NICOLAUS COPERNICUS UNIVERSITY

SCIENTIFIC SOCIETY IN TORUN

THE 14TH EUROPEAN HEATHLANDS WORKSHOP

Heathlands of protected and military training areas in Northern Poland

Poland 2015

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SHORT ABSTRACTS

PROGRAM

21-27 June 2015

Toruń, Poland

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Cover photo: Adam Adamski

Heathlands, similarly like frequently accompanying psammophilous grasslands, are anthropogenic communities, strictly dependent on human activity. Cessation of land use, consisting in livestock grazing by farm animals, burning and mowing, triggers off the succession processes, which quickly bring transformations of grasslands and heaths into fringe, thicket and forest communities. In the conditions of modern Poland, heaths generally develop over small areas in the landscape of pine forests, less frequently mixed forests. Those are forest glades, unsuccessful forest plantations, division lines, roadsides, railway embankments etc. Nowadays, larger areas of the aforementioned heaths occur only on military training grounds or in the nature reserves, frequently formed on former military areas, where active protection must be applied.

Effects of operations carried out by soldiers during their training courses on training grounds, such as explosions of shells and missiles, fires of forests, damaging the ground and vegetation by tanks, conveyors and artillery guns, building trenches, observation points and battle stations, as well as trampling down, act as inhibitors of the overgrowing process, suspending the succession processes of phyto- and zoocenoses, and ecosystems.

In the territory of Poland, there are seven large military training areas of the total area over 90 thousand hectares. The artillery range located near Toruń and directly adjacent to the southern limits of the city is one of the oldest and the largest objects of this type, both in Poland and in Europe. Due to the fact that the training ground in Toruń is continuously used by the army, large areas of heaths have been preserved. Due to the presence of the European dry heaths, i.e. habitat 4030 and the presence of wolf *Canis lupus*, as well as rare species of invertebrates, a Natura 2000 site was established in this area with code PLH040041 "Dunes of Toruń Basin".

The training ground near the town of Borne Sulinowo in Pomerania is yet another area with large heaths preserved thanks to the military use. In 1935-1992, there was a military training ground in this area, first the German one, and after 1945 – the training ground with headquarters of the Soviet army quartered in Poland. A considerable part of the military training ground was afforested, as well as a nature reserve and Natura 2000 Site PLH320048 "Diabelskie Pustacie" (literal translation: Devil's Wastelands) were created. Active conservation aimed at preserving the heaths consists mainly in cutting down wilding trees, in particular silver birch and Scots pine.

An ecological site referred to as "Cietrzewiowe Wrzosowisko" (Black Grouse Heathland) was created on heaths overgrowing the former Soviet military training ground in the Forest Division of Przemków in Lower Silesia, as well as Natura 2000 Site PLH020015 "Wrzosowisko Przemkowskie" (Przemków Heathland) where wilding trees were removed by setting a supervised fire. During the experiment, Polish foresters were assisted by experts on the ecology and fire monitoring from Germany, Spain and Sweden.

Degraded ecosystems have been restored in almost all areas formerly used by the army, and then made open to the public for tourism and recreation purposes, as well as beekeeping. These actions are being accomplished under the project "Environmental restoration of degraded lands and former military training grounds used by State Forests". The project has been implemented under Priority Axis II of the Infrastructure and Environment EU Operational Programme.

Perhaps not only the military use or creation of nature reserves on former military training grounds, but also other forms of human activity will contribute to an increase in heath areas. Such activities may include extensive grazing, the development of which has lately been favoured in Poland by the growing profitability of sheep keeping and the growing interest in nature and cultural values of the historic landscape and the development of agritourism. The growing interest in sheep keeping, particularly in Pomerania, is a throw-back and aspiration to preserve the tradition as this form of breeding played an important role in the economy of the region in the 19th century.

Heathlands occurring on the Polish territory belongs to two main types of plant communities. In the hierarchical phytosociological system proposed for Poland by W. Matuszkiewicz, they are as follows: 1 – Atlantic communities of wet heathlands from the class *Oxycocco-Sphagnetea*, and 2 – dry heathlands from the class *Nardo-Callunetea* and the order *Calluno-Ulicetalia.*

Communities of the first type occur on the peaty and gley-podzol soils in ground depressions with considerable fluctuation of the ground water level in the annual cycle. Floristically they are characterised by a substantial contribution of species with the Atlantic type of range and lack of continental-boreal species, and insignificant contribution of peat-forming species of tufty peat mosses.

Wet heathlands are mainly represented in Poland by the association *Ericetum tetralicis* with the dominant *Erica tetralix* (Habitat Directive code 4010), recorded fairly frequently along the South-Baltic seacoasts, and also seldom in the West of Wielkopolska (Great Poland) and Lower Silesia. The association reaches in Poland its absolute eastern range of occurrence and is distinctively floristically impoverished as compared to typical West-European forms.

The second main type of heathlands, i.e. dry heathlands, is represented by communities dominated by the heather *Calluna vulgaris* and sparsely scattered individuals of juniper and the undergrowth of birch and pine. They occur on poor acid podzols that developed from loose sands or slightly clayey sands in the maritime climate.

Having in prospect the whole range of the order *Calluno-Ulicetalia*, one can distinguish in Poland seven communities and two communities representing four different alliances, three of inland dry heathlands and one of maritime dry heathlands. Habitats Directive codes of three main associations are as follows: 4030-1 *Calluno-Genistetum*; 4030-2 *Pohlio-Callunetum*; 4030-3 *Arctostaphylo-Callunetum.*

In Poland, there have not been ever any doubts concerning the anthropogenic character of those heathlands, which develop only after cutting the coniferous or mixed forests and considerably intensify the podsolization process of soils. Our communities from the order *Calluno-Ulicetalia* are floristically very impoverished, as most of their characteristic species do not reach the western border of Poland. Almost all types of heathlands from this group (occurring in the presented area) should be interpreted as non-typical borderland forms of various syntaxa. *Arctostaphylo-Callunetum* – subcontinental bearberry heathlands of the boreal-continental type, is characterized by the occurrence of *Arctostaphylos uva-ursi* as a sub-dominant species and other continental psammophytes. The range of this association is not yet known in details. Probably its centre is located in the Baltic countries and areas of Belorussia.

The threats to heathlands in Poland are similar to those observed throughout the geographical range of these communities. They include the abandonment of traditional management of rural areas, increasing urbanization, nitrogen deposition on naturally poor soils, turning heaths into waste disposal sites, which results in the eutrophication of habitats, an increase in the number and extent of wildfires, especially in sub-urban areas, an increase in afforestation, or outflow of water from wet heathlands.

When searching for appropriate strategies of heath protection against so different threats, it is important to take into account the current state of plant communities as well as complex ecological, economic and social factors determining these states. The knowledge about the potential effects of our management choices on the ecosystem functions and services provided by these habitats is also required. This will allow to create efficient scenarios of the heathland development and implementation of relevant amendments to our actions.

The 14th European Heathland Workshop will be held in two regions of Poland: Kujawy and Pomerania. The participants will have the opportunity to learn about the main types of Polish heats occurring in areas with different status of protection, different forms and intensity of active conservation or land use. In a large group of experts on the ecology and management of heathlands from several countries, examining different cases demonstrated during the field exploration, paper and poster sessions, we will search for effective ways to preserve and restore these ecosystems across Europe for the rational use also in the future.

We welcome you all to the 14th European Heathland Workshop, which takes place in Poland, 21st-27th June 2015.

On behalf of the Organizer Committee

Andrzej Nienartowicz

Program of the 14th European Heathland Workshop

Sunday, 21 June

Arrival at Hotel Bulwar, Toruń, www.hotelbulwar.pl

17:00 – 19:30 Registration

20:00 – 21:30 Dinner at the hotel

Monday, 22 June

06:30 – 09:00 Breakfast

08:00 – 09:00 Registration

09:00 **Opening of the 14th European Heathlands Workshop – Andrzej Nienartowicz, Wiesław Kozak, Geert de Blust**

09:15 – 10:30 Presentations

9:15 **Andrzej Nienartowicz** Heathlands in Poland: types, management, threats and protection

9:30 **Ingmar Gorissen** Overview about some of the largest open inland lowland heathlands from Poland

9:45 **Peter Emil Kaland** A proposal for a working group to update the european Heathland maps

10:00 **Katia Nagels** Hydrology and ecology: how Natura 2000 and military use can match

10:15 **Katrin Hennig** What restricts generative rejuvenation of calluna vulgaris in continental, dry heathland ecosystems: seed production, germination ability or safe site conditions?

10:30 **Discussion**

10:35 – 10:55 Coffee break

10:55 – 12:10 Presentations

10:55 **Annette Rosengard Holmenlund** Wandering Shepherds - a beginning profession in Denmark

11:10 **Isabel Alonso, Werner Haerdtle** Resolving potential conflicts between different heathland ecosystem services through adaptive management

11:30 **Rene Seifert** Free-range grazing by large herbivores in degraded large-scale dry sandy grassland-heathland ecosystems

11:45 **Chris Dictus** Herpetofauna and management in flemish heathland

11:55 **Mons Kvamme** Why listen to the old farmers? Importance of living traditions for heathland management

12:10 **Discussion**

12:15 – 13:00 Lunch at the hotel

13:00 – 14:15 Presentations

13:00 **Liv Guri Velle** Partitioning floristic variance in post-fire vegetation dynamics along a north-south gradient in northern calluna heaths

13:15 **Geert De Blust** Wildfires in a heathland reserve; prevention measures as part of the management plan

13:30 **Mattias Hennig** The influence of burning and mulching on sand heath birds in SPA Colbitz-Letzlinger Heide

13:45 **Piotr Sewerniak** Wolves (*Canis lupus*) in the Toruń Basin (N Poland): actual status and problems concerning the population

14:00 **Discussion**

14:10 Introduction to excursion – **Piotr Sewerniak, Michał Jankowski**

14:20 – 15:00 Coffee break

15:00 – 19:00 **Excursion to heathlands in the Toruń military training area**

Piotr Sewerniak, Michał Jankowski Deforestation increases differences in morphology and properties of dune soils located on contrasting slope aspects in the Toruń military area (N Poland)

20:00 Grand Dinner at the hotel Bulwar

Tuesday, 23 June

06:30 – 08:00 Breakfast

08:30 Departure in bus

08:30 – 13:30 **Excursion.** Heathlands at former Soviet army barracks grounds (JAR); active protection of grasslands in the Nature Reserve "Ostnicowe Parowy Gruczna", Chrystkowo – "Mennonite's House" Centre for Education and Museum

13:30 – 14:30 Lunch in Charzykowy

14:30 – 18:30 **Excursion.** Heathlands in nature reserwe "Wrzosowiska w Okonku" – Natura 2000 site PLH300021 "Poligon w Okonku"

18:30 Arrival at the hotel in Borne Sulinowo

19:30 Dinner at the hotel

Wednesday, 24 June

08:00 Breakfast

09:00 – 10:00 Presentations

9:00 **Micheline Sheehy Skeffington** Ireland's lusitanian heathers -an *Erica mackayana* perspective

9:15 **Jill Kowal** Novel delivery technique of mycorrizal inoculum for heathland regeneration

9:30 **Sarah Ann Hanrahan** *Arctostaphylos* heath community ecology in the burren, western Ireland

9:45 **Angela Taboada** Effects of increased nitrogen availability on insect predator-prey interactions in *Calluna vulgaris* heathlands

10:00 – 11:30 **Poster session** with coffee and cake

11:30 **Discussion**. The role of the Network and its relation to the European biodiversity policy

12:45 Lunch at the hotel

14:00 – 19:30 **Excursion.** Heathlands of Borne Sulinowo military area

19:30 Arrival at the hotel in Borne Sulinowo

20:00 Dinner at the hotel

Thursday, 25 June

07:30 Breakfast

08:30 Departure in bus

08:30 - 13:00 **Excursion.** Tuchola Forest National Park and Biosphere Reserve: Heathland in Drzewicz; Forest District Laska

13:00 Lunch

14:00 – 19:00 **Excursion.** Visit in the archaeological reserve "Odry"

19:00 Arrival at the hotel in Ostrzyce near Szymbark

20:00 Dinner at the hotel

21:00 **Discussion**. Active protection and restoration of wet heathlands

Friday, 26 June

07:30 Breakfast

08:30 Departure in the bus

08:30 – 19:00 **Excursion**. Nature reserves "Staniszewskie Błoto" and "Bielawa"

19:00 Arrival at the hotel in Ostrzyce

20:00 Grand dinner at the hotel

Saturday, 27 June

07:30 Breakfast

09:00 **Discussion**. Ecological Services and Risks Impacts in Heathlands

10:30 Farewell and departure to Lech Wałęsa Airport in Gdańsk/Rębiechowo (arrival 11:30) and railway and bus stations in Gdańsk (arrival 12:00) or to Toruń (arrival 14.00)

Abstracts of presentations

Isabel Alonso[1], Werner Haerdtle[2]

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RESOLVING POTENTIAL CONFLICTS BETWEEN DIFFERENT HEATHLAND ECOSYSTEM SERVICES THROUGH ADAPTIVE MANAGEMENT

Climate change and consistently high nitrogen atmospheric deposition are causing changes in the ecology and physiognomy of heathland habitats which affect the ecosystem services that they provide. In this presentation we quantified how traditional management practices affect these services, but also how they could be adapted to the current conditions in order to maintain the features that visitors and wildlife value on heathlands.

Keywords: biodiversity, environmental changes, carbon storage, nitrogen leaching

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Geert De Blust

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WILDFIRES IN A HEATHLAND RESERVE; PREVENTION MEASURES AS PART OF THE MANAGEMENT PLAN

Summary. As a response to an extensive wildfire in 2011, prevention measures were included in the new management plan of the heathland reserve 'The Kalmthoutse Heide' (Belgium). These measures consist of an adaptation of the vegetation management, a restructuring of the spatial organization, an assessment of the accessibility and of the water supply. The biggest adaptations are in vegetation management that now also focusses on avoiding accumulation of fuel and favours less flammable species, and in the special organization of the reserve where a network of frequently mown corridors, tracks and roads and the further restoration of shifting dunes, lead to a partition of the area into smaller stretches that are less vulnerable to wildfires.
Keywords: heathland, wildfire, fire control, vegetation management

Introduction. Lowland heath is a semi-natural ecosystem that depends on a periodic disturbance regime that hinders spontaneous succession towards woodland, and on stress inducing environmental conditions that prevent characteristic species to be superseded by more vigorous and competitive species. During centuries and even millennia, farmers used the heath to serve in local economy, applying a variety of management measures to keep the ecosystem delivering the desired goods and services. In this respect, prescribed burning has always been an important technique. Also today, despite the shift from an area that was part of the local production system to an area that mainly supports biodiversity, controlled burning is applied to achieve the set objectives. Wildfires however, can induce major changes in heathland, due to their intensity and the outbreak in seasons when ecosystems and species are highly vulnerable. As a result, well-developed heathland turns into species poor and grass dominated communities. Authorities and site managers work hard to prevent these uncontrolled major fires.

Climate change may influence the incidence of wildfires. In the northern part of Belgium , the region we focus on, expected climate change can by 2100, result in

- a temperature rise of 1,5 to 4,4 °C in winter and 2,4 to 7,2 °C in summer;
- an increase of potential evapotranspiration in winter (from -3% to +37%) and summer (+73%);
- more precipitation in winter and less precipitation in summer (Van Steertegem, 2009).

As a result, growing conditions for most plant species may improve and productivity can rise, yielding more biomass and hence fuel. As a consequence, the risk of wildfires increases. On the other hand, milder winters also mean an earlier start of the growing season, and thus more fresh plant material in the early spring when normally there is plenty of inflammable dry litter. These conditions in turn, may lower the chance of incidences. Finally, more intense and longer periods of summer drought can again increase the risk of wildfires. It is expected that in the geographical region Flanders is part of, the latter will appear sooner than the other changes of incidence brought about by climate change (Albertson et al., 2010).

Wildfires prevention measures in the management plan of The Kalmthoute Heide. During the last decades, the heathland nature reserve 'The Kalmthoutse Heide' in the north of Belgium, was regularly hit by wildfires (see figure 1). The area of degraded and grass dominated heath increased at the cost of species-rich dry and wet heath; the habitat quality deteriorated and populations numbers of endangered species decreased. To avoid further degradation of the reserve, also in the light of climate change, appropriate measures had to be taken. Therefore, a wildfire risk reduction and control plan was prepared as part of the new 24 years management plan for the nature reserve.

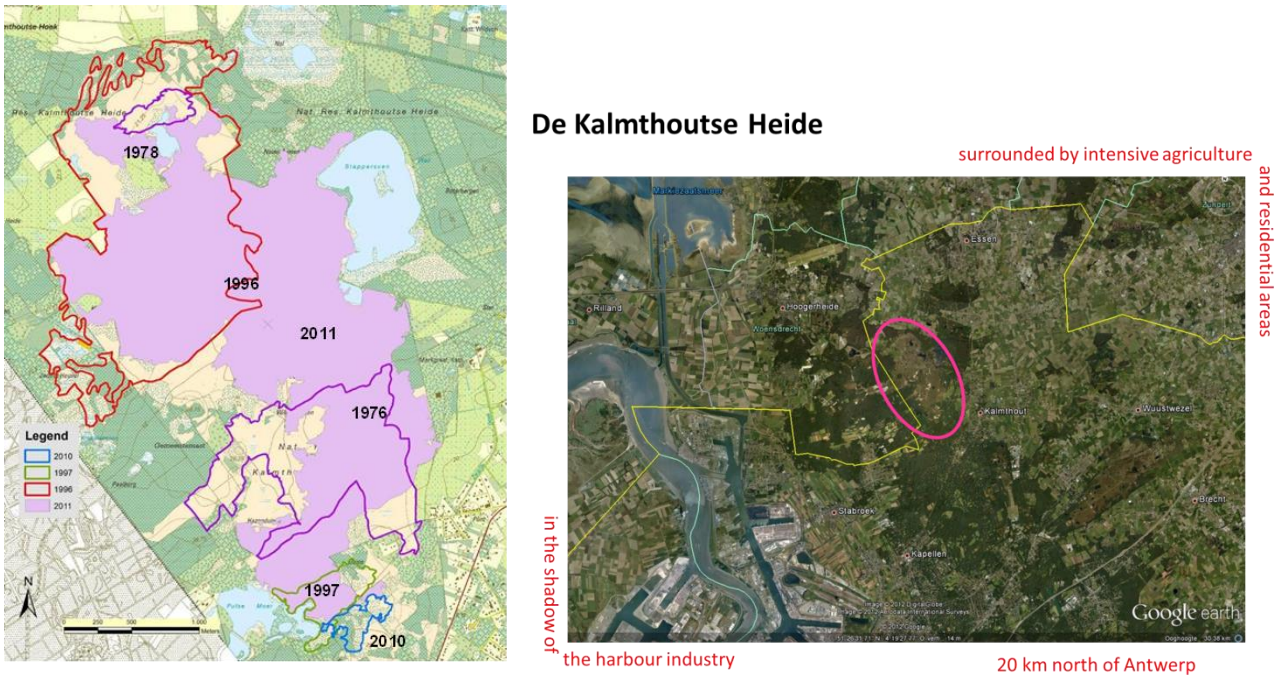

Figure 1. Position of the study area near the Belgian-Dutch border; wildfires since 1976.

The fire management plan was developed in collaboration with the site managers of the nature reserve and the regional fire service. The former brought in the different objectives that were set for the area and formulated the preconditions regarding environmental conditions, management,

organization and activities in the reserve that result from them. The fire service specified the requirements regarding wildfire prevention and control. The task was to find an acceptable balance between safeguarding the nature and landscape values, decreasing the risk of uncontrollable wildfires and ensuring safety of neighborhoods and firemen during fire-fighting.

Within the heathland nature reserve measures were taken regarding

- vegetation management
- spatial organization
- accessibility for the fire brigade
- water supply

Vegetation management. An appropriate vegetation management can diminish the risk of wildfires. The first task in this respect is the *reduction of inflammable biomass*, the potential fuel, by harvesting, thinning, mowing, grazing, or any other means that removes biomass. To achieve this, an increase of the frequency or intensity of the management is often necessary. Therefore, an assessment was made of the vulnerability to fire of the different parts of the reserve and its surroundings, and of the opportunities to intensify the management without hampering the realization of the agreed biodiversity objectives. Places where the management could not be adapted to the fire prevention requirements, because the biodiversity goals did not allow further intensification of the management (for instance development old grown dry heath with a thick litter layer), were identified. There, other measures had to be taken.

Another concern for vegetation management is *to avoid the formation of continuous and extensive layers of litter* that facilitate the rapid spread of a wildfire, or the formation of *fuel ladders*, i.e. the piling of inflammable plant material (live or dead) that allows fire to climb from the surface or the low vegetation into the tree canopy. This requirement can come into conflict with the conservation objective to develop complex and gradual transition zones between heath and forest. These zones sustain a variety of species and are of great value. At sites where complex and extensive forest edges are maintained, accompanying measures are thus implemented. Finally, management can *alter the species composition* so that *less inflammable species dominate*. This is pursued in the pine plantations which are transformed into mixed or deciduous forests and in the forest edges that are then less inflammable and resist the development of uncontrollable forest fires. These edges are at least 50m wide and are only covered by coniferous trees for 10% maximum.

Spatial organization. Broad tracks and roads, moorland pools and bare sand, divide the reserve into compartments that circumscribe the spread of a fire. The regional fire service assumes 25ha or less to

be the optimal size for such compartments. In the current situation, only 17% of the area of the reserve is composed of individual parts of this size. 21% is divided into stretches of 25-50ha, while 62% of the area has compartments of >50ha. Therefore, a new segmentation had to implemented. This was done

- through a network of broad corridors, 20 to 30m wide, that are mown annually and yield a short heath – acid grassland vegetation with hardly any litter;
- by extended verges along the tracks that are mown or stripped more frequently;
- and through the restoration of shifting dunes by removing pioneer vegetation to create bare sand.

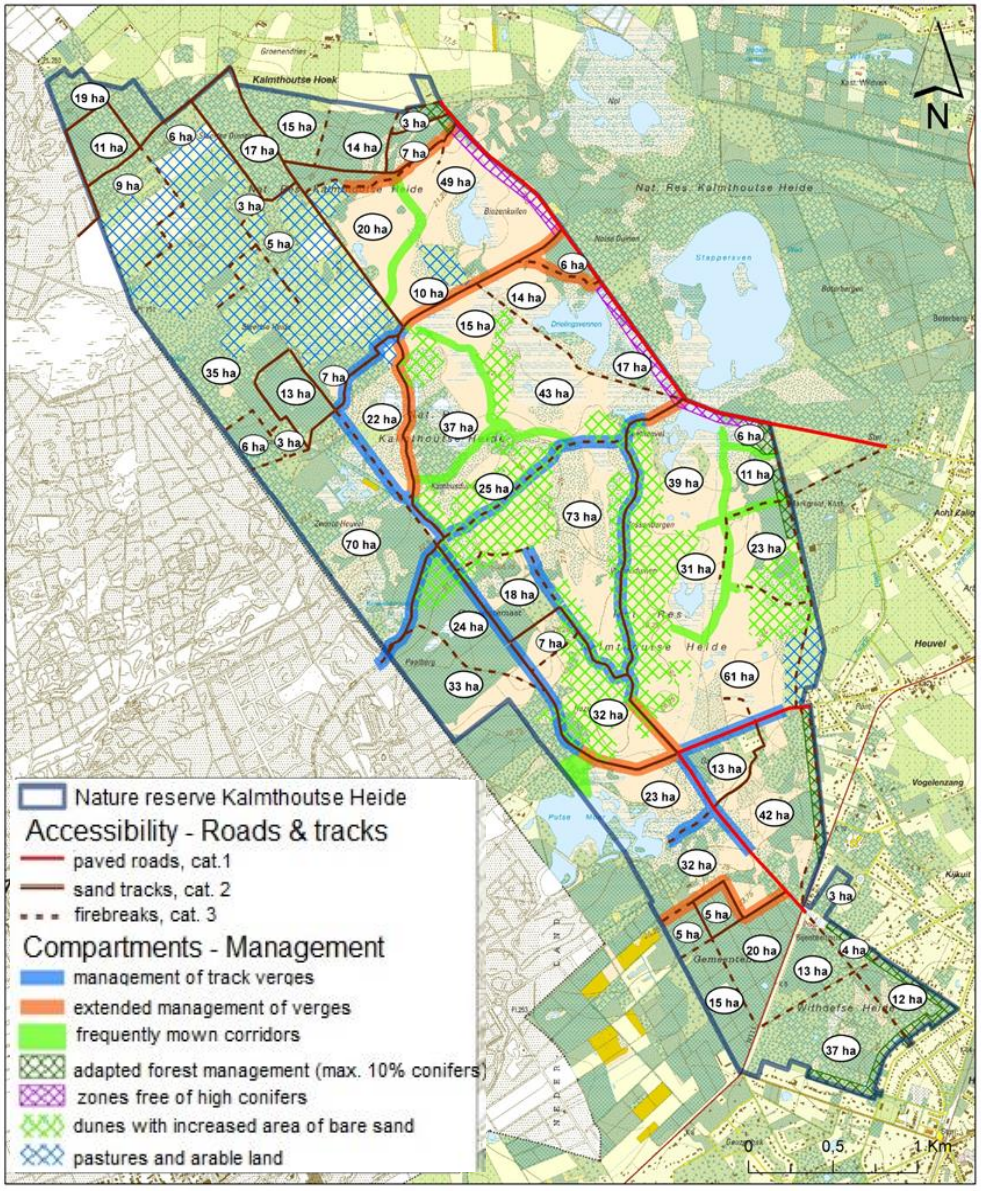

Figure 2. Accessibility and compartments for fire control

As a result, 40% of the reserve will consist of individual stretches less than 25ha each, 40% of the area has compartments between 25 and 50ha and only 20% of the area has larger sectors (see figure 2).

Accessibility. To guarantee access and safe fire control, roads and tracks are categorized in three types that together form a network (see figure 2). Paved roads (category 1) are passable in each season and suitable for the heavy fire trucks. They only occur near the main entrance of the reserve; possibilities to extent them are restricted because of the negative impact on landscape values. Broader sand tracks (category 2) must be passable with four-wheels drives during most of the year and are maintained accordingly. It is a prerequisite that they never lead up a dead end. Finally, firebreaks (category 3) are used by the four-wheels drive emergency vehicles only in case of emergency. They are less maintained and dead ends occur. It was agreed that no new tracks or roads would be constructed. Intersections of tracks and firebreaks however, will be kept free of trees (15m) to enable easy passage and access. With an appropriate management of the verges (intensified grazing, mowing), the roads may retard fires passively because of their width and make it possible for the fire brigade to fight the fire safely. For the latter, the width should be at least 4 times the maximum flame height (or 8 times the height of the vegetation) to avoid injury because of radiation intensity (Butler & Cohen, 1998).

Water supply. Guaranteeing sufficient water to suppress an emerging fire is crucial to prevent a wildfire to become uncontrollable. In our study area, this depends in the first place on good agreements with the water distribution companies operating outside the nature reserve. It is assessed whether new branch-pipes running into the reserve could be of value, or if other supplementary supply facilities such as artificial 60 m³ reservoirs could be installed (maximum 1 km apart from each other) without impacting biodiversity or the landscape characteristics. Moorland pools are excluded because they are not deep enough or because destructive tapping constructions have to be build.

Conclusion. Wildfire prevention measures must and can be included in a traditional heathland management plan elaborated collaboratively between nature conservation managers and regional fire services. More targeted and sometimes also more intensive management is required, preventing the accumulation of fuel. In most cases this is not contradictory to the prevailing biodiversity objectives. Strategically situated corridors and stretches that are managed intensively and hence have little easily inflammable litter, add to the prevention of emerging uncontrollable fires and may increase the diversity of vegetation types.

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HERPETOFAUNA AND MANAGEMENT IN FLEMISH HEATHLAND

An overview will be given of the species typical for Flemish heathlands and their distribution and status will be highlighted. Afterwards the focus will be on a few of these species in view of protection programs and management requirements.
Keywords: amphibians, reptiles, heathland, nature management

All ***herpetofauna*** in ***Flanders*** which can be associated with ***heathland*** is on the local red list. An overview of Flemish amphibians and reptiles with focus on the heathland species and their status, also in an European context, will be given.

We will illustrate habitat requirements and management measures for vulnerable typical heathland amphibians like Moor frog (*Rana arvalis*) and Natterjack toad (*Epidalea calamita).* The precarious situation and protection plan of the critically endangered Common spadefoot (*Pelobates fuscus*) will be explained.

Endangered reptiles like Smooth snake (*Coronella austriaca*) and Adder (*Vipera berus*) will be focused upon. Influence of, amongst others, military use of habitat and recreation are highlighted. We will situate the species in the context of the management plans for the Natura 2000 network and the upcoming protection plans.

Natuurpunt is a volunteer based NGO with professional staff and the largest private nature preservation and management organisation in Belgium. We manage about 20.000 hectares of nature, amongst which a lot of heathland, and we have over 90.000 families as subscribed members. About 5000 active volunteers are supported by a workforce of some 450 professionals. Our organisation is a key player in the Flemish Natura2000 network and in that capacity we have had 22 Life Projects until now, of which 7 are still ongoing.

Ingmar Gorissen

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OVERVIEW ABOUT SOME OF THE LARGEST OPEN INLAND LOWLAND HEATHLANDS FROM POLAND

number in book	name of heath-land/nearest town	location	open landscape structure (around 1993-1994)	development
29	**Oleszno**	60 km east of Szczecin between military camp of Oleszno and the road Recz – Kalisz-Pomorski)	complex of former farming area, dry & wet grassland, *Phragmites*-bogs and small lakes, parts with *Calluna*, *Calamagrostis*, *Corynephorus* > **3.000 ha** (**but only 30% heathland**)	military use; 1933-1945 German, after 1946 Polish military training area
30	**Borne Sulinowo**	40 km north of Piła, between Wałcz and Szczecinek	complex of small open areas with dry grassland (with *Agrostis* and *Calamagrostis*, parts with *Calluna* and *Corynephorus*) inside forests **< 1000 ha**	after 1933 military using, first German (”Großer Born”), after 1945 Soviet using (“Borne Sulinowo”: with tanks), after 1992 abandoned and given in the administration of the State Forests
31	**Toruń**	near Toruń	one of the largest dune komplexes!; *Calluna*, *Avenella*, *Calamagrostis*, *Corynepho-rus*, dry sand areas. **3.500 ha**	before 1900 military using (German “Fußartillerie- und Schießplatz Thorn”, since 1918 Polish, future (after 2015) also
32	**Biedrusko**	near Poznan	not very poor soils; mostly *Sarothamnus*, parts with *Calluna*, *Calamagrostis*, *Corynephorus*; wet grassland (with rare orchids) **1800 – 2000 ha (but only 500 ha area poor soils)**	before 1900 military using, first German, since 1918 Polish, future (after 2015) also
45	**Żagan**	south of Żagan	Dry sand area, parts with *Calluna* and *Calamagrostis* **1600 ha**	after 1945, first Soviet using (tanks, shooting), since 1990 Polish using
46	**Swietoszów**	between Zagan and Bolesławiec	Large dunes; dry and wet sand & wet heath areas (> 200 ha!) (*may be the largest area of wet heathland in inland Poland*), former small lakes **> 3500 (4000) ha**	after 1933 military using, first German (“Neuham-mer”), later Soviet. Since theme one of the largest training areas in Central Europe. Since 1990 Polish using
47	**Sandomierska**	between Sandomierz and Rzeszow	dunes and dry sand area, large parts with *Calluna*, *Corynephorus*, *Calamagrostis* **> 2500 ha**	before 1918?, actually Polish using
48	**Janowskie**	between Sandomierz and Janow Lubelski	dry sand area; central part with dunes, large parts with *Calluna*, *Corynephorus*, *Ca-lamagrostis*, smaller parts with *Sarothamnus* and wet heath, **around 1300 ha**	before 1945?, actually Polish using (so sometimes “U.N.O”-Training area)

(from the book: “Die großen Hochmoore und Heidelandschaften in Mitteleuropa“; Ingmar Gorissen, 1998)

Sarah Ann Hanrahan, Micheline Sheehy Skeffington

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ARCTOSTAPHYLOS HEATH COMMUNITY ECOLOGY IN THE BURREN, WESTERN IRELAND

Arctostaphylo-Dryadetum is a rare sub-type of Alpine and Boreal Heath which is known to occur only in Ireland on the limestone karst Burren, in County Clare. Relevés were taken across the Burren region and three groups were distinguished: *Empetrum nigrum* group; *Erica cinerea* group, *Juniperus communis* group. Altitude and soil conditions were found to be the main ecological factors responsible for the variation in the data set, especially pH, and the organic and mineral content. Winter grazing appears to maintain this habitat. In some areas *Calluna vulgaris* has encroached on the rarer plant species cutting trials are underway in an attempt to restore the habitat to good conservation status.

Keywords: Alpine heath, *Arctostaphylos uva-ursi, Empetrum nigrum,* environmental variables, plant community

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WHAT RESTRICTS GENERATIVE REJUVENATION OF *CALLUNA VULGARIS* IN CONTINENTAL, DRY HEATHLAND ECOSYSTEMS: SEED PRODUCTION, GERMINATION ABILITY OR SAFE SITE CONDITIONS?

Seed production and germination ability of over-aged *Calluna* individuals are not limited in continental heathlands and thus not responsible for restricted generative rejuvenation. Free-range grazing with large herbivores combined with cutting of over-aged *Calluna* stands support the generative rejuvenation due to the creation of safe sites for seedling establishment.

Keywords: disturbance, free-range grazing, germination, management, seedling establishment

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THE INFLUENCE OF BURNING AND MULCHING ON SAND HEATH BIRDS IN SPA COLBITZ-LETZLINGER HEIDE

The active military training ground in SPA Colbitz-Letzlinger Heide is one of the largest heathlands in Germany and is of national importance for typical sand heath birds like the hoopoe, nightjar and tawny pipit. The processes of mulching and burning are strategies to maintain areas. One aim of this current study is to reveal the influence of these management strategies on sand heath birds.

Key words: sand heath birds, military training ground, burning, mulching

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WANDERING SHEPHERDS - A BEGINNING PROFESSION IN DENMARK

Until about 200 years ago, sheep grazing on the heathlands of Jutland was organized by professional village shepherds. During the 19th century this system gradually dissolved, and since then this has been a forgotten knowledge in Denmark.

J.F. Vermehren: *Shepherd in Jutland 1855.*STATENS KUNSTMUSEUM, DK.

On Lystbækgaard in Western Jutland, *Berit Kiilerich* - educated shepherd in Scotland – is revitalizing the old tradition of heathland sheep grazing led by shepherds. She owns approximately 700 ewes and 300 young sheep that are used for grazing on heathlands and other types of nature needing management by grazing. She works together with *Geesje Aaltje Jonker - van der Iest* (Geeke from Nederland), who has studied nature in Holland and formerly has worked on a diary farm. She has been educated to be a shepherd by Berit. Together they have trained 5 year old *Mollie* to be a talented and skilled sheepdog. Together with the sheepdog the shepherd is able:

• Effectively to move the sheep flock between different pastures.

• To regulate the grazing pressure in accordance with the condition of the vegetation.

• Temporarily to avoid harmful grazing of special biotops.

• Move the sheep into a trailer.

In addition the shepherd must be able to:

• Set up and remove the mobile fences.

• Overview sheep health.

• Shear the wool.

• Cut the hooves.

• Evaluate the need of grazing in different types of vegetation.

Geeke moves the sheep along the roads and paths from one fence to another. The flock size is 3-400 sheep. The shepherd takes the lead and the dog is behind and keeps the flock together.

Photo: Annette Rosengaard Holmenlund

Controlled sheep grazing by wandering shepherds. In 2012, Geeke and Berit started to make a system of controlled sheep grazing by *wandering herding*. The sheep grazing takes place in different areas during the day, and the flock is herded back into the night-fence in the end of the working day. The sheep effectively eats unwanted plants, when the shepherd guides them to i.e. pine *(Pinus)*, aspen *(Populus)*, purple moor grass *(Molinia coerula)*, birch *(Betula)*, willow *(Salix)*, black cherry *(Prunus serotina)* and *Rosa rugosa*.

Shepherd's daily life:

8.00-8.30 The sheep health is overviewed for - especially foot injuries, occasionally worms.

8.30-9 The sheep are let out of the night fence and come with Geeke and dogs out to today's current grazing piece. They are allowed to eat a little along the way- but moving on.

9-11 Controlled grazing, where the sheep are pressed to eat selected plants.

11-14 Free grazing nutrient-rich areas, with constant movement- no rumination. The sheep are at work.

14-15 An hour's rest for sheep and shepherd. The sheep are allowed to spread. The shepherd eat the rest of her lunch pack or take a nap while the sheep eat. The grazing of the day is noted. Often the shepherd puts pictures on Facebook especially if she has found some really exciting plants or wild animals.

15-16 Shepherd leads the sheep into the night fence. Here is the water and minerals. She checks the health of the animals. Fences, power and water is checked before she goes home.

In the weekends the shepherd is free. However somebody must look after that the sheep stay in the mobile fences.

Photo: Annette Rosengaard Holmenlund

During the winter there is not enough food in the heathlands in their present condition, and the sheep has to graze in temporarily fenced grazing fields or cutting fields that get a much better quality after the sheep's winter grazing.

Geeke started this year the training of her young border collie Donna. Geeke, Mollie and Donna will make a great future grazing 500 ha of heathlands with 400 sheep in Western Jutland. Sometimes an extra shepherd is hired. Here they wander from late March to October. They will educate more shepherds and dogs on their way. In the future Berit needs at least 3 shepherds to maintain the available heathlands in good conditions.

• A very important experience is that “old” heathlands should be burned before grazing to make the best biodiversity.

• Control of Rosa Rugosa is very efficient using wandering shepherd- a great perspective in DK.

Needs in order to expand the use of wandering shepherds

• Education of shepherds learning new skills of wander shepherding.

• Proving nature value of controlled grazing

• Inform the decision makers about the system of wander- shepherding.

• Investment in sheep and equipement

• Breeding more nature sheep (Norweigian – short tailed sheep)

Table 1. Development in number of specialized nature Ewes at Lystbækgaard

year	Nb of ewes owned by Lystbækgaard	Nb of ha nature grazed
2004	300	150
2010	400	250
2013	500	350
2014	600	450
2015	700	700

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A PROPOSAL FOR A WORKING GROUP TO UPDATE THE EUROPEAN HEATHLAND MAPS

The EU-project HEATHCULT was carried out during the years 1999-2000. Researchers from 17 institutions within 8 countries participated in the project, which was directed from University of Bergen. The purpose of the project was to increase the public awareness of the heathlands as a unique cultural heritage of Europe. The project made maps of the European heathlands, produced an exhibition at EXPO2000 I Hanover, an exhibition at Landwirtschaftmuseum Lünebruger Heide, an travelling exhibition, an Internet program and a book about the European heathlands which was published in 4 languages.

Herbert Diemont at Alerna, Wageningen Universiteit en Researchcentrum was main responsible for the production of a map of the maximum extent of the heathlands around 1850 and a map on the present distribution. During the years after the project ended, we have received new information about the extent of the heathlands. We do know that there are grazed heathlands e.g. along the coast of the Baltic Sea, in the Pyrenees and even at the foot of the Italian Alps.

In parts of Europe the heathlands still are vanishing as a cultural landscape. In Norway our government has planned to plant spruce forest over large areas along the coast to reduce the CO_2-problem. I think the time has come to produce revised maps of the former and present extent of the European heathlands. In addition it could be useful to make thematic maps e.g. to illustrate different landuse (fire, wintergrasing, heather cutting etc). Military heathlands have not yet been properly mapped, and should be included.

I propose to establish a working group to improve the maps of the European heathlands.

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NOVEL DELIVERY TECHNIQUE OF MYCORRIZAL INOCULUM FOR HEATHLAND REGENERATION

Pezoloma ericae (D.J. Read) Baral, the ericoid mycorrhizal fungus of plants in the Ericales, such as heathers, also forms intracellular associations in several families of leafy liverworts (Marchantiophyta, Jungermanniales), at least *in vitro*. The ecological significance of this 'shared' mycobiont remains largely unknown. In field-simulated conditions, using *P. ericae* re-synthesized with axenically-grown liverworts, we tested whether liverworts harbouring *Pezoloma ericae* can act as inoculum that facilitate the establishment of Ericaceae - and can therefore be proposed as a practical application in a restoration ecology context.

Mons Kvamme

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WHY LISTEN TO THE OLD FARMERS? IMPORTANCE OF LIVING TRADITIONS FOR HEATHLAND MANAGEMENT

After the industrial revolution, traditional heathland farming decreased over most of Europe. Since the later part of the Neolithic, heathlands had been used for extensive livestock grazing more or less all-year-round. In order to maintain the fodder quality of the heather plant, regular controlled burning of the heathlands were implemented as an integrated part of the farming practice. In many parts of Europe, also heather mowing contributed substantial to the collection of winter fodder.

19th century changes. During the 19th century, new ideas of increased food production from the heathlands were tried out, including different types of cultivation and changing heathlands into grasslands by adding fertilisers. New kinds of livestock were introduced, demanding fodder of higher nutrient content than they could find on the heathlands. And the industrial revolution started a technological development that increased the efficiency of food production in general. In addition to these changes, the introduction of wide spread forest planting made it difficult to continue traditional heathland farming in many areas.

Early awareness rising. In greater parts of Europe the heathlands came under pressure and started to disappear due to this development. As this took place at the blooming time of the national romantic artists, we have a rich heritage from many countries of paintings and other expressions, illustrating traditional heathland life around the time of mid-1800. Over time this artistic activity contributed to an early awareness rising of the value of the disappearing heathlands. They were regarded as parts of the national natural heritage, and in countries like Germany and Denmark, heathlands were protected as nature conservation areas early in the 20th century. These protected areas were mainly preserved as nature habitats, their origin as extensively grazed farmlands was poorly understood by most conservation authorities.

Later changes in Norway. In Norway, the same modernisation of agriculture and farming as elsewhere in Europe, took place from about 1850. As most heathlands in Norway are situated in marginal areas for agriculture, they were less influenced by the 19th century farming changes than in most other countries. Furthermore, most Norwegian heathlands are maritime, and the population lived mainly from the combination of small scale fisheries and low intensive heathland farming. This type of subsistence prevailed along larger parts of the coast until mid-1900.

After the WWII, rapid economic development and the authorities' demand of higher productivity in both fisheries and farming, put an end to the traditional way of coastal living. This process had started earlier, but it was during the first two decades after the war that the continuity of traditional heathland farming stopped along most of the coast. This initiated a fast overgrowth of the heathlands by shrubs and trees, and alongside this development, the authorities supported an intensive planting of spruce (mainly *Picea sitchensis)* over large coastal areas.

Documentation of traditions. Because the knowledge of the old methods of heathland farming has survived so long as living traditions, people still remember them and they have been documented by photos, film and in interviews. For heathland conservation this documentation is of vital importance. We have the possibility to take further the continuity of heathland farming after only a few decades of break, with exactly the same methods that has been used for centuries before.

Authentic breeds of livestock. Of particular value is the fact that the authentic breed of coastal sheep, the Old Norse Breed of Out-wintered Sheep, was rescued from extinction in the late 1950's. The popular name of this breed is Wild-sheep, and it has adapted to survive all-year-round on the west-coast of Norway through several thousand years. Not only the breed itself, but also all the practical knowledge about how to handle these special animals, have survived as living traditions. The Wild-sheep has today become popular due to the outstanding qualities of its products (meat, skin, wool), and because it is far more effective than other breeds to keep the landscape open. In addition to the Wild-sheep, a small population of out-wintered coastal goats has survived, and several types of ancient cow breeds that are able to graze on the heathlands.

Heathland conservation. In Norway no areas so far have been protected as heathlands. However, some heathlands are protected because they are situated in areas that are protected for some other reason. It was first by the Nature Conservation Act of 2009 that it became possible for the environmental authorities to be involved in heathland conservation. That was 100 years later than in Germany. The main reason for why open heathlands have survived in Norway is not nature protection,

but the living traditions of farming related to them. It has also been possible until present time to receive a small support from the agricultural authorities for maintaining heathland grazing. Most heathland management in Norway has so far been payed for by the agricultural authorities because of their potentials of low intensive food production. This makes Norway different from most European countries where heathlands are protected for purely nature conservational reasons.

Biodiversity. Because of the well documented knowledge of the old methods of heathland farming, it has been possible in many studies to prove their positive impact upon the over all biodiversity, and they stimulate the germination of the seed bank in the soil. The increase in Black Grouse *(Tetrao tetrix)* populations in areas where heathland management has been revitalised by the traditional farming methods, is a nice illustration of their beneficial influence on the biodiversity.

After the industrial revolution, traditional heathland farming decreased over most of Europe. Since the later part of the Neolithic, heathlands had been used for extensive livestock grazing more or less all-year-round. In order to maintain the fodder quality of the heather plant, regular controlled burning of the heathlands were implemented as an integrated part of the farming practice. In many parts of Europe, also heather mowing contributed substantial to the collection of winter fodder.

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HYDROLOGY AND ECOLOGY: HOW NATURA 2000 AND MILITARY USE CAN MATCH

The military domain of Houthalen is a shooting area and also a protected Natura 2000 site, with an alternation of dunes, fens and heathlands. Already years ago, it was determined that the groundwater table is lowered by digging deep canals. Intensive consultation and study work (ecohydrological modeling) has shown that recovery is possible, taking into account the military use. Specific attention was paid to the accessibility through the fire roads and the water level in the fens. Recovery is started up, as well as a monitoring programme.

Keywords: groundwater dependent ecosystem, ecohydrology, wet heath, groundwater flow modeling, monitoring

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HEATHLANDS IN POLAND: TYPES, MANAGEMENT, THREATS AND PROTECTION

According to Matuszkiewicz (2007), heaths occurring in Poland may be classified into two main types of plant communities: 1 − Atlantic communities of wet heaths from the class *Oxycocco-Sphagnetea* Br.-Bl. et R.Tx. 1943 and 2 – dry heaths from the class *Nardo-Callunetea* Prsg. 1949.

The former include Atlantic communities of wet heaths occurring in oceanic climate of north-western Europe on peat and gley-podzol soils in depressions with considerable fluctuations in the groundwater level in the annual cycle. In floristic terms, the communities are characterised by a high percentage of Atlantic species, the absence of continental-boreal species and a small contribution of peat-forming tufty *Sphagnum* species.

According to Matuszkiewicz (2007), the order *Sphagno-Ericetalia* is represented in Poland by one association – *Ericetum tetralicis* R.Tx. 1937 – which comprises wet heathlands with the dominant cross-leaved heath *Erica tetralix* occurring at relatively many sites on the South Baltic Coast, as well as in the west of Wielkopolska and Lower Silesia regions. In Poland, the association reaches the absolute eastern limit of its range and is clearly floristically impoverished compared to typical Western European forms.

The latter type of heaths is represented by low-shrubs communities with the dominant heather *Calluna vulgaris* and, at most, sparsely scattered specimens of common juniper and the undergrowth of birch or pine. They occur on infertile acid podzol soils developed from loose or slightly loamy sands, usually within the influence of oceanic climate. They are an Atlantic vegetation type, particularly widespread and phytosociologically heterogeneous in the lowlands of North-Western Europe where until recently they dominated in the landscape as English “heaths”, French “landes” or

German “Heiden”. The long-term discussion on their genesis and issues related to their natural status showed that in the vast majority of cases, these are anthropogenic communities replacing forest as a result of a specific land-use method, i.e. extensive sheep and pig grazing (local breed Heideschnucken) combined with a removal of the groundcover vegetation from the soil together with raw ectohumus (Plaggenwirtschaft), repeated every few years to obtain bedding material for cattle, which is then used for fertilization of infertile sandy arable lands. The heaths in Poland are of anthropogenic origin – they develop only after coniferous or mixed coniferous forests are cut down, and consequently contribute to the intensification of soil podzolization. The Polish dry heaths are very poor in species because most of their characteristic species do not reach the western border of Poland. The majority of dry heaths occurring in Poland should be considered as an atypical borderland form of various syntaxa.

Characteristic features and the distribution in Poland, as well as threats and recommended protection forms of both types of heaths are analysed and presented after Matuszkiewicz (2007), Ciosek (2000), Herbichowa (2004), Markowski (1997) and Pawlaczyk (2004).

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FREE-RANGE GRAZING BY LARGE HERBIVORES IN DEGRADED LARGE-SCALE DRY SANDY GRASSLAND-HEATHLAND ECOSYSTEMS

Free-range grazing by large herbivores combined with one-time mowing of over-aged heathlands offers an excellent management tool to maintain and enhance biodiversity in degraded large scale, low productive, semi-open dry sandy grassland-heathland ecosystems. Grazing improves habitat quality, supports typical species communities and represses invasive species.

Keywords: year-round grazing, cattle / horses, habitat quality, foraging behaviour, *Prunus serotina*

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DEFORESTATION INCREASES DIFFERENCES IN MORPHOLOGY AND PROPERTIES OF DUNE SOILS LOCATED ON CONTRASTING SLOPE ASPECTS IN THE TORUŃ MILITARY AREA (N POLAND)

In a comparative research we investigated characteristics of soils situated on contrasting slope aspects (northern and southern) in two inland dune ecosystem types: 1. dunes overplanted with a pine production forest and 2. dunes deforested for military purposes, where for some decades natural succession has been the main driver for vegetation development. We found that afforested dune slopes were entirely occupied by Podzols slightly varying by degree of development in respect to slope aspect what clearly changed after deforestation. Removal of forest distinctly predisposed dry south-facing dune slopes for erosion, which affected in truncation of Podzols. Nowadays, deforested southern slopes are covered by regenerating, weakly developed soils – Arenosols; while conditions prevailing on deforested northern slopes preserve Podzols. Such situation implies distinct increase of primarily existing differences in characteristics of soils of opposite slope aspects such as moisture, temperature and organic carbon stocks.

Keywords: inland dunes, soils, forest succesion, heathlands, slope aspect

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WOLVES (*CANIS LUPUS*) IN THE TORUŃ BASIN (N POLAND): ACTUAL STATUS AND PROBLEMS CONCERNING THE POPULATION

The characteristics on the present wolf population of the Toruń Basin were presented in the paper. The subject was introduced in terms of main ecological issues on Canis lupus as well as current problems in man-wolf relations occurring in the region. Forests of the Toruń Basin are populated by 25-30 resident wolves which live actually in five packs. For some last seasons the predators have reproduced what is probably the main reason for stated slight increase in wolf number in the region. The major actual threats to local wolf population were indicated: pouching, car traffic and illegal off-road motor activity. In July 2014, the first for the 21st century documented wolf attacks on domestic ungulates were stated in the Toruń Basin when two unprotected from predators cow calves were bite near the Rafa village (NE of Bydgoszcz).

Keywords: *Canis lupus*, large predators, wolf recovery, forests, Poland

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IRELAND'S LUSITANIAN HEATHERS -AN *ERICA MACKAYANA* PERSPECTIVE

Erica mackayana occurs only in western Ireland and N Spain. It spreads only by cuttings. Its hybrid with *Erica tetralix*, *E. x stuartii*, is more widespread, but localised surrounding *E. mackayana.* Like *Erica erigena*, it may have been introduced from Spain by traders as packing for goods; the remote location of the sites suggests it may have arrived with smugglers.

Key words Atlantic fringe, localised distribution, NW Spain, smuggling, trade

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EFFECTS OF INCREASED NITROGEN AVAILABILITY ON INSECT PREDATOR-PREY INTERACTIONS IN *CALLUNA VULGARIS* HEATHLANDS

Summary. This study confirms that nitrogen enrichment caused by atmospheric pollution augments population numbers of the heather beetle, particularly in the degenerate phase of heather development that results from lack of management. Natural arthropod predators of the heather beetle may not act as effective control measures under future scenarios of increased pollutant levels.
Keywords: heather beetle, ground beetles, harvestmen, pollution, land use abandonment

Introduction. Very few studies have investigated how global change drivers, especially atmospheric nitrogen (N) deposition and land use changes, affect the relationship between heather plants (*Calluna vulgaris* (L.) Hull) and their main insect defoliator, the heather beetle (*Lochmaea suturalis* (Thomson, 1866)) (see Aerts & Heil 1993). This is despite defoliation by the heather beetle being recognised as an increasingly important cause of heather plant mortality and a major threat to heathlands worldwide (Scherber et al. 2013). Populations of the heather beetle periodically reach outbreak densities as high as 2,000 individuals per square meter that last two years, causing serious damage or death of heather plants, their rapid replacement by grasses, and the subsequent loss of heathland. Yet, current management advice to mitigate the heather beetle's damage is conflicting and insufficient, and limited by a number of unsolved fundamental challenges, including the understanding of the factors that trigger the outbreaks, and the development of biological control measures (Rosenburgh & Marrs 2010).

In this study, we aim to determine how N availability increased by atmospheric pollution and the age of heather plants, influence the population dynamics of the heather beetle and the control mechanisms exerted by its main arthropod predators. We hypothesised that N enrichment enhances individual performance of the heather beetle augmenting population numbers, particularly in the degenerate phase of heather development (Watt 1955), that results from the lack of heathland management, and where the heather beetle outbreaks usually start (Rosenburgh & Marrs 2010).

Materials and Methods. The study was performed in three *Calluna* heathland sites located in the Cantabrian Mountains (NW Spain; 43º02-03'N, 5º21-26'W; 1567-1653 m a.s.l.; 2-4 ha), and subjected to minimal regular free-range grazing by cattle and horses (1-2 livestock units/ha). In each site, we selected two differently aged heathland areas: (1) rejuvenated through prescribed fire in 2005, and (2) degenerate after 30-40 years of land use abandonment. We established a total of 90 2x2 m plots and performed a manipulative experiment to modify plant N availability, consisting of five different N treatments (i.e., 3 plots per treatment, age and site): 0 g/m^2yr (control), 1 g/m^2yr, 2 g/m^2yr, and 5 g/m^2yr of granules of ammonium nitrate monthly added in June-November from 2013 to 2014; and 5.6 g/m^2yr monthly added in May-October from 2005 to 2014, equivalent to the predicted N input by 2050 (Phoenix et al. 2012). In August 2014, we used pitfall trapping (one trap per plot) to collect the larvae of the heather beetle during their peak activity period, together with their main ground- and vegetation-active arthropod predators: ground beetles (Coleoptera: Carabidae) and harvestmen (Opiliones), respectively. We fitted generalised linear models (GLMs) to test for differences in the abundance (i.e., number of individuals) of the heather beetle larvae, ground beetles and harvestmen between rejuvenated and degenerate heathland areas and among the five N treatments. Abundance data were modelled following a negative binomial error distribution using the log link function. Data analyses were carried out with R software version 3.1.2 (R Development Core Team, 2014).

Results and Discussion. In total, we captured 183 larvae of the heather beetle, 331 individuals and 15 species of ground beetles, and 351 individuals and 3 species of harvestmen. Both the heather beetle larvae and the majority of ground beetle species responded significantly to the age of the heather plants and to the N treatments. As expected, higher number of heather beetle larvae was collected in plots where 5.6 g/m^2yr of ammonium nitrate were monthly added for the period of 10 years, particularly in the degenerate phase of heather development (Fig. 1). However, no consistent trend in the abundance of arthropod predators was observed, since more ground beetle individuals were significantly found in control and low-N (i.e., 1 and 2 g/m^2yr) treatment plots located in the rejuvenated heathland areas.

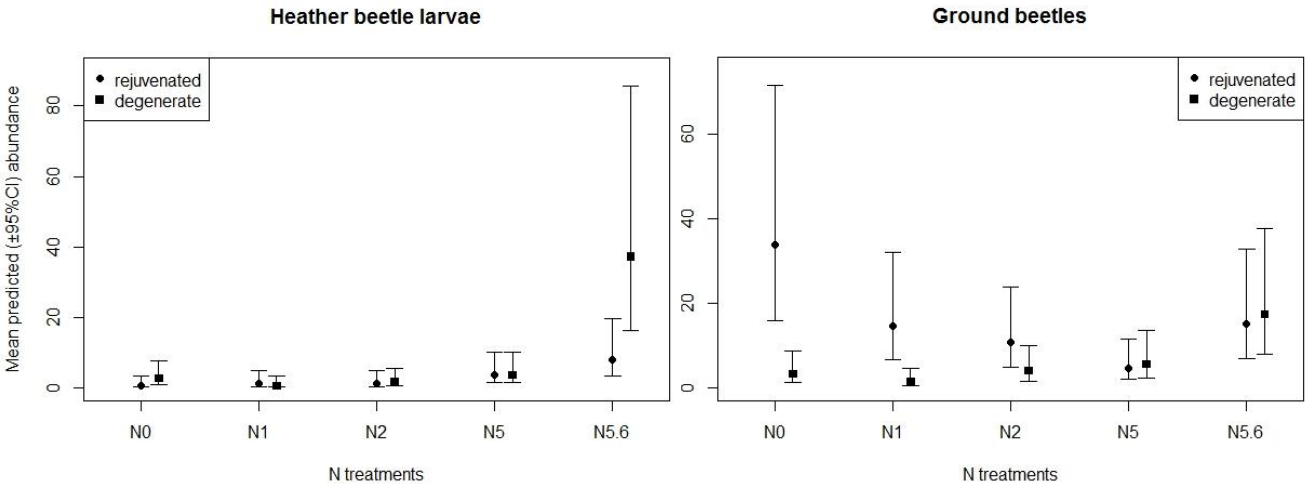

Figure 1. Mean predicted (±95% confidence intervals) number of individuals of the heather beetle larvae and of ground beetles collected at the two differently aged heathland areas and the five N treatment plots: N0=0 g/m^{2}yr, N1=1 g/m^{2}yr, N2=2 g/m^{2}yr, N5=5 g/m^{2}yr, and N5.6=5.6 g/m^{2}yr.

In the last decades, the abandonment of traditional management practices (e.g., controlled burning, turf-cutting, and grazing) used to rejuvenate heathlands, together with the enhanced loading of N due to pollution, have led to increased stress sensitivity (i.e., sensitivity to drought, frost, and defoliation) of the heather plants (Aerts & Heil 1993), and to more severe and frequent attacks by their main insect defoliator, the heather beetle (Rosenburgh & Marrs 2010). In this context, our results evidenced that numbers of the heather beetle larvae rise with the long-term experimental addition of N, possibly denoting increased levels of N in the heather plant tissues (i.e., high quality food). Furthermore, our results also suggest that natural populations of arthropod predators may not be a primary factor in the mortality of larval populations, and thus may not act as effective control measures under future scenarios of increased pollutant levels (Phoenix et al. 2012).

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PARTITIONING FLORISTIC VARIANCE IN POST-FIRE VEGETATION DYNAMICS ALONG A NORTH-SOUTH GRADIENT IN NORTHERN *CALLUNA* HEATHS

Summary. Variance partitioning shows that the four groups of variables: climate, land-use, successional stage and soil chemistry, all contribute to the floristic patterns in post-fire vegetation development. However, the groups explain overlapping variance components, and the respective contributions of the groups vary with scale.

Keywords: Prescribed burning, biogeography, scales, species richness, gradients

Introduction. The coastal heathlands of northwest Europe are classified as a highly endangered and a habitat of high conservation importance throughout their geographic range. Heathland communities have a wide distribution, and span across a strong bioclimatic gradient. This gradient includes differences in temperature and precipitation, create differences in community dynamics (Gimingham 1972) and production (Peñuelas et al. 2004), and influences land-use regimes like grazing strategies (including winter-grazing) and burning rotations (Gimingham 1992). In this study we have sampled post-fire vegetation along a biogeographic gradient in western Norway and annually over a time period of three post-fire years. We partition the floristic variance on three scales: along the biogeographic gradient (between sites), among wet and dry habitats within sites and, within local communities within sites, and ask: Are the post-fire vegetation patterns at these different scales determined by climate, land-use, soil chemistry or successional status?

The study area. The study was carried out in wet and dry *Calluna* heath vegetation in four sites (A-D) spanning a latitudinal gradient along the west coast of Norway, from 60.70° to 63.30° N. Four sites were selected to reflect a north-to-south bioclimatic gradient. At all sites, we sampled wet and dry acidic heathland vegetation, the most common heathland vegetation along the Norwegian coast.

Research methods. At each study sites, five experimental blocks, each approximately 100 m^2, were randomly positioned within wet and dry heathland stands, with the exception of site C where only dry heath was found. Within each block, two 1-m^2 plots were placed randomly and permanently marked, and floristic data recorded. The sites were experimentally burned and vegetation recorded three post-fire years (n=280). Environmental variables reflecting climate, successional status, land-use and soil chemistry (n=19) were collected. Species composition was analysed by means of partial RDAs and variance partitioning in CANOCO 4.5 (ter Braak and and Šmilauer 2002).

Results. There are four strong groups of explanatory variables in the dataset; climate (correlated with geography), land-use, soil chemistry and successional status. However, they share much of the same variation. The best ordination model illustrates that most of the compositional variation is found between sites (24.3%), and here all four groups contributes to the explained variation; climate and land-use the most. Among habitats within sites (23.1%) land-use and soil chemistry are the strongest explanatory variables. Within local wet or dry communities only a small fraction of the variation is explained (3.5%), and only soil chemistry contributes. The species composition between sites is explained by two strong gradients; climate (first RDA axis) and land-use (second RDA axis). The highest diversity is found in the southernmost site, in which also has the most intense land-use (grazing intensity). Species composition within sites is strongly influenced by fire and post-fire succession (first RDA axis) and wet vs. dry habitats (wet and dry heaths; second RDA axis). The highest diversity is found in the third (last) year after burning, and in dry habitats.

Discussion. Variance partitioning shows that all of the four groups of variables contribute to explained variance in the post-fire vegetation composition. However, the variance explained by the groups overlap, and moreover, contributions vary between the spatial scales. At the landscape level (between sites) all four groups contribute to variation in the floristic patterns, however, climate and land-use stands out as the two most important gradients determining species richness. Higher species richness in the south can be linked to warmer climate conditions, larger species pools, and to the level of land-use intensity here (intermediate disturbance hypothesis) (Rustad et al. 2001, Whittaker et al. 2001, Peñuelas et al. 2004). Fire, bare soil and soil chemistry are the most important determinants for the floristic variation between wet and dry habitats within sites. The lowest diversity is found immediately after burning, and increase throughout the years, as expected from other heathland studies. Moreover, habitat type is an important determinant for species richness within sites; favouring dry habitats in which harbour a lower cover of *Calluna* compared to wet heath the first years after fire and thus a higher number of grasses and herbs (Velle and Vandvik 2014).

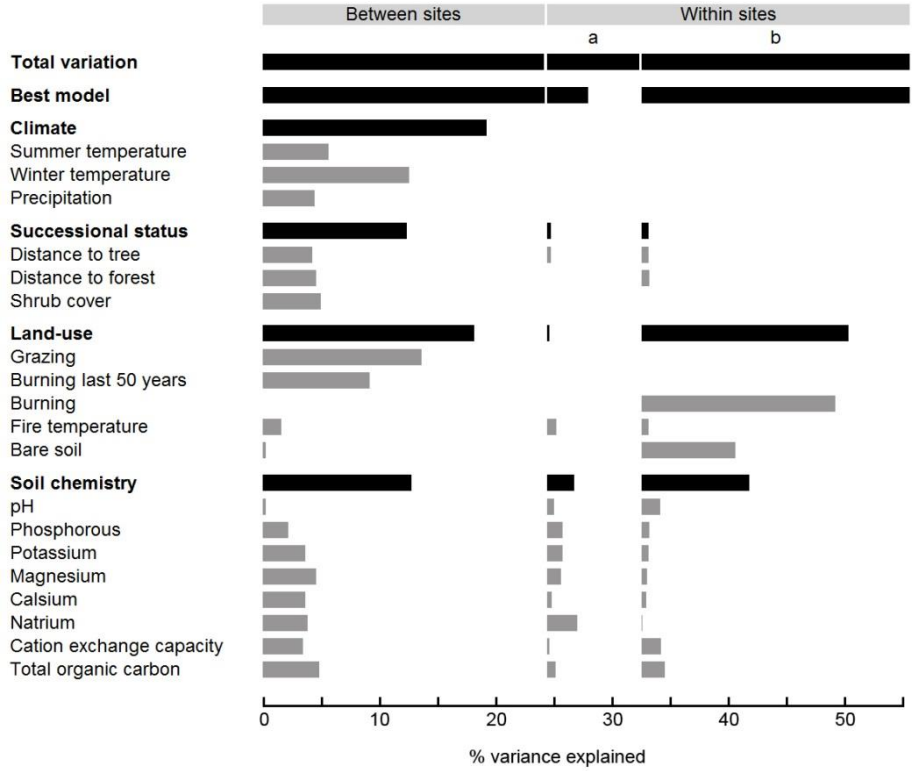

Figure 1. The amount of variance (%) in the floristic dataset explained by total variation, best model, and four groups of variables: climate, successional status, land-use and soil chemistry. The explained variance is partitioned along the biogeographic gradient (between sites), among wet and dry habitats within sites (a) and, within local communities within sites (b).

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Abstracts of posters

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EPIGEIC LICHENS OF DIFFERENT DEVELOPMENT STAGES OF FOREST GROWING ON THE HEATHLAND – PRELIMINARY RESEARCH

The study deals with the occurrence of epigeic lichens on the study plots with a varying percentage of *Calluna vulgaris* (L.) in different forest development stages on the heathland Glinki near the southern boundary of Toruń. Five plots were established in the gradient of the increasing density of pine. A total of 17 lichen species were identified, typical of this type of habitats, mainly from the genus of *Cladonia,* including e.g.: *Cladonia arbuscula, C. furcata, C. gracilis, C. uncialis* as well as *Cetraria aculeata, C. islandica,* and also *Stereocaulon condensatum* and *Trapeliopsis granulosa*. Two species, i.e. *Cladonia digitata* and *C. portentosa* occurred only on the heath.

Keywords: heathlands, afforestation, lichens, epigeic lichens, dry grasslands

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MATERIALS FOR BIOTA OF LICHENS AND LICHENICOLOUS FUNGI IN THE MILITARY AREA NEAR TORUŃ, POLAND

The paper presents the first species list of lichens and lichenicolous fungi found and identified in the artillery training area located near the city of Toruń. Lichenological studies were conducted in that area in 1998-2001 and 2009. A total of 100 taxa were identified, including 4 species of lichenicolous fungi, with particular emphasis on epigeic lichens – mainly from the genus *Cladonia* and *Cetraria* associated with heaths and arenaceous grasslands. The identified lichens include some threatened and protected taxa, i.a. *Bryoria subcana*, *Cetraria islandica*, *Physconia distorta*, *Peltigera canina*, *P. polydactylon*, *P. praetextata*, *Ramalina fraxinea*, *Stereocaulon condensatum.*

Keywords: military area, dry grasslands, heathland, lichen biota, threat, protection

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THE ROLE OF PRESCRIBED FIRE IN THE PROVISION OF REGULATING ECOSYSTEM SERVICES OF SPANISH HEATHLANDS

We provide a synthesis of evidence of the effects of burning and N deposition on the provision of regulating ecosystem services of Cantabrian heathlands (NW Spain). We quantified carbon sequestration in litter, above and belowground biomass, root and soil compartments in heathlands after burning and burning plus N fertilization.

Keywords: Carbon sequestration, prescribed burning, nitrogen deposition, Cantabrian Heathlands

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SHORT-TERM EFFECTS OF NITROGEN DEPOSITION ON MICROBIAL BIOMASS IN *CALLUNA* HEATHLANDS NW SPAIN: CRITICAL LOADS

We evaluate the short-term effects of different N deposition loads on nutrient dynamics of soil microbial biomass in Cantabrian heathlands. A surplus of 10 kg N ha^{-1} y^{-1} in these heathlands increases soil microbial biomass N in old *Calluna*, while a surplus of 20 kg N ha^{-1} y^{-1} was needed in young *Calluna*. The increase in atmospheric N deposition showed no change in C content. This caused a decrease in C:N ratio with the highest N deposition loads and a dominance of bacterial biomass.

Keywords: *Calluna vulgaris*, Cantabrian heathlands, N critical loads, soil microbial biomass, C:N ratio

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CHANGES IN THE ORGANIC CARBON RESOURCES IN SUCCESSIVE FOREST DEVELOPMENT STAGES ON DUNES IN THE TORUŃ BASIN

One way to prevent the growing carbon dioxide amount in the atmosphere consists in afforestation of forest wastelands such as: heaths, peat bogs, swamps. Replacing such ecological systems by planting them with trees allows to increase the afforested area and, at the same time, to increase the accumulation of organic carbon in the plant biomass. The growing contribution of forest stands may lead to natural restoration, mostly by self-seeding.

This study determined changes in the organic carbon resources at the following stages of the natural succession occurring on heaths. The changes were compared with values obtained for the pine cultivation developed from artificial afforestation of the inland dune. The study was conducted on the heathland near the southern boundary of Toruń. Four plots were established in the gradient of the increasing density of pine. The second object of the study was an artificial pine cultivation established on the suburban inland dune (Zadroże Dune). The heather was preserved in abundant quantities in places where wilding pine trees occurred in small numbers (plot I), whereas in places with older self-sown plants (plots III and IV), the heath covered only a small part of the study area, beneath the canopy gaps allowing greater sunlight penetration. The artificial forest cultivation established on a dry habitat with trees three times older compared to self-sown pines on the heathland accumulates similar amounts of carbon in the biomass. The performed analysis showed that there are no significant differences in the carbon resources accumulated in the artificial and well-developed forest ecosystem (ca. 108.30 t Corg./ha) compared to carbon resources in the naturally developing area (plot IV; 94.61 t Corg./ha).

Key words: afforestation, *Calluna vulgaris*, forest cultivation, heath, inland dunes, Toruń.

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LIVERWORTS TO THE RESCUE: AN INVESTIGATION OF THEIR EFFICACY AS MYCORRHIZAL INOCULUM FOR VASCULAR PLANTS

Summary. *Pezoloma ericae* (D.J. Read) Baral, the ericoid mycorrhizal fungus of plants in the Ericales, such as heathers, also forms intracellular associations in several families of leafy liverworts (Marchantiophyta, Jungermanniales), at least *in vitro*. The ecological significance of this 'shared' mycobiont remains largely unknown. In field-simulated conditions, using *P. ericae* re-synthesized with axenically-grown liverworts, we tested whether liverworts harbouring *Pezoloma ericae* can act as inoculum that facilitate the establishment of Ericaceae - and can therefore be proposed as a practical application in a restoration ecology context.

Methods. Fungi isolated from leafy liverwort rhizoids of *Cephalozia connivens* and *C. bicuspidata*, and the hair roots of *Erica tetralix* and *Calluna vulgaris* were confirmed to share the same mycobiont, *Pezoloma ericae*, through molecular analysis. Using *P. ericae*, nursery trials were conducted experimenting with treatment regimes at different stages of plant establishment. Plants were propagated in nutrient-poor, sterilized peat-sand mixes. Fungal colonization, germination/rooting, and plant survival under stress were assessed, and plant growth response variables were measured.

Results. The experiments demonstrated fungal symbionts emanating from leafy liverwort rhizoids, repeatedly colonized the ericoid hair roots forming typical ericoid mycorrhizal fungus coils in both seedlings and cuttings. Plant establishment with cuttings was more successful when plants were co-planted with liverworts containing *P. ericae*. Seed germination was not affected by inoculation. Plant biomass growth increased significantly, but was initially suppressed by inoculation due to an initial cost of forming the symbiosis. *Erica tetralix* was more responsive to inoculation than *Calluna*.

We demonstrate that liverworts harbouring *P. ericae* can act as inoculum that facilitates the establishment success of heathers. We propose liverworts can contribute towards a practical solution in a restoration ecology context in some habitats, particularly under environmental stress. Field studies in have commenced in two British lowland heathlands.

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SOIL-PLANT RELATIONSHIP IN *CALLUNA* HEATHLANDS SEVEN YEARS AFTER BURNING AND NITROGEN DEPOSITION

We study changes in the relationship between soil nutrient content and plant species richness in *Calluna* heathlands after seven years of experimental burning (B) and nitrogen fertilization (N). Our results indicate that both the treatments (B, N, B+N) and soil characteristics (total N, available Na, and C:N ratio) caused a significant increase in plant species richness.

Keywords: *Calluna vulgaris*, Cantabrian heathlands, nutrients, richness

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AFFORESTATION OF HEATHLANDS AND ITS INFLUENCE ON THE LAND COVER, ACCUMULATION OF PLANT BIOMASS AND ENERGY FLOW IN THE LANDSCAPE. AN EXAMPLE FROM ZABORSKI LANDSCAPE PARK

In the mid-19th century, the sheep industry played a considerable part in sheep breeding in Pomerania. Livestock grazing took place on extensive heathlands developed as a result of land deforestation performed in the 17th and 18th century, as well as during and after the Napoleonic wars. The sheep industry and the related textile craft developed until the 1890s when the Prussian government began the restoration of forests after the period of their excessive exploitation. The Prussian government policy contributed to the afforestation and the growing forest range through purchasing of landed estates, in particular the Polish ones, and creating forest divisions, followed by reconstruction of forests.

This work presents the history of the Widno estate belonging to Mr. Konstanty Przytarski. The estate was located in the northern part of the present-day Zaborski Landscape Park, near the town of Brusy and Chojnice. In 1894, the estate was sold to the Prussian forest administration.

The paper presents changes in the land use and the forest above-ground biomass. Furthermore, changes in the structure of the energy flow network through the natural and production-cultural subsystems are presented. The network structure was analysed according to the methodology presented by H. T. Odum. Data contained in the sales contract of the Widno estate were used in the analysis, together with a forest inventory book of the Prussian Forest Inspectorate Zwangshoff and inventory books of the Polish Inspectorate Przymuszewo.

The study highlighted the increasing role of sheep breeding on small family farms established by employees of the forest division on the leased lands.

This form of activity refers to the economic traditions in the region of Zabory.

Keywords: ecological history, forestry, landscape structure, network analysis, sheep-farming, forest-stand biomass, Pomerania.

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SMALL-SCALE HEATHLAND RESTORATION: CONFLICTING TARGETS

Heathlands, including wet and dry heath, inland dunes, Nardus grasslands, ... once covered extensive areas of Flanders. From the 19th century onwards, agricultural intensification, afforestation with *Pinus sp.* for the mining industry and expanding urban development lead to large scale habitat loss. Nowadays few large heathlands (>1000ha) are limited to a few military areas and nature reserves, while more small scale (often <50ha or less) relicts of the once widespread heathlands remain. Yet, despite facing the inherent consequences of fragmentation and isolation, these small relicts still harbor many typical species of different taxonomical groups. Hence, the conservation, restoration and expansion of these relicts to preserve the natural heritage linked to this formerly widespread landscape has always been one of the aims of Natuurpunt. It should come as no surprise that one of the first private nature reserves in Flanders was purchased in 1953 by Natuurreservaten, which later merged with De Wielewaal to become Natuurpunt, to save a heathland area which would otherwise be lost to urban development[i]. Today Natuurpunt, a non-governmental organization with 90.000 members - of which more than 6000 are actively volunteer - manages more than 20.000 hectares. Hereby we contribute to the preservation of many typical heathland species of high-conservation value like Viper *Vipera berus*, Red-backed shrike *Lanius collurio*, Ilex Hairstreak *Satyrium ilicis*, Grayling *Hipparchia semele*, Alcon Blue *Phengaris alcon*, … amongst many others. Being a non-governmental organization with limited funding, Natuurpunt has relied on external funding as the LIFE programme (the EU's funding instrument for the environment and climate action)[ii] to accomplish her conservation targets. Since the start of the program in 1992, Natuurpunt was (co-)beneficiary of more than 30 LIFE-projects, of which many addressed the restoration of heathland habitats.

Both small and large nature reserves face comparable problems (eg increased nitrogen deposition). However, the management of small-scale reserve often faces specific problems of different origin:

- Relict populations of species with contrasting ecological preferences can occur on a small area. In dry heaths eg, the Small heath *Coenonympha pampilus* reacts positively on grazing[iii] while the Heath Rustic *Xestia agathina* on the other hand has locally suffered dramatically from grazing[iv].

- Gradients (moisture, nutrients, …) are minimal or absent, leaving vulnerable species with few alternatives in case of climatic disaster or management faults. Severe summer rains for example lead to the local extinction of Alcon blue as their host plants drowned.
- Subsidizing agencies often expect a short-term outcome of conservation measures while nature often recovers slowly. Hence, conservationists are often tempted to implement large-scale measures, even in a small area.

Fortunately, in the last decades some progress has been made to overcome several of the above-mentioned challenges. First of all, ecological research on the management consequences is no longer restricted to flora but also takes fauna into account[v]. Natuurpunt, like many practioners, now incorporates this knowledge in the implementation of large-scale conservation measures. For example, when transforming former pine plantations to heathland, large tree trunks of 4-5m are left for xylobiont beetles, solitary bees and wasps[vi], top soil removal in wet heaths is no longer carried out on large areas but preferably in a fish bone or similar structure[vii], … Unfortunately, for many species groups (e.g. moths[viii]) basic ecological information is still lacking, making it very difficult to take these groups into account in everyday management. Next, Natuurpunt adopted the innovative webtool www.waarnemingen.be since 2008. This allows observers to enter their observations for any taxonomical groups directly in the field, even with an accuracy of a few meter. This up-to-date information on local distribution now allows local site-managers to carry out restoration measures and spare the habitat of vulnerable species. Especially in small-scale reserves, mowing or grazing regimes are now adopted to the presence of relict populations of eg. Ilex hairstreak. Last, but not least, Natuurpunt has always and still is an organization run by volunteers supported by a professional team. With our social economy projects, long-term unemployed people perform high quality conservation work together with our voluntary managers. Many rare species such as Alcon blue owe their survival to the combined efforts of both professional and voluntary collaborators.

Keywords: Natuurpunt, small-scale, fauna, heath, LIFE

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ASSESSMENT OF HEATHLAND QUALITY INDICATORS USING HYPERSPECTRAL IMAGE DATA

Summary. We aimed to use hyperspectral images to map and monitor heathland habitats and their conservation status. Using an innovative approach, we obtained maps with accuracy levels on par with field mapping campaigns. The method provides insight into species composition within the habitat patches, enabling a more quantitative assessment of conservation status.
Keywords: Natura 2000, conservation status, remote sensing, monitoring, management

Introduction. Detailed and up-to-date information on the status and trends of biodiversity is indispensable for its effective conservation. It is therefore essential to map and monitor nature in a fast and cost-effective way. Field surveying is one option, but this is time-consuming and rather costly. Remote sensing, i.e. aerial and satellite imagery processing, can provide substantial added value or in some cases even provide a full alternative (Spanhove et al., 2012). The general aim of our project[1] was to develop a methodological framework to map, monitor and evaluate protected habitats and their local conservation status using hyperspectral images.

The study area. The Kalmthoutse Heide is an Atlantic heathland area situated in the north-west of the sandy Campine region in the north of Belgium. Table 1 lists the typical habitat and vegetation types in the area.

Research methods. The project's methodology is summarized in figure 1. Hyperspectral image data were obtained from the Airborne Hyperspectral Scanner (AHS-160), with 63 bands in the range 400 – 2500 nm and a spatial resolution of 2.4 m. A large set of vegetation plots (1325 in total), including measurements of habitat structure indicators, were sampled and analyzed with multivariate statistics. This resulted is a classification scheme (table 1) used for the land cover and vegetation classification.

[1] Habistat (2006- 2011), executed by a consortium of the Flemish Institute for Technological Research (VITO), INBO, Alterra Wageningen (NL) and the Universities of Antwerp and Brussels. Financed by the Belgian Science Policy Office (BELSPO) under contract no. SR/00/103 (STEREO II program).

These vegetation cover maps then served as input for spatial structuring algorithms (a moving kernel-based reclassification) to build a habitat patch map. To this end rules were developed to relate land cover composition (in %) to the targeted habitats. Combined analysis of the vegetation cover maps and the habitat patch maps allowed for a quantitative assessment per habitat patch of several relevant indicators of heathland conservation status (e.g. encroachment by *Molinia caerulea*, *Campylopus introflexus*, cover of bare sand, etc.) (see Haest et al. (2010) for a more detailed account of the methodology).

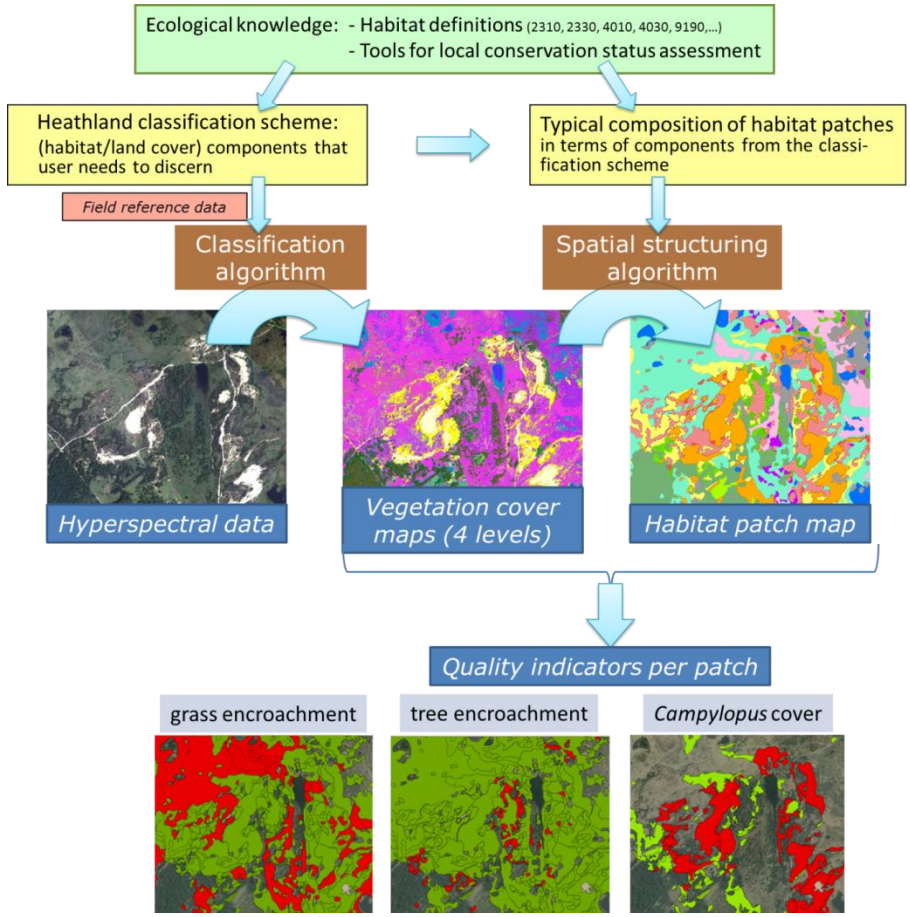

Figure 1. Synthesis of the methodology and some map results

Results and discussion. Table 1 shows the result of the vegetation analysis used as input for the classification of the hyperspectral images. Level 1 or 2 corresponds with the Natura 2000 habitat types while level 3 and 4 are linked to indicators of the habitat conservation status.

For the levels 1 to 3 the results of the image classification (see examples in figure 1) turned out to have similar accuracies as field mapping of predefined vegetation types (88 – 100% of pixels with a validation plot are correctly classified for most of the classes of the scheme). Level 4 had sometimes lower accuracies (e.g. 40 - 60% for age classes of *Calluna*), but e.g. the classification of pixels with the invasive alien species *Campylopus introflexus* had a high accuracy (80 – 92%).

Table 1. Simplified classification scheme (excluding grasslands and arable land), with reference to the Natura 2000 habitat types (*HT*)

Level 1	Level 2	Level 3	Level 4
Heathland	Dry heathland *HT: 2310 (4030)*	Calluna dominated heathland	*Calluna* -stand of predominantly young age
			Calluna-stand of predominantly adult age
			Calluna-stand of predominantly old age
			Calluna-stand of 2 or 3 mixed age classes
	Wet heathland *HT: 4010*	*Erica*-dominated heathland	*Erica*-dominated heathland
	Grass-encroached heathland *Mostly HT 4010, but also 2310 (4030)*	*Molinia*-dominated heathland	*Molinia*-stand on dry soil
			Molinia-stand on moist (wet) soil
Sand dune *HT 2330*	Bare sand	Bare sand	Bare sand
	Fixed sand dune *HT 2330*	Sand dune with grasses as important fixators	Sand dune fixed by grasses and mosses
		Sand dune with mosses as dominating fixators	Fixed sand dune with predominantly *Campylopus introflexus*
			Fixed sand dune with predominantly *Polytrichum piliferum*
Water body	Oligotrophic water body	Shallow, vegetated oligotrophic water body (banks of pools)	Shallow, vegetated oligotrophic water body (banks of pools)
		Unvegetated (deep) oligotrophic water (centre of pools)	Unvegetated (deep) oligotrophic water (centre of pools)
Forest	Coniferous forest	Pine (*Pinus* sp.) forest	Corsican pine (*Pinus nigra laricio*)
			Scots pine (*Pinus sylvestris*)
	Deciduous forest	Birch (*Betula* sp.) forest	Birch (*Betula pendula/pubescens*)
		Oak (*Quercus* sp.) forest	Pedunculate oak (*Quercus robur*)

The heathland habitat types and their quality indicators are to a large extend determined by dominance ratios of a limited number of plant species. The innovative idea of the project was to first map dominant plant species at a very detailed scale, and then to rearrange this into habitats, taking into account the spatial arrangements. This also gave insight into species dominance and composition within the habitat patches, enabling an assessment of their conservation status.

The project achieved substantial scientific progress in hyperspectral image analysis, while at the same time producing the most detailed maps on habitat distribution and conservation status that exist for Kalmthoutse Heide. With one pixel on the maps corresponding to 2.4 m on the ground, a level of detail was reached that is beyond the practical capabilities of traditional field surveys.

The site managers of Kalmthoutse Heide showed great interest in the results. By combining the final maps with their own management records, they were able to assess the effects of different measures (sod cutting, mowing, grazing) on different time-scales, and to identify areas where new or more intense measures are needed to counteract undesirable developments. The full strength of the approach will however only be achieved when comparisons on a longer time- and spatial scale can be made. Therefore, VITO and INBO continue to develop this method into a cost-effective and widely applicable monitoring tool for heathland habitats in Flanders and even in Europe.

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POTENTIAL OF ROCK FLOUR ADDITION TO COUNTERACT ACIDIFICATION OF HEATHLAND ECOTYPES – AN OVERVIEW OF RESEARCH INITIATIVES IN THE NETHERLANDS

As a result of extreme soil acidification during the last century, a substantial amount of minerals in the soil of Dutch pleistocene sandy ecosystems has been lost due to accelerated weathering. These minerals play a key role in maintaining soil buffering capacity, (micro)nutrient supply and organic matter development in the soil and ultimately, govern patterns and processes in aboveground biota. Due to increased loss of these minerals, fundamental soil functions such as buffering capacity and micronutrient regulation have been deteriorated. Consequently, weakly buffered habitats in North-west European lowland sandy landscapes have suffered severe losses in biodiversity, both in plants and animals.

Due to the European implementation of strict environmental legislation schemes, acidifying deposition has declined considerably. The loss of soil silicate minerals as a result of acidification however, is not restored by simply reducing acidic inputs. Measures to restore soil buffer capacity have mainly focused on exchangeable calcium and magnesium by means of addition of lime (which contains $CaCO_3$; CaO; $MgCO_3$ and MgO). Liming has been successful in increasing the soil buffer capacity, resulting in suitable conditions for characteristic vegetation of weakly buffered habitats. Liming,

however, can only be executed with measures aimed at removing a large fraction of soil organic matter, due to the risk of accelerated mineralisation resulting in eutrophication.

A novel method to restore soil buffer capacity is by adding finely ground igneous or metamorphic rocks (rock flour). These minerals are potentially able to slowly release soil base cations as well as other (micro)nutrients, without the risk of accelerated mineralisation. Another advantage of rock flour addition is that it is possible to restore the mineral composition that resembles the original mineral composition of the soil, which differs considerably on a regional scale, even in a small country such as The Netherlands.

In The Netherlands, several research and demonstration projects with rock flour addition in heathland habitats have been initiated. These projects together encompass an interdisciplinary approach in restoration ecology, connecting the fields of soil biogeochemistry, plant and animal ecology, food web studies and geology. This integrative approach makes these projects highly innovative. In this poster presentation, we will present an overview of the current state of knowledge, methods and research questions of the Dutch rock flour projects.

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