ABANDONMENT OF SOD-CUTTING MAY CAUSE LOSS OF CHARACTERISTIC HEATHLAND COMMUNITIES - THE CASE OF A MILITARY TRAINING AREA IN THE NETHERLANDS

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ABSTRACT - Dry lowland heathlands in north west Europe belong to the *Genisto anglicae-Callunetum* Tüxen 1937. This dwarfshrub community has declined over the last century in most of its area, mainly caused by land reclamation. Recently, the main thread of the *Genisto-Callunetum* is grass-enchroachment. Traditional management consisted mainly of sod-cutting, burning, mowing and sheep grazing, but recently sod-cutting is abolished in many Dutch heathlands, mainly due to financial drawbacks. In 2002/2003, we studied changes in the area of dwarfshrub communities and grass swards and changes in floristic composition on military training area Balloërveld after abandonment of sod-cutting in 1994. The area of dwarfshrub communities increased since 1993, probably due to sod-cutting in 1994. Species composition of the *Genisto-Callunetum* on the Balloërveld changed considerably. Most obvious is the increase of the pleurocarpous moss species *Hypnum jutlandicum*, indicating ageing of the *Genisto-Callunetum*. Discussion leads to the hypothesis that this ageing smooths the microclimate, probably leading to a decrease of characteristic (thermophilous) animal species of heathlands. Therefore, we strongly advocate to include sod-cutting in the management schema of heathlands wherever this is possible.

KEYWORDS - *Calluna vulgaris*, grass encroachment, management, monitoring, structure, succession.

NOMENCLATURE - *Vascular plants*: Van der Meijden 1996; *mosses*: Touw & Rubers 1989; *liverworts*: Gradstein & Van Melick 1996; lichens: Wirth 1995.

INTRODUCTION

The major vegetation type of dry lowland heathlands in north west Europe is the *Genisto anglicae-Callunetum* Tüxen 1937 (Tüxen, 1937; Rodwell, 1991; Pott, 1995; Stortelder *et al.*, 1996), a dwarf-shrub community which is mostly dominated by *Calluna vulgaris*. It is stressed by several authors that heathlands in this territory are semi-natural landscapes, induced by man (De Smidt, 1979; Gimingham & De

Smidt, 1983; Webb, 1986, 1998; Hüppe, 1993). Similar to the surrouding countries, the area of heathlands in the Netherlands has strongly decreased. From 1833 to 1940, the area of heathlands declined from more than 600,000 ha, representing 20% of the country, to only 100,000 ha (Beijerinck, 1940, Diemont, 1996). In 1990, from this area only 36,000 ha had left (Van der Meij & Van Duuren, 2000). Dry heathlands have a high conservational value, and are recognised as a priority habitat in the Annexes of the European Union's Directive on Habitats and Species.

Recently, the main thread of the *Genisto-Callunetum* in north west Europe is grass-encroachment (Berdowski & Zeilinga, 1987; Heil & Diemont, 1983; Biermann *et al.*, 1994; Marrs & Britton, 2000; Britton *et al.*, 2000), resulting in species-poor, dense swards of *Deschampsia flexuosa* in dry and nutrient poor environments and *Molinia caerulea* in somewhat moist and nutrient richer environments. Grass encroachment is considered to be a natural succession phenomenon, although it is promoted strongly by aerial nitrogen deposition (Heil & Diemont, 1983; Terry *et al.*, 2004). Management of heathlands is focussed on decreasing grass heaths and increasing the area of dwarf-shrub communities like the *Genisto-Callunetum*, mainly by the use of traditional management methods like sheep-grazing, mowing, burning and sod-cutting (Webb, 1998). Due to financial drawbacks (Anonymous, 1988) and a change in nature management philosophy favouring 'naturalness', sod-cutting in the Netherlands became in disregard in many heathland areas recently, and replaced by free-ranging herbivores, mainly cattle and horses. The effects of abandonment of sod-cutting and the introduction of free-ranging herbivores are hardly studied. Bokdam & Gleichman (2000) concluded from a study in the central part of the Netherlands that grazing with free-ranging cattle combined with tree cutting appears to be a suitable management regime for the maintenance of open heathlands. They showed that the result is a grass-heather mosaic, with small patches of dwarf-shrub communities. What remains unclear is the effect of the abandonment of sod-cutting on the floristic composition of the dwarf-shrub community.

In this paper we describe the changes in area, floristic quality and internal structure of the *Genisto-Callunetum* under a management regime of mowing and sheep-grazing after abandonment of sod-cutting on the Balloërveld, a military range in the northern part of the Netherlands. This study was part of the regular monitoring program on military training areas for the evaluation of conservation management. The underlying research question was whether the management regime was adequate to conserve the typical community of dry heathlands. Obviously, this question not only addresses the botanical component of heathlands, but also the faunistic. This paper has a botanical focus; however, we will substantiate the faunistic relevance of the results.

METHOD

Study area

The Balloërveld (367 ha) lies 10 m above sea-level and is situated 5 km east of Assen (53°00'N, 06°40'S), in the northern part of the Netherlands. The soils are strongly podsolized and derived from Pleistocene aeolian sand deposits of various thickness overlaying glacial boulderclay from the Riss glacial period. Holocene driftsands occur where human influence caused degradation of the vegetation and erosion. The climate is subatlantic, with an average annual precipitation of 825 mm, and a precipitation surplus of 280-320 mm.yr^{-1}.

Since 1918, the Balloërveld is used by the ministry of defence for small-scale military exercises which were put to an end in 1999. In 1994 the vegetation of the Balloërveld was mapped by Van der Berg & Franken (1995) in the framework of MSc thesis. The vegetation mainly consisted of dry dwarf-shrub communities, belonging to the *Genisto anglicae-Callunetum* (136 ha) and sites with dominance of the grasses *Deschampsia flexuosa* and *Molinia caerulea* (124 ha). Smaller areas were covered with a vegetation belonging to the *Nardo-Galion* alliance (15 ha), the *Sperguio-Corynephoretum* and open sand (27 ha) and forest plantations (56 ha). Wet heathlands belonging to the *Ericetum tetralices* were found on 8 ha in 1994.

In 1981, year round sheep grazing was reintroduced on the Balloërveld, starting with 58 sheep of a traditional regional breed (Drenths heideschaap). Up to 1986, the herd grew to 750 sheep and 450 lambs, eventually causing overgrazing of the heathland. Therefore, the herd was decreased to a mean of 400 sheep and 280 lambs in 1986. Overnight, the flock is kept in a barn at the edge of the Balloërveld. Additional, until 1994 the management consisted of mowing and sod-cutting, but in 1994, sod-cutting was ceased. From 1994 to 1996, 5.7 hectares heathland were mown annually, from 1997 this area was increased to 7.2 hectares per year (Van Zanten, 1996).

Monitoring method

Changes in the area of the dwarf-shrub communities were studied by comparison of the vegetation structure in 1994 and 2003. Therefore, the vegetation map 1994 (Van der Berg & Franken, 1995) was transformed into a structure map with 5 categories: 'open sand', 'grass encroachment', 'heathland', 'forest', and 'other'. The vegetation structure in 2003 was mapped on a monochromatic airial photo, scale 1: 5000. All borders between polygons were checked in the field, recognising 7 categories: the category 'grass encroachment' was divided in 3 classes for management applications. Both maps were imported in a GIS for comparison of the area of the categories.

To compare the floristic composition, in 2002 62 vegetation relevés were made in dwarf-shrub communities dominated by *Calluna vulgaris*. The plots measured 3 x 3 meter, species abundances of all vascular plants, mosses, liverworts and lichens were estimated according to the modified scale of Braun-Blanquet (Barkman *et al.*, 1964), only dividing the classical '2'. Differences in species frequencies within the *Genisto anglicae-Callunetum* (GC) between 1994 (n = 72) and 2002 were tested using Chi-square statistics in the total set of relevés. In addition, frequency changes were tested in subsets of relevés, belonging to the *Genisto-Callunetum typicum* (GCt, n(1994) = 32, n(2002) = 15), the *Genisto-Callunetum cladonietosum* (GCc, n(1994) = 30, n(2002) = 31), respectively the *Genisto-Callunetum danthonietosum* (GCd, n(1994) = 10, n(2002) = 18). In the statistical evaluation, species with expected or observed frequencies less than 5 were not considered, because Chi-square statistics give less reliable results at low frequencies (cf. Kent & Coker, 2003).

RESULTS

Vegetation structure

The area of the different structure types in 1994 and 2003 is shown in FIGURE 1. The area of dwarf-shrub communities increased notably in this period from 37% to 55%. The total area of grassland and grass encroachment decreased in the same period, from 46% to 30%. Open sand showed the largest percentual decrease, from 2% in 1994 to 1% in 2003. In contrary, the forested area showed no or only little difference in between both maps.

Floristic composition

TABLE 1 comprises the floristic composition of the Genisto-Callunetum and its subassociations in 1994 and 2002. Only the species which showed a change in frequency from the 90% significance-level up are shown.

In the whole set of relevés (GC), 4 species (*Campylopus flexuosus*, *Cladonia grayi*, *Polytrichum piliferum* and *Cerastium fontanum* subsp. *vulgare*) decreased between 1994 and 2002. In this set 9 species increased, from which especially the increase of *Hypnum jutlandicum*, *Festuca filiformis* and *Cladonia macilenta* is conspicuous.

Considering the GCt, only two species show a significant change in frequency, i.e. *H. jutlandicum* and *Dicranum scoparium*. Both species occur twice as often in 2002 as in 1994, and *H. jutlandicum* in 2002 is found in all the relevés. In the CGc, three species (*C. flexuosus*, *C. grayi* and *P. piliferum*) increased significantly between 1994 and 2002 and five species showed an increase. Most of the later show an increase also in the total set, the only additional species is *Carex pilulifera*, wich increased from 43.3% in 1994 to 67.7% in 2002. In the smallest subset, GCd, three species show significant changes in frequency, from which *Molinia caerulea* and *Potentilla erecta* decreased and *Galium saxatile* increased.

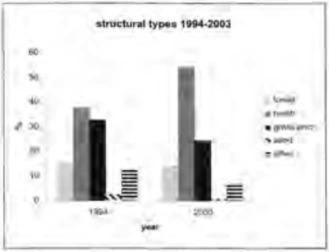

FIGURE 1 - Percentage of the area of the structural types in 1994 en 2003, as derived from the vegetation map 1994 and the structure map 2003 (see text for explanation).

DISCUSSION

Method

We evaluated changes in species frequencies over time, using Chi-square statistics. Although the location of the relevés was not randomly selected and therefore violate statistical assumptions, we believe that the method we used overcomes this problem. Because only relevés of rather species poor dwarf-shrub communities are used in our comparison, there will be no bias towards species rich and 'more interesting' communities (*e.g. Nardo-Galion saxatilis* vegetation). Furthermore, in 1994, relevés were made by two students, and it can be assumed that relevés were made without a prevailing classification scheme. In 2002 relevés were made arbitrarily and scattered over the whole area. We therefore think, the species composition of both sets reflects the species composition of the heathland community in both years adequately.

Species composition and consequences for heathland habitats

Species composition of the *Genisto-Callunetum* on the Balloërveld changed considerably over the research period. Most obvious is the increase of the pleurocarpous moss species *Hypnum jutlandicum.* It is common in Dutch heathlands dominated by *Calluna vulgaris* and considered to be a character species of the class *Calluno-Ulicetea* (Stoutjesdijk, 1959; De Smidt, 1977; Stortelder *et al.*, 1996). Despite this, *H. jutlandicum* is not evenly distributed in all phases of dry heathlands. According to several authors (Daniëls *et al.*, 1993; Biermann *et al.*, 1994) and our own observations in several heathland reserves, it has his optimum in older stages of dry heaths (later optimal and degeneration phase), where it is favoured by the relatively thick humus layer (Daniëls *et al.*, 1993;) and more or less sheltered and therefore relatively humid microclimate under old, dense *Calluna* stands (Chapman *et al.*, 1975; Scandrett & Gimingham, 1989). There is a large amount of evidence that most of the other increased species show affinities to stages of *Calluna* with a well developed humus layer. *Deschampsia* is considered to be a raw humus indicator by numerous authors (Scurfield, 1954; Stoutjesdijk, 1959; Hansen, 1974; Oberdorfer, 2001; Swertz *et al.*, 1996). On the Veluwe in the central part of The Netherlands, Stoutjesdijk l.c. associates occurences of *Galium saxatile* with *Deschampsia* heaths. Also Hansen l.c. and Oberdorfer l.c. consider *Galium* to be a humus indicating species. Like the two former species, *Carex pilulifera* and *Festuca filiformis* are characteristic for *Nardetea* grasslands, which in The Netherlands only occur on sandy soils if a humus layer has developed (Swertz *et al.*, 1996). Also Dagnelie (1965) found a positive association between soil humus content and occurrence of *Festuca.* The increase of *Erica tetralix* in GCc could probably be explained by the accumulation of humus also, since this species is more confined to sites with a somewhat better moisture regime (Stoutjesdijk, 1959; Hansen, 1974; Oberdorfer, 2001), which could be caused by humus accumulation.

Pleurozium has a ecology similar to that of *Hypnum* (Scandret & Gimingham, 1989), with which it grows often together (Daniëls *et al.*, 1993; Biermann *et al.*, 1994). Gimingham & Burse (1957) showed that mosses with a pleurocarpous growth form ('mats' and 'wefts') like *Pleurozium* and *Hypnum* increase when relative humidity increases. According to Stoutjesdijk (1959; 1977), *Dicranum scoparium* is frequent in the older stages of the *Genisto-Callunetum*. In Dutch dune grasslands, this large acrocarpous moss species can become dominant after accumulation of raw humus (Weeda *et al.*, 1996). Also in wet dune heaths, *Dicranum* shows a increase, together with other species from later successional stages like *H. jutlandicum* (Westhoff & Van Oosten, 1991). *Cladonia macilenta* is considered to be a species of decaying wood and humus containing soils (Drehwald, 1993; Biermann *et al.*, 1994; Wirth, 1995).

Three of the four species that show a decrease over the research period in the total data set are typical species from open heathlands or otherwise disturbed patches. In general, acrocarpous mosses like *Campylopus flexuosus* and *Polytrichum piliferum* have a lesser demand for humidity than pleurocarpous species (Gimingham & Birse, 1957) and can therefore grow in less sheltered habitats. *Polytrichum piliferum* is one of the first colonisers of sand and in young *Calluna* vegetation (Leach, 1931; Watson, 1981) and it is one of few frequent constituents of the *Spergulo morisonii-Corynephoretum*, the pioneer grassland association from inland drift sands (Weeda *et al.* 1996; Haveman & Schaminée, 2003), where it also is a basic component in transitional stages to the *Genisto-Callunetum* (Masselink, 1994). According to Daniëls *et al.* (1993), *Campylopus* occurs frequently in synusiae which characterise early heathland stages; in their table of the late successional *Hypnum-Pleurozium* synusia it is lacking completely. Although *Campylopus* has a high light demand, it prefers sites with high air humidity and grows often on soils with high humus content (Ratcliffe, 1968). This explains why Stoutjesdijk (1959) found this species especially on open spots with degenerating *Calluna* vegetation: these sites still have a soil profile with an intact humus layer. On the basis of own observations, *Cerastium fontanum* ssp. *vulgare* can only be found in heathlands in disturbed patches, e.g. near rabbit warrens. The fourth species with a negative trend over the research period is *Cladonia grayi*. According to Wirth (1995), this species has a broad ecological amplitude. It normally grows on acidic, sandy soils, with or without a well developed humus layer. Stoutjesdijk (1959) reckoned this species (under *C. pyxidata*) typical for patches with dead *Calluna* bushes. This would indicate a high demand for light, a character which is also pointed out by Van Herk & Aptroot (2004). However, the same holds for *C. macilenta*, a species that increased in our dataset (see above). Two species decreased in the GCd, *Potentilla erecta* and *Molinia caerulea*. Both species are known to be very susceptible to grazing, as was shown in upland grassland in Great Britain (Hulme *et al.*, 1999).

The conclusion from our study is that the abandonment of sod-cutting from the heathlands of the Balloërveld has lead to a system in which humus is accumulated, and succession lead to developmental stages of the *Genisto-Callunetum* with a denser canopy of *Calluna*. Younger, open stages with more sandy soils became scarce, even when the total area of dwarf-shrub communities maintained or even increased, as was shown in the vegetation structure map. Rejuvenation of the vegetation is only realised if the succession of the soil, i.c. the accumulation of organic matter, is set back.

Management implications

The ageing of a heathland system can have severe negative consequences for the typical heathland community. Although the flora seems to be changed only marginal, the characteristic fauna is likely to be more affected. "Typical" heathland species are understand here as species with a relatively small ecological amplitude and which only or almost only occur on heathlands. An adequate management of heathlands is therefore requisite for the conservation of these species. According to numerous authors, the typical species of dry heathlands in north-western Europe are xerophilous and thermophilous species (for *Orthoptera* see Kleukers *et al.* 1997, for *Carabidae* see Rabeler, 1947; Thiele, 1977; Telfer & Eversham, 1996; Turin, 2000). These species do not meet their favourable conditions in ageing heathland systems. Gimingham (1985) demonstrated that carabid beetles were more abundant in the pioneer and degenerate phases of *Calluna* development. From a study from an upland heath in Great Britain (Gardner, 1991) it is clear that the high requirements which characteristic species have are not met under the dense canopy of *Calluna*. Kleukers *et al.* (1997) mention grass encroachment and humus accumulation under the main causes of the decline of heathland grasshoppers. It was concluded from a study in some west European countries (Desender & Turin, 1986, 1989) that thermophilous carabid beetles decreased more than hygrophilous species. The authors argue, changes in vegetation structure could be responsible for changes in microclimatic conditions, causing this decline.

We conclude that a management scheme which does not include sod-cutting eventually can lead to the loss of typical heathland species. A management of mowing combined with grazing will not lead to enough open patches to ensure survival of thermophilous and xerophilous invertebrate species. The grass-heather mosaic, induced by a management of free-ranging grazing, combined with tree cutting as found in the study of Bokdam & Gleichman (2000), seems not to be sufficient for the maintenance of the typical heathland community, despite their conclusion. Therefore, we strongly advocate including sod-cutting in the management schema of heathlands wherever this is possible. Sod-cutting will lead to the removal of litter and nutrients, after which the regeneration of the vegetation will be slowed down (Gimingham, 1981). Instead of a grass-heather mosaic, the result will be an open sand-heater mosaic, which seems to be more appropriate for the conservation of our valuable heathland ecosystem.

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TABLE 1 - Frequencies of the species of the *Genisto anglicae-Callunetum* on the Balloërveld showing a significant ($p < 0.100$) increase or decrease between 1994 and 2002 in at least one of the (sub) sets. GC = the total set of relevés; GCt = subset *Genisto-Callunetum typicum*; GCc = subset *Genisto-Callunetum cladonietosum*; GCd = subset *Genisto-Callunetum danthonietosum.* p is printed bold if the species shows a significant change in the concerning (sub)set and placed between brackets if Chi-square statistics are not reliable because of low numbers (see text).

	GC			GCt			GCc			GCd		
	1994	2002	p	1994	2002	p	1994	2002	p	1994	2002	p
n=	72	62		32	15		30	31		10	18	
Campylopus flexuosus	27.8	7.8	**0.003**	18.8	6.7	0.278	43.3	12.9	**0.008**	10.0	0.0	0.172
Cerastium fontanum subsp. *vulgare*	11.1	3.1	**0.075**	0.0	0.0	-	20.0	0.0	(0.009)	20.0	11.1	0.520
Cladonia grayi	51.4	31.3	**0.018**	31.3	6.7	0.084	86.7	51.6	**0.003**	10.0	16.7	0.629
Molinia caerulea	54.2	46.9	0.396	59.4	53.3	0.696	40.0	45.2	0.684	60.0	44.4	**0.069**
Polytrichum piliferum	25.0	10.9	**0.035**	6.3	0.0	0.322	40.0	16.1	**0.038**	40.0	11.1	(0.074)
Potentilla erecta	18.1	9.4	0.145	6.3	0.0	0.322	3.3	0.0	0.305	100.0	33.3	**0.001**
Hypnum jutlandicum	50.0	81.3	**0.000**	50.0	100.0	**0.001**	33.3	64.5	**0.015**	100.0	94.4	0.448
Festuca filiformis	16.7	42.2	**0.001**	0.0	6.7	0.140	10.0	35.5	**0.018**	90.0	83.3	0.629
Cladonia macilenta	5.6	25.0	**0.001**	3.1	0.0	0.489	10.0	45.2	**0.002**	0.0	11.1	0.274
Galium saxatile	13.9	34.4	**0.005**	3.1	20.0	(0.053)	16.7	12.9	0.679	40.0	83.3	**0.019**
Pleurozium schreberi	4.2	17.2	**0.013**	0.0	0.0	-	0.0	0.0	-	30.0	61.1	0.115
Quercus robur	8.3	23.4	**0.015**	3.1	13.3	0.182	6.7	16.1	0.246	30.0	44.4	0.453
Cladonia coccifera	30.6	50.0	**0.021**	3.1	13.3	0.162	66.7	77.4	0.349	10.0	33.3	0.172
Dicranum scoparium	34.7	51.6	**0.047**	28.1	60.0	**0.036**	46.7	51.6	0.699	20.0	44.4	0.196
Deschampsia flexuosa	70.8	64.4	**0.060**	62.5	86.7	(0.091)	73.3	74.2	0.939	90.0	100.0	0.172
Carex pilulifera	61.1	70.9	0.352	65.6	46.7	0.217	43.3	67.7	**0.055**	100.0	88.9	0.274
Erica tetralix	52.7	53.2	0.887	78.1	73.3	0.716	23.3	51.6	**0.023**	60.0	33.3	0.172