (18th century) the country was covered by 17 % of heathlands (250 000 ha). Until now these heathlands have been reduced to about 250 ha by cultivation and by plant succession which is accelerated by immissions of ammonia from agriculture. Most of the heathlands are rather small and they are scattered all over the country. In some of them measures have been taken since about 1980 in order to restore some heathland or related habitats. The most intensive and manifold management has been done in the nature reserve 'Sorgwohlder Binnendünen' (32 ha) which is one of the very few inland dune heathlands. The work is organized by a private society of nature conservation. Methods of management are: Felling trees, grazing by different races of moorland sheep, by different mowing, by sowing, by ploughing and by sod-cutting.

As a result of these measures the habitat is dominated by various units of heathland, lichen and grassland vegetation. There is a rather big number of arthropods which are specialized to these habitats some of which are extremely rare in North Germany.

As immissions of ammonia are still increasing the measures must be repeated at shorter intervals. So there is a permanent danger that many plants and arthropod species can no longer fulfil their life cycles. There are two essentials to the survival of heathlands: a) Restoration of a network of about 35 000 ha, and b) management on a large scale.

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HEATHLANDS OF SOUTHWESTERN SWEDEN AND CRITERIA FOR THEIR RESTORATION.

Lars Påhlsson (and Monica Danielsssson)

Department of Plant Ecology, University of Lund.

The coastal landscapes of southwestern Sweden in 1850 were widely covered by vast heathlands. They originated from wooodland clearings as early as in the iron age and were for hundreds of years managed by grazing - also in wintertime - ,burning and cutting of bushes. About one hundred years ago they were abandonded. Some were left to overgrow, but they were most often planted with woods, mainly coniferous with pine and spruce. This in contrast to the original woodlands of oak, birch and sometimes beech. The decline is illustrated by the following:

Year	Heathland, ha
1850	150.000
1928	58.000
1946	13.500
1990	10.000 (Only about 1000 ha Calluna-heath)

Nature conservation in Sweden is now directed onto the preservation of the few remaining heathland areas, and also on restoring areas which now have become overgrown or planted with woods. An example of these efforts can be illustrated by the management activities of the nature reserve "Kullaberg promontory" situated in northwestern Scania with an area of about 1000 ha. The historical land use pattern follows that of the whole heathland area of southwestern Sweden.In 1850 about 90% of the mountain was heath- and grassland. In the late 19 th century most of the the heathland was planted, mainly with Pinus nigra. Other areas were left to overgrow mostly by junipers. On deeper soils the junipers came to cover areas totally. Only on windswept cliffs and mountain tops, did the heath survive and even now can be found with its original vegetation components.

To prepare a restoration of the former heathland areas of the nature reserve an investigation of the vegetation was carried out in 1975 to find out criterea for areas to be restored. Square analyses were done within all stages of overgrowth and also in the different wood plantations. In many parts, the natural woods of oak and beech have been established. Also in these woods square analyses were carried out.

The vegetation analyses were treated statistically. Calculation of similarity index was performed with nodes either in the relict heathland vegetation on cliffs and mountain tops or in the original woodland types. The result was converted into areas on maps representing the vegetation types of the square analyses. From these maps areas containing sufficient heath species for restoration were identified.

Now twenty years has passed. Most of the coniferous plantations have been cut, and after clearing of small branches and bushes some areas are grazed with sheeps and highland cattle for about ten years. The heathland vegetation is regularly monitored and is developing very well. The heathland area of the nature reserve has grown considerably, benefitting both research (the reserve is affiliated to Lund University) and visitors experiences.

EXPERIMENTS WITH HEATHLAND RESTORATION

Forest manager
Bo Holst-Jørgensen

Observations concerning immigration of heather on abandoned agricultural areas in an old heathland area:

A survey of 14 areas covering approx. 200 ha in all has been conducted. The areas have been cultivated in periods ranging from 10 to 50 years and thereafter cultivation has been stopped for periods of 6 to 47 years.

The picture is ambiguous. The percentage of heather covering the areas varies between 0 and 82 as below (percentage covered):

0 - 10 % heather:	10 lots
10 - 50 % heather:	2 lots
50 - 80 % heather:	2 lots

Experiments with herbicides and deep ploughing before germination of heather:

Methods used:

Deep ploughing	(Up to 70 cm deep with a plow that covers the former surface layer completely with earth)
Round-up	(Glyphosat)
Fusilade	(Fluazifop-P-butyl)
Reference area	

All the used methods showed poorer results than doing nothing.

Experimental area for heather production on previous agricultural area:

On an area covering 25 ha, that had been cultivated since 1890, the cultivation was stopped i 1991 after harvest of a rye crop.

Since 1992 the following methods have been attempted:

1) Reference area
2) Sheep grazing
3) Mowing and then removal of naturally occuring vegetation
4) 6 harrowings per year
5) Growing of oats and harvesting when green (direct sowing)
6) Growing of winter rye and harvesting when green (direct sowing)
7) Spreading of 650 kg ammonium sulphate/ha/year and mowing twice a year plus removal of occuring vegetation

National Forest and Nature Agency
Ulborg state forest district
Paradisvej 4, 6990 Ulfborg, Denmark

Restoration of a former lowland heath area which had become covered in dense 35-45 year old Scots Pine *Pinus sylvestris*

Bryan P. Pickess

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Over a period of 35-45 years an area of 8,0 ha. of former lowland heath had succeeded to dense Scots Pine *Pinus sylvestris* woodland with no ground flora but a dense herb layer of Bracken *Pteridium aquilinum*. The former seed bank of ericoid species was now under a 3-8 cm. compacted layer of pine litter. To attempt to return the site to lowland heath major management was required.

Methods

Work commenced in November 1990 on clearing the pines using commercial timber cutter to fell and extract the timber. The felling yield over 1050 tonnes of saleable timber.

The top and lop was put through a tractor mounted chipper and blown into a trailer to be taken off site, for storage to be sold later as a horticultural mulch. The site produced ca. 1000 m^3 of woodchip mulch

To reach the ericoid seed bank the compacted litter layer was loosened using a tractor mounted rotating brush. It was now possible using a tractor mounted vacuuming machine to pick up the material and blown into a trailer for storage off site, for later horticultural sale. The material produced was similar in texture to dried peat. On average about 300 m^3 is produced per ha.

Pteridium is being controlled with the use of the chemical *Asulox*.

Results

Removal of the litter layer from the site has taken four years because the material cannot be gathered when it is very dry or during the summer when the site is covered in *Pteridium*. The initial area of ca. 0.4 ha was cleared between early May and the end of June, 1991. By the end of June, 1991 *Calluna* and *Erica* seedlings were appearing in the area that had been cleared in early May. In August 1992, a search for seedlings in 10 random quadrats of 10 cm X 10 cm in the initially cleared area produced in total 42 *Calluna* (10 plots), 23 *Erica cinerea* (seven plots) and two *Ulex europaeus* (one plot).

In June 1995 15 random 1m X 1m quadrats in the 1991/1992 cleared area showed ericoid species well established and most plants between 5-10cm tall. As an average percentage cover *Calluna* occupied (31.5%), *Erica cinerea* (6.6%) and Bryophyte/bare ground (61.1%). *Calluna* was present in all plots and *Erica cinerea* in 14 plots. Other seedlings recorded were *Betula* sp. 21 (10 plots), *Rumex acetosella (0.1%) (two plots), Luzula campestris* two (two plots), *Agrostis curtisii* one plant and *Pteridium* four fronds (two plots).

A similar establishment of ericoid species is occurring from the seed bank over most of the now treated site.

Key factor analyses for conservation and management of rare Danish heathland birds species

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Lowland heathland in Northern Europe is generally inhabited by a restricted bird community with a rather low bird density. Nevertheless, this habitat supports several rare birds adopted on the EU Annex-I list.

In 1992 the Danish Ministry of Environment obtained EU funds for a integrated ecological project with the title 'Management of North European Heathland Areas, in relation to the Directive 79/409/EEC'. The objective of this project, which was initiated the following year, was to portray the breeding habitat of rare Danish heathland birds with a view to identify suitable, specific management measures to be applied in nature conservation plans for these species on the remaining Danish heaths. This study thus aimed at revealing key factors for the presence/absence patterns for bird species exhibiting narrow habitat preferences for heathland and heathland bogs.

In all, 24 heathland sites were covered by the study, including sites which have been abandoned by heathland birds, in particular Golden Plover *Pluvialis apricaria* and Wood Sandpiper *Tringa glareola*. The occurrence of these species was mapped within present breeding sites. Botanical surveys were conducted in 19 sites. The vegetation in the study sites was categorized in a limited number of classes prior to the field work in order to ensure a comparable classification in each site, using already existing heathland classification standards and visual interpretation of aerial photos. These aerial photos will be kept as a documentation of the present land use and overall habitat structure in the sites, to be used for future nature monitoring purposes. In the field this preliminary classification was checked and adjusted prior to detailed surveys within each vegetation class. This approach allows for a rapid mapping of vegetation types over large areas with a relative high degree of precision.

On the landscape level these studies were augmented by remote sensing analyses of high resolution satellite images in order to facilitate a mapping of landscape features over large areas and to compare heathland habitat analyses on different scales. The botanical surveys were used as ground checks for the satellite imagery.

The results, which are being drawn up at the moment and which will be presented on the workshop, have included new information of the habitat demands of the heathland birds covered by the project. On the landscape level it was clear that even the largest Danish sites have a limited geographical extent that possibly restricts long-term sustainable populations of Golden Plover. Also Wood Sandpiper is sensitive to encroachment of plantations and woody regrowth which renders otherwise suitable heath lakes and ponds of inferior importance. These findings have implications for the size of heathland areas. On the habitat level the Golden Plover is confined to open, low-growing dwarf shrub vegetations and tends to avoid grass heaths. The presence of wet depressions is essential for the survival of juveniles. The Wood Sandpiper demands an open, flat terrain with a mosaic of small heath lakes and ponds. The species seems to exhibit a social threshold for a minimum viable population, which hinders an effective (re)settlement on small sites.

POSTERS

SUCCESSION ON DORSET HEATHS: THE EFFECTS OF SOILS AND THE EFFICACY OF CONSERVATION MANAGEMENT TO REVERSE SUCCESSION.

R.J Mitchell, R.H Marrs and M.H.D Auld

The University of Liverpool
and
The Royal Society for the Protection of Birds

This is the start of a three year project looking at the problems of succession on the lowland heaths of Dorset (a county in Southern England) and at the effectiveness of management to reverse succession.

Twelve sites in the Poole basin area of Dorset where invasion of the following late-successional species - *Pinus sylvestris*, *Betula* spp, *Pteridium aquilinum*, *Rhododendron ponticum* and *Ulex europaeus* has occurred,are being studied. Soil samples from both open heath and from under late-successional communities are sampled and have been analysed for pH, loss on ignition, nitrogen, phosphorus, potassium and calcium.

The project aims to look at the following questions:

- What are the effects of soil nutrients on the type of succession that occurs?
- Do different successional species have different impacts on the soil?
- How effective is conservation management to reverse succession?
- How successful are management practices in removing nutrients?

SOIL ACIDIFICATION AND HEATHLAND / ACID GRASSLAND ESTABLISHMENT ON FORMER ARABLE LAND AT MINSMERE RSPB RESERVE, SUFFOLK, ENGLAND.

Kathy Owen[+], Rob Marrs[+], Ceri Evans, & Geoff Welch

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This poster complements the paper presented by Evans *et al.* on heathland/acid grassland creation on arable land at Minsmere RSPB Reserve. It provides a more detailed account of the experimental techniques used to reduce soil pH to levels comparable to those of adjacent heathland (pH 3.5 to 4), by applying chemical means.

In 1993, two fields were taken out of cultivation and a series of experimental plots (5 m x 5 m) set up. Bracken litter and pine chippings: both available on the reserve, were added to depths of 0, 2, 4 and 10 cm. Sulphur powder was applied to other plots in quantities ranging from 0 to 12 t ha^{-1}. All plots were then rotovated. Each treatment was replicated three times in both fields.

Since 1994, soil samples have been analysed from three depths every two months to test the efficiency of the treatments over a long time period, but in particular to assess the minimum amount required to effect the required reduction in soil pH to 3.5.

Of the two acidic materials, only bracken litter has been successful in reducing soil pH, but only to 4.5 where 10 cm was added. All sulphur treatments have resulted in a considerable reduction, to a soil pH as low as 2 where 4 t ha^{-1} and above have been applied.

In January 1994, locally forage-harvested heather (mainly *Calluna vulgaris*) propagules were spread on the plots of one field at a rate of 2 kg m^{-2}. The plots from the second field were sown with an acid grassland seed mix (4.5 g m^{-2}) in September 1994. This mix consisted mainly of *Festuca ovina*, *Agrostis capillaris*, *Deschampsia flexuosa* and *Rumex acetosella*, plus a number of grasses and vascular species abundant on Suffolk's heaths and commons.

The second part of the project relates soil pH changes to vegetation establishment, particularly of those species introduced as propagules or seed, but also of arable species, many of which pose a serious threat to the establishment and survival of desired species.

So far establishment of *Calluna vulgaris* and acid grassland species has been relatively successful, although differences in the management of experimental plots between the two fields illustrates the importance of sufficient arable weed control prior to any vegetation restoration attempts.

The Control of *Molinia caerulea* (L.) Moench, Purple Moor-Grass in Upland Moorlands

Anna L. Milligan, R.H. Marrs and P.D. Putwain The University of Liverpool and The Heather Trust

Molinia caerulea (L.) Moench is a tough, perennial grass which is replacing *Calluna vulgaris* and other dwarf heath shrubs in many areas of upland Britain. As moorland is an important conservation habitat it is essential to be able to control *M. caerulea* and replace it with other moorland species, especially *C. vulgaris*. The Ministry of Agriculture, Fisheries and Food (MAFF) has awarded a three year project to devise methods for the control of *M. caerulea* and the restoration of moorland on a large scale. Here, the effectiveness of different herbicides, especially graminicides, and different application methods will be examined. Field work will be done in environmentally sensitive areas (ESA's) in Exmoor, the Yorkshire Dales and the Peak District. The effects of herbicides on both white sites i.e. monospecific stands of *M. caerulea* and grey sites i.e where *M. caerulea* is co-dominant with *C. vulgaris* will be examined. Spraying of *M. caerulea* with three rates of glyphosate (0.4, 0.75, 1.5 kg ai $ha^{-}l$) was done in May, July and August 1995 to determine the optimal spraying period and rate (if any) for most effective treatment. Dose response experiments are scheduled for later in the year when a suite of herbicides efficiency will be investigated. The effect of these concentrations on associated heath species will also be tested under controlled conditions. It is hoped that this will enable us to devise cost effective control techniques for *M. caerulea* which will not harm other moorland flora.

The effectiveness of a weed wiper will also be investigated to assess whether the herbicide can be applied topically and selectivity achieved by height differentiation.

EFFECTS OF ALTITUDE AND SEED SIZE ON GERMINATION AND SEED PRODUCTION OF HEATHS IN NORTH SPAIN

M.L. VERA

Dpto. Biología de Organismos y Sistemas. Universidad de Oviedo. Oviedo. Spain.

Calluna vulgaris, Erica cinerea and *Erica vagans* are three heaths common in Asturias (North Spain). *Calluna* is the species that occurs over a wider altitudinal range, spreading from level of sea until above 2000 m. *Calluna* and *E. cinerea* appear in acid soils, while *E. vagans* grows in both calcareous and acid soils. These dwarf shrubs grow in sites frequently disturbed. The aim of this study is to analyze the seed production and the germinative capacity of these heaths in different altitudes. This information is necessary for studies of restoration of these areas and distribution of these species.

Effects of altitude where the seeds were collected and seed size on germination and survival of seedlings were studied. The different experiments were carried out in the laboratory. The seeds collected in different altitudes in November 1994 were selected in two size class, and sowed in January 1995 in dishes that were placed in chambers at 20° C with a photoperiod of 12 h light and 12 h darkness.

The seeds of *Calluna vulgaris* showed the earliest (the germination began before 14th day from sowing) and highest germination percentage, mainly among seeds from zones more elevated (average 94% seeds from above 2000 m germinated on the 2nd month from sowing). The seed size in *Calluna* did not affect on the germination. *Erica vagans* germinated moderately and the percentage of germination from large seeds was higher than small seeds, but the altitude had not a significant effect, although the rate of germination was upper in the 1st month in highest altitude. The germination in *Erica cinerea* took place later; no germination was produced until 9th week and it was very low, reaching a higher level of germination in the seeds collected in higher altitude, but it was not very representative (average 10% at 4th month).

The percentage of surviving seedlings in relation to germinated seeds was higher in the large seeds from all localities. The survival was greater in germinated large seeds from highest altitude. Also, a positive relationship between seed size and seedling weight was found. This study only was realized in heather, the species with rate of germination more elevated.

Finally, these results were related with the production and size of seeds in each altitude in order to analyze the reproductive efficiency of these species. The estimate of the seed production was obteined by multiplying the mean number of seeds produced per capsule by the total number of flowers in the plot. Seed production was estimated in five 100 cm^2 plots for each specie along altitudinal gradient.

The effect of altitude and type of substrate could influence in the seed production, varying the number of seeds per capsule and number of flowers. *Erica cinerea* and *Erica vagans* near to their upper altitudinal limit produced fewer seeds. Moreover the less proportion of large seeds in *E. vagans* in the zone more elevated could influence in its scarcely spread up 1500 m. The highest production of seeds in *Calluna vulgaris* was about 1600 m on siliceous substrate, where the germinative capacity was high. In these zones heather is widespread. However this study must be complemented with observations realized in the field about germination and survival of seedlings.

Session V: *Future perspectives for heathland areas*

Invited Lecturer Prof. C.H. Gimingham

FUTURE PERSPECTIVES IN HEATHLANDS

C.H. Gimingham
Dept. of Plant and Soil Science, University of Aberdeen

This paper will be influenced to a considerable degree by many of the contributions to preceding Sessions. It will endeavour to synthesise new knowledge and understanding from different countries, in reflecting on the future of European heathlands. While the more stable heath vegetation of some upland areas may be little threatened (apart, in places, from the effects of overgrazing), lowland heaths have been fast disappearing. Since in the great majority of instances, heathland is a semi-natural "cultural" vegetation-type, as soon as its traditional uses lose significance, successional changes take place and the heath disappears. Add to this the deliberate conversion of heath to other uses and the effects of nutrient enrichment as a result of atmospheric pollution, and the future looks bleak.

On the positive side, there is much interest - in all countries of the heath region - in research on management for conservation, and on the re-creation of heath in habitats from which it has disappeared.

There is now evidence that many traditional management regimes had the effect of preventing nutrient accumulation in heath ecosystems, and this provides a key to management for conservation. Similarly, re-creation of heath on "improved" sites requires some means of depleting the concentration of certain nutrients. With the excess of agricultural production in Europe and reduction in demand for arable land, the prospect for conserving what remains of heathland, or even promoting its expansion, is now brighter.

Heathlands, although formerly extensive in some countries, have always, because of the variety of their origins, been interspersed with other types of vegetation. They have often contributed to a mosaic of land-cover, and have been intimately related to various land-uses. The future of heathlands may depend on protecting some large areas, and providing sufficient corridors and links between smaller patches in order to maintain a rich mosaic in the landscape. Heathlands are part of our cultural as well as our natural heritage, and the case for their conservation is a powerful one.

ORAL COMMUNICATIONS

5th EUROPEAN HEATHLAND WORKSHOP

FROM A NATIONAL NATURE POLICY TO THE MANAGEMENT OF HEATHLANDS: A BRIGHT OUTLOOK

In its strategy to concentrate on policy outlines and results, the Dutch Ministry of Agriculture, Nature Management and Fisheries is devolving all nature management activities to lower levels. The National Forest Service -the biggest nature manager in the Netherlands- will shortly be privatised. Private organisations such as the 'Natuurmonumenten' Association and Provincial Nature Conservation Societies - just like the National Forest Service- are independent in their management practices. On the other hand clear agreements are being made concerning the results of nature management and their monitoring. Similar agreements are being made between the national government and private owners, local communities and farmers.
In our lectures we hope to provide an insight into the Dutch intentions and experiences in translating nature policy into actual management, with special emphasis on heathlands.

Dutch nature is highly man-made. About a century ago the idea developed in the Netherlands that nature should be protected. Up to now nature management was focused on semi-natural nature. Recent efforts also aim to develop nature that is able to maintain itself as much as possible: self-sustaining nature. The ideas about what nature is desired are changing.

In 1990 the Nature Policy Plan was adopted by Dutch parliament. The view on the ecosystem for the heathlands described in "Heathlands do have future!" (1988) was important material for the policy on heathlands and other types of nature. In 1994 a system of intended types of nature (target types) was developed. This system now acts as a tool in setting goals on the quality and quantity of nature in the future, in terms of areas, species and processes.

The heathlands in the Netherlands are threatened by air pollution. The second National Environmental Policy Plan of the Ministry of Housing, Physical Planning and the Environment gives us the possibility to implement the "Forest and Nature Survival Plan". On behalf of this plan it is possible to subsidise projects which aim to restore forest and nature areas damaged by air pollution (acidification and eutrofication) and lowered water tables. There are problems with polluted dredge and litter layer (contaminated with heavy metals and hydrocarbons).

The use of grazing as a nature management tool increased. Grazing as such a tool and grazers as an independent part of the ecosystem did not come to the fore until in recent decades. It taught us a lot and the outlook is bright. Still, there are some problems left. Some of them are close to being solved, both at the level of management (the effects of grazing on flora, fauna and vegetation) and at the level of animal health and welfare.

Discussions with the agricultural sector in and outside the Ministry have shed light on the (seemingly) conflicting interests between nature management and agriculture. Discussions with conservationists, in particular with researchers, will crystallise the role of grazing and grazers.

We intend to inform you about our approach, the progress we have made and our experiences.

We will discuss -in two lectures- the following subjects:

- Dutch nature policies: from Nature Policy Plan via ecosystem views to intended types of nature;
- Heathland policy: possibilities and problems;
- Forest and Nature Survival Plan;
- Management: differences between mechanical management and grazing;
- Grazers in nature reserves: grazing as a management tool, grazing types, grazing as a part of the ecosystem, costs of grazing;
- Animal health and welfare: (inter)national rules, illnesses, dead animals;
- Grazing and man: accessibility of sites, risks, animal welfare;

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MAINTAINING THE QUALITY OF DUTCH HEATHLANDS FROM A NATIONAL POINT OF VIEW

Henk Beije
National Reference Centre for nature management, The Netherlands

Hans Kampf has already mentioned the Dutch governmental policy to increase the ranges of nature areas in general and heathlands in particular. In addition I will focus on the quality aspects for heathland communities. First some political choices, second some results of measures.

In 1994 a national nature inventory in The Netherlands was carried out by the National Reference Centre for Nature Management. A serious decline of species and communities all over the country was reported, particularly in nutrient poor areas. The main causes are acidification, eutrofication and lowering groundwater tables. Another conclusion is, that the degree of naturalness of Dutch nature areas is generally small.

According to the Nature Policy Plan (1988) of the Dutch government there are two main criteria for nature quality: biodiversity and naturalness. Both should be increased, but are actually declining. Therefore an offensive approach has recently been adopted, to improve Dutch nature at two levels:

a. at system level, by developing specified areas (hectares) with specified **nature target types**. Especially target types with many endangered species and virtually natural areas will be enlarged.

b. at species level, by selecting so called **target species**. Three criteria are considered in order to select target species:

- the species is strongly dependent on Holland in its West-european range
- the species decreases in Holland
- the species is rare in Holland.

Species that meet at least two of these criteria, are selected as target species. These species will get special attention in planning and management activities as well as in the evaluation of these activities.

Both levels are integrated by assigning each target species to one or more nature target types. Each target type is defined in terms of target species, abiotic conditions and range requirements. It can be used as a management goal for a specific area. Thus the set of nature target types is primarily a toolbox for local planning, ensuring consistency with national priorities. It also is a powerful tool for scenario-studies.

The national nature inventory will be repeated in 1997. Nature target types en target species will be important tools to evaluate changes.

Except new plans, a great number of practical measures are taken by the government, local authorithies, managers, etc. in order to improve the quality of nature. At the moment 'crisis' management is necessary to neutralize the effects of acidification, eutrofication and drying up. Many communities and species only survive in decimated areas and populations or, in the case of plants, only by seedbank. It will take years before the general abiotic conditions are restored. For that reason the government has raised a special arrangement to subsidize short-term measures.

During the last 20 years most restoration measures in heathlands were intended to reduce the invasion of grasses due to atmospheric nitrogen enrichment. Sod cutting, grazing and (in some cases) mowing and burning have proved to be succesfully to change grass-dominated heathlands into heather vegetation. Subsidizing these measures will be continued, although the results, in terms of species richness, were generally not spectacular. One should take into account however, that the quality of heathland management - as far as ecological goals are concerned - depends on the actual species composition in relation to the potential composition. Most of the Dutch heathlands are originally poor in vascular plants.

Recently, methods are tried out to restore heathlands especially with a somewhat buffered soil. The vegetation of these heathlands potentially belongs to the subassociations *sieglingietosum* and *orchietosum*, with much more endangered species than most of the Dutch heathlands. The main experiments are:

a. removing the topsoil by sod cutting, because acid matter is concentrated there.

   So far reasonable results are obtained in dry heathlands. It was found however that ammonium concentration increases temporarely and that germinating plants of *Arnica montana* for instance are very sensitive to this phenomenon. Species even run the risk to become extinct after sod cutting, if their seeds are only shortly germinative. To avoid extinction, it is recommended to cut sods only on small areas. Such areas can easily be colonized from the surroundings as soon as ammonium concentration has lowered.

b. raising pH values by supply of chalk, gypsum or marl.

   Experience so far is limited.

ENGLISH NATURE'S NATIONAL LOWLAND HEATHLAND PROGRAMME AND SOME PROBABLE FUTURE TRENDS IN HEATHLAND CONSERVATION IN ENGLAND

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This paper will describe the work to conserve lowland heathland that English Nature, England's statutory nature conservation service is undertaking through its National Lowland Heathland Programme. The presentation will outline the key objectives of the Programme which are to emphasize the importance of heathland animals and plants, promote the sustainable management of heathland for wildlife conservation, particularly by light grazing and to promote action to conserve heathland by key partners and local communities. The main achievements of the Programme will be reviewed and the work that is planned for the future described. This includes schemes for the positive management and restoration of heathland, the development of inventories of heathland sites, producing plans to re-create heathland, work directed at heathland species and publicity to raise awareness of the importance of lowland heathland. Finally some probable future trends in heathland conservation in England will be considered. These include the importance of the Biodiversity Action Plan targets for heathland, the need for organisations to form partnerships to promote the extensive light grazing of blocks of heathland, and the importance of European legislation and policy such as the European Union's Habitats and Species Directive and agri-environmental measures.

WORLD HEATHLANDS BIOTOPES DATABASE PROJECT: CONCEPT AND INTRODUCTORY SUGGESTIONS

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Heathlands biotopes are important part of world biodiversity. Some types of heathlands vegetation are not-sustainable, another are threatened by human activity, especially in Europe and North America. Both, anthropogenous and natural heathlands communities need sustainable management systems through out the world.

Sustainable management possibilities are based on biodiversity codification and universal form of classification implemets. The last years EC and UNESCO activity gave two main paths of biodiversity codification.

European (and, now, PalaeoArctic) CORINE program is a first of its. Basic CORINE principle - Braun-Blanquet approach to biotopes and vegetation classification - is clear and successfull for some types of vegetation, but CORINE coding system are developed only for Europe and some related countries and there are no any expensive works for Asia arctic, tundra and arid (steppe, desert) regions according to Braun-Blanquet technique. In the territories of the former USSR, Central and East Asia, China some dominance approachs of vegetation classification were developed, as well as in Scandinavian countries, Canada and United States. So, great body of scientific knowledges on heathland vegetation was prepared in non-Braun-Blanquet techniques.

Consequently, universal database data description form should be expected when scientific community want to present world heathlands biodiversity. So, system effective and permissible both for Braun-Blanquet and dominance approachs is needed.

In this reasons, it should be real to use Linnaeus II and IdentifyIt software set developed by Expert Center for Taxonomic Identification (University of Amsterdam) for UNESCO "The World Biodiversity Database" project. Linnaeus II designed for taxons description and identification and used context-independant structure of data fields and polytomous keys technique give a possibility to mix dominance and Braun-Blanquet descriptions in one database.

Mentioned above don't stands that only Linnaeus II software is a good way for global database development, but gives a principle - only context-independant system should be realized for vegetation codification projects when different techniques are turned into accout.

Heaths are very vulnerable and ecologically narrow type of vegetation. But in another case, heaths is a habitat type with very special biodiversity characteristics, both for flora and fauna species. Global Heath Vegetation Database Project should be populated with an information about heaths vegetation, its structure and floristic diversity, and (in future stages of projects) its faunistic components. World list of threatened heathlands species and communities shoud be created under the project for a system for global heathlands preservation.

Implementation plan of the project must include: a). a special protocole for formalised heathlands vegetation description development, b). database format and technique design, c). the database population with information about world heathlands vegetation (at first, for Europaean and North American heathlands vegetation).

Formalized description should include every type (association) of heaths characteristic (floristic components, vegetation structure, soils, etc.), landscape characteristic, determination tables, every type of heaths global distribution map, etc..

General Information

HEATHLANDS IN GALICIA

USES

Within Galicia's almost 30,000km2 of geographical surface, heathlands have an enormous importance due to their extension, as well as for their cultural and ecological value. According to the Forestry Inventory for 1986, there are 877,964 ha. of low level woodland (especially heathland and some pastures), and 1,109,213 of woodland with trees. According to these figures, heathland occupies 29% of the geographical surface and 43% of the forest surface.

The existence of this large extension of heathland may be explained in two ways: the intense deforestation that took place in forest areas, and the traditional uses to which the heathland was submitted.

The predominant mixed deciduous woodland was exploited for the construction of housing, agricultural tools and for energy use in kitchens and ovens. However, more intense timber cutting was carried out for naval construction and the iron industry, and , in the last century, for the installation of the railway.

In traditional agriculture, use of the forest was substituted for heathland use as the trees disappeared, and thus heathland was integrated in a mixed and intensive agricultural system during the XVII and XVIII centuries, particularly in the more Atlantic regions.

The cutting system implies an exploitation of heathland in lengthy turns, rotating with cereals, which includes in many areas sowing gorse, resulting in the cycle: gorse sowing-> growth for 10-12 years -> cutting -> working of the arable soil and burning the different varieties 'in situ' to take advantage of the fertility of the ashes -> cereal sowing during 1-2 years and the renewed sowing of gorse.

The young shoots of the cut gorse were used as foodstuff for sheep and horses, its trunks used as firewood, and its oldest branches as bedding for the animals and for the production of compost, which was used on the land dedicated to intensive agriculture. The productivity of the woodlands limited the fertility and production of the areas of cultivation, which brought about in Galicia a proportion of the areas of 2/3 dedicated to forestry, and 1/3 to agriculture.

Apart from gorse, species such as *Erica arborea* and *E. australis* were used as firewood and also for the production of utensils (pipes, cutlery etc.)

The areas of shrubland were also used for other purposes, such as for widespread grazing, hunting and the production of honey.

These traditional ways of benefiting from the heathland have descended notably during this century, so that the approximately 1,275,000 ha. of woodland controlled by cutting and grazing, reached in recent years a level of only 140,000 ha. controlled in these ways. (Perez Iglesias, 1979).

However, today research is being carried out about the possibility of taking advantage of the biomass of heathlands, through new technology dedicated to agroenergetic results; industrial fabrication of components for foodstuffs for cattle, and for substitute materials for fuel-oil.

The production of honey is being promoted, with the high meliferous content of the Ericacea species in Galicia already known, and the high value as beehive-maintaining flora of other abundant species: Gorse, *Lavandula sp.*, *Rosmarinus officinalis*, etc.

However, it should be noted that no heathland ecosystem is currently protected as such, despite the doubtless benefits to the landscape, culture and ecology that some of these possess.

HEATHLAND ECOLOGY

The climate of Galicia is fundamentally oceanic; gentle temperatures with small variance, and abundant and regular precipitation. Certain areas have a tendency towards a mediterranean, continental or high mountain climate.

The predominant substrates are granite and slates, over which thin soils develop, acidic and poor in nutrients.

With these environmental conditions, the majority of Galician heathlands may be considered as stages of the degradation of the climatic woodland; generally they are communities with a paucity of species and always more regressive than the initial ecosystem, with a predominance of Papilionaceas and Ericaceas with few demands (Diaz Vizcaíno, 1984).

Although they have well defined characteristics of structure and diversity, the different communities have suffered a certain homogenisation due to repeated human actions: sowing, cutting, and burning. The case of gorse is a clear example of a species favoured by man directly by being sown, and indirectly favoured by cutting and burning, especially the latter.

Basanta et al. (1988) found in 7 heathland communities aboveground biomasses between 3 and 42 t/ha., and Casal et al. (1984) found between 10 and 25 t/ha. in communities of *Ulex europaeus*.

Forest fires are widespread in Galicia, which was the most affected part of Spain in the 70's and 80's. From 1961 to 1987 1,074,528 ha burned, which corresponds to 50.7% of the wooded surface.

The potential climatic erosiveness in Galicia is very elevated, and the actual erosion after a fire is very high. Diaz Fierros et al (1991) found that in burnt heathlands of *Ulex europaeus* the natural level of erosion was multiplied by 3 in the case of a mild fire, and was multiplied by 9 in the case of an intense fire, although later studies showed even greater losses of ground.

The regeneration of the vegetation after a fire passes through 3 stages; a first stage, lasting 0 - 6 months, characterised by high levels of bare ground, which began to be invaded by surviving plants that were able to reshoot and by pioneering plants which are favoured by these new conditions created by the fire. In a second stage, lasting 6 - 30 months, appears the predominance of herbaceous species, many of them annuals, which benefit from the lack of competitors for light and nutrients, at the same time as populations of woody plants become more abundant. Finally, the third stage, from 2.5 years, is characterised by the palatine growth of heathland that increases in coverage and biomass, and the elimination of opportunist species (Casal et al, 1984). A similar process of recovery occurs in communities of birds (López 1988), with a large number of individuals during the first stages that can take advantage of a large amount of food, a number which is reduced with time as the availability of seeds of herbaceous species diminishes and the competition between species grows, while the community stabilises.

Fires tend to move the competition between gorse and Ericaceae in favour of gorse, given that as it possesses a strategy to reshoot it reaches a greater biomass and coverage in the first years of recuperation than the majority of the species of Ericaceas present in Galicia, that reshoot little or not at all after intense fires. In this sense, repeated fires erode the soil, impoverish the structure and specific composition of the plant communities and cause imbalance between its populations, with a tendency to favour those species which reshoot.

Other ecological factors, such as climatic conditions, may also modify competition between species and modify communities: for example, *E. umbellata* and *E. tetralix*, which characterise respectively communities on the extremes of dryness and waterlogging, may be affected by climatic crises that substantially modify the environmental conditions that they endure.

Mercedes Casal

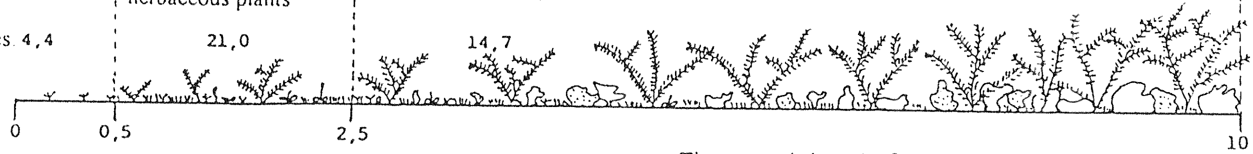
DIAGRAM

Characteristic:
Bare ground —

pioneering herbaceous plants

perennial species

number of species 4,4 — 21,0 — 14,7



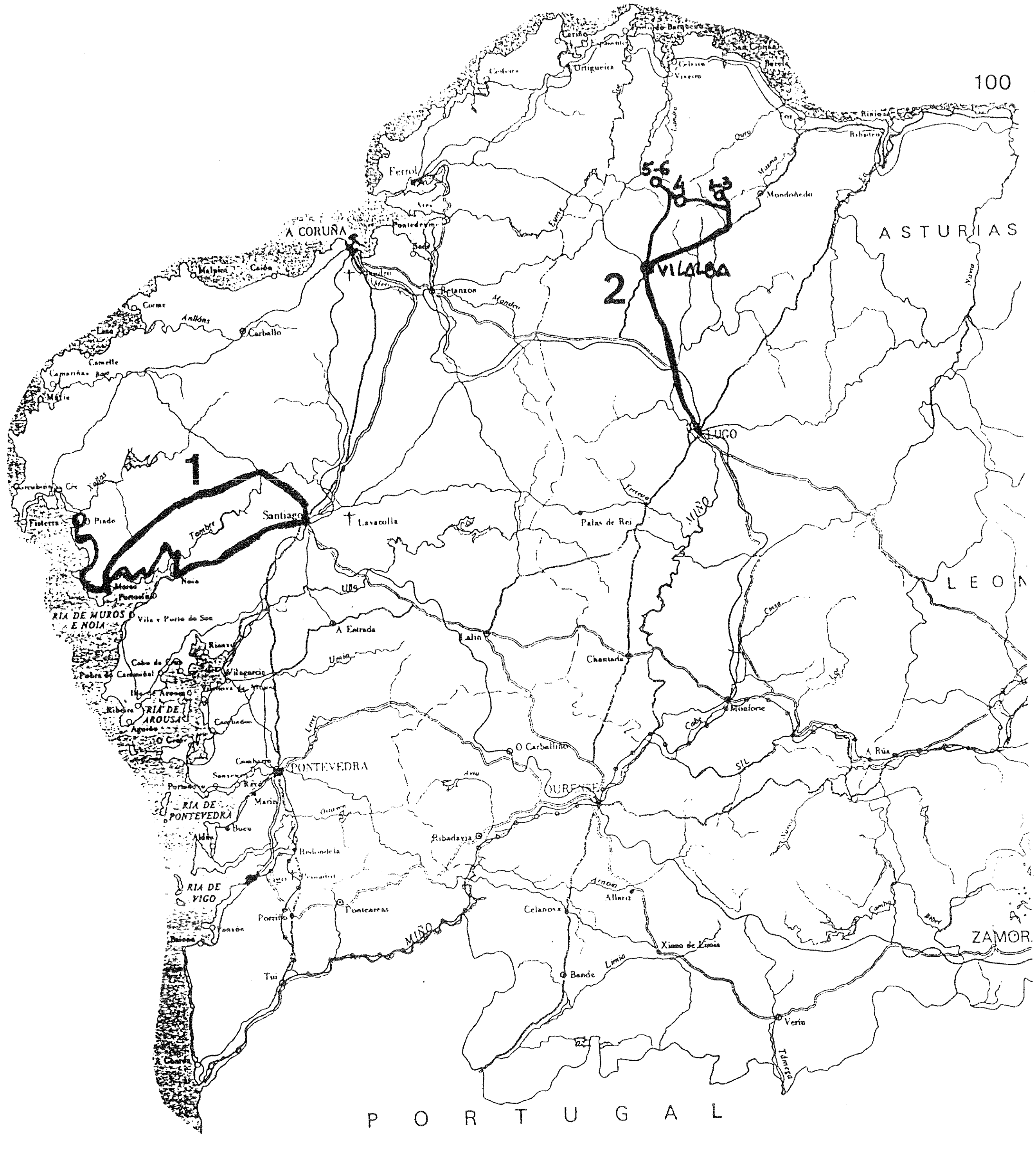
Time passed since the fire in years

shrubland structure:

	0	0,5	2,5	10
Coverage	0	9,25	60,82	98,32 (%,
Height	0	0,32	0,94	1,47 m
Biomass	0	0,15	1,65	12,11 t/

Figure Synthesis o the dynamic of vegetation recovery after a fire, identified by 3 distinct stages. The verage values refer to those obtained through prediction equations taken from 53 amples of 25m2 studied in shrublands dominated by *Ulex europaeus*.

A DESCRIPTION AND MAP OF OUTINGS



1- Short field trip (Tuesday 12 September)

2- Long field trip (Thursday and Friday 14, 15 September)

2- Long field trip (Thursday and Friday 14, 15 September)

ITINERARY FOR THE NORTHERN GALICIAN SIERRAS

The northern sierras are a group of mountainous lines (Montes do Buio, Serra da Faladoira, Serra da Carba, Macizo de Toxiza, Serra do Xistral, Macizo de Monseibane) which separate the Cantabrian/Galician coast from the large interior depression known as Terra Cha (Flat Land). They are medium altitude sierras with a generally suave topography, whose average peak height is between 900 and 1000 m, coinciding with outcrops of resistant rocks (cuarcitic strata, granitoids). The litological variety is, together with the network of faults and fractures, responsible for the existence of a drainage network well heirarchised in the gneissic areas, more easily eroded, and of the abundance of areas of difficult drainage in the granitic sectors, where a relief characterised by alteration alveoli interconnected among themselves and separated by rocky outcrops (tors etc) of varying dimensions.

Climatically, these mountains are characterised against those of the rest of Galicia by a greater distribution of precipitation during the year, brought about by a continuation in summer of the rains and fog due to the condensation of cloud masses originating in the ocean when the Azores anticyclone extends its influence over the Iberian peninsula. This constant presence of water, together with a topography favourable for the temporal storage of freatic water, has led to the persistence of hygrophytic vegetal communities in a large part of this territory within a climatic context tending towards summer dryness. In the thermometric area, the nearness of the sea gives these mountains a decidedly oceanic character, with an annual temperature of between 10 and 12°c. The period of frosts is estimated to be between 50 and 100 days per year.

The itinerary consists of the following stops:

Stop N°1: Heathlands and wetlands of Curro Vello. From the crossing of Curro Vello, the traditional system of usage of the valleys and mountains below the south-eastern vertices of the Northern Sierras may be observed. The vegetal landscape extends around small villages, comprising of crops (potatoes, rye, wheat, maize, vegetables), abandoned crops, river meadows and small wooded areas (oak and birch woods). In the high part of the slopes are wooded repopulation masses (*Pinus sylvestris, P pinaster, P radiata*) and heathlands transformed to grazing land.

The change from metamorphic substrates (anphibolic slates) to granitic (granodiorite of A Toxiza) benefits the formation of endorreic areas and the change in use of the territory; there is a predominance of flooded and fertile áreas at the bottom of the altering alveoli, and hygrophile shrubland on the better drained slopes. The diversity of the Ericaceas (*Erica cinerea, Calluna vulgaris, Erica mackaiana, Erica ciliaris, Daboecia cantabrica)* and herbaceous plants (*Ulex europaeus, U gallii)* make up the different communities of heathlands both hygrophytic and non-hygrophytic; *Ulici europaei-Ericetum cinerae, Gentiano pneumonathe-Ericetum mackaianae, Erico mackaianae-Sphagnetum papillosi, etc.* comprised of an important number of endemic species.

Stop N°2: Xesteiras of A Balsa. One of the most typical uses of the heathland formations of the Iberian Northwest has been the Xesteiras or Xestales. Regionally they are dominated by herbaceous species that reach a considerable size and dense coverage, belonging to the gen *Cytisus, Genista* and *Ulex*. At the head of the River Eume these heathlands are dominated by *Cytisus striatus* and *C scoparius* that reach over 4 metres in height. The herbaceous strata is variable with the state of development of the community.

Stop N°3: Erica australis heathland. In the SW vertices of the Serra do Xistral, there is a diminishment of the influence of the *foëhn* effect during the summer, a phenomena which has a repercussion in the increase of hours of sunlight both annually and daily; that is to say, a tendency towards continentalisation. In the surrounding areas of the River Boó we find heliophilic gorse and heathlands ruled over by *Erica australis, Genistella tridentata, Dabeoecia cantabrica* and *Ulex europaeus*, widespread throughout the interior regions of Galicia.

Stop N°4: Wetlands with Genista anglica. Near to the last stop and over a fluvial terrace, there is a hygrophytic heathland with *G anglica* and *Erica mackaiana* (*Genisto anglicae-Ericetum*), corresponding to this type of topographical situation and which, on occasions, may appear half way down a slope, coinciding with flowering areas of the freatic layer. It is a characteristic community of the hillside floor.

TRADUCCIÓN DO TEXTO DE CADAVAL

"Reinando o emperador Carlos e a súa nai, o ilustre Alonso de Fonseca, primeiro Arzobispo de Santiago e despois de Toledo, mandou que se edificase este colexio na casa do seu avó materno, para ornato da súa patria e para que os xoves aplicados puidesen aprender sen gastos de ningunha clase. Sorprendido, sen embargo, pola morte, deu no seu codicilo encargo de concluílo ó Rector Lope Sánchez de Ulloa, Arcediago da Raíña da igrexa compostelana. Morreu o 4 de febreiro do ano do Señor de 1534, ós 60 anos de idade. Agora brilla Galicia co seu fillo que lle deu tanto honor. O mesmo Lope Sánchez, nacido da propia estirpe, levou a cabo en breve este encargo, don a todos inestimable, para que servise de grato pracer ás Musas, e escorrentase as tebras. Con razón pois, o pobo, os próceres e o universal aplauso dan gracias sen fin por tan inestimable facho de luz. 1544. Cadaval fixo esta inscripcción."

TEXTO EN LATÍN

CAROLO CAESARE CVM MATRE REGNANTIBVS, ALFONSVS FONSECA ILLVSTRIS ANTEA COMPOSTELLANVS DEMVM VERO TOLETANVS ARCHIPRAESVL AD DECOREM PATRIAE ET VT STVDIOSI ABSQVE SVMPTV DISCERE POSSENT GIMNASIVM HOC IN AVI MATERNI AEDIBVS EXTRVENDVM CVRAVIT. MORTE VERO PRAEVENTVS LVPO SANTIO DE VLLOA ARCHIDIACONO RECTORI PERFICIENDVM EX B. TESTAMENTO RELIQVIT. QVI OBIIT PRIDIE NONAS FEBRVARII ANNO DOMINI MILLESIMO QVINGENTESIMO TRIGESIMO QVARTO. AETATIS QVIDEM SVAE SEXAGESIMO. NVNC MAGIS ATQVE MAGIS GALLAECIA FVLGET ALVMNO / QVI DEDIT HVNC PATRIAE TANTVM GENEROSVS HONOREM. / SANCTIVS IPSE LVPVS PROPRIA DE STIRPE CREATVS / VT MVSIS GRATVM FACERET TENEBRASQVE FVGARET / OMNIBVS HOC BREVITER COMPLEVIT AMBILE MVNVS. / QVO POPVLUVS MERITO PROCERES ET CONCIO TOTA / INNVMERAS TANTO GRATES PRO LVMINE REDDVNT. / 1544.

EXPLICACIÓN AL LEMA "GALLAECIA FVLGET"

Gallaecia Fvlget [brilla Galicia] é unha frase entresacada do texto que corre polo friso do patio do Colexio de Fonseca, que o profesor Alvaro de Cadaval escribíu no ano 1544 en louvanza do seu fundador Alonso de Fonseca.

TRANSLATION OF CADAVAL'S TEXT

"Reigning the Emperor Carlos and his mother, the illustrious Alonso de Fonseca, First Archbishop of Santiago and later of Toledo, orders that this college be constructed in the house of his maternal grandfather, for the adornment of his country and so that worthy young people may learn without any form of expense. Surprised, however, by death, he gave in his codicil the task of completion to the Rector Lope Sânchez de Ulloa, Archideacon of the Queen of the Compostelan church. He died on the 4th of February in the year of our Lord 1534, at the age of 60. Now Galicia shines thanks to its son that gave it such honour. This same Lope Sânchez, born of the same lineage, carried out this project rapidly, a priceless gift for all, so that it may serve to gratify the muses, and may frighten away the darkness. Reasonably, thus, the people, national heroes and universal applause give endless thanks for such a priceless halo of light. 1544. Cadaval made this inscription."

Gallaecia Fulget (Galicia Shines) is part of the text which runs as a frieze around the patio of the College of Fonseca, wich the professor Alvaro de Cadaval wrote in the year 1544 in prarise of its founder, Alonso de Fonseca.