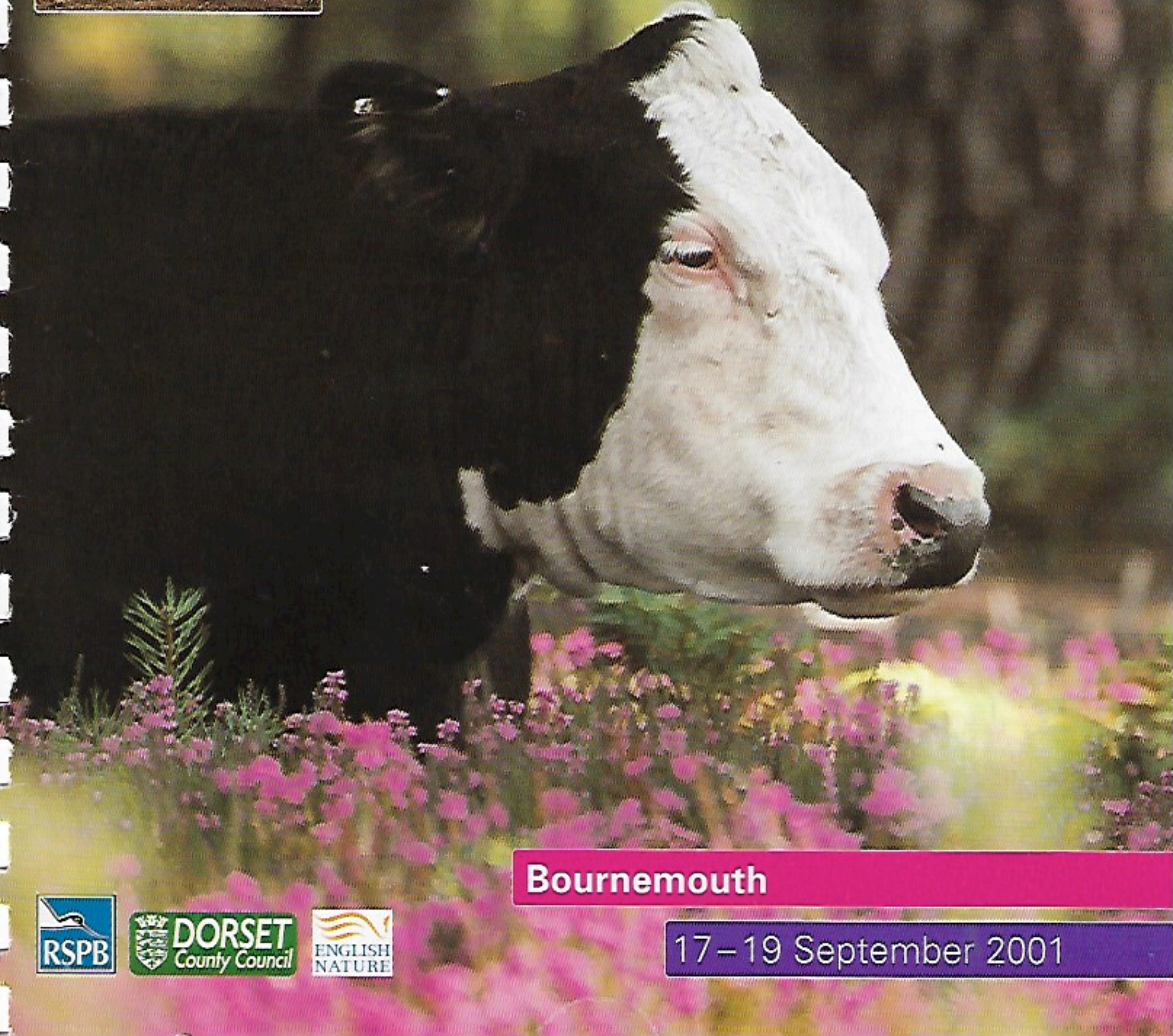
Proceedings of the

Sixth National Heathland Conference



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The conference was organised and sponsored by the following organisations:

Centre for Ecology and Hydrology
Dorset County Council
English Nature
The Royal Society for the Protection of Birds

Contents

Dedication

These conference proceedings are dedicated to Nigel Webb who has devoted his life to understanding and conserving heathlands. He has shared his enthusiasm, scholarship and wisdom with colleagues and friends freely and modestly over many years, and we hope will continue to do so during a long and happy retirement.

Foreword

Heathland management techniques have come a long way since the first National Heathland Conference, held in Suffolk in 1988. From small beginnings, management is now conducted across the country and the lottery funded Tomorrow's Heathland Heritage project is achieving heathland management on a national scale that conservationists back in the early 1990s could have only dreamed about. The dynamism and extent of management work being conducted across the country is evident from the fact that 200 people, all involved in managing heathlands, attended this conference.

The papers presented in these proceedings cover a wide range of issues. Although many of the talks focused on work conducted in Dorset, this had relevance at a national level. For example, reports on how site managers in Dorset have addressed the problems of dealing with the arisings from management work and some of the issues concerning the management of the urban heaths around Bournemouth have potential for application elsewhere. A number of speakers came from much further afield than Dorset. We were pleased to welcome speakers from the UK from as far away as Newcastle, Liverpool and Devon, and were especially pleased to welcome two international speakers, from Holland and Germany.

Six of the talks also had a connection with the Centre of Ecology and Hydrology (CEH), evidence for the ecological work that they, both under their current guise and as the old ITE, have been involved with on the Dorset Heaths.

Acknowledgements

The conference was organised by a steering group comprised of John Day, Durwyn Liley, Andrew Nicholson, Bryan Pickess, Phil Sterling and Nigel Webb. Making such a conference a success requires much more help. Jenny Goy handled the entire administration; a full-time job for a number of weeks, and it is thanks to her that things ran so smoothly. We are also grateful to the other RSPB staff, from both Arne and the Dorset Heathland Project, who helped with bookings and site visits. In particular we would like to acknowledge the help of Dante Munns (for technical support for speakers) and Neil Gartshore (for organising the site visits).

It was the role of the convenors to ensure that each session ran smoothly and to time, and we would therefore like to thank Nigel Bourn, Tony Gent, Andrew Nicholson, Bryan Pickess, Nigel Webb and Jim White for convening their respective sessions. On the site visits, we were grateful for the expertise and site knowledge of all the guides, especially to Neil Gartshore, Geoff Hann, Jez Martin, Bryan Pickess and Nick Woods.

Finally, we would like to thank the speakers, without whom no conference would have been possible.

Proceeds from the Conference

Proceeds from the conference will be used to establish a small trust fund to finance individuals conducting research (maximum of £100) or wishing to travel to a conference or similar event (maximum £200) concerning heathlands. Further information is available from Jenny Goy (address in the delegates list).

Heathland management I: grazing

Heathlands and pastoralism: an historical perspective

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Heathland is usually defined by ecologists as evergreen dwarf shrubs growing on poor, acidic soils under an oceanic climate. One might further add that this type of vegetation spread following forest clearances, and persisted for several millennia because a variety of factors prevented succession to scrub and woodland again. Four factors are generally regarded as important for controlling succession; burning, grazing, cutting of the vegetation, and peat and turf cutting. It is these factors on which we still depend to manage heathlands for wildlife. However today, we tend to apply each factor in isolation, although it is now clear that in the past this was not the case. The more we look back at the historical use of the heathlands, the more we find that a complex system of land management operated, and that this system was more or less the same over all the heathlands of Europe (Webb, 1998a).

We now recognise the European heathland region to be more extensive than was formerly thought (Gimingham, 1972; Webb, 1986). Heathland is to be found throughout the Iberian Peninsula and northwards on the west coast of Norway to the Lofoten Islands beyond the Polar Circle (Webb, 1998b). Eastwards there is heathland in north western Poland and possibly in Lithuania. We now estimate that there are at least 400,000 ha of heathland in Western Europe and probably more. It has also been recognised that the somewhat formal botanical definition of heathland, which I outlined above, can be replaced by a definition which embodies the type of land use practised – the concept of the cultural landscape. We find that the heathland cultural landscape extended over much the same area, and that it comprised not only the dwarf shrub vegetation but other associated vegetation types particularly grasslands, wetlands and mires, all of which were essential components of the farming system.

So what was this system that was common to the cultural landscape of the European heathlands? The most familiar form is the plaggen system that operated in the Netherlands and northwards over the north European plain (Gimingham & De Smidt, 1983; Diemont & Jansen, 1998). In the plaggen system, sheep were allowed to graze on the open heathland for about six hours each day under the control of a shepherd with a dog. For the remaining time the animals were confined to a barn. Turves with their emergent vegetation were cut from the heath and laid in the barn to absorb the excrement from the animals. Periodically, this material was dug out of the barn and dug into the nearby arable fields. Cattle were also kept in a barn all the year round and supplied with turves and fodder cut from the heath. This system prevents the growth of scrub on the open heath and depletes the nutrients in the heathland soil. There is a flow of nutrients from the heath through the animals and the barn to the arable land and its produce. The process of digging manure and turves into the arable fields resulted in characteristic raised soils (plaggen soils) where the surface was raised 40-80 cm. These soils extended over some 300,000 ha of the Netherlands alone with over a million sheep grazing some 800,000 ha of heathland (Diemont, 1996). In some cases the pastures, hay meadows and arable areas were irrigated by diverting nearby small rivers and streams.

A not dissimilar system can be found on the northern-most heaths in western Norway, Faeroe Islands, Orkney and Shetland, Western Isles and probably Ireland. Here the practices were well established by Viking times (Kaland, 1986) and persisted until the mid 20th century. In these regions, the settlements on the coastal heathlands were made up of an infield area of pasture, hay meadows and arable plots around the farmstead. An extensive outfield of heathland and peatlands surrounded the infield and was separated from it by a wall. Sheep and horses grazed the outfield throughout the year, whereas cattle were kept in a byre over winter and supplied with fodder cut from the heath. This small-scale cutting of the vegetation on a 3-5 year cycle, combined with burning small areas to improve the grazing, resulted in considerable small-scale variation in the diversity and structure of the heathland vegetation. Peat was also cut from the mires for fuel and to place on the floor of the byre to absorb the excrement of the animals. The material in the byre together with the remains of the fodder, and in the case of coastal farms, fish entrails and seaweed, were dug out of the byre and spread on arable plots as manure. This resulted in raised soil profiles in the arable areas (Kaland, 1986). Because of the high rainfall in these regions, irrigation was unnecessary.

In the Iberian Peninsula, a system similar to that in western Norway operated. Here, in the steep landscape, there was an outfield with free range grazing and an infield of pasture, arable, wood lots, olives and vineyards. Again, stock were kept in a barn and supplied with vegetation cut daily from the heath. Vegetation and peat were spread on the floor of the barn to absorb the excrement and again this was periodically dug out and spread on the arable areas. In this case, rain falling on the higher ground was channelled down the hillsides to irrigate the terraced arable fields lower down.

In Jutland (Denmark), there was a similar system. The heaths were grazed all the year round by sheep under the control of a shepherd. Cattle were also grazed, but were often tethered and every so often taken to their stalls to collect their dung, often on heathland turves. For fodder, especially in the winter, young heather was cut from the heath and mixed with lichens and hay. Peat turves were cut for fuel and for other uses such as house insulation. However, added to these practices was burning of heathland vegetation or turves to produce ash. This ash was scattered on the arable land together with the manure from the stables. Alternatively, the ash left on the small areas that were burnt could be ploughed, and cereal crops, usually rye, grown for a year or two while fertility was higher. Additional supplies of ash could be obtained by cutting and burning the heather. These plots were short-lived and soon abandoned to revert to heath (Højrup, 1970; Odgaard, 1994). Elsewhere in eastern Jutland, heathland would be ploughed and cereals grown for up to 8 years before the land was abandoned. It then reverted to heath for several decades as it regained its fertility through nutrient accumulation, before it could be cultivated again (Worsøe, 1990).

Burning vegetation to produce nutrient-rich ash, as was the case in Jutland, was another widespread practice. When heathland vegetation is burnt some of the nutrient accumulated in the vegetation, mainly nitrogen, is released and lost in the smoke. However, others, such as potassium (potash), are present in the ash which will temporally fertilise an area and enable crops to be grown. Besides areas in northern Europe, there was an extensive area extending from Belgium southwards to the Iberian Peninsula (Jansen *et al*, 1997) over which the practice, known as ecobuage, was widespread. For instance in Brittany, turves were turned over in long, straight lines and burnt. Buckwheat (*Fagopyrum* spp) was sown. These lines are still evident in today's landscape in some areas of Brittany.

Although we now have a fairly clear picture of the way in which food was produced on the poor soils in many countries of Western Europe, we still have little idea of the detail of agricultural practice in Britain. In the northern and western Isles and on the coasts of Scotland, it seems that the system was similar to that in western Norway. It was also similar in Ireland. For instance, Lucas (1960) reports that furze and vegetation were cut and supplied to animals in the barn where they provided fodder and material to absorb the dung. The management of moors in northern England and Scotland for sheep and grouse is a practice that developed from the 18th century onwards. This involved the regular burning of the vegetation. However, we have little idea of the form of land use which preceded these practices.

There are other fragments of information. In East Anglia, animals were grazed on the heaths in the daytime and folded on arable lands at night. In the New Forest and Ashdown Forest, there has traditionally been free range grazing by ponies and cattle. In the New Forest, regulation by law of these ancient practices exists to this day (Tubbs, 1986). We also know that there was widespread cutting of peat and turf from the heaths and bogs, but there is no evidence yet that arable plots were fertilised with heath material impregnated with animal dung.

Farming, at least on the southern heaths, changed after the middle of the 18th century as the means began to exist to convert or improve poor soils rather than to use them as they were. As a consequent the traditional farming practices disappeared. The import of guano and later the use of inorganic fertiliser enabled the fertility of the heathland soils to be raised and their output increased. This process was further hastened by improvements in the transport systems. Until now almost the only accounts of farming in the 18th century come from the 'improvers' who emphasised the potential of these soils to have their productivity increased. They tell us nothing of the traditional farming practices. Because the practices changed well ahead of other regions of Europe memory of these practices has been lost.

Some clues remain and I am sure that others await discovery. For example, if we look at the plans of pre 18th century farmsteads in Cunningham (1974) we can see what is essentially an infield and an outfield system, with the open heath making up the outfield. The infield consists of arable fields, pastures, wood lots and hay meadows. Some of these meadows lie adjacent to small rivers and streams and can be irrigated. A pattern of landscape, which is so similar to that elsewhere on European heathlands, suggests that the land was worked in the same way. However, we lack documentary and other evidence that this was the case. Another clue exists in the presence of raised soils. On the Dorset heathlands, areas surrounded by banks can be found. Within these banks there appear, from a very preliminary examination, to be raised soils. To form a raised soil there must be an input of mineral material, usually as turves cut from the adjacent heath. If only organic matter is added to soil a raised profile does not form. Whether the turves were added in combination with manure is not known. So there are clues and I feel sure that if we look more closely from a new viewpoint we shall probably find that a system similar to that on other heathlands operated.

It is not surprising that we find similar farming practices throughout the heathlands of Europe. The farmers all faced the same problem, that of producing food on nutrient deficient soils. On these soils the only source of nutrients was rainfall. What the farmers created was a system for capturing these nutrients from rainfall concentrating them through the turf, the barn and the animals into the manure that enabled them to grow crops to eat on the arable fields: a simple yet effective system. However, as increasing demands were made on this system in some parts of Europe it broke down. Alternatively, as we have seen in Britain, improvements in agriculture enabled the soils to be improved and their output increased. So long as the traditional system operated the heaths persisted. However, today, the heaths lie outside the agricultural system. As a consequence, nutrients accumulate in the system because they are not removed through food production or by burning and grazing. As a result of this nutrient accumulation, scrub and trees invade and succession proceeds.

The greatest problem facing heathland in Dorset, as in other areas, is encroachment by scrub and trees. Despite management to control this, since 1986 it has been estimated that scrub and trees are increasing at an annual rate of 1-2% (Webb, 1990; Rose *et al*, 2000). Removing and controlling trees and scrub are an absolute cost to conservation organisations. At the moment, we are living in a golden age as far as funding this type of conservation work is concerned and considerable funds from a variety of sources are available. However, we have no reason to believe that this situation will continue. Indeed, we should not expect this.

So, is an understanding of the traditional farming practices on the heathlands relevant to today's conservation problems? The traditional system struck a balance between the input of nutrients to the system through rainfall and the take off of nutrients in food production. In a sense this was a sustainable system. However, if food production was increased then this balance was not maintained and the system broke down. This happened in some areas of Europe where an increase in the human population made greater demands on the system than it could meet (Diemont *et al*, 1996). The present day methods of conservation management, while altering the composition and structure of the vegetation, do little to deplete nutrients. The most effective single method is to burn heathland periodically, but grazing largely redistributes nutrients. Unless there is effective depletion of nutrients, which matches the input of nutrients to the heathland ecosystem, the control of scrub and trees will remain a problem.

The restoration of a more traditional pattern of management in which grazing, cutting of vegetation, turf and peat, and burning are integrated would be useful. To go further with livestock and arable production would be more difficult and unlikely except in a few instances. However, alternative agricultural outputs should be considered to enable a balance to be maintained between nutrient input and take off. Bringing heaths in some way within an agricultural system again could help to offset the cost of conservation management.

References

Cunningham, G L (1974) *The changing landscape of the Dorset heathlands since 1700*. PhD thesis, University of London. 317pp.

Diemont, W H (1996) Survival of Dutch heathland. *IBN Scientific Contributions No.1*. Institute for Forestry and Nature Research, Wageningen.

Diemont, W H & Jansen, J (1998) A cultural view of European heathlands. *Transactions of the Suffolk Naturalists' Society*, 34, 32-34.

Diemont, W H, Webb, N R & Degn, H J (1996) A pan-European view on heathland conservation. *Proceedings National Heathland Conference 1996*. English Nature, Peterborough.

Gimingham, C H (1972) *Ecology of Heathlands*. Chapman & Hall, London.

Gimingham, C H & De Smidt, J T (1983) Heaths as natural and semi-natural vegetation. *Man's Impact on Vegetation*. Eds W Holzner, M J A Werger & I Ikusima. Dr W Junk, The Hague.

Højrup, O (1970) *Hedens udnyttelse, Danmarks Natur 7*. Eds A Nørrevang & T J Meyer. Politikens Forlag, København.

Jansen, J, Rego, F, Goncalves, P & Silveira, S (1997) Fire, a strong land shaping element in the Sierra da Estrela (Portugal). *NNA Berichte*, 10, 150-162.

Kaland, P E (1986) The origin and management of Norwegian coastal heaths as reflected by pollen analysis. *Anthropogenic Indicators in Pollen Diagrams*. Ed K-E Behre. A A Balkema, Rotterdam.

Lucas, A T (1960) *Furze: a survey and history of its uses in Ireland*. National Museum of Ireland, Dublin.

Odgaard, B V (1994) The Holocene vegetation history of north west Jutland, Denmark. *Opera Botanica*, 123, 1-171.

Rose, R J, Webb, N R, Clarke, R T & Traynor, C H (2000) Changes on the heathlands in Dorset, England, between 1987 and 1996. *Biological Conservation*, 93, 117-125.

Tubbs, C R (1986) *The New Forest*. Collins, London.

Webb, N R (1986) *Heathlands*. Collins, London.

Webb, N R (1990) Changes on the heathlands of Dorset, England between 1978 and 1987. *Biological Conservation*, 51, 272-286.

Webb, N R (1997) The effects of fire on the dynamics of heathland communities in southern England. *NNA Berichte*, 10, 134-141.

Webb, N R (1998a) The traditional management of European heathlands. *Journal of Applied Ecology*, 35, 987-990.

Webb, N R (1998b) History and ecology of European heathlands. *Transactions of the Suffolk Naturalists' Society*, 34, 1-10.

Worsøe, E (1990) *Mols Bjerge*. Skippershoved, Randers.

The role of livestock grazing in the conservation of lowland heath

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Introduction

Grazing is increasingly being used as a management tool for the conservation of lowland heathland. For example in 1996 at least one-third of lowland heathland National Nature Reserves were grazed (Michael, 1997), and in Dorset the number of grazed heathland sites has increased from two to twenty in the last decade (I Alexander, pers comm). The justification for this has largely been historical or drawn from other semi-natural habitats such as grassland where grazing is an established management tool.

Historical heathland grazing systems in other parts of Europe were described in a previous paper (Webb, 2002). It is likely that a similar system was used in the UK. In any case, it can be assumed that livestock grazing played a key role in the traditional farming practices, which linked heathlands and other elements of the cultural landscape.

However, the use of heathlands for grazing livestock declined throughout the 18th and 19th centuries as agricultural improvement changed farming practices. Decline was widespread across UK and other heathland areas in Europe. There is little information for Dorset, but grazing is considered to have declined in the 19th and 20th centuries until it virtually ceased during the 1950s (Table 1).

Widespread grazing ceased beyond living memory. In addition, historical records are sparse. Consequently little is known about the way in which grazing was carried out including which species and breeds were used, stocking densities, grazing season and husbandry practices.

In addition, there is little available research on grazing lowland heathland – a recent review found only three journal papers relating to lowland heathland grazing in the UK (Lake *et al*, 2001). However, there is a substantial body of literature relating to grazing upland heathland. This generally concerns dry heaths – wet heath and mires have received less attention. Nonetheless, a proportion of this literature is relevant to lowland heathland. There are also a number of papers from other European heathland areas.

Table 1. Decline of lowland heathland grazing throughout Europe

Heathland area	Livestock decline	Period of decline	Source
New Forest, England	2,200-1,000 ponies 30,000-750 cattle	Late C19-1940	Tubbs, 1968
Breckland, England	Sheep grazing largely ceased	By 1956	Crompton & Sheail, 1975
Dorset, England	Cattle and pony grazing largely ceased	By 1950s	Local sources
Pembrokeshire, Wales	Cattle and pony grazing largely ceased	By 1960s	Evans, 1989
Luneberg Heaths, Germany	750,000-25,000 sheep	1860s-1950s	Henke, 1982
Monts d'Arree, Brittany, France	Extensive sheep grazing ceased	1900s-1970s	Lefeuvre, 1980

In addition there are a number of reports and unpublished works. Using this resource, the following generalisations can be made (Lake *et al*, 2001).

1. At intermediate stocking densities grazing is likely to produce maximum species and structural diversity on all heathland vegetation.
2. Both high and low extremes will lead to an increase in grass cover and consequent reduction in dwarf shrub cover.
3. Low extremes may also lead to an increase in scrub cover.
4. Livestock presence can control and reduce invasive species such as wavy hair-grass *Deschampsia flexuosa* and purple moor-grass *Molinia caerulea*.
5. Livestock presence may benefit individual plant species provided they are not selectively grazed or dominant in the vegetation community.
6. Populations of many characteristic heathland species will benefit from an increase in bare ground and reduction of competitive grasses resulting from livestock presence.

Given the increasing use of grazing as a conservation management tool on lowland heathland and the lack of knowledge concerning the outcome of such grazing. The Royal Society for the Protection of Birds funded a three year PhD project carried out at the Centre of Ecology and Hydrology (Dorset) to research the role of livestock grazing in the conservation of lowland heathland. This project, which is based on the Dorset heaths, has four main elements.

1 Livestock behaviour – the way in which extensively grazing livestock use heathland sites in relation to conservation ends.
2 The effects of livestock presence on both community composition and structure on wet heath habitats.
3 The potential effects of livestock presence on the germination of key plant species found on wet heath and associated habitats.
4 The potential effects of livestock presence on the regeneration of key plant species from the buried seed.

The first two are discussed here.

Livestock behaviour

An interview of thirty-five site managers of grazed heathlands across the UK revealed a gradient of grazing systems. At one extreme are small grazing units, often enclosing a single vegetation type. At the other are large sites incorporating a variety of vegetation types, for example dry heath, wet heath, valley mire, acid grassland, scrub and woodland. While on smaller sites, husbandry techniques will largely dictate the grazing pressure on the vegetation community, on larger sites, animal behaviour will dictate how much time is spent in different vegetation communities. The Dorset heaths studied fell into this second category of more extensively grazed sites, and were used to investigate how livestock behaviour effects grazing pressure.

Five sites were considered where cattle and/or pony grazing had been reintroduced. From three of these sites it was possible to obtain a daily location record for the stock over the grazing season. In addition, on each site, the herd was followed from dawn to dusk, and in some cases over 24 hours. Location and activity of the herd were recorded every 15 minutes and more detailed information was recorded every 5 minutes for a particular focal animal in each case.

Figure 1 shows an example of the daily location records for Arne RSPB Reserve between 1998 and 2000. Non-random use of the site is apparent (Chi-square 565.512, $P < 0.001$), and can be further explored by superimposing the habitat types over the OS map (Figure 2).

Clearly, the cattle show a relative preference for particular habitats. This can be considered numerically using a selection index. The Jacob's index used here (Jacobs, 1974) compares observed habitat use with expected use according to the area available. Scores between 0 and +1 show that the numbers of visits are more than expected, those between 0 and -1 that the number of visits are less than expected. +1 shows that only that habitat is selected, -1 that it is avoided completely. Figure 3 shows the Jacob's index for the combined data, and for each year separately. Although the ranking is slightly different between years, the index values themselves are not statistically different between years. Differences between habitats are significant (two-way ANOVA F-value 10.66, $P < 0.001$).

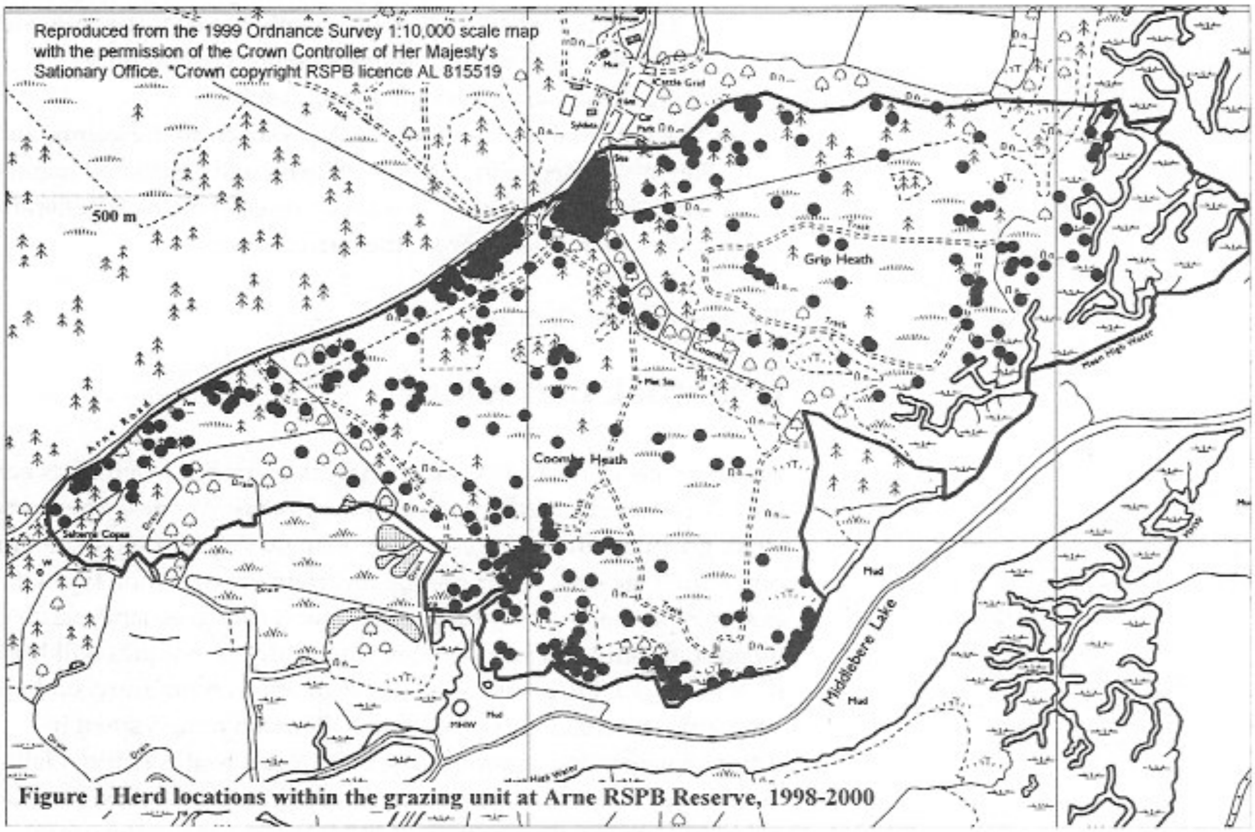

Figure 1 Herd locations within the grazing unit at Arne RSPB Reserve, 1998-2000

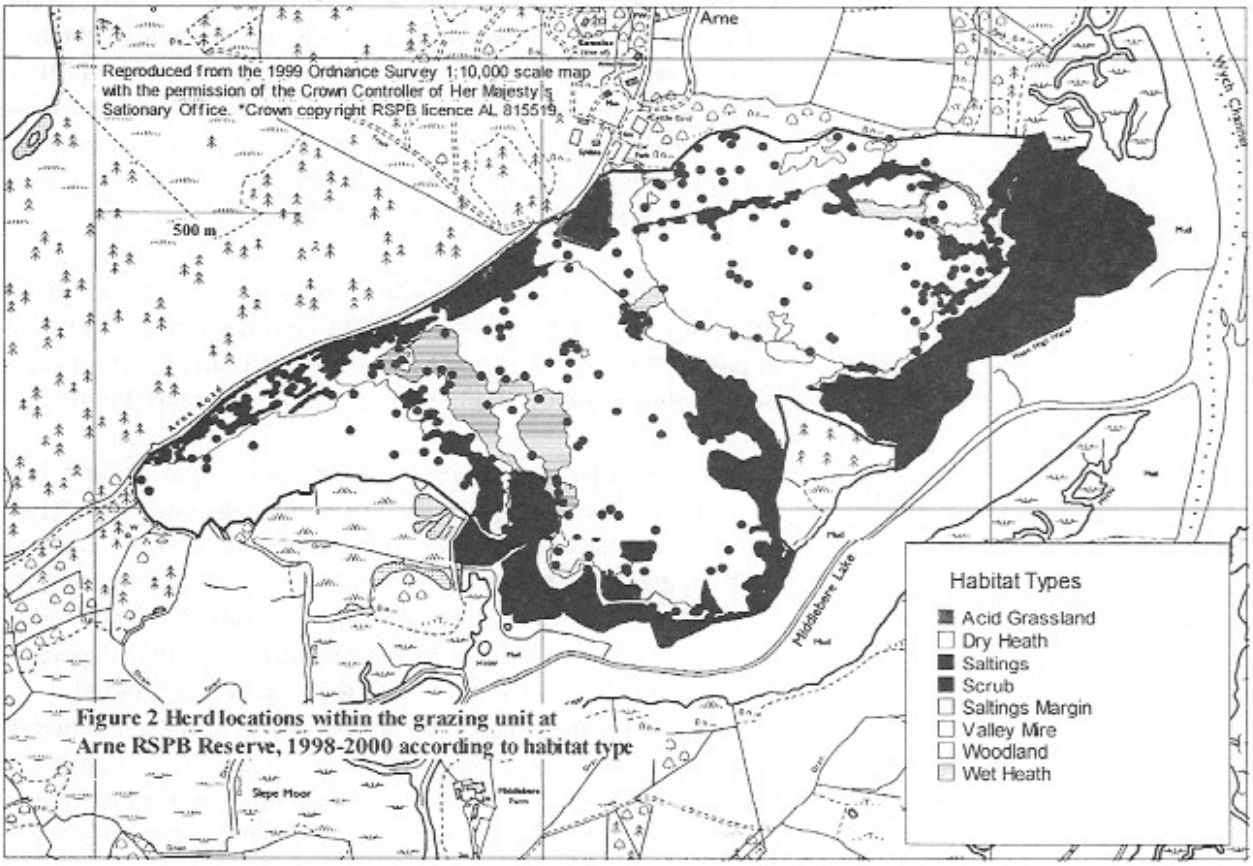

Figure 2 Herd locations within the grazing unit at Arne RSPB Reserve, 1998-2000 according to habitat type

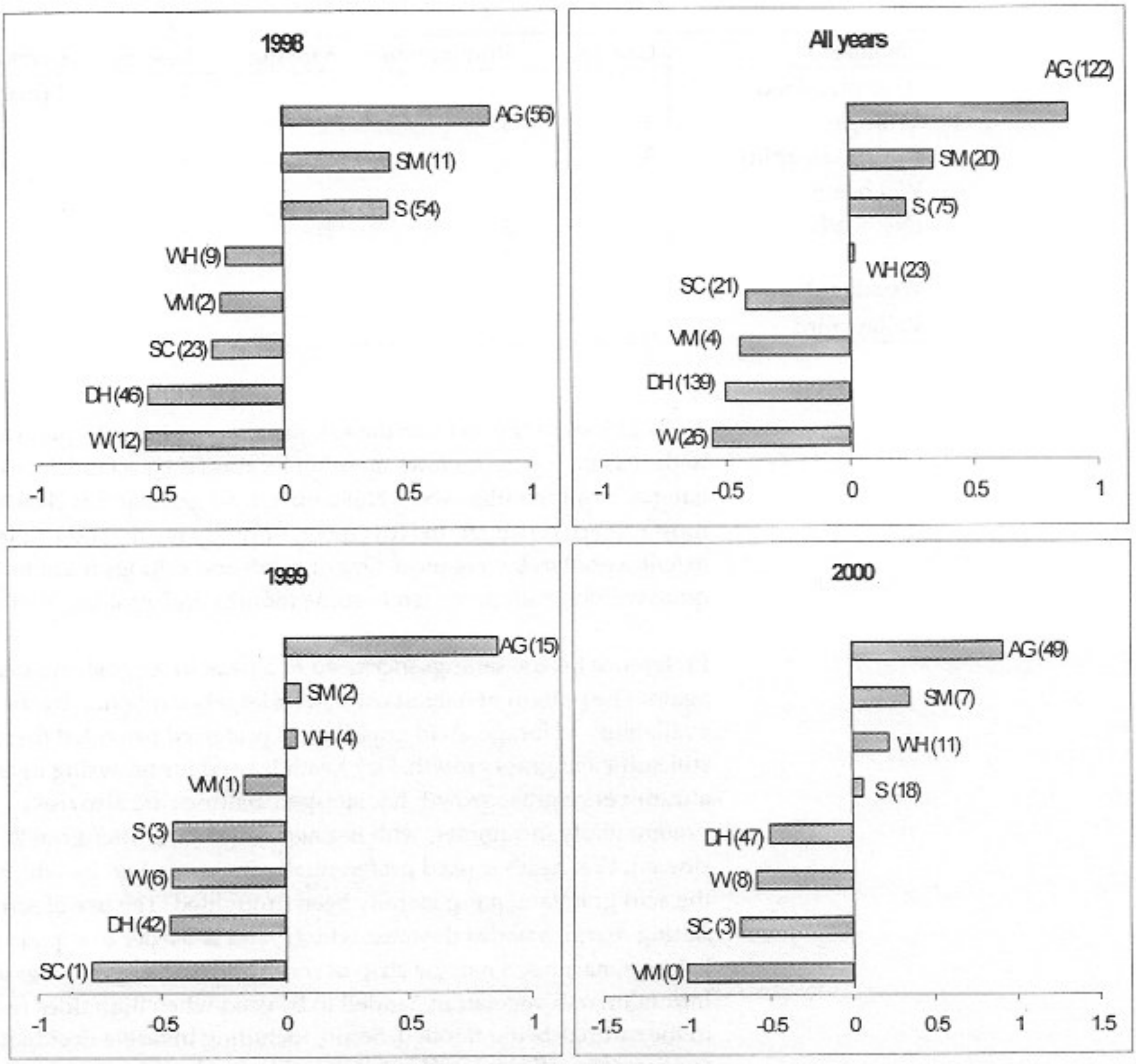

Figure 3. Jacob's indices for yearly cattle location records at Arne RSPB Reserve according to habitat type
AG – acid grassland, SM – saltings margin, S – saltings, WH – wet heath, VM – valley mire, SC – scrub, DH – dry heath, W – wood. Numbers of sightings in parentheses.

Acid grassland is used more than all other habitats except the saltings margin, which is itself used more than dry heath, scrub, valley mire and woodland. There are no differences between the other habitats types.

The preference for these two habitats is likely to be primarily due to the abundance of good quality forage, although other habitats types are also used for grazing. Data from the dawn to dusk and 24hr observations follows which shows the main activities carried out in each habitat. These data are not fully presented here, but Table 2 gives an indication of the main activities generally carried out in each habitat.

Table 2. Main activities carried out by livestock in each habitat type at Arne RSPB Reserve

Habitat	Grazing	Ruminating	Moving	Resting	Drinking
Acid grassland	3	3		3	3 (trough)
Saltings	3	3			
Saltings margins	3	3		3	
Wet heath	3				3
Dry heath		3	3	3	
		3		3	
Woodland					
Valley mire	3				3

A closer look at the location data shows that habitat selection varies with season. Figure 4 shows monthly location data according to habitat. In all months except November, acid grassland is clearly the most preferred habitat. In November, only dry heath, and to a lesser extent woodland, were used. Use of scrub and saltings margins varied quite widely, both preferred in some months and avoided in others.

Preference for the saltings increased to a peak in August and declined again. The pattern of habitat use can be largely explained by the availability of forage. Acid grassland is preferred provided there is still sufficient grass growth. Dry heath is used for browsing in late autumn once grass growth has stopped. Saltings are also used preferentially in summer, with use again declining after growth has slowed. Wet heath is used preferentially in September, by which time the acid grassland has generally been droughted. The use of scrub and salting margins varies the most widely, and is harder to explain. Saltings margins, a narrow strip of scrub and acid grassland grading into saltmarsh vegetation, tended to be used when high tides resulted in the saltings being flooded. Scrub, including invasive deciduous species gorse *Ulex europaeus* and pine *Pinus sylvestris*, often had a ground flora of grass species, and these were used for grazing. Scrub browsing was rarely observed. Behaviour in most habitats remained relatively constant, with the exception of dry heath, used mainly for resting throughout the summer, but then used extensively for browsing *Ulex minor* in late autumn.

Manipulation of habitat use by livestock

Knowledge of how livestock use a site can be useful particularly in restoration phases of heathland management. On a varied site such as Arne, a decrease in the dominance of, for example, purple moor-grass *Molinia caerulea* is most likely to be achieved by late summer grazing. Scrub species and heather are most likely to be browsed in autumn when dry heath is preferentially used. Conversely, if areas are to be excluded from the grazing regime, stock may *be removed at* the times these areas are most likely to be used. Such knowledge is of course also valuable in maintenance management.

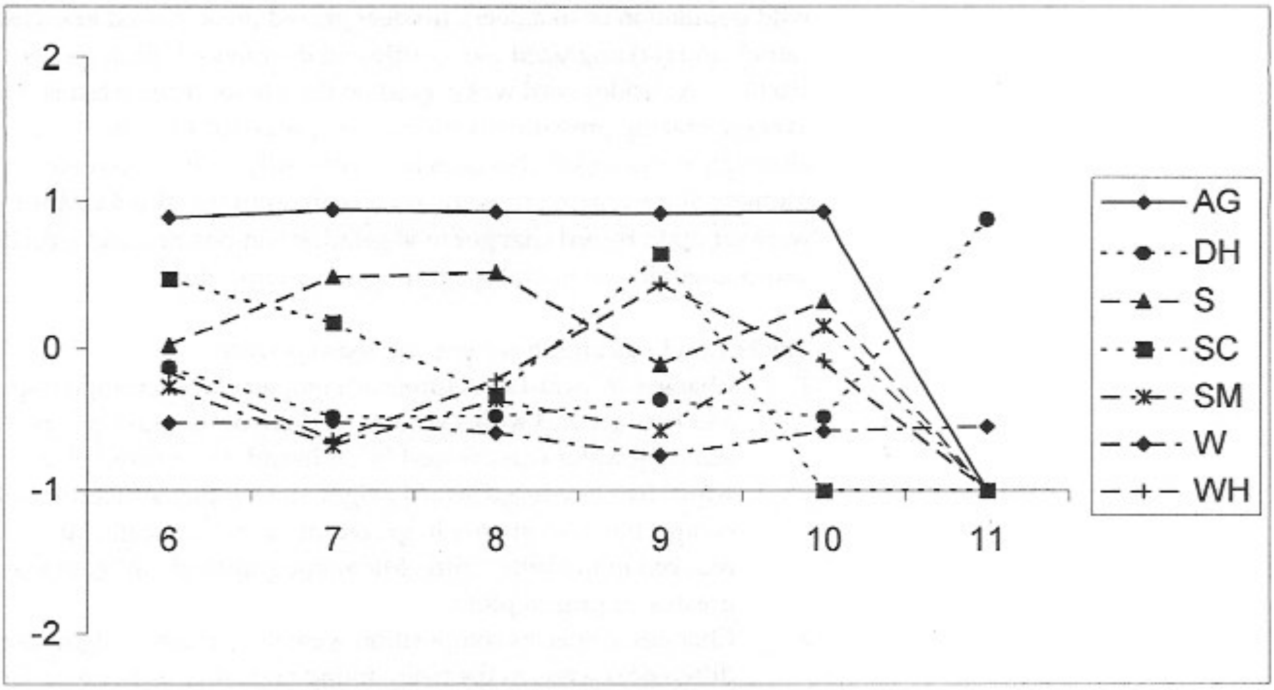

Figure 4. Change in habitat use as expressed by Jacob's selection index by livestock at Arne RSPB Reserve, 1998-2000
AG – acid grassland, SM – saltings margin, S – saltings, WH – wet heath, VM – valley mire, SC –scrub, DH – dry heath, W – woodland.

There are a number of additional aspects, such as the location of water, shelter and supplementary feed, and particularly vegetation management through cutting and burning, which can also be used to manipulate livestock behaviour to achieve particular management aims. However, it should be stressed that the selection of habitats shown here is of course in relation to the other habitats present. It is likely that livestock behaviour will be to some extent site specific.

The effects of livestock presence on wet heath communities

Ungrazed wet heath and mire communities can become dominated by purple moor-grass in the absence of management. However, circumstantial and monitoring evidence suggest that grazing wet heath and mire communities can prevent such a dominance (Clarke, 1988; Sanderson, 1994; Cox, 1998). This allows an increase in the richness and diversity of other species present. However, much of the information we have is anecdotal or based on unreplicated monitoring plots, which are themselves few and far between.

To look at the effects of grazing on wet heath communities a little more rigorously, the RSPB set up monitoring plots in Coombe bog at Arne RSPB Reserve. Cattle were then introduced in 1998, after a lapse in grazing of over thirty years. Three different grazing treatments were replicated in a randomised block design 10 times over the areas. They were (i) unfenced cattle and deer grazed plots (the site has a wild population of sika deer), (ii) deer grazed plots (fenced to exclude cattle), and (iii) ungrazed plots cattle and deer fenced. Each plot is 10x10 m. A suckler herd was grazed on the site for three seasons. The average grazing pressure (including deer) was 0.08 LU $^{-1}$ ha^{-1} yr^{-1}, although as discussed, this does not necessarily give an accurate estimate of the grazing pressure on all communities. These exclosures were set up to record changes in vegetation composition and structure and changes in soil microtopography and compaction.

The key findings after three grazing seasons were:

1. Changes in sward structure, soil compaction, microtopography and bare ground were evident. The area of bare ground and of standing water was greatest in cattle and deer grazed plots, which had a reduced sward height and simpler structure. Soil compaction was greater in grazed plots on wet heath, but reduced in the valley mire. Microtopographical variation was greatest in grazed plots.
2. Changes in species composition were less evident – significant differences were, in the main, found only after three years. Deer paths running through the deer and cattle exclosures remained un-colonised after three years.
3. The higher cover of bare ground on cattle and deer grazed plots was at the expense of vascular plant species – cover was significantly lower in the cattle and deer grazed plots. Reduction was mainly in graminoid species, and there was a slight increase in forbs.
4. No significant differences were found in the cover of *Sphagnum* or lichen species, although there were local differences.
5. Ordination diagrams characterising the proportional changes in species over the three years show a correlation between cattle and deer grazing and increases in round-leaved sundew *Drosera rotundifolia* and deer grass *Trichophorum cespitosum*, and a negative correlation with increases in purple moor-grass, pine seedlings, bog asphodel *Narthecium ossifragum* and *Sphagnum compactum*.

Clearly wet heath and valley mire are sensitive to livestock presence. These results show that cattle have a significant impact on community types that are used relatively little. Generally, grazing responses were strongest in the valley mire, a habitat that was never shown to be positively selected by the cattle. While the strong responses in the area of bare ground and changes in compaction suggest that trampling is particularly important, the disproportionate reduction in graminoids shows that grazing is also having an effect. Changes in soil compaction, standing water and area of bare ground suggest that further changes in vegetation composition may follow. Longer term studies are need to confirm this.

Conclusions

- Extensively grazing livestock on heathland sites with a number of communities present will show preference for particular vegetation communities.
- Different communities will be used for different activities, for example wet heath for grazing, dry heath predominantly for resting and moving, although these uses may changes seasonally.
- Detailed knowledge of such preferences can be used to fine-tune grazing management.
- The impact of livestock presence was shown to be significant on wet heath and mire communities, which were used relatively little. A large part of this impact is through trampling, and was seen in changes in soil compaction, microtopography and the area of bare ground and standing water. Changes in vegetation structure resulting directly from grazing were clear. Changes in vegetation composition are slower.

Acknowledgements

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References

Clarke, M J (1988) *Past and present mire communities in the New Forest and their conservation.* PhD thesis, University of Southampton.

Cox, J (1998) *Botanical monitoring of the Dorset heathlands Wildlife Enhancement Scheme – West Bog, Hartland Moor NNR.* English Nature.

Crompton, G & Sheail, J (1975) The historical ecology of Lakenheath Warren in Suffolk, England: a case study. *Biological Conservation*, 8, 299-313.

Evans, F (1989) *A review of the management of lowland wet heath in Dyfed, West Wales.* Nature Conservancy Council.

Henke, H (1982) The Luneberger Heide – conservation of a cultural landscape. *Parks*, 4(2), 13-17.

Jacobs, J (1974) Quantitative measurements of food selection. A modification of the forage ratio and Ivlev's electivity index. *Oecologia*, 14, 413-17.

Lake, S, Bullock, J M & Hartley, S (2001) *Impacts of livestock grazing on lowland heathland in the UK*. English Nature, Peterborough.

Lefeuvre, J C (1980) Possibilites d'elevage de moutons de race rustique dans les landes des Monts d'Arree. *Bulletin d'Ecologie,* 11, 765-773.

Michael, N (1997) *Key future issues in lowland heathland conservation.* English Nature, Peterborough.

Sanderson, N A (1994) *Notes on heathland grazing in the New Forest.* Ecological Planning and Research, Winchester. Unpublished.

Sheail, J (1979) Documentary evidence of the changes in the use, management and appreciation of the grass heaths of Breckland. *Journal of Biogeography,* 6, 277-292.

Tubbs, C R (1968) *The New Forest: an ecological history.* David & Charles, Newton Abbott.

Webb, N (2002) Heathlands and pastoralism: an historical perspective. In: J C Underhill-Day & D Liley (eds) *Proceedings of the Sixth National Heathland Conference*. The RSPB, Sandy, Beds, England.

Grazing as a management tool in natural and semi-natural heathland in the Netherlands

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Introduction

Since the beginning of the Quaternary, natural ecosystems have been transformed into hunting/gathering, agricultural and urban systems (Diamond, 1999). Man evolved as an invasive species *par excellence* (Kolar & Lodge, 2001). *Homo sapiens* eliminated competing carnivores, omnivores and herbivores, replacing them with a broad spectrum of domestic animals and tools and a rich array of hunting and harvesting strategies (Bunzel-Drücke *et al*, 1994; Clutton-Brock, 1999). Traditional agricultural landscapes became the major habitat for wildlife (Bignal *et al*, 1994). Since the 19th century, large parts of these traditional agricultural landscapes (based on local resources) have been replaced by modern agricultural, urban and industrial landscapes (based on global resources). The biodiversity of the remnant areas is now declining by intensification or abandonment, environmental changes (eg drainage, eutrophication, acidification, pollution) and fragmentation.

Natural (pristine) ecosystems have not only been the major evolutionary environment of our flora and fauna, they also offer the safest habitat for their survival (Wilson, 1999). European (terrestrial) nature reserves, established in the 20th century, are predominantly remnants of traditional agricultural landscapes. Nature conservation is therefore facing a dilemma: continuation of semi-natural, but economically unfeasible (hence subsidised) traditional agriculture or restoration of natural ('self-organising' or 'wilderness') ecosystems with more or less complete herbivore and carnivore guilds? Traditional farmers have – irrespective of the Holocene extinctions – guaranteed the survival of most species, especially species of open, nutrient-poor habitats, during many centuries. Traditional pastoralism and arable farming provided essential disturbance, resource redistribution and dispersal processes. Cessation of these interventions, as proposed by the natural management strategy, might put early successional stages on nutrient-poor soils at risk, unless these conditions are generated by the restored new natural system (Ellenberg, 1988; Bokdam *et al*, 2001). The basic question is whether natural grazing systems are able to generate and maintain open, nutrient-poor ecosystems and their biodiversity.

Heathland management strategies in the Netherlands

Heathland represents the major traditional pastoral landscape type of W Europe. The ecosystem is characterised by low productive, short vegetation, often with ericaceous dwarf shrubs, on neutral-acid soils (Gimingham, 1972; Webb, 1986; Heil & Aerts, 1993). Lowland heath remnants in the Netherlands cover ~ 42,000 ha, ie 5 % of the 18th century area. This area includes coastal heaths (1,000 ha), heaths on inland dunes (drifting sand) landscapes (2,000 ha) and ~ 39,000 ha of inland heaths on podsolic soils and drained peat bog (WHH, 1988). Most Dutch heathlands are managed as nature reserves with recreational functions. They constitute an important component of the National Ecological Network (Dutch: 'Ecologische Hoofd-Structuur'). The National Ecological Network is the ambitious long-term conservation plan launched to enlarge and connect the major conservation areas in order to upgrade their naturalness and biodiversity (MLNV, 1990; Baerselman & Vera, 1995). According to this plan, a recent update (MLNV, 2000) and subsequent provincial plans, the Ecological Network, and hence heathlands, may be managed as a ***natural***[1] or ***semi-natural*** ecosystem.

The ***natural*** strategy includes two sub-strategies, ***nearly-natural*** ('nagenoeg-natuurlijk' with unmanaged, free ranging, feral livestock and wild herbivores) and ***controlled-natural*** ('begeleid-natuurlijk' with managed herbivore populations and hydrology, but without other interventions) (Bal *et al*, 1995). In the ***nearly-natural*** strategy, biodiversity is only a target insofar as it results from natural processes ('self-regulation' or 'non-intervention', Baerselman & Vera, 1995). Species-directed interventions are excluded. The target is the restoration of natural (= complete) food webs, successional mosaics and abiotic gradients. 'Complete' refers to Eemian or Holocene (Atlanticum pre-farming period) systems (Baerselman & Vera, 1995; Bunzel-Drücke *et al*, 1994; Prins, 1998). So far, nearly-natural management has been applied only in the Oostvaardersplassen, an isolated nutrient-rich wetland of 5,000 ha in the Flevopolder (Groot Bruinderink *et al*, 1999). Conservation organisations are reluctant to apply this strategy because of the uncontrollable outcome and because of conflicts with animal welfare and public health interests. ***Controlled-natural*** management is more common (eg at Imbosch, where cattle grazing started in 1982 in a woodland-grassland-heathland mosaic, Van Wieren, 1988). With interventions in the hydrology and herbivore assemblage, the manager can control the composition of the successional mosaics at landscape scale, but not its configuration.

[1] in fact 'sub-natural' because of irreversable changes

In the most widely applied ***semi-natural*** strategy, self-regulation is not a target. Intervention is not restricted. Herding, fencing, cutting, mowing, burning, turf-stripping, liming etc may all be used, offering opportunities for traditional and modern pastoralism and mechanical management (Bal *et al*, 1995). The allocation of heathland areas to either of the two strategies may raise controversy because of the consequences for biodiversity.

The National Ecological Network and its underlying ideas (Van de Veen, 1975; Baerselman & Vera, 1995) had a tremendous impact on grazing management. It induced a shift from semi-natural towards more natural management. Since 1970, livestock grazing had been introduced in more than 400 Dutch nature reserves, many of them with heathland (De Molenaar, 1996). Initially, managers viewed free ranging livestock predominantly as a substitute for lost traditional pastoralism (Oosterveld, 1975). After 1990, livestock was considered more as a substitute for extinct wild herbivores; herding and non-native sheep and goats became taboo in grazing. Year-round grazing was declared 'natural', irrespective of the grazed area. To improve the carrying capacity of incomplete landscapes, heathlands were enlarged by adding grasslands and woodland and by local connections with nutrient-rich Holocene river valleys (eg at Overijsselse Vecht and Drentse Aa) (Bokdam & Wallis de Vries, 1992; Wallis de Vries, 1994, 1996). Larger-scaled corridors between the Pleistocene Veluwe and the Holocene Rhine valley and between coastal dunes and peat landscapes are in preparation.

Despite these steps towards naturalness, all nature reserves remain incomplete systems if compared to Eemian or early Holocene references. Small size, isolation, irreversible extinctions and introductions, irreversible changes of atmosphere, soil and hydrology and – last but not least – lack of money and political support are major constraints for further completion. Semi-natural interventions aimed at endangered habitats and species are excluded in areas under the natural management strategy. Therefore some conservationists fear that natural management in incomplete ecosystems will lead to succession and eutrophication, putting early successional nutrient-poor habitats and their species at risk (Bokdam, in press). Recently reported negative effects of grazing on lichens (Aptroot & Van Herk, 2001), reptiles (Strijbosch, 2001) and insects (Peeters *et al*, 2001) seem to support this fear.

The shift to the natural grazing strategy in management of heathland raises three questions:

1. Will natural management in a complete landscape lead to inland heath?
2. Is the transition from semi-natural to natural grazing in incomplete conservation areas putting heathlands and their species at risk?
3. If so, how can lacking components and processes be substituted or compensated?

The Wolfhezerheide Research Project

Materials and methods

The effects of free ranging and successional up-scaling on succession and biodiversity have been studied since 1983 in the Wolhezerheide, a nature reserve owned and managed by Natuurmonumenten (Bokdam & Gleichman, 2000). The grazed area (60 ha) included ~ 20 ha woodland, 30 ha *Deschampsia* heath, 3 ha of *Molinea* heath and 7 ha of *Calluna* heath. The major part of the woodland and *Deschampsia* heath was situated on podsolic soils, a minor part on fertile plaggen soils on medieval, arable fields. The *Calluna* vegetation was mainly in the degenerate stage, on podsolic soils. Minor parts were in the building stage on podsolic soils turf-stripped in 1980. In 1983, Dutch-Friesian heifers (0.2 animal units/ha, 1 animal unit = 450 kg) were introduced for year-round grazing. Major targets were the recovery of *Calluna* in the grass heaths and the prevention of tree invasion in the open heathland. The animals received minor food supplements in late winter. Some horses were also allowed in the area. Densities of roe deer (2-4 km^{-2}) and rabbits (~ 100 km^{-2}) were low. Vegetation was monitored in permanent quadrats. Habitat use and diet selection were investigated by direct 24hr observations in 1983-1985. The results allowed the calculation of nutrient balances for the various successional habitats and micro-sites.

Results – nutrient-dependent cyclic succession

The monitoring revealed cattle-induced grass-heather cycles and mosaics on soils of intermediate fertility only. *Calluna* re-established and expanded in the *Deschampsia* and *Molinia* heath. Grasses invaded gaps in degenerate *Calluna*. Monitoring of micro-patches (10 x 10 cm) between 1989 and 1994 confirmed *Calluna-Deschampsia* alternation and cyclic succession (Bokdam, in press). *Calluna* failed to recover in *Deschampsia* on the more nutrient-rich plaggen soil sites through a combination of factors. Its recruitment was poor, due to a relatively poor seed bank and, probably, to the thick, trampling-tolerant grass litter with few gaps. Intensive grazing defoliation limited the expansion of the scarce *Calluna* seedlings on the plaggen soil. On the turf-stripped, nutrient-poor podsolic soil, *Calluna* built a dense canopy without grass invasion.

Cattle prevented the encroachment by mid-seral trees (*Quercus*, *Prunus*, *Sorbus*). Unpalatable, early-seral tree species *Betula* spp and *Pinus sylvestris* were removed by the managers. Woodland was locally replaced by grass (*Deschampsia*) (Bokdam & Gleichman, 2000; Bokdam, in press).

The significant resource-dependency of the grass-heather cycle raised the question whether grazing was driving the cycle only by providing light for germination or also by soil depletion. The answer is crucial for the role of grazing as compensation for increased atmospheric nutrient inputs.

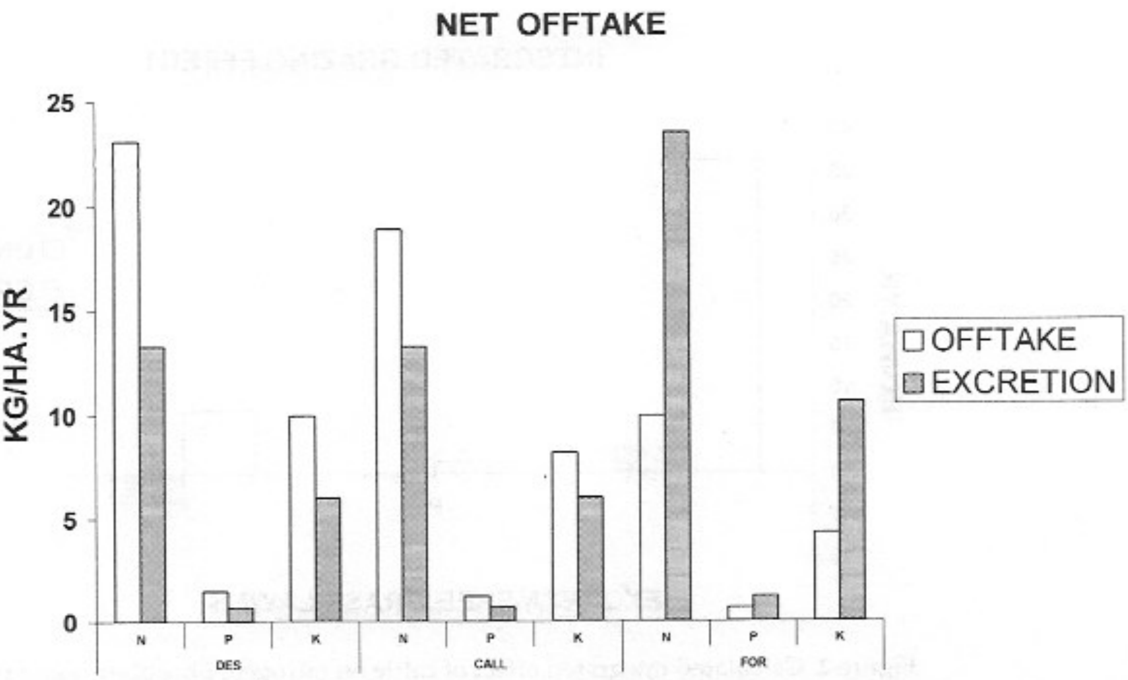

Figure 1. Nutrient removal (offtake) and gain (excretion) in the three habitat types DES – *Deschampsia* heath, CALL – *Calluna* heath, FOR – Forest

Cattle as nutrient movers

The use of habitat by cattle was selective and differential for foraging and non-foraging (Bokdam, unpub). Cattle selected open heathland as foraging habitat and woodland as non-foraging habitat. Foraging habitat and diets were linked. *Deschampsia* was selected during spring and autumn, *Molinia* during mid-summer and *Calluna* during winter. The differential habitat use generated a substantial nutrient redistribution from foraging sites (grass lawns) to non-foraging sites (woodland). The net nitrogen offtake (consumption - excretion) in the *Deschampsia* habitat was ~ 10 kg ha^{-1} yr^{-1}. This net offtake did not compensate for the local atmospheric deposition (Bokdam, unpub). The integrated (total) grazing effect on lawns is higher because of additional losses by ammonium volatilisation, denitrification, leaching, erosion and because of a lower dry atmospheric deposition in short-cropped lawns (Figure 1).

Substantial parts of the grass lawns remained unaffected by dung and urine. Because of the relatively low grass production (~ 2-3 ton dry matter ha^{-1} yr^{-1}) inducing a low occupation time (occupation = foraging and non-foraging) and significant avoidance of lawns for non-foraging, only 3 % of the *Deschampsia* lawn was annually affected by dung or urine. By 1993, 10 years after the start of the grazing, > 70% of the initial grass lawn had not yet received an input of dung or urine. On these excreta-free lawn sites, the integrated nutrient balance (atmospheric deposition - offtake) revealed nutrient depletions for phosphorus and potassium. Nitrogen maintained a small surplus (Figure 2).

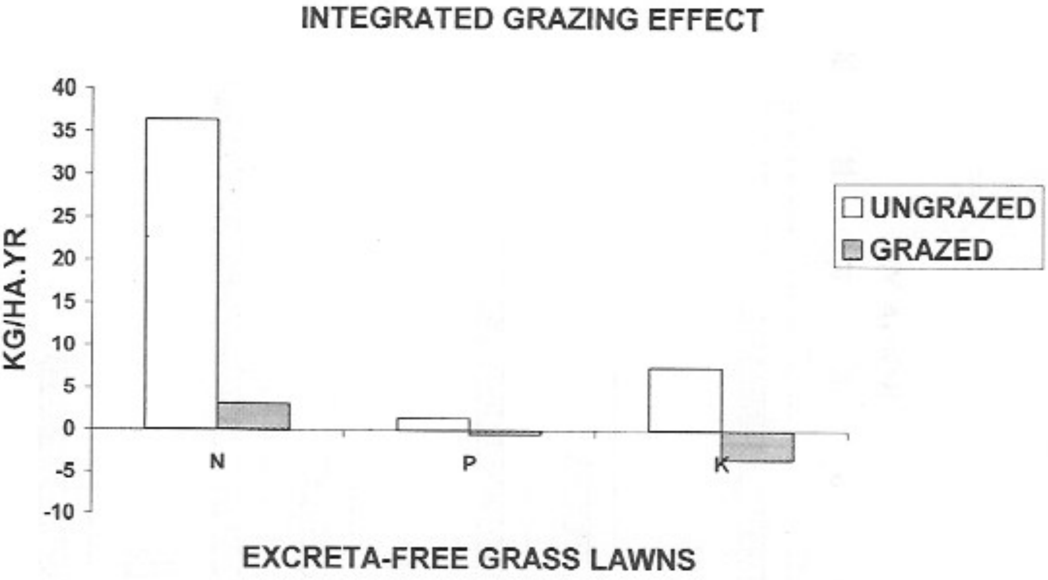

Figure 2. Calculated integrated effect of cattle on nitrogen, phosphorus and potassium soil pools in excreta-free *Deschampsia* lawns

In litter gaps, generating treading and hoof slidings, nutrient depletion was very obvious. Removals by treading are comparable to turf-stripping. The probability of treading gaps is highest in winter and other wet periods.

Conclusions of the project

The Wolfhezerheide Research Project has yielded two major conclusions:

a) *Free-ranging cattle ('large generalist grazers') are able to induce resource-mediated successional grazing cycles and mosaics with heath.* The causal mechanism is the optimal exploitation of the area, leading to differential use across 24hr, annual and successional timescales. The shifting habitat use results in biomass and nutrient availability cycles.

b) *Intensified disturbance as compensation for overcomplete resource inputs (eg nutrients) may create an ecological 'trap' for disturbance-sensitive species of open, low productive ecosystems, reducing the biodiversity of the generated heath ecosystem.*

An ecological 'trap' combines 'attraction' and 'capturing/killing'. Intensive defoliation and treading by cattle on the nutrient-rich plaggen soil 'attracted' *Calluna* by favouring its germination. The survival and expansion of these seedlings were subsequently impaired by the same defoliation and treading The life-cycle was completed on less fertile, podsolic soils (Bokdam & Gleichman, 2000). The reported declines of lichens, insects, reptiles and other disturbance-sensitive guilds of low productive grass- and heathland may be attributed to the same trap.

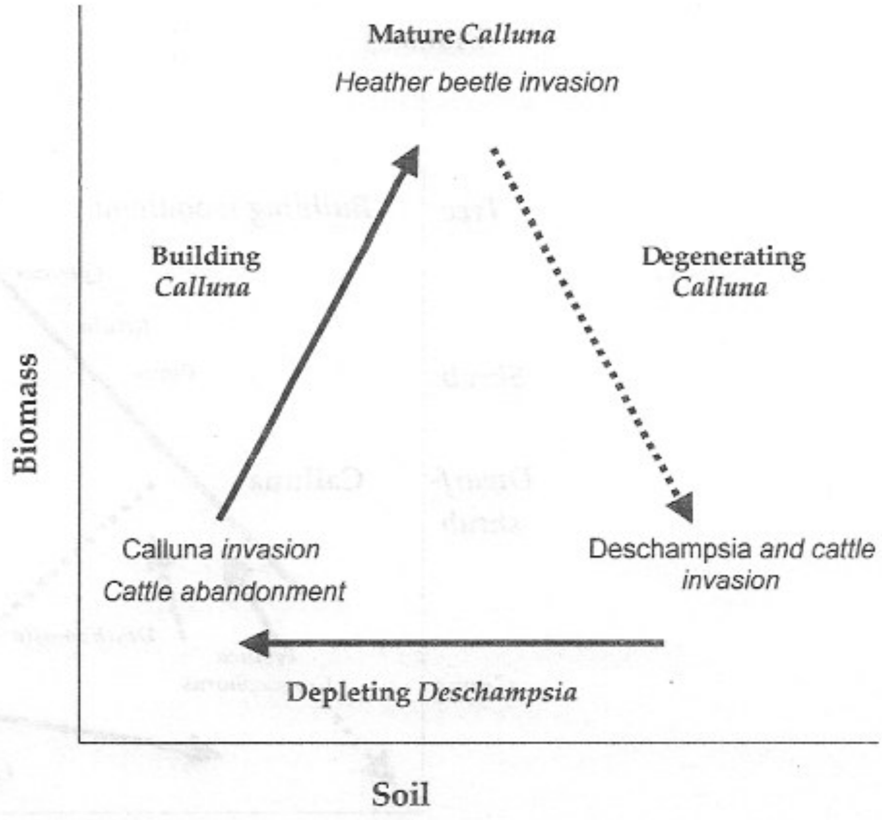

Figure 3. Resource-mediated successional grazing cycle (heather-grass cycle)

Resource-mediated successional grazing cycles

Heather-grass cycle

The emerging resource-mediated successional grazing cycle (RSGC) was summarised in a triangular model. The sides represent the phases succession, regression (gap development) and oligotrophication (soil nutrient deletion) (Figure 3). During succession, the biomass and soil nutrient pools are increasing. During regression (caused by ageing, herbivory or abiotic disturbance), biomass nutrients return to the soil pool. Some nutrients may be lost by consumption, burning, erosion etc. In nutrient-rich gaps, grasses may invade, followed by grazers. Grazing depletes the soil nutrient pool, especially on excreta-free sites and litter gaps in the lawn. Unpalatable, early-seral dwarf-shrubs (eg *Calluna* and *Erica tetralix*) invade below a certain soil fertility threshold. Underlying mechanisms may be an increased light availability for germination and a decreasing disturbance (defoliation and treading) risk for the seedling. The decreased defoliation is a result of a lower productivity and nutritional quality of the less productive grass component. A mounting C/N ratio might enhance the resistance of the invading, unpalatable, woody pioneer (Bokdam *et al*, 2001). The anti-herbivore resistance of Ericaceae, pine and birch depend on carbon-based tannins and terpenes.

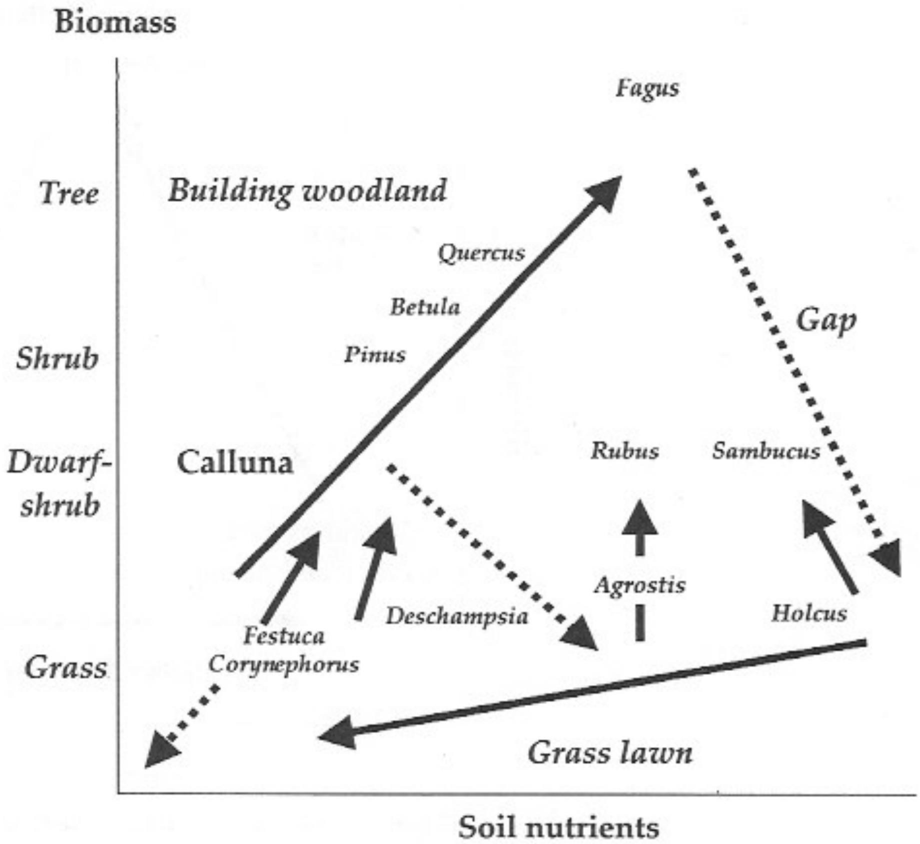

Figure 4. Calculated integrated effect of cattle on nitrogen, phosphorus and potassium soil pools in excreta-free *Deschampsia* lawns

Tree-grass-heather cycle and alternative successional pathways

The concept of a resource-mediated successional grazing cycle might also apply in a longer tree-grass-heather cycle (Figure 4). Without removal, birch and pine would have replaced substantial proportions of *Calluna* in the study area, preventing (or preceding) the shift toward grass. In woodland gaps in the study area, cattle induce grass dominance by suppressing recruitment of palatable, mid-seral trees (*Quercus, Prunus serotina, Sorbus aucuparia*). In some of these *Deschampsia*-dominated woodland gaps *Calluna* invaded. In other gaps and in the open heathland bramble (*Rubus fruticosus*) also established. This unpalatable shrub acted as nurse-crop for *Quercus* and *Sorbus* (Bokdam, 1998; Olff *et al*, 1999). On night-camps ('latrines') unpalatable *Sambucus nigra* invaded. The completion of a grazed tree-grass-heather cycle (Figure 4) requires suppression of unpalatable species with other anti-herbivore defence mechanisms (spines, thorns, glycosides, alkaloids) in the *Dechampsia* lawn. These and other woody species may prevent the development of dwarf shrub heaths, by initiating alternative successional pathways from grassland to woodland on sites with intermediate and high soil fertility (Bokdam, 1998; Olff *et al*, 1999; Bokdam *et al*, 2001).

Implications for heathland grazing

Importance of grazing across abiotic gradients

The RSGC model is linking biomass (light availability) and nutrient availability as essential requirements for *Calluna*. Dwarf shrubs and other heathland organisms require a nutrient-poor soil and absence of competing taller plants. Nutrient-poor soils and the absence of taller competitors may be also generated by abiotic processes (sedimentation, leaching, erosion, low atmospheric deposition, salt spray, wind, low temperature, fire). The hierarchy of grazers and their role as nutrient and competitor remover vary therefore across abiotic gradients. The hierarchy is low in primary heaths on coastal and inland dunes and peat bogs and high in secondary heaths (eg in the study area).

Heaths may occur in complete natural landscapes

The occurrence and proportion of open space and inland heath in an imaginative, complete, natural W European, lowland ecosystem remains speculative, and has been debated (Vera, 1997; Prins, 1998). Geomorphological sites with a natural low nutrient availability and high abiotic disturbance will have offered the best perspectives: dunes and levees in river valleys with a high sand load eg Overijsselse Vecht, Dommel and Ems (Germany), Pleistocene sandy borders along river valleys (S Veluwe) and drained edges of peat bogs. Overflow from neighbouring productive grasslands might have provided the necessary herbivory pressure. At natural levels of atmospheric deposition, grazing depletes not only excreta-free lawn patches, but also lawns as a whole.

The switch from semi-natural to natural grazing may put heath at risk

Switching from semi-natural grazing to natural grazing in an incomplete landscape may put inland heathlands at risk if soil depletion and suppression of competitors remain inadequate. Unpalatable, woody invaders (eg *Rubus, Ulex, Betula*) may invade in grass lawns before heather (Figure 3, 4). Existing heathlands may change into woodland before new (natural) heathland sites have developed (Bokdam *et al*, 2001). Natural grazing includes up-scaling of the successional mosaic, completion of the abiotic landscape, completion of the herbivore and carnivore assemblage and the cessation of intervention in the population. These effects will be shortly explored.

Successional up-scaling by adding woodland will lead to displacement of night-camps from open heathland to the added woodland, reinforcing the nutrient depletion in the open heathland. It may accelerate dwarf shrub or pioneer tree invasion in the grass heath. Grass-rich gaps in the added woodland may divert grazing pressure from the heathland. Adding woodland may therefore lead to a reversal of the mosaic configuration.

Added grass heaths may attract grazing pressure during summer (*Molinia*), spring and autumn (*Deschampsia,* dry farm grassland) from dwarf shrub heath. It may postpone or prevent browsing of *Calluna* and accelerate tree encroachment. Hay feeding has a similar effect. Adding dwarf shrub heath has a minor effect.

Up-scaling of the abiotic gradient by adding floodplains, minerotrophic peat, dune slacks, coastal marshes etc implies addition of productive, attractive grassland and forb vegetation. Adding modern farm grassland has a similar effect. It will lead to abandonment of heath as foraging habitat during summer, but non-foraging pressure may remain high. During winter, foraging may shift back to dry grass or dwarf shrub heaths because of inaccessibility and declining forage quality in the nutrient-rich part of the gradient (Bokdam & Wallis de Vries, 1992; Wallis de Vries, 1994, 1996; Bokdam, unpublished). This terrain-use pattern will lead to nutrient transport by the herbivores from the fertile grasslands in the lower part of the gradient to nutrient-poor, non-foraging areas in the upper part. Nutrient inputs in the fertile grasslands by flooding or fertilisation may keep the production and grazing pressure high and the lawn open. The proportion of heath in the dry part of the abiotic gradient depends on the composition of the gradient and the herbivore assemblage.

Completion of the herbivore assemblage may intensify the defoliation and soil depletion of the lawns dependent on the added herbivores. It may be argued that more herbivore types (grazers, intermediate feeders, browsers, omnivores, frugivores, gramnivores), species, sexes and age classes will broaden the range of used abiotic zones, successional stages, plants and plant parts, and hence increase utilisation (consumption/primary production ratio). Species display overlap in niche, habitat and diet, hence competition and facilitation (Putman, 1986, 1996). The spatial scale and magnitude of nutrient redistribution depends strongly on body size, home range and latrine behaviour of the herbivores. Burrowing species and central-place foragers (eg rabbits) may accelerate lawn depletion locally. Rabbits and large herbivores in combination may initiate drifting sand in cover sand and dune areas.

Free ranging at controlled densities below the carrying capacity, as practised in the Wolfhezerheide, allows the herbivores to forage very selectively and to abandon less productive or unattractive patches (eg *Calluna* and *Rubus*). It prevents soil depletion and may stimulate a tree-grass mosaic. Non-intervention may lead to high densities and finally saturation (population densities at carrying capacity), overshooting the carrying capacity. Population crashes occur in late winter after an unfavourable growing season.

Non-intervention may interact with the size and completeness of the abiotic landscape. Increased herd size as a result of non-intervention or area enlargement may lead to larger grass patches because of the overflow of grazing and treading pressure from occupied or depleted grass patches to the edges of neighbouring heather and woodland stands (Hester & Baillie, 1998). Carnivores may delay or limit population growth. They also modify the spatial distribution of the herbivores. Non-intervention in isolated areas may lead to dominance by a superior herbivore competitor and to local extinction and constrain re-establishment of inferior competitors. Long-term effects of these natural processes and interactions with isolation on the soil-vegetation-herbivore subsystem are still poorly understood (Groot Bruinderink *et al*, 1999). Annual migration between summer and winter foraging ranges enhance population densities, because of a decreased winter mortality. The increased density may lead to foraging overflow from the summer range to the winter range. Depletion of the winter range during the growing season implies starvation and mortality during winter.

Substitution and compensation by traditional farming

Substitution and compensation

Restoration implies reintroduction of lost components and removal of over-complete ones. Irreversable losses may be substituted. Negative effects of irreversable over-completeness may be compensated. Semi-natural management and especially traditional farming (pastoralism and arable farming) may be used as a substitute and as compensation.

Traditional farming as substitution

The study area represented an incomplete abiotic gradient. Nearby nutrient-rich river valley grassland was not accessable. The herbivore assemblage was incomplete and densities of cattle and wild herbivores were below carrying capacity.

The cattle selected and removed grasses and mid-seral trees during summer and autum, *Calluna* during winter and spring. Bramble, pine and birch were avoided and their cover increased. The encroaching pine and birch were removed by the manager. By doing so, he mimicked moose, red deer, elephants and other missing (Eemian) native herbivores. Cattle, roe deer and rabbits at saturation densities might have suppressed the trees. Herded cattle, sheep or goats and traditional farmers might also have done the job. Traditional pastoralism might have been a better approximation of natural herbivory than the actual incomplete herbivore assemblage, which seems to change the open heathland into a wood-pasture landscape.

Unpalatable species are defoliated and suppressed in natural and traditional systems by forced grazing. In natural systems forced grazing results from food scarcity for the herbivore. In semi-natural herding systems forced grazing is generated by food scarcity of the herdsman. In both situations forced grazing is unprofitable for the animal (gains < losses, intake below maintenance requirements). Sustained unprofitable grazing requires supplementation from body reserves or forage supplements. Forced grazing may lead to overgrazing and erosion of the ecosystem.

Nomadic pastoralists (without a permanent settlement) might substitute a natural grazer more appropriately than sedentary pastoralism. Free ranging grazers and nomadic pastoralists are both selective (optimal) exploiters, invading resource-rich patches and abandoning them after resource (food, soil) depletion and/or 'weed' invasion. The RSGC model seems valid for both categories. Nomadic farmers also create dynamic mosaics at landscape level.

Nomadic and sedentary pastoralists mimic natural grazing processes. Winter grazing simulates natural use by migratory herds using river valley grasslands as summer range. Summer grazing in heathlands may mimic natural overflow from saturated river valley grasslands. The daily migration between heathland and stable substitutes the daily movements between foraging and non-foraging habitats in complete landscapes. Supplements provided in the stable mimic small quantities of good natural forage. Stabling and winter feeding substitute for migration to natural winter ranges. Summer grazing in wetlands combined with winter grazing in dry heathland and other forms of traditional migratory pastoralism (transhumance) may mimic natural grazing better than forced year-round grazing in fenced, incomplete landscapes.

Traditional farming as compensation

Settlement transformed nomadic livestock farmers into central-place foragers. It fixed the dynamic mosaic of pastures, arable fields and stables. Transhumance systems are a mixed system, with fixed seasonal central-places (dwellings, camps). The influences of livestock and associational cutting, mowing, turf-stripping, burning and digging, mimic a broad range of herbivores and herbivory influences.

Central-place foragers and sedentary farmers depleted lawns more than wild grazers, nomadic pastoralists and transhumance, because of the year-round fixed nutrient transport from foraging area to resting place. The nutrient drain from pasture to arable land was reinforced and prolonged by inventing methods to exploit dwarf shrubs ('heather croppers' such as sheep, goat, ponies, bees), and turf-cutting. The nutrient drain allowed centuries-long rye cultivation on the plaggen soils. Sustainability required subsidies: supplements for the exploited livestock (eg hay, crop residues) or for the lawn (manure, fertilisers) to prevent a break-down. Without these inputs, livestock and livestock farmers would have had to move in order to escape starvation. Sedentary farming at a scale as practiced in the 18th century in the Netherlands might be considered as 'over-compensation', as it is hard to imagine that natural herbivore assemblages would have been able to turn > 100,000 ha of woodland into drifting sand.

After periods of abandonment and succession to heathland and pine woodland, many of the Dutch former drifting sand landscapes are now being grazed as conservation areas.

Invasion-depletion-abandonment-replenishment cycles are a common phenomenon in biological and cultural systems. They are all generated by mobile, optimal exploiters exceeding exploitation limits.

Conclusions

1. Restoration of complete natural ecosystems is of primary importance as the ultimate long-term nature conservation target.
2. Heathland communities and species might occur in natural landscapes.
3. Traditional farmers may be considered as optimal-foraging 'super-omnivores' exploiting local resources. Nomadic pastoralism and transhumance might mimic natural grazers better than sedentary pastoralism. Traditional farming systems may be viewed as stages in a cultural evolution process controlled by changing ecological conditions.
4. These circumstances suggest that traditional farming techniques are a 'natural' solution for incomplete natural systems.
5. Substitution and compensation may prevent unnecessary losses of early successional stages on nutrient-poor soils during the restoration trajectory from semi-natural to natural ecosystems.
6. If incomplete natural grazing strategies fail to maintain or generate desired habitats and species, it is wise to apply semi-natural techniques.
7. Intensified grazing (or other harvests) as compensation for increased productivity may create an ecological trap for disturbance-sensitive species from early succesional, nutrient-poor habitats. These species require (restored) low productive systems.

References

Aptroot, A & Van Herk, C M (2001) Veranderingen in de korstmosflora van de Nederlandse heiden en stuifzanden. *De Levende Natuur*, 102, 150-155.

Baerselman, F & Vera, F W M (1995) *Nature development. An exploratory study for the construction of ecological networks.* Ministery of agriculture, nature management and fisheries, The Hague.

Bal, D, Beije, H M, Hoogeveen, Y R, Jansen, S R J & Van der Reest, P J (1995) *Handboek natuurdoeltypen in Nederland. IKC Natuurbeheer.* Informatie-en Kennis Centrum Natuurbeheer, Wageningen.

Bignal, E M, McCracken, D I & Curtis, D J (eds) (1994) *Nature Conservation and pastoralism in Europe.* Proceedings of the third European forum on nature conservation and pastoralism, 21-24 July

1992, University of Pau, France. Joint Nature Conservation Committee, Peterborough.

Bokdam, J (1998) Free ranging cattle as driving force for shifting mosaics in heathland vegetation. In: R Cornelius & R R Hofmann (eds) *Extensive Haltung robuster Haustierrassen, Wildtiermanagement, Multi-Spezies-Projekte-Neue Wege in Naturschutz und Landschaftspflege?* pp 39-45. Institut für Zoo- und Wildtierforschung (IZW), Berlin.

Bokdam, J (in press) Effects of browsing and grazing on cyclic succession in nutrient-limited ecosystems. *Journal of Vegetation Science.*

Bokdam, J, Cornelius, R & Krüsi, B O (2001) A conceptual model for nutrient-mediated successional grazing mosaics. In: Gerken B & Görner, M Neue Modelle zu Masznahmen der landschaftsentwicklung mit groszen Pflanzenfressern und praktische Erfahrungen bei der Umsetzung. *Natur- und Kulturlandschaft* 4, 122-131. Höxter/Jena, Germany.

Bokdam, J & Gleichman, J M (2000) Effects of grazing by free-ranging cattle on vegetation dynamics in a continental north-west European heathland. *Journal of Applied Ecology*, 37, 415-431.

Bokdam, J & Wallis de Vries, M F (1992) Forage quality as a limiting factor for cattle grazing in isolated Dutch Nature Reserves. *Conservation Biology*, 6, 399-408.

Bunzel-Drüke, M, Drüke, J & Vierhaus H (1994) Quaternary Park. Üeberlegungen zu Wald, Mensch und Megafauna. *ABU-Info* 17(4)/18, 4-38. Arbeitsgemeinschaft Biologischer Umweltschutz im Kreis Soest e.V. Bad Sassendorf-Lohne (Germany).

Clutton-Brock, J (1999) *A natural history of domesticated mammals.* Cambridge University Press, Cambridge.

De Molenaar, H (1996) *Gedomesticeerde grote grazers in natuurterreinen en bosssen: een bureaustudie. I.* De werking van begrazing. IBN-rapport 231, Wageningen.

Diamond, J (1999) *Guns, germs and steel. The fates of human societies.* W W Norton & Companies, New York.

Ellenberg, H (1988) *Vegetation Ecology of Central Europe.* Fourth edition. Cambridge University Press, Cambridge.

Gimingham, C H (1972) *Ecology of Heathlands.* Chapman and Hall, London.

Groot Bruinderink, G W T A, Lammertsma, D R, Kramer, K, Wijdeven, S, Baveco, J M, Kuiters, A T, Cornelissen, P, Vulink, J T H, Prins, H H T, Van Wieren, S E, De Roder, F & Wigbels V (1999) *Dynamische interacties tussen hoefdieren en vegetatie in de Oostvaardersplassen*. IBN-rapport 436, Wageningen.

Heil, G W & Aerts, R (1993) Synthesis: Perspectives for heathland. In: R Aerts & G W Heil (eds) *Heathlands. Patterns and Processes in a Changing Environment*. pp 201-217. Kluwer Academic Publishers Dordrecht.

Hester, A J & Baillie, G J (1998) Spatial and temporal pattern of heather use by sheep and red deer within natural heather/grass mosaics. *Journal of Applied Ecology*, 35, 772-784.

Kolar, C S & Lodge, D M (2001) Progress in invasion biology: predicting invaders. *Trends in Ecology and Evolution*, 16, 199-204.

MLNV (Ministerie van Landbouw, Natuurbeheer en Visserij) (1990) *Natuurbeleidsplan*. Den Haag.

MLNV (2000) *Natuur voor mensen, mensen voor natuur. Nota natuur, bos en landschap in de 21e eeuw*. Den Haag.

Olff, H, Vera, F W M, Bokdam, J, Bakker, E S, Gleichman, J M, de Maeyer, K & Smit, R (1999) Shifting mosaics in grazed woodlands driven by the alternation of plant facilitation and competition. *Plant Biology*, 1, 127-137.

Oosterveld, P (1975) Beheer en ontwikkeling van natuurreservaten door begrazing. *Natuur en Landschap*, 29, 161-171.

Peeters, T, Nijssen, M & Esselink, H (2001) Bijen in het Nederlandse heidelandschap. *De Levende Natuur*, 102, 159-165.

Prins, H H T (1998) Origins and development of grassland communities in northwestern Europe. In: M F Wallis De Vries, J P Bakker & S E Van Wieren (eds) *Grazing and conservation management*. pp 55-105. Kluwer Academic Publishers, Dordrecht.

Putman, R J (1986) *Grazing in Temperate Ecosystems. Large herbivores and the ecology of the New Forest*. Croom Helm, London.

Putman, R J (1996) *Competition and resource partitioning in temporate ungulate assemblies*. Chapman and Hall, London.

Strijbosch, H (2001) Het belang van het heidelandschap voor de herpetofauna. *De Levende Natuur*, 102, 156-158.

Van de Veen, H E (1975) *De Veluwe Natuurlijk*. Gelderse milieufederatie, Arnhem.

Van Wieren, S E (1988) *Runderen in het bos. Begrazingsproef met Schotse hooglandrunderen in het naturgebeid de Imbos*. Eindrapport. Instituut voor Milieuvraagstukken, Vrije Universiteit, Amsterdam.

Vera, F W M (1997) *Metaforen voor de wildernis. Eik, hazelaar, rund en paard*. PhD thesis, Agricultural University, Wageningen.

Wallis de Vries, M F (1994) *Foraging in a landscape mosaic. Diet selection and performance of free-ranging cattle in heathland and riverine grassland*. PhD thesis, Agricultural University, Wageningen.

Wallis de Vries, M F (1996) Nutritional limitations of free-ranging cattle: the importance of habitat quality. *Journal of Applied Ecology*, 33, 688-702.

Webb, N (1986) *Heathlands*. Collins, London.

Wilson, E O (1999) *Consilience*. Vintage Books, Random House Inc, New York.

WHH (Werkgroep Heidebehoud en Heidebeheer) (1988) *De Heide heeft Toekomst. Directie Natuur, Milieu en Faunabeheer*. Ministerie van Landbouw, Natuur en Visserij, Den Haag.

Species on heaths I: heathland invertebrates

Bare ground, associated insects, and comments upon their conservation on heathlands

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Introduction

The provision of dry, bare ground is often an accepted part of heathland management. It is important to insects as it can provide an area of warmth for basking, and, more importantly, a place where larval development can proceed rapidly. The major users of bare ground for larval development are the bees and wasps, together with a few specialist fly species, some of which are closely connected with the bees and wasps present.

Bees and wasps bring concentrated food resources – insect prey or pollen – to a nest and there ensues a race to consume these, between the larval bee or wasp and other organisms such as fungi. The extra warmth provided by the bare ground gives the larvae a head start over the fungi. The creation of nest burrows in sandy soil is also relatively easy; hence bare patches on heathland are very valuable habitat components for this group. The bare ground needs to be firm and there may be a different nesting assemblage associated with vertical and horizontal areas.

In contrast, the flies associated with dry bare ground on heathlands, other than those directly associated with the bees and wasps, are associated with areas of relatively loose soil, where their larvae are often predators, hunting other insect larvae living in the soil. Deep, loose soil which is regularly disturbed, such as that created by heavy horse use, does not provide valuable habitat for any insect.

Management of bare soil for insects

I have investigated the creation and maintenance of areas of bare soil on heathlands. Generally, scraping the turf off is preferable to rotovating, or burying it, giving a firmer, longer-lasting result. It is clear that most areas of bare ground do not last for very long, five years being typical for areas without further management. This lifetime can be extended by factors such as grazing, wear along footpaths or the physical conditions (ie whether it is created on very dry sand or is vertical). The size and relative proportions of the areas also affect the potential longevity. This typical lifetime implies that either a series of areas of bare ground will need to be created over time, or the areas will eventually need re-creation. This latter option is less favoured for two reasons; it risks destroying those species using the area at the time of re-creation and, more importantly, it removes the opportunity to allow succession to progress. Succession provides short-lived, but very valuable habitat components, such as tussock grasses and heather with small areas of bare ground in between, or flowering plants typical of re-vegetation, such as the various yellow composites.

The way insects use bare ground, and the effects of grazing

Although bare ground can provide larval habitat, this provision may not be direct. For example, the heath potter wasp *Eumenes coarctata* collects mud on areas of exposed soil, especially if these are damp, and uses this mud to build its nests on the stems of tall heather plants. This pot is then filled with caterpillars collected from the surrounding heath and an egg laid in the cell, which is then sealed up.

This utilisation of different parts of the overall heathland habitat for specific parts of the life-history introduces a complication to management, the issue of partial habitats. Ornithologists are familiar with the tendency of birds to nest in one place, but to display and forage in others, with these areas often being well separated. There is a need to consider all partial habitats for a species when considering overall management action. The loss of any component and the population is finished. It is not often realised that many insect species utilise an overall habitat in a similar fashion. I shall here stay with bees and wasps and their associated flies for examples, as they exhibit this behaviour very strongly.

The distances between partial habitats may be considerable. For example, on Mersehead RSPB Reserve on the Solway Firth, a very large population of the heather-specialist bee *Colletes succinctus* nests in areas of bare and sparsely vegetated ground at the rear of the sand dunes. The bee forages for pollen, however, on the heathers growing up to a mile away on the hill-sides behind.

In the south of England, the bee-fly *Bombylius minor* scatters its eggs into likely looking holes, which may be nests of this same bee. These are often in small cliffs within the heath. Such searching activity costs the fly energy, where does it get this? Observations of the bee-fly show it not to be visiting the flowers of heather for this purpose, despite the abundance of these, but to be searching out stands of ruderal and early successional vegetation at the margins of the heath, or grassland areas within the heath. Unfortunately these are the same areas that many grazing animals graze preferentially, often removing the very resources which the heathland insects require, as, although the plant species may still be present, it is the presence of the flowers which is essential for the insects.

My next two examples also deal with the impact of grazing management upon heathland insects, but similar impacts can also be caused by other management techniques; the success of the movement to re-introduce grazing makes this management option currently the single most likely ongoing action to have a serious impact on insect populations on heathland.

The Purbeck mason wasp *Pseudepipona herrichii* is found in a very restricted area of Purbeck, with its major population at Godlingston Heath. This species is rare throughout Europe, being closely associated with heathland and having very exacting foraging and nesting requirements. The wasp digs a nest in exposed areas of clay within the heath and stocks this with paralysed caterpillars of the moth *Acleris hyemana*. The moth lays its eggs on the dormant growing tips of building phase heathers during February and March, and the larvae spins together the new shoots, making a well-protected feeding place. The wasp, however, is able to drive the moth larva from its web, pouncing on it, stinging it and carrying it back to the nest. Early research showed the wasp to be dependent upon: areas of bare clay in which to build nests; a supply of water to mould clay when closing the nest; a supply of *Erica cinerea* flowers for nectar for the adult; and a supply of moth larvae for larval food.

The Godlingston population of the wasp is currently large and has been so for some fifteen years; it has not always been so, however, with evidence of cyclical population boom and bust. Circumstantial evidence links this cycle to periodic fires on Godlingston. It was suspected that a major factor in this cycle related to the abundance of prey, which is itself related to the successional stage of the heathers (all species) following burn events. The moth larva is very scarce in extensive areas of old heathers, and large areas of old heathers are prevalent in many former locations for the wasp in Purbeck.

Accordingly, we set up a number of trial plots on which the heathers were burnt, and the height of the re-growth and the numbers of moth larvae were monitored. During this trial, grazing was established on Godlingston. Looking at the plots of heather growth, it was clear that something happened to our plots, co-incident with the introduction of grazing, the height of heather decreased (Fig 1) and the number of moth larvae, which had been increasing, declined steeply (Fig 2). It was apparent that the ponies had found the relatively succulent new heather growth in the plots and were nibbling out the growing tips in the spring, complete with moth eggs/larvae. There does not have to be a large amount of grazing at this time to have a significant effect, the plants shoot again later (as they did in 2001), but, by then, the moth is not about to lay more eggs, so the caterpillar population is permanently affected.

It is clearly time to re-consider the impact of grazing at this site and alter management in some way. This will be experimental as

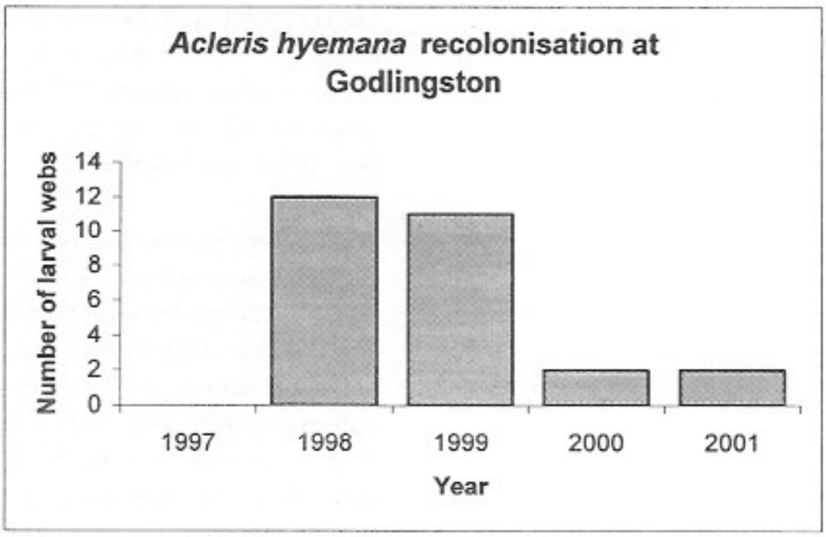

Figure 1.

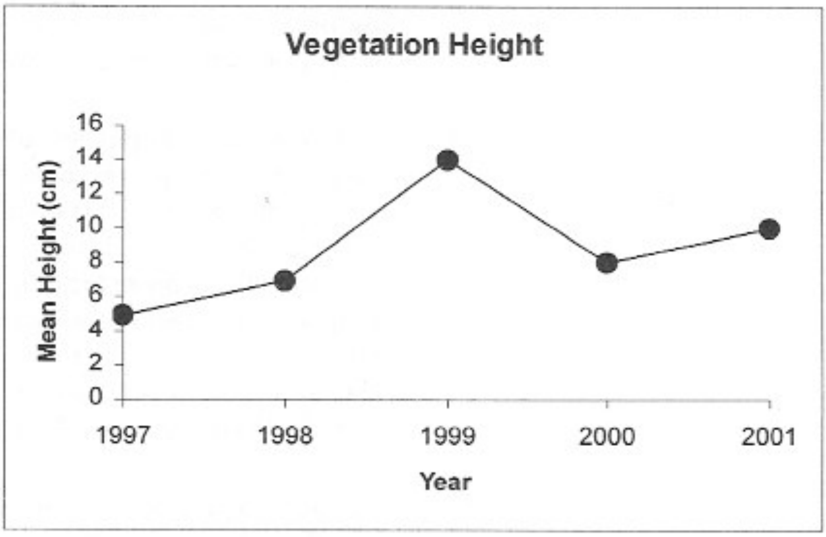

Figure 2.

we do not yet have the detailed information required to establish the balance of grazing impact and sustainability of the moth/wasp system.

At Stedham Common in Sussex grazing with Shetland cattle has been established for two years. An unexpected result of this action was the loss of flowering wood sage *Teucrium scorodonium*. This plant is often abundant on rabbit-grazed heaths and provides an important pollen and nectar source for heathland bees, including *Anthophora bimaculata*. This bee is undergoing severe decline throughout England, as the grassland edge habitat associated with sandy heathlands is lost to succession and there is an overall decline in suitable heathland, something which an appropriate grazing regime could help rectify. However, during summer grazing on such sites, the animals clearly prefer grazing these grasslands, removing the forage resource of the insects the grazing management is meant to be helping.

Conclusions

These examples are just that, examples of impacts, they are not anti-grazing sentiments, but I consider that serious consideration of the way in which grazing is implemented should be an integral part of the process of management. The situation is complicated by the fact that many insects, which nowadays have their major populations on heathlands, are there only because of the physical conditions of the habitat, warmth and a light soil; they have no close association with the heather component. In previous times, they would have been more associated with the fields around the heathlands, than the grazed heath. There is a very serious issue here, which should be debated. Should conservation of heathlands in a modern environment take account of the needs of individual species, as well as the broader habitat, and if not, where do they fit in? This decision is not restricted to insects alone. Specialist heathland species such as the woodlark and Dartford warbler also come into this category.

Clearly there is a need to include some form of risk assessment for insect species when undertaking management, as is often already done for birds and reptiles. Such assessment need not necessarily be at the species level. There are characteristic vegetation structures that give good guides as to the likely suitability of particular areas for insect populations, although where specific species of high conservation value are concerned, more detailed information may be more appropriate.

The Scarce Ground Beetle Project – conserving the ground beetle fauna of Britain's lowland heaths

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Introduction

Ground beetles all belong to the family Carabidae, and include some of our most familiar British beetles. As their name suggests, most carabids live on the ground, where they prey on a range of other invertebrates, such as grubs and worms. Many ground beetles can be found under stones and logs, but they are extremely diverse in their habitat requirements. For example, a number of species occur in the woodland canopy, whilst others are restricted to the tops of mountains. Wetlands support many species, as do lowland heaths and coastal habitats such as saltmarshes.

There are about 365 species of ground beetles in Britain. Of these, half of the species are considered to be scarce or threatened. Many have shown considerable declines in their abundance this century, primarily as a result of the loss of their habitats to intensive agriculture and forestry, or to inappropriate development. The presence of populations of scarce ground beetles is a very good indication that the quality of the habitat is still high. Carabids are one of the best-studied groups of British beetles, being relatively easy to identify and including a number of extremely attractive species.

Because of these threats to our carabid fauna, and the relatively good knowledge that we have of their distribution, habitat and identification, they are well represented in the list of priority species in the UK Biodiversity Action Plan (BAP). In all 33 ground beetles are included in the UK BAP, a full list of these can be found in Table 1 of the *Scarce Ground Beetle Project Newsletter*, circulated to all delegates. For each of these species, the UK BAP provides a series of actions that will need to be addressed by 2010 in order to maintain and enhance their populations.

The Scarce Ground Beetle Project (SGBP)

These 33 species are the main focus of the project. However, its remit also includes other Nationally Scarce and Red Data Book carabids, where there is thought to be a pressing need for conservation action. English Nature are charged by government with accomplishing the actions laid out in the UK BAP. They have already initiated work on a number of the priority ground beetles in conjunction with voluntary conservation organisations in the Biodiversity Challenge partnership, and with Invertebrate Link.

The SGBP was set up with funding from English Nature to complement and extend this work. The project only covers populations of scarce ground beetles occurring in England. It will run from 2000 until 2004. The aims of the project are:

- to achieve a good understanding of the current distribution, ecology and conservation needs of the 33 priority ground beetles
- to encourage the adoption of management regimes that will maintain and enhance populations of scarce ground beetles
- to consider the requirements of other Nationally Scarce or Red Data Book carabids
- to disseminate the results of the project to conservation organisations and the general public, primarily through the establishment and servicing of a scarce carabid network.

Scarce Ground Beetles of Lowland Heaths

In talking about the ground beetle fauna of lowland heaths, I have defined the habitat to include, in addition to lowland heathland in its strict sense, the wet valley mires that are an integral part of the habitat mosaic on most lowland heaths in southern England. For this reason I have included a discussion of the ground beetles of mire habitats in this paper. Certainly mire habitats are of great importance for scarce ground beetles, with two of the species included in the BAP priority species list being mire specialists, in addition to the four species that are restricted in Britain to dry lowland heath. These six species of carabid are listed below in Table 1, with brief notes on distribution and habitat.

Table 1. Priority BAP Ground Beetles of Lowland Heathland

Species	Range	Habitat
Amara famelica	Sussex, War & Yorks	Lowland heath
Anisodactylus nemorivagus	Dorset, Hants (New Forest), Wilts & Surrey	Lowland heath
Wood Tiger Beetle *Cicindela sylvatica*	Dorset, Hants (New Forest), Sussex & Surrey	Lowland heath with patches of bare sandy ground
Pterostichus aterrimus	Hants (New Forest)	Valley mire & poor fen
Kugelann's Ground Beetle *Pterostichus kugelanni*	Devon, Dorset & Hants (New Forest)	Lowland heath with bare, sandy banks
Tachys edmondsi	Hants (New Forest)	Valley mire

Four of these ground beetles, *Amara famelica, Cicindela sylvatica, Pterostichus kugelanni* and *Tachys edmondsi,* have been targeted for action in 2001. The remaining three are not currently considered to be a priority for action. Further information on these ground beetles is included in a short discussion of each below.

Amara famelica (Zimmerman)

Amara is one of the larger genera of British ground beetles, with 31 species being included in Lindroth (1974). It is also one of the more difficult groups to identify, with many of the species, including *A famelica,* being superficially very similar and requiring close microscopic examination for reliable identification. This species is not covered by the SGBP, as it is already the subject of a study being overseen by the Action for Invertebrates project, supported by Biodiversity Challenge, English Nature and the Joint Committee for the Conservation of British Invertebrates, with survey work undertaken by Dave Hemingway. Thus far this study has not located populations of this extremely elusive insect. There are recent records from three widely spaced sites in England: Ashdown Forest in Sussex, Strensall Common in Yorkshire (Luff, 1998) and Sutton Park in Warwickshire (Lane, 1999). All these records are from dry/humid *Calluna vulgaris* dominated heathland. There are also scattered pre-1970 records from a number of sites in southern and eastern England. Until established populations are discovered, it is impossible to discuss the ecology of the species, or to formulate conservation management recommendations for it. There is a full Action Plan for *A famelica* included in the UK BAP (UK Biodiversity Group, 1999a).

The species is rated Red Data Book (RDB) 3 (Rare) by Hyman and Parsons (1992).

Anisodactylus nemorivagus (Duftschmid)

This is a very rare inhabitant of dry, sandy heathland. Recent records are from a handful of southern heathland sites in Dorset, Hampshire, Wiltshire and Surrey. It has always had a very restricted southern distribution in Britain, though there are also pre-1970 records from the Norfolk and Suffolk Brecks, and from south Wales (Luff, 1998). This species is only accorded a Species Statement in the UK BAP (UK Biodiversity Group, 1999b), and for this reason is not considered a priority for funded research. It is a spring breeder, with larvae developing over the summer. Both adults and larvae are thought to be seed feeders. Other than this basic ecological information, very little seems to be known of its ecology, and it is not possible to formulate management recommendations for it currently. *A nemorivagus* is listed as Nationally Scarce (A) in the UK Coleoptera Review (Hyman and Parsons, 1992). *A nemorivagus* was recorded by A J W Allen at a new site on the MoD range at Bovington in 2001 in the course of carrying out work on *Cicindela sylvatica* (see below).

Wood Tiger Beetle _Cicindela sylvatica_ (Linnaeus)

Cicindela sylvatica is the largest British tiger beetle, and is distinguished from other species by its predominantly charcoal-black colouration and the deep pits that adorn its wing cases. Like most tiger beetles, it flies readily, and is very wary and difficult to approach. The carabid atlas (Luff, 1998) shows that formerly this species had a localised but widespread distribution on the southern heaths of Dorset, Hampshire, Sussex and Surrey, with a handful of sites elsewhere, including a single very isolated locality in Lincolnshire. By contrast, post-1970 records are very sparse, and it appears to have been lost from many of its former sites. In some cases this is clearly the result of the loss of its heathland habitat to intensive agriculture, forestry or development, but worryingly it also seems to have vanished from a number of sites where heathland is still present. In particular, its complete disappearance from the New Forest is perplexing. This species is currently only rated as Nationally Scarce (A). However, it is certain to be updated to Red Data Book status at its next review, on account of its steep decline in the UK.

This is one of the species for which work has been funded under the SGBP during 2001. Fieldwork carried out by A J W Allen and the RSPB's Dorset Heathland team has resulted in the species being recorded from six sites during the year. Five of these sites are on the lowland heaths of Dorset, with the only other currently known British population being in Surrey. The discovery of the wood tiger beetle on two new areas of heathland on MoD land is particularly encouraging. As with other tiger beetles, *C sylvatica* requires heathland with patches of bare, sandy ground in which the larval burrows can be constructed, and over which the adults are able to hunt. One of the primary reasons for the decline of this species in the UK is thought to be the lower levels of management disturbance, and consequent reduction in bare ground that this causes. On many of its former sites, lack of grazing and burning in particular have resulted in the development of large expanses of dense, tall heath, with very little open ground. This point is highlighted by the discovery of wood tiger beetle colonies on two areas of MoD land that are much disturbed by military training, and still have an abundant supply of bare, sandy ground. Having discovered good populations in 2001, the challenge in 2002 will be to start to build a better understanding of the ecology of the species and its conservation management requirements.

Pterostichus aterrimus (Herbst)

This is a distinctive jet-black ground beetle, with a very shiny, 'varnished' appearance. It has always been considered a great rarity, with sporadic records interspersed with long periods when it has been feared extinct. In the 19th century it was thought to be restricted to East Anglia, but in the following century it disappeared from this area as its fenland habitats were drained. However, in 1969, it was found in the New Forest in a bog-moss *Sphagnum* spp-dominated valley mire surrounded by dry heath. Unfortunately, this bog was drained soon after the species had been discovered, and by 1973 it had become extinct here, and was again feared to be lost as a British species. This remains the case to the present day, though it has recently turned up at a number of sites in Ireland. It is listed as RDB1 in the Coleoptera Review (Hyman and Parsons, 1992). Due to the uncertainty regarding the status of this species in southern England, no work is planned currently. However, the recent discoveries in Ireland indicate that new British colonies may still exist in the New Forest, and possibly elsewhere.

Kugelann's ground beetle _Pterostichus kugelanni_ (Panzer)

A striking ground beetle, with metallic green elytrae, contrasting with a metallic coppery-pink forebody. Formerly this species had a widely scattered distribution in southern Britain, ranging from Cornwall and Glamorgan east to the London commons, with outlying populations in Norfolk and Nottinghamshire. During the 20th century, this species has shown a massive contraction in its British distribution, and by the beginning of this project there had only been recent records from two sites in the New Forest and at two sites in Devon. This decline has resulted in its designation as RDB1 (Endangered) (Hyman and Parsons, 1992).

The ecology of this species is broadly similar to that of the wood tiger beetle, as it is also a denizen of lowland heathland with a requirement for bare ground. Kugelann's ground beetle is another of those species that is the subject of ongoing research as part of this project, with John Walters being contracted to carry out the work. As with the other species, the initial focus has been on establishing the extent of the British distribution. This has proved to be very successful, with additional populations being discovered at two further sites in Dorset and another small colony being located in Devon. One of the Dorset sites is on MoD land at Bovington, where populations of the two other dry heathland BAP priority species *Anisodactylus nemorivagus* and

Cicindela sylvatica were also found in 2001, making this a site of outstanding importance for the conservation of rare ground beetles.

More detailed autecological studies have begun at the population of this species on Dartmoor. The habitat here is heavily grazed and frequently burnt dry heath, with abundant patches of peaty and rocky, bare ground. This conforms to its habitat elsewhere in England, though on the lowland heaths of Dorset and the New Forest, it generally occurs on heathland with patches of bare, sandy ground, and at another Devon site, it is found on pebblebed formations. The wider range of substrates it is able to utilise helps to explain its wider British distribution in comparison to *A nemorivagus* and *C sylvatica*, which are confined to sandy substrates. In all cases, Kugelann's ground beetle is found on south-facing slopes, and is clearly extremely thermophilous. In the New Forest, it has been noted visiting the burrows of solitary bees on a south-facing sandy bank, though this relationship has not been observed at other sites. An association with the dung of grazing animals has also been postulated, and though this is clearly not an obligate relationship either, it is nonetheless interesting that much the densest population occurs on common land on Dartmoor, where grazing pressure is still quite high. At this site, adults may be readily observed during sunny days from March through to July. Adults have been recorded feeding on small bugs (Heteroptera), and on the darkling beetle *Cylindrinotus laevioctostriatus*. Larvae have also been found, and have been reared through to the adult stage in captivity on a range of invertebrate prey. As with other rare heathland invertebrates, its decline is probably attributable to the withdrawal of management from many of our lowland heaths, and the consequent reduction in bare ground that this has created.

Edmond's ground beetle *Tachys edmondsi* (Moore)

Edmond's ground beetle is a tiny, dark reddish-brown carabid. It is a great rarity that has only ever been recorded from the New Forest. It was discovered in a valley mire here in the 1912, with the last record being by A M Massee in 1936. After this, there was a long hiatus during which time it was feared that it had become extinct. However, in 2000, a coleopterists' meeting organised in the New Forest rediscovered *T edmondsi* in a small valley mire quite close to the historical site.

For many years it was thought that this was our only endemic species of ground beetle, however, recent research suggests that once a thorough taxonomic revision of this group is undertaken, *T edmondsi* will be shown to be conspecific with other members of the sub-genus *Paratachys* already known to occur in south western Europe and north Africa. Currently its UK status remains RDB3/5 (Rare and Endemic).

Bryan Pinchen is undertaking further work on this species funded by this project. A major element has been to attempt to find further populations, and thus far he has discovered two new 'sites', though both of these are very close to the original colony, and probably constitute sub-populations. In the following years, more emphasis will be placed on elucidating the ecology of the species, though with such a small and cryptic beetle, this will present a major challenge. The most interesting point to emerge from investigations thus far is that *T edmondsi* appears to favour hummocks of bog-moss lying on the interface between valley mire and humid heath habitats. Such hummocks become very warm over the summer, and given the southern distribution of many members of this sub-genus, it seems probable that this is a thermophilous species, with 'relict' populations in the New Forest. Sites favoured are generally very sheltered by scrub and bracken, which also helps to create an extremely warm microhabitat.

Conclusion

The UK BAP has provided a major stimulus promoting work on the scarce and threatened ground beetles of our lowland heaths. Thus far, work carried out by English Nature's Scarce Ground Beetle Project has aimed to try and understand better the British distribution of the 33 BAP priority ground beetles. To this end, the project has already been extremely successful, and in lowland heathland habitats, new colonies of *Cicindela sylvatica, Pterostichus kugelanni* and *Tachys edmondsi* have been located during 2001. The challenge in future years of the project will be to build on this information, particularly by developing our understanding of the ecology of lowland heathland ground beetles, and thus to inform our conservation management decisions.

Acknowledgments

The author would like to thank Tony Allen, Dave Hemingway, Bryan Pinchen and John Walters, who have provided much of the information on which this paper is based, and to Roger Key, English Nature Nominated Officer for this project. Also special thanks to Durwyn Liley, Andy Schofield and Pete Brash of the RSPB Dorset Heathlands team for all of their input and assistance during the year.

References

Hyman, P S & Parsons M S (1992) *A Review of the Scarce and Threatened Coleoptera of Great Britain Part 1*. UK Nature Conservation Report No 3. JNCC, Peterborough.

Lane, S A (1999) *Amara famelica* Zimmerman (Carabidae) from Warwickshire (vc 38) and Staffordshire (vc 39) heathland. *Coleopterist*, 8(1), 43.

Lindroth, C H (1974) *Handbooks for the Identification of British Insects. Coleoptera: Carabidae Vol IV Part 2*. Royal Entomological Society, London.

Luff, M L (1998) *Provisional Atlas of the Ground Beetles (Coleoptera, Carabidae) of Britain*. Centre for Ecology and Hydrology, Monks Wood.

UK Biodiversity Group (1999a) *Tranche 2 Action Plans. Volume IV – invertebrates*. English Nature, Peterborough.

UK Biodiversity Group (1999b) *Tranche 2 Action Plans. Volume VI – terrestrial and freshwater species and habitats*. English Nature, Peterborough.

Heathland management II

Is there life after bracken?

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Background – why is bracken a problem?

Bracken *Pteridium aquilinum* (L) Kuhn is an invasive native fern, which covers large tracts of land in the UK (Pakeman & Marrs, 1992a). It is a particular problem in upland and marginal areas where it impacts on conservation, agriculture, forestry, sporting interests and causes animal and human health problems (Pakeman *et al*, 2000a). Bracken is a problem for many land users. It can have a substantial commercial impact through obstructing agricultural and forestry practices; it is poisonous and carcinogenic to browsing livestock (Marrs *et al*, 2000); and it presents a risk to human health by harbouring ticks, which act as vectors for Lyme disease. Bracken invasion is regarded as a conservation problem, mainly because it tends to replace biotopes that have a greater species diversity, although there are exceptions, where the bracken canopy provides a habitat for butterflies for example. The canopy of bracken fronds, which emerges in spring, shades out most competitors and the thick litter layer, which develops underneath, hampers the growth of other species (Marrs *et al*, 2000).

The spread of bracken over recent decades has been partly blamed on a combination of (i) a decline in harvesting for soap, livestock bedding and thatch and (ii) a general reduction in its management (Pakeman *et al*, 2000b). Increases could be due to changes in land use, eg a switch from cattle to sheep, change from heavier wether sheep to smaller ewes, increased sheep grazing and reduced management, especially bracken control measures. Part of the difficulty is poor/inaccurate recording, inherent in measuring a plant that can exist at relatively low frond density. Until recently no measure of bracken infestion under trees has been made. Moreover, predictions suggest that bracken will increase as climate warms (Pakeman & Marrs, 1996).

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Strategies used to control bracken

Generally there are three strategies which can be used.

1 *Mechanical control.* Fronds are cut during early summer, before and up to the point of maximum frond expansion. The aim is to ensure a maximum withdrawal of carbohydrates and nutrients from the rhizome reserves. When this strategy is used it is advisable to cut the fronds before the new assimilates start being translocated from the fronds to the rhizomes in large amounts (late July/early August in Britain). Cutting can be carried out one, two or three times annually.

2 *Herbicidal control.* Herbicide action is unlikely to have a significant effect on the amount of rhizome carbohydrate reserves, so herbicides which attack frond buds on the rhizome are most successful. Asulam [methyl (4-aminobenzenesulphonyl) carbamate] is the most widely used herbicide for bracken control; it is translocated into the rhizome and accumulates in both active and dormant buds, where it effects a lethal action. Asulam frequently produces a very good reduction in fronds in the year after spraying, but there is often rapid frond recovery unless other treatments are applied in subsequent years (Lowday & Marrs 1992).

3 *Inhibition by other vegetation.* Usually where dense bracken is to be controlled, managers want to remove the bracken and replace it with some other vegetation. There is some evidence that this approach can work in some situations (Watt 1955; Lowday & Marrs, 1992).

Toward a national strategy for bracken control

In order to develop a comprehensive national strategy for bracken control, it is essential to investigate how much needs to be treated, the initial effectiveness of treatments and long-term prospects for bracken recovery. There is only a limited amount of information available on the initial effectiveness of control. There is considerable debate about the exact amount of bracken present in Great Britain and in most other countries where bracken is a problem (Pakeman *et al*, 1995). Marrs *et al* (1998) argue that the reasons why it is difficult to obtain reliable estimates of the amount of bracken infested land and encroachment rates of bracken are because of great uncertainties about previous bracken cover, historical management techniques and long-term recovery after past treatment.

To gain some insight into these process, information on long-term responses of bracken to control are needed. We are attempting to do this using a combination of: responses from short-term experiments; responses of bracken and ground vegetation to commercial asulam spraying using a space-for-time substitution (chronosequence) approach; and mathematical models of the carbohydrate fluxes in the bracken plants.

1 *Bracken control experiments*. We have set up a series of 11 experiments in 4 regions of the UK (Scottish Borders, Peak District, Cannock Chase and Snowdonia). In 7 of the experiments the same suite of bracken control treatments have been applied to dense bracken using randomised block experiments. The same 6 bracken control treatments have been applied at each site, these are: (1) control (untreated), (2) cutting (flail cutter trailed by ATV) once per year (cut once/yr), (3) cutting twice per year (cut twice/yr), (4) asulam application (knapsack) in first year only (asulam), (5) asulam application in first year followed by single cut in second (asulam + cut), (6) cutting in first year followed by asulam in second (cut + asulam). At each site, various site-specific revegetation treatments have been applied, including addition of seed, nurse crops, *Calluna* litter, *Calluna* brash, fertilisers, burning and harrowing, as well as some bracken re-treatments (spot spraying and weed wiping). Full details of the methods are available in Le Duc *et al* (2000).

2 *Chronosequence approach*. Our initial study involved an assessment of change in vegetation after aerial applications of asulam in the North York Moors National Park (Pakeman & Marrs, 1992b). The applications had been made at various times before the sampling and it was assumed that there was a time course. This work has been repeated and extended to a much larger sample of 117 sites across the UK. This survey is also being repeated and for some sites we are following the time course of change from before the initial spraying. The analysis of these data is complex and we are in the process of developing techniques for sub-classification of the data and the use of multivariate analysis to identify important trends. One trend that was quickly isolated was that the ground vegetation that develops after asulam treatments on many sites shows an affinity with woodland ground flora, and it may be cost-effective to develop native woodland on such sites.

3 *Modelling*. Models of both bracken control and the response of vegetation have been developed and tested against independent data (Paterson *et al*, 1997, 2000). Whilst these models still require to be augmented as a result of new data collected in the experiments and chronosequence survey, our aim is to develop a national bracken control strategy that can be delivered via a Decision Support System. We also provide *Guidelines for bracken control*, which are updated regularly, and are available from http://appliedvegetationdynamics.co.uk/Land Management/

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References

Le Duc, M G, Pakeman, R J, Putwain, P D & Marrs, R H (2000) The variable responses of bracken fronds to control treatments in Great Britain. *Annals of Botany*, 85 (Supplement B), 17-29.

Lowday, J E & Marrs, R H (1992) Control of bracken and the restoration of heathland. I. Control of bracken. *Journal of Applied Ecology*, 29, 195-203.

Marrs, R H, Johnson, S W & Le Duc, M G (1998) Control of bracken and restoration of heathland. VI. The response of bracken fronds to 18 years of continued bracken control or 6 years of control followed by recovery. *Journal of Applied Ecology*, 35, 479-490.

Marrs, R H, Le Duc, M G, Mitchell, R J, Goddard, D, Paterson, S & Pakeman, R J (2000) The ecology of bracken: its role in succession and implications for control. *Annals of Botany*, 85 (Supplement B), 3-15.

Pakeman, R J & Marrs, R H (1992a) The conservation value of bracken (*Pteridium aquilinum* (L) Kuhn) dominated communities in the UK, and an assessment of the ecological impact of bracken expansion or its removal. *Biological Conservation*, 62, 101-114.

Pakeman, R J & Marrs, R H (1992b) Vegetation development on moorland after control of *Pteridium aquilinum* (L) Kuhn with asulam. *Journal of Vegetation Science*, 3, 707-710.

Pakeman, R J & Marrs, R H (1996) Modelling the effects of climate change on the growth of bracken (*Pteridium aquilinum*) in Britain. *Journal of Applied Ecology*, 33, 561-575.

Pakeman, R J, Marrs, R H, Howard, D C, Barr, C J & Fuller, R M (1995) The bracken problem in Great Britain; its present extent and future changes. *Applied Geography*, 16, 65-86.

Pakeman, R J, Le Duc, M G & Marrs, R H (2000a) Bracken distribution in Great Britain: strategies for its control and the sustainable management of marginal land. *Annals of Botany*, 85 (Supplement B), 37-46.

Pakeman, R J, Thwaites, R H, Le Duc, M G & Marrs, R H (2000b) Vegetation re-establishment on land previously subject to control of *Pteridium aquilinum* by herbicide. *Applied Vegetation Science*, 3, 95-104.

Paterson, S, Marrs, R H & Pakeman, R J (1997) Evaluation of a bracken (*Pteridium aquilinum* (L) Kuhn) growth model in predicting the effects of control strategies across a range of climatic zones in Great Britain. *Annals of Applied Biology*, 130, 305-318.

Paterson, S, Pakeman, R J & Marrs, R H (2000) Describing vegetation succession after bracken control: evaluation of the REBRA model. *Journal of Environmental Management*, 59, 31-45.

Watt, A S (1955) Bracken versus heather: a study in plant sociology. *Journal of Ecology*, 43, 490-506.

Burning lowland heaths: the management method of the past, present and future?

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Introduction

Heathland is a semi-natural vegetation type, created by forest clearance that began in Neolithic times. The maintenance of the dwarf shrub communities throughout the centuries was due to some form of management. In the absence of management, heathland would undergo succession to scrub and eventually woodland. Today, management techniques such as cutting, burning, grazing and turf-cutting are used to create structural diversity to benefit invertebrates, birds and reptiles.

Heathlands as part of a rural economy

Prior to the agricultural advances of the late 17th century onwards, heathland soils were too infertile to cultivate and therefore open heath was used for other purposes. Heathland provided fuel, thatch, rough grazing and animal bedding for many rural communities, who settled and cultivated the more fertile soils within the heathland areas. Grazing was widespread on the lowland heaths of southern Britain until the middle of the 19th century (Webb, 1986). The practices of cutting gorse for fodder and rotational burning were associated with grazing, both of which helped to maintain the open nature of heathland.

The use of fire to manage the heathlands of Scotland and northern England has been established since about 1800 (Gimingham, 1972). Burning may not have been so common on the southern heaths. There are only occasional records of heath fires (eg White, 1789) and legislation existed to prevent them (Rackham, 1986). The traditional uses of heathland such as fuel gathering and grazing may have prevented scrub invasion without the need for burning (Webb, 1986). Indeed, closely grazed heather would be difficult to burn and the ungrazed areas were required for fuel (Rackham, 1986). Regular burning may have been introduced as late as the 19th century, following the example set in the uplands, possibly in response to the decline in grazing and other activities (Webb, 1986).

The decline of heathlands

The agricultural improvements of the late 17th century enabled cultivation of some of the heathland. Open commons and wastelands were enclosed and the use of fertilisers, crop rotations and weed control increased dramatically. Enclosed heathland was often stripped of vegetation, ploughed and burnt. Where heathlands escaped ploughing, the decline in grazing and fuel gathering permitted the invasion of trees and scrub. By the mid-19th century nearly one sixth of Surrey had changed from heathland to woodland (Rackham, 1986). The extent of the Dorset heathlands changed little between Roman times and the mid-18th century (Haskins, 1978), when the area of heath started to decline due to agriculture and afforestation (Moore, 1962; Webb and Haskins, 1980). The expansion of Poole and Bournemouth in the late 19th century covered extensive areas of heathland. The heathlands of the Poole Basin shrank from 40,000 ha in the mid-18th century to only 5,832 ha in 1978 (Webb and Haskins, 1980).

Moore (1962) states that: 'probably the most important effect of the decline of rough grazing has been the virtual extinction of controlled burning which used to accompany it.' The area of heathland in Dorset that is burnt each year has declined further since Moore's 1960 survey. Between May 1959 and May 1960, approximately 8% of the heathland existing at that time was burnt (Moore, 1962). The 1978 survey described by Webb and Haskins (1980) found only 13.6% of the existing heathland had been burnt in the preceding two years. It was estimated that 11% of this was in 1976, when there were extensive accidental fires. In the two years preceding the heathland survey of 1987 (Webb, 1990), only 6% of the area had been burnt. The cessation of controlled burning and the lack of any adequate alternative management has led to an increase in scrub cover of 1.7% per year on the Dorset heathlands between 1978 and 1996 (Rose *et al*, 2000). Furthermore, the build up of fuel in the form of vegetation biomass may increase the frequency and severity of uncontrolled fires in the spring and summer.

Heathland management today

The precise aims of management and the techniques used depend on the site and its particular objectives. For example, small urban sites may be managed primarily for amenity and education, whereas large rural sites might manage different compartments with different objectives, targeted at a particular species or group of species eg the Dartford warbler *Sylvia undata* or sand lizard *Lacerta agilis*. Heathland sites are subject to a range of influences which also affect the choice and frequency of management, such as deposition of pollutants, the size of the reserve, whether or not the site has been invaded by scrub or alien species, and the degree of human disturbance. However, the objectives to maintain a diversity of vegetation structure and a range of growth phases of the dwarf shrubs are generally applicable.

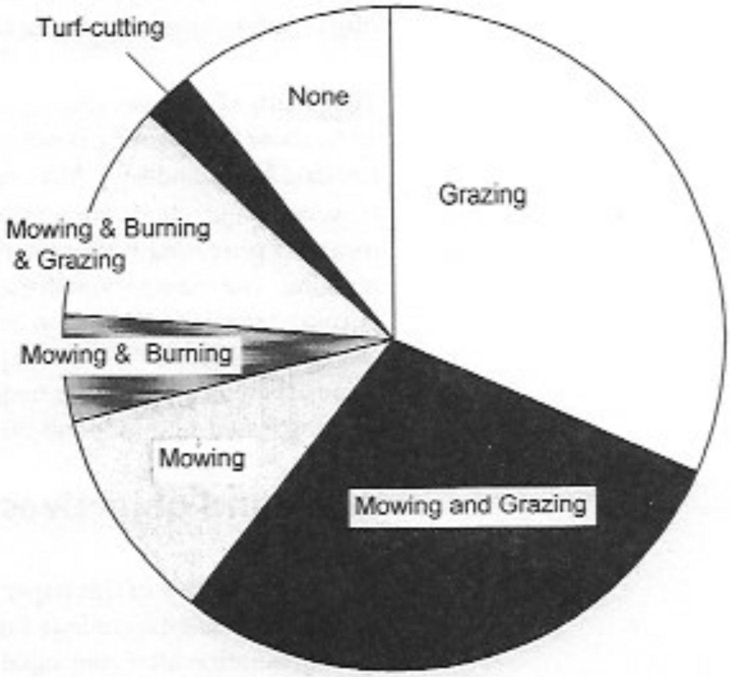

Figure 1. Results of a survey showing the management techniques used on 40 lowland heathland sites

The *Calluna* growth cycle has been described in detail by Watt (1955). The development of seedlings from small pyramid-shaped plants to bushes is known as the pioneer phase. The time spent in this phase is variable, but tends to be between six and ten years. The building phase is the phase of maximum production (Barclay-Estrup, 1970) and continues until the age of about fifteen years. An even-aged stand of building phase *Calluna* has a closed canopy and dense shoots. The mature phase lasts for approximately ten years and is recognised by the increasing proportion of woody material and the opening-up of the canopy. After about thirty years, plants enter the degenerate phase, when bushes begin to die off from the centre forming a more heterogeneous vegetation structure. Degenerate heath has a higher vegetation biomass than mature heath, and a higher proportion of the biomass is due to woody material.

In contrast to the uplands, in particular grouse moors, where the heather is burnt on a rotation of 10-15 years to maintain maximum productivity, on lowland heaths there is often a high proportion of heather in the degenerate growth phase. Degenerate heather can present a problem because the gaps created by dying plants are not always replaced by *Calluna* (ie cyclical succession). The gaps may be colonised by potentially invasive species such as trees, grasses and bracken (*Pteridium aquilinum*). Furthermore, because the ability of heather to regenerate vegetatively declines with age (Kenworthy, 1963; Miller and Miles, 1970; Hobbs and Gimingham, 1984a) managing degenerate heather by burning or cutting may itself result in persistent bare ground that is open to invasion. As a result, site managers are often loath to burn degenerate heathland.

The results of a survey (Fig 1), with 40 respondents, carried out in 1999, show that burning is not the favoured technique on most lowland heathland sites. Mowing and grazing are used more frequently and a high proportion of sites use only grazing with no means of providing fresh growth of *Calluna* through burning or mowing. The main factors dissuading heathland managers from burning are a fear of invasion by undesirable species such as birch, grasses and bracken and the impacts on reptiles and amphibians. On some urban fringe sites, the frequency of arson is such that controlled burning is not necessary and there is also a fear of 'copycat' burning.

Aims and objectives of this work

The main objective of this paper is to demonstrate that burning is a valid management technique for lowland heathlands by describing the regeneration after controlled burning of mature and degenerate stands of heath at RSPB reserves in Dorset and Devon. The aims were to discover if fire temperature affects post-fire regeneration and to elucidate the relative contributions of fuel load and growth phase of the vegetation as factors controlling fire temperature. A three year study of post-fire succession followed, to test the hypothesis that controlled burning resets the *Calluna* growth cycle and does not facilitate invasion by other species.

Methodology

The experiments were performed at two sites in southern Britain – Arne in Dorset and Aylesbeare in Devon. A stand of mature and a stand of degenerate growth phase heath were selected at both sites. Biomass was sampled before burning and found to be greater at the degenerate stands than at the mature stands. *Calluna* was the only dominant species at both stands at Arne, but it was co-dominant with *Ulex gallii* and *Erica* species at Aylesbeare.

A randomised block design was employed, with two burning treatments of low and high fuel loads plus an unburnt control, replicated four times at each stand. Vegetation was added to the high fuel load treatments at the mature stands and bushes were removed from the low fuel load treatments at the degenerate stands (Table 1).

Table 1. Summary of the fuel load treatments

	Treatment	
Stand	**Low Fuel Load**	**High Fuel Load**
Mature	Burn existing vegetation	Add vegetation
Degenerate	Remove vegetation	Burn existing vegetation

Pyrometers were constructed by painting strips of temperature-sensitive paints (Tempilaqo) and crayons (Tempilstikso)[1] onto 20 x 20 cm floor tiles. The paints and crayons had specified melting points of between 38 and 1038°C to cover the temperature range expected in controlled burning (eg Whittaker, 1961; Hobbs and Gimingham 1984b). Three pyrometers per plot were inserted randomly in the ground to a depth of 6 cm. The plots were burnt against the wind (back-burnt) in March 1994. The pyrometers were removed when cool and the positions of the soil and litter surfaces marked. Then the minimum height at which each paint/crayon strip had melted was recorded.

Regeneration was monitored for three growing seasons after burning. The following parameters were measured (although not all results are presented here):

- biomass of resprouting regeneration
- frequency of resprouts
- flowering of resprouting vegetation
- seedling establishment and mortality.

Results and discussion

Fire temperatures

The temperatures reached at the litter surface varied widely within each fire, but were significantly higher in high fuel load treatments than in low fuel load treatments, except at the Aylesbeare degenerate stand (Fig 2). Here all fires were very cool and there was no significant difference between treatments. The high moisture content of the vegetation and litter at this stand may have prevented the fires from burning successfully.

In general, temperatures depended on fuel load rather than on growth phase. At Arne, both the low and the high fuel load treatments produced temperatures that were not significantly different between the mature and the degenerate stands.

The temperatures produced by the low fuel load fires at Aylesbeare were similar at both stands, but the high fuel load treatment at the mature stand was significantly hotter than in the same treatment at the degenerate stand. Therefore, with the exception of the high fuel load treatment at Aylesbeare, it seems that biomass manipulation was generally successful in creating two temperature treatments.

[1] Manufacturers: Tempil' Division, Big Three Industries Inc, 2901 Hamilton Blvd, South Plainfield, New Jersey 07080 USA. British Distributor: Optimum Heat Control Ltd, Mere House, Mere Park, Dedmere Road, Marlow, Bucks SL7 1PD.

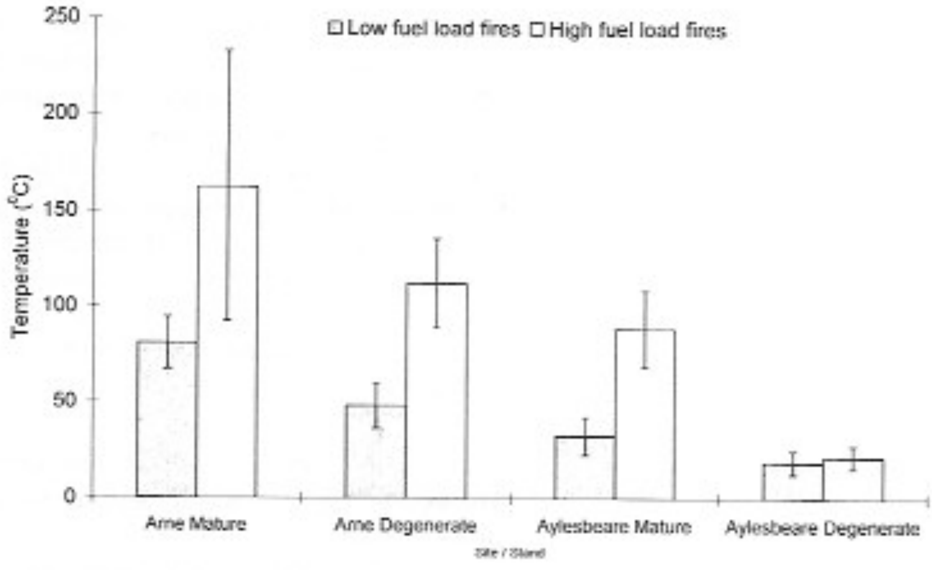

Figure 2. Litter surface temperatures recorded by pyrometers
Values are means ± 1SE.

Vegetative regeneration

There were no significant differences between the fuel load treatments for either biomass or resprout frequency (data not illustrated). This indicates that, although the temperatures were significantly different between fuel load treatments, the difference was not sufficient to affect the response of the vegetation. This was probably because rootstocks were insulated by the litter and were unaffected by elevated temperatures above-ground.

However, there were significant differences in regeneration between the mature and degenerate stands at both sites for all the parameters measured. Figure 3 shows the resprouting frequency at the mature and degenerate stands at Arne for three growing seasons after burning. Cover increased throughout the study at both stands, but was much lower at the degenerate stand than at the mature stand. This result is consistent with the findings of other workers (Kenworthy, 1963; Kayll and Gimingham, 1965; Miller and Miles, 1970; Hobbs and Gimingham, 1984a). It has been suggested that stem bases are killed by the higher temperatures reached in fires on degenerate heath (Kenworthy, 1963), but the data presented in this paper show that such fires were cooler than fires in the younger stand. Therefore it is the inherent characteristics of the vegetation that determine regeneration success, either because sprouting buds become lignified with age (Mohamed and Gimingham, 1970) and cannot regenerate after fire, or stem density declines with age due to self-thinning, so there are fewer sprouting centres per unit area (Miller and Miles, 1970).

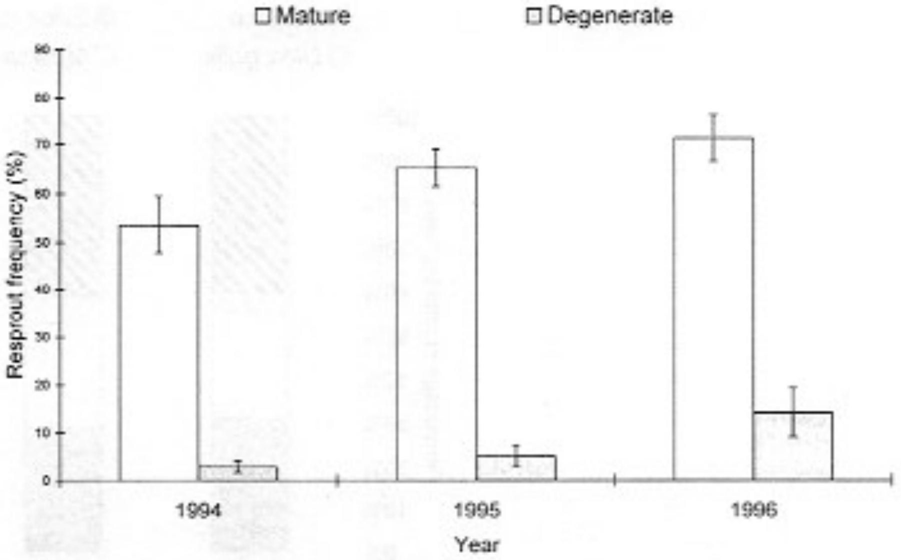

Figure 3. Resprout frequency at Arne

Despite the persistence of bare ground at the degenerate stands, there was no invasion by undesirable species such as birch or bracken. This is a favourable result because it indicates that, at least at these two study sites, there is no evidence that burning degenerate heath results in replacement of the dwarf shrubs by non-heathland species. At both Arne and Aylesbeare, there was some vegetative regeneration, albeit patchy, in the burnt plots at the degenerate stands. This regrowth, coupled with seedling establishment, will eventually result in development of ericaceous cover. Until then, a strip of bare ground serves the purpose of a fire-break as well as providing habitat for a number of invertebrates.

Calluna was the only dominant species before burning at Arne, and remained so after burning. The presence of a number of other species at Aylesbeare, and the speed with which vegetation regenerated at the mature stand, enabled examination of successional trajectories following burning. At the Aylesbeare mature stand, *Calluna* was co-dominant with *Erica tetralix* and *Ulex gallii* before burning but was infrequent after burning. *Agrostis curtisii* was dominant for the first two growing seasons, making up over 40% of the total biomass (Fig 4), compared with about 2% in the pre-burn vegetation. The proportion declined by the third year and *Erica tetralix* increased, implying a successional trajectory favouring replacement of grasses by ericaceous species.

Care must be taken in extrapolating this result to other sites. Although the temporary abundance of *Agrostis curtisii* has also been observed after uncontrolled fires in Dorset (Gray, 1988), in the UK this grass species is confined to the south-west and is a relatively poor competitor. On sites where there is an abundant seed source of more

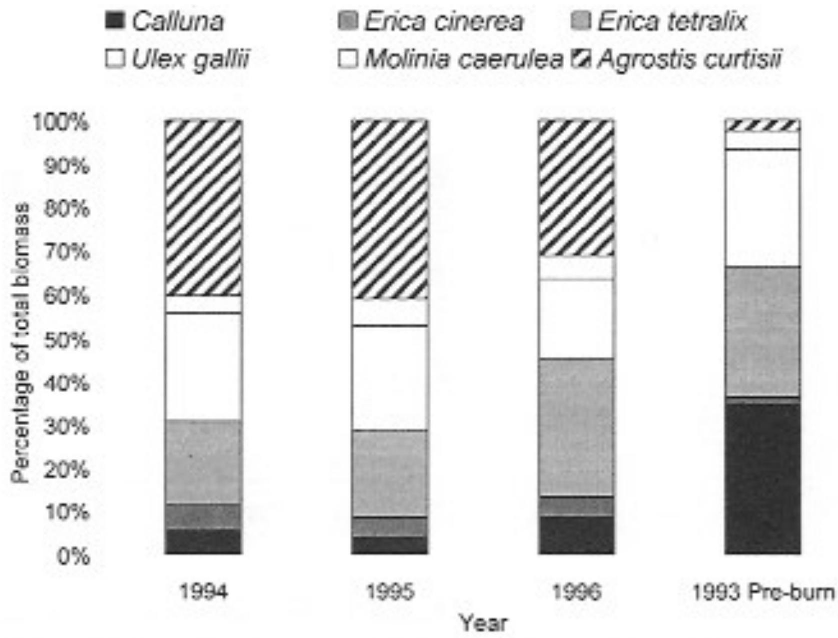

Figure 4. Proportional representation (by biomass) of species regenerating at the Aylesbeare mature stand

competitive graminoid species such as *Deschampsia flexuosa* and *Molinia caerulea*, these species may establish and maintain dominance after burning, if conditions are favourable.

There is evidence that these species can assume dominance if high nitrogen deposition has caused accumulation of nutrients in the system. Ericaceous dwarf shrubs are slow-growing and adapted to low nutrient conditions. *M caerulea* and *D flexuosa* are faster-growing but more demanding of nutrients. Replacement of *Calluna* and *Erica tetralix* by *D flexuosa* and *M caerulea* was been observed on the Dutch heathlands, where it is estimated that 35% of the heathland has been converted to grassland. The mechanism behind this change is thought to be high nitrogen deposition causing an increase in the frequency and severity of heather beetle outbreaks, which caused breakdown of the *Calluna* canopy and allowed grasses to colonise the gaps (Heil and Diemont, 1983; Brunsting and Heil, 1985). Due to the high nitrogen availability in the soil, grasses were able to establish and out-compete ericaceous seedlings in the gaps. Although few parts of the UK receive the same rates of nitrogen deposition that have been recorded in the Netherlands (where some areas receive in excess of 100 kg $ha^{-1}yr^{-1}$), the critical load of nitrogen (15 – 20 kg $ha^{-1}yr^{-1}$ for lowland dry heath) is frequently exceeded, and there is evidence of vegetation change in which increased nitrogen deposition is thought to play a part (eg Breckland, Norfolk (Marrs, 1993)). The role of management in reducing nutrient levels has been demonstrated by a number of field studies (eg Power *et al.* 1998; Carroll *et al* 1999; Barker, 2001) and by mathematical models (Heil and Bobbink, 1983; Allchin *et al*, in prep.)

Conclusions

The experimental work described here shows that controlled burning of dry lowland heathland resets the succession of the ericaceous dwarf shrubs, which maintain dominance over other species, despite a temporary increase in grasses at one of the sites. There is no evidence that burning degenerate heath allows other species to establish, despite slow regeneration of dwarf shrubs. In the light of the threat of accumulation of nitrogen due to aerial inputs causing vegetation change on the UK heathlands, there is ongoing research on the mechanisms behind heathland vegetation dynamics in response to nitrogen, and their interactions with management and heather beetle outbreaks.

References

Allchin, E A, Power, S A, Ashmore, M R & Heil, G W (in prep) Modelling effects of nitrogen deposition on British heathlands. To be submitted to *Ecological Modelling*.

Barclay-Estrup, P (1970) The description and interpretation of cyclical processes in a heath community II. Changes in biomass and shoot production during the *Calluna* cycle. *Journal of Ecology*, 58, 243-249.

Barker, C G (2001) *The impact of management on heathland response to increased nitrogen deposition*. PhD thesis, Imperial College, University of London.

Brunsting, A M H & G W Heil (1985) The role of nutrients in the interaction between a herbivorous beetle and some competing plant species in heathlands. *Oikos*, 44, 23-26.

Carroll, J A, Caporn, S J M, Cawley, L, Read, D J & Lee, J A (1999) The effect of increased deposition of atmospheric nitrogen on *Calluna vulgaris* in upland Britain. *New Phytologist*, 141, 423-431.

Gimingham, C H (1972) *Ecology of Heathlands*. Chapman & Hall, London.

Gray, A J (1988) Demographic and genetic variation in a post-fire population of *Agrostis curtisii*. *Acta Oecologica-Oecologia Plantarum*, 9, 31-41.

Haskins, L E (1978) *The vegetational history of south-east Dorset*. PhD thesis, University of Southampton.

Heil, G W & Bobbink, R (1983) *'Calluna'*, a simulation model for evaluation of impacts of atmospheric nitrogen deposition on dry heathlands. *Ecological Modelling*, 68, 161-182.

Heil, G W & Diemont, W H (1983) Raised nutrient levels change heathland into grassland. *Vegetatio*, 53, 113-120.

Hobbs, R J & Gimingham, C H (1984a) Studies on fire in Scottish heathland communities. II. Post-fire vegetation development. *Journal of Ecology*, 72, 585-610.

Hobbs, R J & Gimingham, C H (1984b) Studies on fire in Scottish heathland communities. I. Fire characteristics. *Journal of Ecology*, 72, 223-240.

Kayll, A J & Gimingham, C H (1965) Vegetative regeneration of *Calluna vulgaris* after fire. *Journal of Ecology*, 53, 729-734.

Kenworthy, J B (1963) Temperatures in heather burning. *Nature*, 200, 1226.

Marrs, R H (1993) An assessment of change in *Calluna* heathlands in Breckland, eastern England, between 1983 and 1991. *Biological Conservation*, 65, 133-139.

Miller, G R & Miles, J (1970) Regeneration of heather (*Calluna vulgaris* (L.) Hull) at different ages and seasons in North-east Scotland. *Journal of Applied Ecology*, 7, 51-60.

Mohamed, B F & Gimingham, C H (1970) The morphology of vegetative regeneration in *Calluna vulgaris*. *New Phytologist*, 69, 743-750.

Moore, N W (1962) The heaths of Dorset and their conservation. *Journal of Ecology*, 50, 369-391.

Power, S, Ashmore, M R & Cousins, D A (1998) Impacts and fate of experimentally enhanced nitrogen deposition on a British lowland heath. *Environmental Pollution*, 102, 27-34.

Rackham, O (1986) *The History of the Countryside*. Dent, London.

Rose, R, Webb, J N R, Clarke, R T & Traynor, C H (2000) Changes on the heathlands in Dorset, England, between 1987 and 1996. *Biological Conservation*, 93, 117-125.

Watt, A S (1955) Bracken versus heather, a study in plant sociology. *Journal of Ecology*, 43, 490-506.

Webb, N R (1986) *Heathlands*. Collins, London.

Webb, N R (1990) Changes on the heathlands of Dorset, England, between 1978 and 1987. *Biological Conservation*, 51, 273-286.

Webb, N R & Haskins, L E (1980) An ecological survey of heathlands in the Poole Basin, Dorset, England in 1978. *Biological Conservation*, 17, 281-296.

White, G (1789) *Natural History of Selborne*. Everyman, London.

Whittaker, E (1961) Temperatures in heath fires. *Journal of Ecology*, 49, 709-715.

The problem of arisings

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What are arisings?

For the purpose of heathland restoration arisings can be defined as residual material from unwanted trees and other plants which are surplus to the process of heathland restoration.

Arisings typically may consist of:

- whole coniferous or broadleaved trees
- unwanted or unmarketable parts of such trees
- branchwood and tops
- gorse and broom
- rhododendron
- gaultheria.

Why are arisings a problem?

The recent increase in the programme of heathland restoration as a result of English Nature and Lottery Funding has led to a consequent increase in the amount of arisings which will be produced annually throughout the life of these programmes.

The situation of many heathland sites – within the urban fringe or simply near dwellings – means that there is the need to find new solutions to this problem, in order to retain public support. The problem is particularly acute in these areas as urban attitudes being applied to countryside problems leads to public resistance to change. There is a need to remove arisings from heathland sites in order to promote rapid regeneration, and to dispose, efficiently and effectively, of a vast quantity of material in a manner acceptable to the public.

The increase in the heathland clearance programme

Heathland clearance in Dorset has increased from approx 40 ha per year in 1998 to about 200 ha per year in 2001. It is anticipated that 1,000 ha (2,500 acres) of heathland, currently in 'unfavourable condition' will be reinstated by 2005. All of this land will require the removal of trees, scrub, gorse, rhododendron or whatever, and all of this land will generate large quantities of timber, firewood and arisings. A mechanism will therefore be necessary to dispose of all of this material, and adequate funding exists to help achieve these aims.

Why do we need new solutions?

It is (conservatively) estimated that 1,000 ha of heathland clearance will generate about 56,000 tonnes of non-utilisable 'arisings'. This would represent 2,240 articulated lorry loads of material to be removed from sites, which in turn equates to 450 lorry loads during each year of the 5 year programme. Even if this had an easy location to go to, which it does not, the pollution involved would still be considerable. Burning this material on site would also result in unacceptable pollution, of a different sort, and such smoke pollution would be socially and legally unacceptable.

What are the solutions to the arisings problem?

The problem is the need to dispose, efficiently and effectively, of a vast quantity of material in a publicly acceptable manner. Existing methods for doing this include:

- burning this material
- baling it and removing the bales from site
- chipping it and removing the chips
- mulching it and removing the mulch.

These solutions, the number of separate operations involved in each, their cost, the social implications and main disadvantages are shown in Table 1.

Summary

Rural sites present few problems, though burning on the scale required may have an environmental backlash. Urban sites have a suite of inter-connected problems that need careful consideration and a measured approach. Acceptable solutions here will be much more expensive, yet vital. The only real alternative to burning which is currently available, likely to be reasonably cost-effective and which uses the material again (recycling) is likely to be chipping, with an outlet for the quantity of chips envisaged.

Outlets may become available during the life of the project. The investment could be substantial, and either the partnership will need to bear this, or contracts for the term of the project, with quantity guarantees, would become a requirement to attract outside investment. Such a solution would require a partnership approach throughout, with partners acting for the common good as opposed to self-interest. Would this be possible? The testing time may come quicker than we think.

Table 1. Options currently available for dealing with arisings

Chosen solution	Method	No of operations	Likely cost £/ha	Social aspects	Main disadvantages
Burning	Heap and burn using 2 machines. Result leaves ground in good state for heather seeding	2	400 - 700	Unacceptable, except in rural locations. Smoke pollution	Cheap but unacceptable for urban sites and difficult to defend environmentally
Baling	Two operations – bale and extract bales. Result not as good for reseeding as burning, but OK	2	> 2,000	Not readily available. Needs big programme to attract machinery	Efficient, but expensive as no ready outlet for bales at this time. Environmentally sound
Chipping	Problems with logistics, to find most efficient system. Result as for baling	2 / 3	2,000 – 4,000	Cost will reduce with bigger chippers, but site damage will increase	Outlet may shortly become available, but difficult to organise to be efficient. Will be environmentally sound if chips have secondary use
Mulching	Three operations. Mulching is cheap and easy to organise, but mulch removal requires loading shovels and trailers, as well as a convenient dump site	3	3,000	Basic operation is easy and cheap. Cost increases disproportionally to remove mulch	Can be effective, but can also result in site damage, often when removing mulch. Needs large dump site and mulch currently has no value
Incinerating	Three operations – chip, haul chip, load chip. May be good for small-scale tasks with no alternative	3	not known	Probably quite acceptable, though no recyclable material	Likely to be very expensive in respect of the cost of the total operation

A partnership approach?

If we can get a woodchip operation going for the Tomorrow's Heathland Heritage Project (and then subsequent heathland work), this is what is likely to be required by the market place:

- biomass woodchip produced at a hard standing for easy lorry pick-up
- a hydraulic loader capable of loading bulk transporters, with a 3.5 metre loading height
- a product with no stones or soil contamination.

If we can produce this, there is likely to be a ready market quite soon, for the quantities which the project could produce. There is much work to be done to get to this stage, and there will be a need for most, if not all partners, to be actively involved. Can we rise to this challenge?

Heathland re-creation/restoration

Heathland and acid grassland creation on arable soils at Minsmere

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Background

Lowland heathland is a threatened habitat in Britain (Farrell, 1993) partly because of losses in heathland area due to changes in land use and partly because of successional changes brought about by a reduction in management (Marrs *et al*, 1986). Lowland heath has been identified as a priority habitat for conservation action within Great Britain, and attempts are now being made to re-create heathland areas where heathland has been present in the past.

In east Suffolk there is an area of heathland known as the 'Suffolk Sandlings' or 'Sandlands', on account of the underlying glacial sands. It has been estimated that > 90 % of heathlands within this region have been lost (Fitzgerald *et al*, 1987). Of the remaining heathland, only 30 % can be viewed as true open heath (Fitzgerald *et al*, 1985), and most of this has some form of designated protection.

The Royal Society for the Protection of Birds (RSPB) manages a large nature reserve at Minsmere that contains fragments of Sandlings heathland. In 1989 the RSPB extended this reserve by buying 11 arable fields (158 ha) with the aim of establishing heathland and/or acid grassland on this area to join existing fragments of heathland on the reserve and adjacent protected heaths. It was hoped that this would help redress previous losses. In addition, it was hoped that this new habitat would increase populations of 'Red List' birds such as the woodlark *Lullula arborea* and stone-curlew *Burhinus oedicnemus*.

One of the potential difficulties in establishing heathland on former arable soils is that of 'residual fertility', where the concentrations of nutrients have been elevated by past agricultural practice and are too high for successful heathland establishment and maintenance (Marrs, 1993). As lowland heaths tend to occur on acidic, sandy soils of very low fertility (Gimingham, 1992) any elevation of soil nutrient supplies is likely to impede successful heathland establishment. As the fields at Minsmere have been farmed since at least the early 1800s, soil factors

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are likely to be problematic. Initially we carried out a baseline comparison of heathland and arable soils to assess their potential for restoration and then considered methodologies for achieving the restoration goals.

The baseline survey

In order to assess whether soil fertility was a problem, a baseline study was done at the start of the project. Here, soil properties were measured within the arable fields at Minsmere and contrasted with soils from adjacent *Calluna*-dominated heathlands. The results from the heathlands were used as 'target values', to identify which, if any, soil factors were likely to be problematic and to determine the scale of any treatment required (Marrs *et al*, 1998). It has also been established that there was no seed of heathland or acid grassland species remaining in the topsoil of the arable field, but there were large numbers of seeds of ruderal species, which if they established would prevent the establishment of desirable heathland or acid grassland species (Yallop & Davy, 1992).

The change in soil chemical properties through the soil profile was also measured in the arable fields to determine if the surface soils were more fertile than deeper layers. This study tested whether it might be possible to reduce surface soil fertility quickly by: (1) removing the fertile topsoil from the site (2) diluting the topsoil with infertile subsoils, or (3) burying the fertile topsoil below the main rooting zone (Marrs, 1993).

Three soil factors were identified as potential constraints, soil pH, exchangeable calcium and extractable phosphorus. The arable soils had a much higher soil pH and greater concentrations of exchangeable calcium and extractable phosphorus than heathland soils, almost certainly from previous lime and fertiliser additions. These factors will almost certainly have to be reduced in order to establish heath or acid grassland communities on the arable soils at Minsmere. There was no detectable change in any of these properties down through the soil profile suggesting that stripping the topsoil, or diluting/burying the topsoil would not help in this instance.

Cropping to impoverish the soil

In the initial stages the RSPB followed the prescription adopted by MAFF for the re-establishment of heathland on arable soils within the Breckland Environmentally Sensitive Area. This involved an arable cropping regime designed to reduce 'soil fertility'. At Minsmere, linseed, spring and winter barley, and cereal rye were planted, and inorganic nitrogen and potassium fertilisers applied. The rationale behind adding these fertilisers was that neither were at elevated concentrations in the arable soils and their addition might improve crop yield, increase crop nutrient uptake and hence the overall effect would be an increased removal of calcium and phosphorus from the system.

The crops were harvestable in most years, although yields were lower than those found under normal farm management (Marrs *et al*, 1998). The cropping removed more nutrients from the system than measured inputs, but there have been no appreciable reductions in soil pH or available nutrients. There was a slight indication that the exchangeable calcium concentrations may be declining after 9 years, but no large reduction in soil pH was found. Cropping must, therefore, be viewed as a medium to long-term option (> 10 years) for impoverishing the arable soils at Minsmere. Accordingly if a rapid result is required then more direct techniques are needed to reduce soil pH, calcium and phosphorus levels.

Acidification

Three types of materials were tested for their ability to acidify the arable soils (pH 6-7) to heathland levels (pH 3.5-4). These were: elemental sulphur, bracken litter and pine chippings (Owen *et al*, 1999). Sulphur was most effective in reducing soil pH, although the efficacy of acidification was related to application rate. Rates of 1 and 2 t S ha^{-1} produced soils of about pH 4. Rates of 8 t S ha^{-1} and above reduced the soil pH to < pH 3. Equations were derived to enable calculations of the S additions required to reduce pH to a given value. Bracken litter reduced soil pH to 4-4.5, and pine chippings reduced the soil pH by 0.5-1 unit to pH 5.5. The addition of pine chippings is not an effective means of acidifying the soil where large reductions in pH are needed. Soil acidification did not significantly increase the available concentrations of calcium, magnesium, potassium and phosphorous; indeed reductions in extractable phosphorous and exchangeable calcium were found, which may aid the establishment of heathland and acid grassland species.

In an experiment to test techniques for establishing *Calluna* where cut *Calluna* shoots were added as a seed source, the main result was that that the cover of the ruderal species was significantly reduced where the soils had been acidified, which should help *Calluna* to establish (Owen & Marrs, 2000a). However, *Calluna* establishment was relatively poor, mainly because of inadequate weed control in the early phases, but seedlings were most abundant where sulphur was applied at between 1-4 t S ha^{-1}. We tentatively suggest that the most appropriate treatment is to apply 4 t S ha^{-1}, a rate that gives acidification to the appropriate range and maintains good control of ruderal species. Weed control is essential at the time of adding the *Calluna* seed.

In a parallel experiment where acid grass species were sown, a similar result was obtained with the cover of ruderals being reduced and the cover of the sown species increased in acidified plots (Owen & Marrs, 2000b). The sown species colonised adjacent unsown sub-plots naturally and this was most pronounced where the acidity had been reduced by treatment. The most effective treatment was 2 t S ha^{-1}, which gave the optimal reduction in soil pH, controlled ruderal growth and provided a reasonable cover of the sown species. The addition of bracken litter or pine chippings gave good establishment of sown species, but control of the ruderals was less effective.

In a final experiment the combined effects of adding elemental sulphur (0-8 t S ha^{-1}) and bracken litter (0-10 cm depth layers) were tested (Owen & Marrs, 2001). Significant interactions were detected, especially in the period immediately after application. Where bracken litter was applied, soil pH fell immediately. In contrast, sulphur took at least 6 months to start reducing pH. Where mixtures were applied there was a synergistic effect which produced a lower pH compared to where the sulphur or bracken litters were applied alone. These effects were most marked at low sulphur application rates, between 0.5-4 t S ha^{-1}. The effects of the bracken litter addition also reduced the growth of ruderal species in the period immediately after application, probably through a combination of acidification and physical smothering. There is, therefore, a clear potential to acidify ex-arable soils using combinations of sulphur and bracken litter in schemes designed to restore *Calluna* heathland.

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References

Farrell, L (1993) *Lowland heathland: the extent of habitat change*. English Nature Science No. 12. English Nature, Peterborough.

Fitzgerald, C, Martin, D & Auld, M (1985) *The Sandlings Project*. Sandlings Group, Suffolk.

Fitzgerald, C, Martin, D & Auld, M (1987) *The Sandlings Project*. Sandlings Group, Suffolk.

Gimingham, C H (1992) *The lowland heathland management handbook*. English Nature, Peterborough.

Marrs, R H (1993) Soil fertility and nature conservation in Europe: theoretical considerations and practical management solutions. *Advances in Ecological Research*, 24, 241-300.

Marrs, R H, Hicks, M J & Fuller, R M (1986) Losses of lowland heath through succession at four sites in Breckland, East Anglia, England. *Biological Conservation*, 36, 19-38.

Marrs, R H, Snow, C S R, Owen, K M & Evans, C E (1998) Heathland and acid grassland creation on arable soils at Minsmere: identification of potential problems and a test of cropping to impoverish soils. *Biological Conservation*, 85, 69-82.

Owen K M & Marrs, R H (2000a) Creation of heathland on former arable land at Minsmere, Suffolk: the effect of soil acidification on the establishment of *Calluna* and ruderal species. *Biological Conservation*, 93, 9-18.

Owen K M & Marrs, R H (2000b) Acidifying arable soils for the restoration of acid grasslands. *Applied Vegetation Science*, 3, 105-116.

Owen, K M & Marrs, R H (2001) The use of mixtures of sulphur and bracken litter to reduce pH of former arable soils and control ruderal species. *Restoration Ecology*, 9, 397-409.

Owen, K M, Marrs, R H, Snow, C S R & Evans, C (1999) Soil acidification – the use of sulphur and acidic litters to acidify arable soils for the recreation of heathland and acidic grassland at Minsmere, UK. *Biological Conservation*, 87, 105-122.

Yallop, A R & Davy, A J (1992) *Seed bank project at Minsmere RSPB reserve.* Unpublished report to the RSPB. University of East Anglia, Norwich.

Prioritising heathland re-creation at the landscape scale: a case study of the Dorset Heaths

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Introduction

The reduction and fragmentation of lowland heath due to modern land usage has been well documented in the UK (Moore, 1962; Webb & Haskins, 1980; Farrell, 1989; Webb, 1990) and elsewhere in Europe (van der Zande *et al*, 1988). Furthermore, it is clear that the cessation of traditional management practices, such as grazing and burning, have caused the degradation of many of the remnant patches of heathland through the invasion of scrub and bracken (Marrs *et al*, 1986; Webb, 1990; Mitchell *et al*, 1997; Rose *et al*, 2000). Consequently the Biodiversity Action Plan (BAP) (Anon, 1995a, b) has set targets of maintaining the remaining 58,000 ha of heathland in favourable condition and re-creating a further 6,000 ha of this habitat by 2005. However, abiotic constraints, including high residual soil fertility and elevated pH, and biotic constraints, such as lack of heathland propagules and an excess of competitive species, make the restoration of heathland on other land use types problematical and costly (Pywell *et al*, 1994; Clarke, 1997; Pywell *et al*, 1997a; Bakker & Berendse, 1999). It is therefore important that sites chosen for re-creation are carefully selected to ensure the maximum probability of a successful outcome. Furthermore, recent research into metapopulation theory (eg Gilpin & Hanski, 1991) indicates that consideration must be given to the establishment of extensive and inter-connected networks of heathland habitat across the landscape, in order to increase the resilience and resistance of the characteristic species to environmental change (Webb & Thomas, 1994).

Veitch *et al* (1995) used a Geographic Information System (GIS) to combine historical and current (1990) land cover information in order to identify areas suitable for heathland re-creation in Dorset. The aim of this paper is to update and refine this work using:

1. Recent (2000) and more sophisticated land cover information derived from remote sensing – the Land Cover Map 2000 (LCM 2000).

Table 1. The 26 land cover subclasses identified by Land Cover Map 2000

Code	Land cover subclass	Code	Land cover subclass
1.1	Broadleaved woodland	11.1	Fen, marsh, swamp
2.1	Coniferous woodland	12.1	Bog
4.1	Arable cereals	13.1	Water (inland)
4.2	Arable horticulture	15.1	Montane habitats
4.3	Non-rotational horticulture	16.1	Inland bare ground
5.1	Improved grassland	17.1	Suburban/rural developed
5.2	Set-aside grass	17.2	Continuous urban
6.1	Neutral grassland	18.1	Supra-littoral rock
7.1	Calcareous grassland	19.1	Supra-littoral sediment
8.1	Acid grassland	20.1	Littoral rock
9.1	Bracken	21.1	Littoral sediment
10.1	Dwarf shrub heath	21.2	Saltmarsh
10.2	Open dwarf shrub heath	22.1	Sea/estuary

2. An objective system for scoring site suitability for re-creation based on:
   (i) the results of long-term field trials to determine the relative cost and effectiveness of heathland re-creation techniques on different land cover types
   (ii) simple spatial criteria: (a) the proximity of each land parcel to existing heathland, (b) the length of boundary common with heathland, and (c) the number of heathland patches touching the parcel.

These data were combined in a GIS to model and analyse the distribution and extent of areas suitable for heathland re-creation.

Materials and methods

Current land use

The current extent of heathland and other land cover types in Dorset was derived from the LCM 2000. This is a complete national map of land cover derived from a combination of summer and winter images from satellite-based instruments (Smith & Fuller, 2001). An advanced image segmentation procedure is used to identify spectrally homogeneous land parcels from the 25 x 25 m pixel-based images. The result is a field-by-field scale vector coverage of 26 land cover subclasses corresponding, in the main, to the widespread Broad Habitat types defined by the BAP (Table 1). Validation of the map has shown that greater than 85% of the parcels are correctly allocated to these classes (Smith & Fuller, 2001).

Potential for heathland restoration of different land cover types

Heathland re-creation was considered to be feasible on five of the 26 land cover subclasses: broadleaved, mixed and yew woodland (1.1), coniferous woodland (2.1), arable and horticulture (4.1 to 4.3), improved grassland (5.1), and acid grassland (8.1). For other habitat types, heathland re-creation was either politically unacceptable eg continuous urban (17.2), ecologically inappropriate eg calcareous grassland (7.1) or not applicable eg littoral sediment (21.1).

A considerable amount of research has been carried out into the potential for regeneration and re-creation of heathland on the five target land cover subclasses, the results of which are summarised below.

Coniferous and deciduous woodland

Rapid colonisation of felled pine woods by heathland plant species, including *Calluna vulgaris* and *Erica cinerea*, has been described in Surrey (Summerhayes & Williams, 1926), and more recently in Dorset, Suffolk and Norfolk (Fowbert *et al*, 2000). Large seed banks of heathland species have been reported in the soils of coniferous woodland in Dorset (Bourn, 1987; Fowbert *et al*, 2000) and Shropshire (Pywell *et al*, 1997a), as well as plantations in upland Britain (Hill & Stevens, 1981) and afforested sites in Sweden (Granström, 1988). In addition, large seed banks have been found under coppiced deciduous woodland (Warr *et al*, 1994), and under *Quercus-Betula* woodland in the Netherlands (Willems, 1988). Furthermore, only small differences in soil pH or nutrient concentrations were found when soils from coniferous plantations (Fowbert *et al*, 2000; Pywell *et al*, 1997a) or naturally colonised conifer woodland (Mitchell *et al*, 1997) were compared with those of adjacent heathlands. However, soil pH, extractable phosphorus and exchangeable calcium concentrations were all found to increase following succession of heathland to *Betula* woodland (Mitchell *et al*, 1997). This suggests that the potential for heathland re-creation is very high on coniferous woodland sites, but likely to be slightly lower on deciduous woodland sites.

Improved pasture and unimproved acid grassland

Colonisation by heathland plant species has been recorded on unimproved acid grassland and derelict, improved grassland in Dorset (Smith *et al*, 1991; Pywell *et al*, 1994) and Norfolk and Suffolk (Fowbert *et al*, 2000). Relatively large seed banks of heathland species have been recorded beneath these unimproved grasslands, whereas those of improved grasslands were found to be much smaller (Pywell *et al*, 1997b). However, the seeds of ruderal and competitive species were abundant in the seed banks of both land cover types. Soil pH was found to be significantly higher in both improved and unimproved grasslands compared to heathland soils (Pywell *et al*, 1994; Clarke, 1997). In addition, phosphorus and calcium concentrations were significantly higher in improved grassland soils compared to unimproved grassland and heathland soils.

Table 2. Relative score of the cost and feasibility of heathland re-creation on the target LCM 2000 land cover subclasses

Code	Target land cover subclass	Re-creation feasibility score	
2.1	Coniferous woodland	10	High
1.1	Broadleaved woodland	8	↑
8.1	Acid grassland	6	Moderate
5.1	Improved grassland	4	
4.1	Arable cereals	2	
4.2	Arable horticulture	2	↓
4.3	Non-rotational horticulture	2	Low

The application of heathland propagules following turf removal (Smith *et al*, 1991) and cultivation (Pywell *et al*, 1995) have been shown to be an effective means of restoring heathland vegetation on both unimproved and improved grasslands.

Arable land

The natural regeneration of heathland vegetation on abandoned arable land has rarely been observed (Fowbert *et al*, 2000). Heathland seed banks are invariably absent and arable soils have very high pH and soil fertility compared to heathland soils (Clarke, 1997; Fowbert *et al*, 2000). Costly and highly interventionist techniques are required to re-create heathland on arable land, including soil nutrient stripping (eg Aerts *et al*, 1995; Chambers *et al*, 1996), and pH amendments using sulphur (eg Ford & Williams, 1994; Owen & Marrs, 2000) and acidic peat material (Dunsford *et al*, 1998). This must be followed by the application of heathland propagules.

Each of the five cover classes was scored on the basis of the severity of the constraints on heathland re-creation imposed by the current land use, together with the cost and reliability of techniques to overcome them (Table 2). Low scores reflected relatively severe constraints on re-creation, high scores reflected minimal constraints.

Spatial criteria

Studies of seed dispersal in *Calluna* and *Erica cinerea* showed that > 90% of the seeds shed fall close to the parent plant (Bullock & Clarke, 2000) or the heathland patch (Pywell, 1993). However, small numbers of seeds have been recorded up to 80 m from the parent plant (Bullock & Clarke, 2000) or 180 m from the heathland patch (Pywell, 1993). It is therefore likely that land adjacent or within 180 m of an existing heathland will receive some heather seeds through wind dispersal and will therefore have some potential for natural colonisation by heathland plant species.

Many heathland invertebrate species are known to be highly habitat specific and relatively immobile. For example, the maximum observed

Table 3. Relative score based on spatial criteria

Spatial criteria	Score
(i) Proximity to heathland (m)	
0-200	10
201-400	8
401-600	6
601-800	4
801-1,000	2
(ii) Length (m) of common boundary with heathland	
> 1000	5
501-1,000	4
251-500	3
101-250	2
1:100	1
(iii) Number of touching heathland parcels	
21-40	5
11-20	4
6-10	3
3-5	2
1-2	1

single-step colonisation distances in other landscapes for *Plebejus argus* in which new habitat islands were generated were between 0.6 and 1.0 km (Thomas & Harrison, 1992; Rose, this volume). Detailed capture-re-capture studies revealed that most adult *P argus* move less than 20 m per day and few travel more than 50 m (Thomas, 1983). Therefore the strategic restoration or re-creation of small heathland patches in the landscape could provide vital links to increase the size and continuity of heathland fragments for such sedentary species. This is an effective means of increasing the number of component populations comprising metapopulations (Webb & Thomas, 1994). Ecological theory suggests that large metapopulations with a high degree of connectivity are likely to be more resilient to environmental perturbations than small, isolated populations.

With this in mind three spatial criteria were calculated for each land parcel (Table 3):

(i) proximity of the nearest heathland using a concentric 200 m buffer to a distance of 1,000 m

(ii) the length (m) of any common boundary with heathland parcels

(iii) the number of touching heathland parcels.

Table 4. Categories of potential for heathland re-creation

Combined score	Potential for heathland re-creation
1-6	Low
7-12	Low to moderate
13-18	Moderate
19-24	Moderate to high
25-30	Very high

Potential for heathland re-creation

The above criteria (from Table 2 & 3) were used to calculate a summary value for each land parcel of the five land cover subclasses deemed suitable for heathland re-creation falling within 1 km of an existing heathland patch (Table 4).

Results

Combining the Dwarf shrub heath (10.1) and Open dwarf shrub heath (10.2) subclasses from Table 1 indicated that the total area of dry heathland in Dorset identified by LCM 2000 was 5,156 ha distributed in 321 patches. Approximately 3,800 ha of the coniferous woodland subclass (2.1) was situated within 1 km of the heathland patches (Table 5). There was a strong spatial association of this habitat with heathland with over 3,200ha (84%) of conifer woodland occurring within 400 m of the heath. Similarly, over 4,200 ha of broadleaved woodland (1.1) was situated within 1 km of the heath. In this case, 50% of this habitat occurred within 400 m of heathland. Acid grassland (8.1) was the least numerous cover class with 1,500 ha found within the 1 km buffer and 70% of this within 400 m of the heathland boundary. Improved grassland (5.1) and arable land (4.1 to 4.3) were the most numerous of the cover types with potential for heathland re-creation with over 7,400 and 6,800 ha of each habitat within 1 km respectively. There was no strong spatial association of these intensively managed and widespread habitats with heathland.

On the basis of the criteria outlined above approximately 3,500 ha of land was classified as having high potential for heathland re-creation (Table 6). Patches falling into this category were typically coniferous or deciduous woodland either within or adjacent to existing heathland (Fig 1). A further 5,700 ha had moderate to high potential for re-creation. This often comprised acid and improved grassland adjacent to the heathland edge, together with woodland which was > 200 m from heathland. The 7,200 ha with moderate re-creation potential typically consisted of improved grassland which was not adjacent to the heath. Finally, land with low to moderate re-creation potential was typically arable land and improved grassland which was far from the heathland edge.

Table 5. Proximity to heathland patches of the target Land Cover Map subclasses

		Proximity to heathland patch (m)					
Land cover (ha)	LCM class	1-200	201-400	401-600	601-800	801-1000	TOTAL
Coniferous woodland	2.1	922	2,259	388	175	42	3,786
Deciduous woodland	1.1	1,002	1,138	1,389	514	218	4,261
Acid grassland	8.1	604	508	269	145	35	1,561
Improved grassland	5.1	975	1,382	2,709	2,201	166	7,433
Arable land	4.1 to 4.3	1,090	1,599	2,406	1,416	280	6,791
TOTAL (ha)		4,593	6,886	7,161	4,451	741	23,832

Table 6. Total area of potential heathland re-creation classes

Restoration potential	Score	Area (ha)
High	25-30	3,492
Moderate-high	19-24	5,675
Moderate	13-18	7,235
Moderate-low	7-12	6,384
Low	1-6	1,048
TOTAL		23,834

Discussion

This approach demonstrates the value of GIS in providing a synoptic overview of the potential for heathland re-creation throughout the Poole Basin and Dorset. The use of remote sensed data in the guise of the LCM 2000 accurately describes the current size and distribution of the remaining heathland fragments. Importantly, the LCM allows the heathland to be analysed in the context of the surrounding land cover types. The per-parcel based classification approach used for LCM 2000 permits identification and classification at the field or land parcel scale rather than the per-pixel based classification used in the 1990 Land Cover Map (Veitch *et al*, 1995). This produced a superior representation of the fabric of the landscape, which has greater biological and practical relevance. Most importantly, remote sensing offers the capability for objective, repeatable surveys of large areas at a fraction of the cost of ground survey.

Over the last 10 years there have been considerable advances in the science and practice of heathland re-creation and management at the site level (briefly reviewed in this paper). Furthermore, we are beginning to understand much more of the habitat requirements and

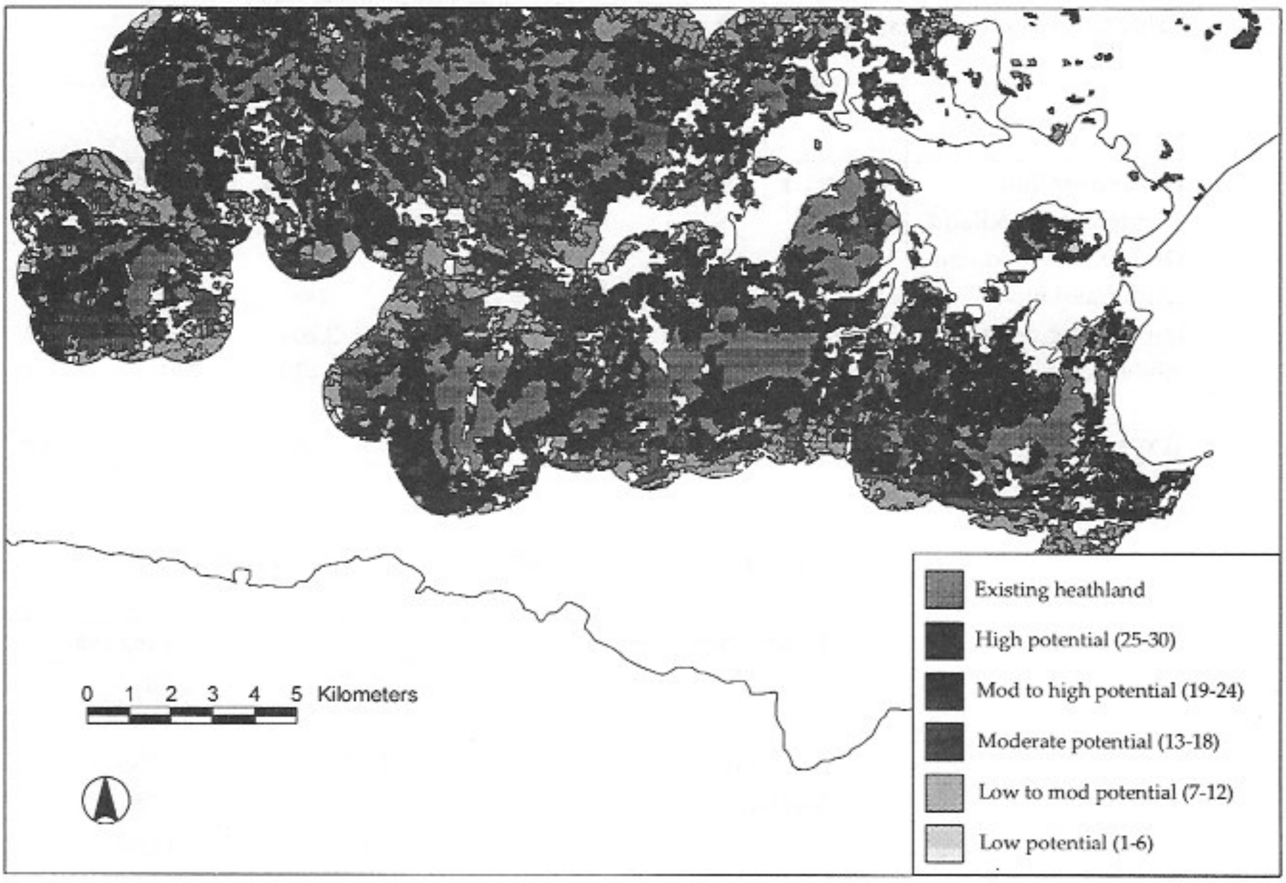

Figure 1. The distribution of potential heathland re-creation categories around Wareham, Dorset

population dynamics of the fauna characteristic of heathlands. Such research has demonstrated the importance of creating and maintaining networks of suitable habitat patches within the landscape for the conservation of many species. It is therefore timely and appropriate to integrate our current ecological knowledge with the recent land cover data to derive an objective framework for prioritising and targeting heathland re-creation at the landscape scale.

This approach has a number of other applications which have not as yet been fully explored. Remote sensing has the potential for providing a means of monitoring the conservation status and condition of the existing heathland patches, in terms of vegetation structure and composition. This would provide a further useful criteria for planning management and re-creation activities at the landscape scale. Furthermore, the capability of remote sensing for objective change detection could also be used to chart the progress of heathland re-creation and restoration initiatives across the region (Coppin & Bauer, 1994). These capabilities would be required to achieve the dynamic, landscape scale management of habitat patches required for the conservation of species such as *Plebejus argus*. This methodology also provides the capability to explore a wide range of possible heathland re-creation and management strategies using different biological, agronomic and socio-economic criteria. Finally, this approach to targeting conservation management is not exclusive to the Dorset heaths and could be applied to almost any habitat or region in the UK.

References

Aerts, R, Huiszoon, A, Van Oostrum, J H A, Van de Vijver, C A D M & Willems, J H (1995) The potential for heathland restoration on formerly arable land at a site in Drenthe, The Netherlands. *Journal of Applied Ecology*, 32, 827-835.

Anon (1995a) *Biodiversity: The UK Action Plan*. HMSO, London.

Anon (1995b) *Biodiversity: The UK Steering Group Report, Vol. 2 Action Plans*. HMSO, London.

Bakker, J P & Berendse, F (1999) Constraints in the restoration of ecological diversity in grassland and heathland communities. *Trends in Ecology and Evolution*, 14, 63-68.

Bourn, N A D (1987) *A comparative study of viable seed on dry heathland and different aged pine plantations planted on dry heathland in Dorset, England*. BSc thesis, University of Hertfordshire.

Bullock, J M & Clarke, R T (2000) Long distance seed dispersal by wind: measuring and modelling the tail of the curve. *Oecologia*, 124, 506-521.

Chambers, B J, Cross, R B & Pakeman, R J (1996) Recreating lowland heath on ex-arable land in the Breckland Environmentally Sensitive Area. *Aspects of Applied Biology*, 44 (Vegetation management in forestry, amenity and conservation areas: managing for multiple objectives), 393-400.

Clarke, C T (1997) Role of soils in determining sites for lowland heathland reconstruction in England. *Restoration Ecology*, 5, 256-264.

Coppin, P & Bauer, M E (1994) Digital change detection in forest ecosystems with remote sensing imagery. *Remote Sensing Reviews*, 13, 207-234.

Dunsford, S J, Free, A J & Davy, A J (1998) Acidifying peat as an aid to the reconstruction of lowland heath on arable soil: a field experiment. *Journal of Applied Ecology*, 35, 660-672.

Farrell, L (1989) The different types and importance of British heaths. *Biological Journal of the Linnean Society*, 101, 291-299.

Ford, M A & Williams, C M (1994) On the establishment of heath vegetation on ex-arable land. *Aspects of Applied Biology*, 40 (Arable farming under CAP reform), 563-570.

Fowbert, J, Walker, K J, Pywell, R F, Chambers, J & Bhogal, A (2000) *Assessment of success of schemes to recreate lowland heath*. Report to MAFF (BD1504). ADAS/CEH, Gleadthorpe.

Gilpin, M E & Hanski, I (1991) *Metapopulation dynamics: empirical and theoretical investigations*. Academic Press, London.

Gränstrom, A (1988) Seed banks at six open and afforested heathland sites in southern Sweden. *Journal of Applied Ecology*, 25, 297-306.

Hill, M O & Stevens, P A (1981) The density of viable seed in soils of forest plantations in upland Britain. *Journal of Ecology*, 69, 693-709.

Marrs, R H, Hicks, M J, & Fuller, R M (1986) Losses of lowland heath through succession at four sites in Breckland, East Anglia, England. *Biological Conservation*, 36, 19-38.

Mitchell, R J, Marrs, R H, Le Duc, M G & Auld, M H D (1997) A study of the succession on lowland heaths in Dorset, southern England: changes in vegetation and soil chemical properties. *Journal of Applied Ecology*, 34, 1426-1444.

Moore, N W (1962) The heaths of Dorset and their conservation. *Journal of Ecology*, 50, 369-391.

Owen, K M & Marrs, R H (2000) Creation of heathland on former arable land at Minsmere, Suffolk, UK: the effects of soil acidification on the establishment of *Calluna* and ruderal species. *Biological Conservation*, 93, 9-18.

Pywell, R F (1993) *The restoration of heathland on farmland in southern Britain*. PhD thesis, University of Liverpool.

Pywell, R F, Pakeman, R, Walker, K J, Manchester, S J & Barratt, D (1997a) *Habitat restoration study: the Stiperstones*. EN/ITE.

Pywell, R F, Putwain, P D & Webb, N R (1997b) The decline of heathland seed populations following the conversion to agriculture. *Journal of Applied Ecology*, 34, 949-960.

Pywell, R F, Webb, N R & Putwain, P D (1994) Soil fertility and its implications for the restoration of heathland on farmland in southern Britain. *Biological Conservation*, 70, 169-181.

Pywell, R F, Webb, N R & Putwain, P D (1995) A comparison of techniques for restoring heathland on abandoned farmland. *Journal of Applied Ecology*, 32, 400-411.

Rose, R J, Webb, N R, Clarke, R T & Traynor, C H (2000) Changes on the heathlands in Dorset, England, between 1987 and 1996. *Biological Conservation*, 93, 117-125.

Smith, G M & Fuller, R M (2001) Land Cover Map 2000: much more than just an update. *SoC Bulletin*, 33, 13-16.

Smith, R E N, Webb, N R & Clarke, R T (1991) The establishment of heathland on old fields in Dorset, England. *Biological Conservation*, 57, 221-234.

Summerhayes, V S & Williams, P H (1926) Studies on the ecology of English heaths. II. Early stages in the recolonisation of felled pinewood at Oxshott Heath and Esher Common, Surrey. *Journal of Ecology*, 14, 201-243.

Thomas, C D (1983) *The Ecology and Status of* Plebejus argus *in North West Britain*. MSc thesis, University of Wales.

Thomas, C D & Harrison, S (1992) The spatial dynamics of a patchily distributed butterfly species. *Journal of Animal Ecology*, 61, 437-446.

van der Zande, A N, Minnaard, P R, Beije, H M, Berendse, F, Bosch, A L, van Gelder, T, Hendriks, J L J, Kampf, H, Kooy, W J, Lichthart, R H, Sipkens, J, de Smidt, J T & Vera, F W M (1988) *De Heide Heeft Toekomst!* (Heathland has a future!). Report of the State Forestry Service, Utrecht (in Dutch with English summary).

Veitch, N, Webb, N R & Wyatt, B K (1995) The application of geographic information systems and remotely sensed data to the conservation of heathland fragments. *Biological Conservation*, 72, 91-97.

Warr, S J, Kent, M & Thompson, K (1994) Seed bank composition and variability in five woodlands in south-west England. *Journal of Biogeography*, 21, 151-168.

Webb, N R (1990) Changes on the heathlands of Dorset, England, between 1978 and 1987. *Biological Conservation*, 51, 273-286.

Webb, N R & Haskins, L E (1980) An ecological survey of heathlands in the Poole Basin, Dorset, England in 1978. *Biological Conservation*, 17, 281-296

Webb, N R & Thomas, J A (1994) Conserving insect habitats in heathland biotopes: a question of scale. In: P J Edwards, R M May & N R Webb (eds) *Large Scale Ecology and Conservation Biology*, pp 129-151. Blackwell Scientific Publications, Oxford.

Willems, J H (1988) Soil seed bank and the regeneration of a *Calluna vulgaris* community after forest clearing. *Acta Bot. Neerl*, 37, 313-320.

Restoration on the Lüneburg Heaths

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Introduction

The 'Lüneburger Heide' nature reserve is situated in the North German Bundesland of Niedersachsen, about 50 km south of Hamburg. It covers a total of 234 km², about 20 % of which is still existing heathlands or heathlands in a state of restoration (Cordes *et al*, 1997). Large parts of the former heathlands within this nature reserve have been used for military purposes, mainly by the British army from the end of World War II until 1994. The legal basis for this use was given by the 'Soltau-Lüneburg Agreement' which came into effect in 1963 (Kreie *et al*, 1993). It confirmed the rights of British and Canadian troops to conduct exercises throughout the year in a specified area between the towns of Soltau and Lüneburg (Fig 1). Almost unrestricted tank driving activities were permitted in some core areas. About 3,000 ha of these so called 'red areas' were situated within the Lüneburger Heide nature reserve (with respect to its current boundaries). In June 1994, the British army ceased military exercises and withdrew from the Lüneburger Heide. Since then the 'red areas' have become the subject of policies aimed at landscape restoration. A considerable part of these former heathlands belong to Verein Naturschutzpark (VNP), a private association, that played an important role in initiating the Lüneburger Heide nature reserve by purchasing heathland areas, mainly at the beginning of the 20th century, for the purpose of nature conservation. In 1992 VNP tasked a scientific commission with documenting damage and formulating development objectives for land within the 'red areas', covering about 1,600 ha (Lütkepohl *et al*, 1996). The results from this study, the realisation of concepts and preliminary results from restoration measures can be summarised as follows.

Influence of military activities on vegetation and landscape

The training grounds are mainly based on sandy, glacial-fluvial deposits. The upper layer consists of nutrient-poor, acid sediments locally rich in stones, covered in a few places by shifting sand sheets. The soils are predominantly podsolic (Luttig, 1996). Earlier maps from the 1930s and 1940s (Buchwald, Preising & Tuxen unpub) indicate

that the former vegetation consisted mainly of *Calluna* heathlands, locally enriched by *Empetrum nigrum, Vaccinium myrtillus, Arctostaphylos uva-ursi* and patches of acid grassland.
Intensive tank driving activities resulted in the large-scale degradation and even destruction of vegetation. In recent years, more than 50 % of the total area was bare ground, devoid of any plant growth. Investigations in these areas showed that the seed bank was nearly exhausted (Tauber, 1996).

Artificial soil compaction reached its highest possible values on vehicle tracks. In many places the upper soil horizons were destroyed, with severe erosion being a contributory factor. Concentrations of humus material and other fine sediment particles in depressions, and wind-blown transport from exposed sites to adjacent areas, were typical. Oil, rubble and waste pollution occurred locally (and, as far as possible, was later removed); elevated levels of heavy metals such as Pb, Zn and Cd were also found (Gerold, 1998).

In order to prevent erosion, about 130 dense coniferous stands of about 1 ha each were planted, using many foreign tree species. In addition, several artificial ponds were built to collect rainwater run off and to prevent gully erosion. Traditional pathways within the range, and monuments such as prehistoric graves, were irretrievably lost.

Restoration objectives

The restoration plan worked out by the VNP-commission aimed at developing a mainly open landscape dominated by *Calluna* heathlands, integrating a typical range of related wet and dry habitats (Fig 2). Thus, further landscape development on the training grounds should be linked with the former landscape pattern as far as possible, and adjacent heathlands enlarged. It was assumed that these objectives would not be prevented by the extent of soil degradation in the meantime.

Remnants of old forest stands that had survived the military period will be preserved. On the other hand, the artificial coniferous plantations will be removed totally, while established single broadleaved trees (eg oak, birch), or even thin stands, will be left wherever found. Some random forest sites will be cut at reasonable intervals and left to succeed naturally over time.

Artificial water ponds will be changed by removal of dams and dikes. Whether the remaining depressions remain wet, or even initiate bog development in future, will depend mainly on the degree of reduction in surface water supply associated with regenerating vegetation. The redevelopment of an oligotrophic shallow waterbody will be attempted in a suitable, exposed area by adding sealing clay sediments to a particular landscape depression.

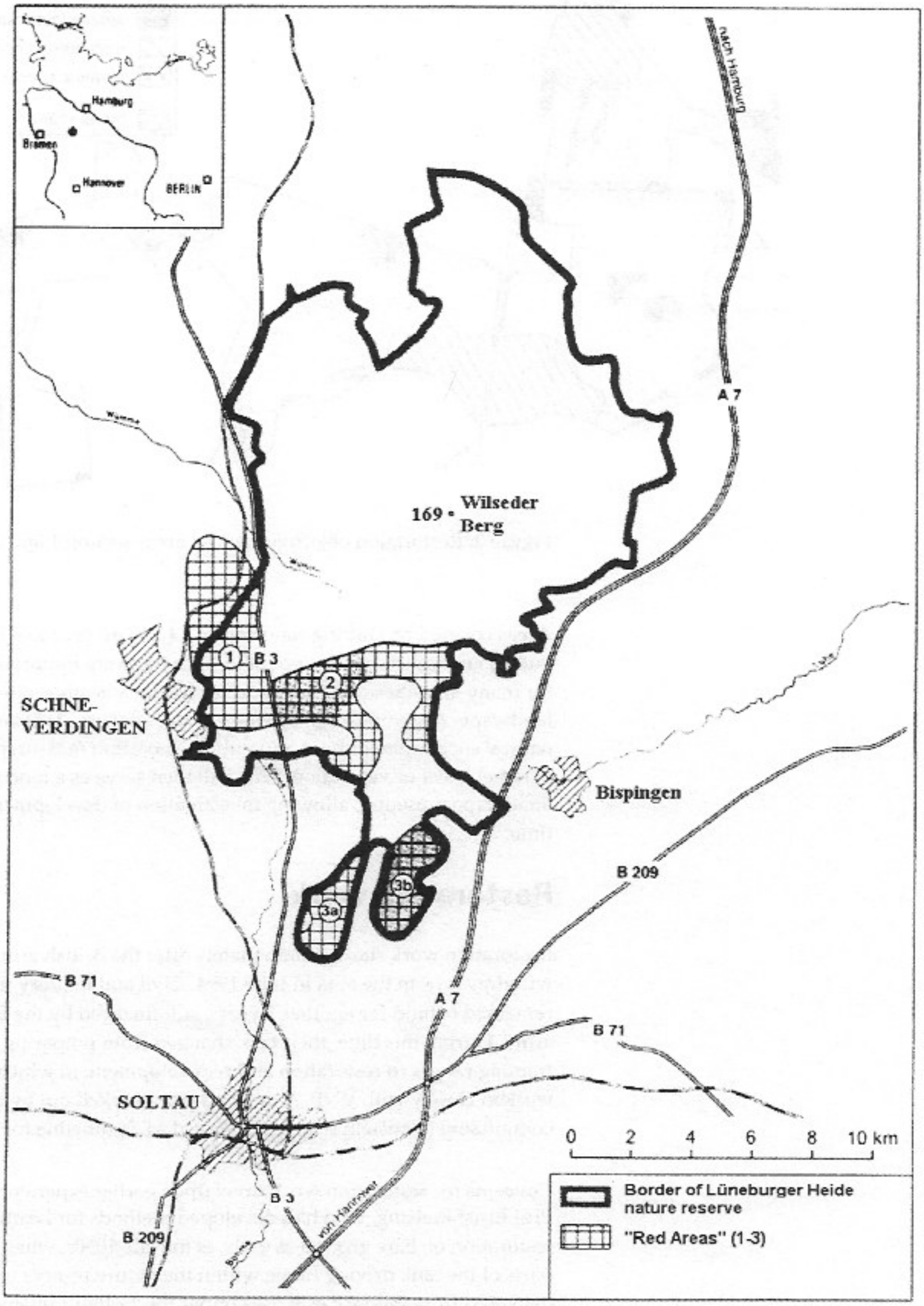

Figure 1. Location of the 'red areas' within the Lüneburger Heide nature reserve

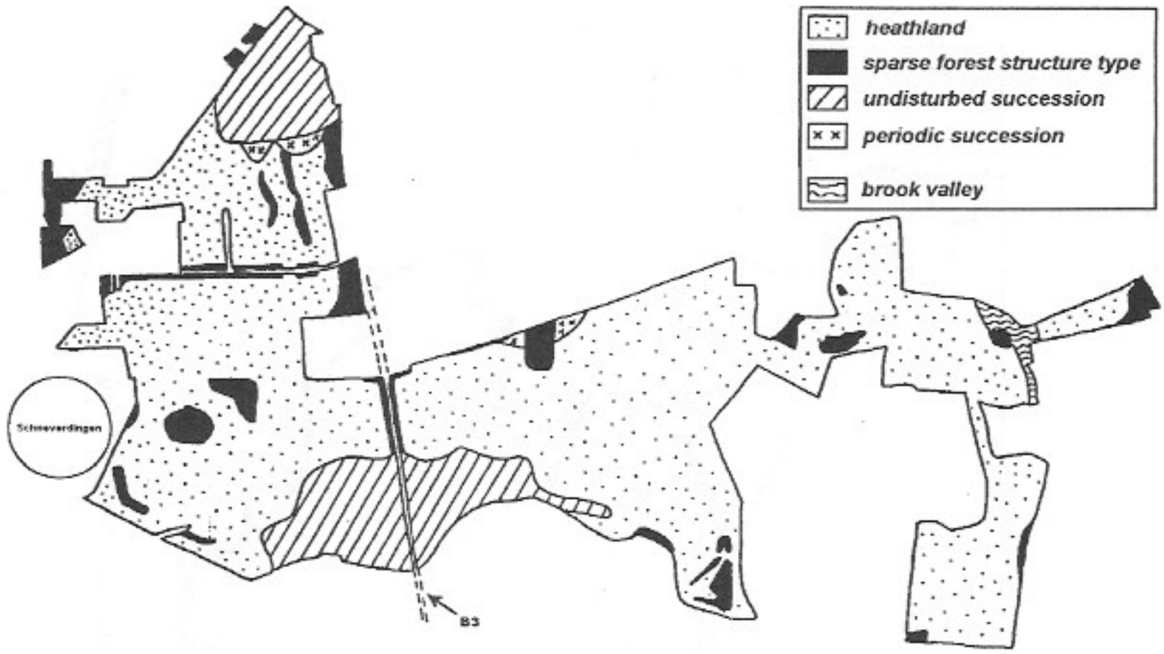

Figure 2. Restoration objectives on red areas section 1 and 2

Areas covered by shifting sand sheets which are very low in humus will be kept open as far as possible since these are important habitats for many xero-thermophilous species within a heather-dominated landscape. A significant proportion of the total area will be left to natural succession without any initial restoration measures, in terms of either relief or vegetation. This will then serve as a kind of 'landscape museum', allowing investigation of developments over time.

Restoration work

Restoration work started immediately after the British army had withdrawn from the area in June 1994. Civil and military field staff remained behind for another 3 years, still financed by the British army. During this time, their task changed from preparing military training ranges to restoration and redevelopment, in which they worked closely with VNP. A detailed plan worked out by the VNP-commission (Hanstein *et al*, 1994) served as a guideline for fieldwork.

Concepts for restoration work drew upon earlier experience gained by Prof Ernst Preising, who had developed methods for heathland restoration on bare ground as early as the late 1950s, when the first parts of the tank driving range within the nature reserve were delivered from military exercises under the 'Soltau-Lüneburg Agreement'. Today, vital heathland vegetation can be found on these sites, rich in structure and also species composition, so this may be regarded as an encouraging model for which to aim.

Methods used for today's restoration work can be summarised as follows.

1 In order to regenerate former features of an original near-Pleistocene landscape, some very obvious signs of tank driving were erased, mainly by tractors pulling heavy iron bars to flatten the tracks.

2 The idea of rotavating the entire area to reverse the effects of soil compression was rejected in order to save remnants of undisturbed soil profiles. The intensity of artificial soil compaction varies within the area and, as a whole, was not expected to retard heathland regeneration, so these measures were restricted to just a few places.

3 In order to get rid of artificial dams and dikes the removal of about 100,000 m^3 of ground material was necessary.

4 Nearly all coniferous plantations were cut. Special attention was directed at the removal of established *Prunus serotina*, an invasive foreign species. As many fruit-bearing bushes as possible were uprooted by a small dredger. In some places, upper soil layers rich in *Prunus serotina* seeds had to be removed and buried elsewhere in order to prevent further regeneration.

5 In large parts of the open areas that were still covered by thin grass or dwarf shrub vegetation, no initial measures for plant regeneration were carried out. Other measures were carried out in areas affected by severe wind erosion. *Festuca filiformis* was initially sown to stabilise the soil (Table 1), thus facilitating the establishment of a heather canopy. This pioneer grass species has been shown to be able to withstand extreme climatic conditions on bare ground. Moreover, *Festuca filiformis* itself provides suitable microclimatic conditions for the subsequent growth of *Calluna* seedlings. The development of *Calluna* and other plant species belonging to the heathland community was encouraged by spreading heather material obtained during the management of adjacent heathlands. These initial measures were carried out on about 1/3 of the total area of bare ground.

6 A totally new system of pathways was established taking into account, as far as possible, the demands of both tourism and nature conservation.

Preliminary effects

Despite very dry summer periods after the initial sowing, *Festuca filiformis* built up a soil-fixing grass layer very rapidly in most areas. Even one year after spreading heather material, the first *Calluna* seedlings could be observed between the rows of grass. The timing and intensity of *Calluna* germination varied considerably from place to place. In some areas it took 5 to 6 years before the first *Calluna* seedlings were observed. Today, dense heather stands can already be found on favoured sites. Areas of bare ground are restricted to sand fields, where they will be maintained as long as possible.

Table 1. Management measures on 'Red Area 2' in the Lüneburger Heide nature reserve

Management measures	Area (ha)	%
Removal of coniferous plantations	64	5.3
Sowing of *Festuca filiformis*	22	1.8
F.f. + 'Plaggmaterial'	88	7.3
F.f. + heather mowing material	73	6.0
F.f. + heather threshing material	15	1.2
Total	198	16.3
Spreading of		
'Plaggmaterial'	57	4.7
Heather mowing material	2	0.2
Heather threshing material	6	0.5
Total	65	5.4
Succession	39	3.2
Overall Total	366	30.3
Total Area of 'Red Area 2'	c 1,200	

In many places however, pine and birch regeneration has taken place at an undesired intensity, so that large-scale mowing, in addition to extraction of some exposed mature trees, has become necessary.

Long-term investigations on soil invertebrates had already begun in 1993 (Melber *et al*, 1996). As expected, bare ground specialist species predominated at the beginning, as in the preceeding period (Mossakowski *et al*, 1990). Changes in vegetation development are reflected in the invertebrate community, both in terms of species composition and numbers.

Several typical heathland/moorland bird species find suitable habitat conditions at least at the edges of the red areas today, eg common cranes, black grouse, curlews, nightjars or woodlarks (breeding densities of 0.8-1.0 breeding pairs/10 ha, amongst the highest values found in Northern Germany (Lütkepohl & Pruter, 2000).

References

Cordes, H, Kaiser, T V D, Lancken, H, Lutkepohl, M & Pruter, J (eds) (1997) *Naturschutzgebiet Lüneburger Heide – Geschichte, Ökologie, Naturschutz*. Hauschild Verlag, Bremen.

Gerold, G (1998) Landscape degradation in the Lüneburger Heide nature reserve by military tank training – pedological consequences and problems of renaturation (English summary). *Petermanns Geogr. Mitt.*, 142, 413-426.

Hanstein, U, Lütkepohl, M, Pflug, W, Preising, E, Pruter, J & Tonnieben, J (1994) *Rekultivierung und Renaturierung auf den im Eigentum des Vereins Naturschutzpark e.V. befindlichen Roten Flächen im Naturschutzgebiet Lüneburger Heide*. Niederhaverbeck (unpub).

Kreie, B, Pruter, J & Vauk, G (1993) *'Bear Ye One Another's Burden' – 12782 Days of the Soltau-Lüneburg Agreement*. Mitteilungen aus der NNA 4, Sonderheft (unpub translation by Andrew Yabsley).

Lütkepohl, M & Pruter, J (2000) *Die Vögel im Naturschutzgebiet Lüneburger Heide*. Hauschild Verlagb, Bremen.

Lütkepohl, M, Pruter, J, Pflug, W, Tonnieben, J & Hanstein, U (1996) Entwicklungskonzept für die im Eigentum des Vereins Naturschutzpark befindlichen militärischen Übungsflächen im Naturschutzgebiet 'Lüneburger Heide'. *NNA – Berichte*, 9, 105-121.

Luttig, G (1996) Geologische Gegebenheiten im Gebiet der 'Roten Flächen' im NSG Lüneburger Heide. *NNA – Berichte*, 9, 121-130.

Melber, A, Purter, J, Assing, V & Sprick, P (1996) Erste Ergebnisse der Erfassung ausgewählter Wirbellosen-Gruppen in einer kleinen Vegetationsinsel auf den Panzerübungsflächen des NSG Lüneburger Heide (Heteroptera; Homoptera, Auchenorrhyncha; Coleoptera, Carabidae, Stapylinidae, Curculionidea). *NNA – Berichte*, 9, 93-102.

Mossakowski, D, Frambs, H & Baro, A (1990) Carabid beetles as indicators of habitat destruction caused by military tanks. In: Start, N (ed) *The Role of Ground Beetles in Ecological and Environmental Studies*. pp 237-243. Intercept Ltd, Andover, Hampshire.

Tauber, T (1996) Vegetationskundliche und ökologische Untersuchungen auf militärischen Übungsflächen Im NSG Lüneburger Heide. *NNA – Berichte*, 9, 59-78.

Species on heaths II

Habitat fragmentation and landscape scale processes: examples from invertebrate ecology

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Introduction

The fragmentation of habitat has often been cited as a cause of the loss or decline of a species, particularly those that have poor powers of dispersal. This has been suggested for many groups of animals, but invertebrates are thought to be by far the most vulnerable. Habitat fragmentation is likely to be a particularly important factor for those species that have a need for a specific set of conditions for all or a part of their life cycle. Those species that are specialised and require a certain vegetation structure can only exist in any one area for a short time while conditions are favourable. Therefore they have to colonise new areas of suitable habitat to maintain their populations. This relies on the appropriate vegetation type, at the correct stage in the succession or management cycle, being present within the dispersal distance of the existing area of habitat. However, the more fragmented the vegetation type is, the less likely that there will be suitable habitat for colonisation within the dispersal distance and the more likely the risk of extinction.

The study system and species

To demonstrate how the distribution of the appropriate vegetation type and structure effects the distribution of invertebrate species, it is important to use a distinctive vegetation type and a species that have been well-studied and are of conservation interest. Therefore I have chosen to concentrate on the implications of heathland fragmentation and the specific habitat fragmentation of a single species the silver-studded blue butterfly.

The fragmentation of the heathlands of Dorset has been studied for many years (Moore, 1962; Webb & Haskins, 1980; Webb, 1990; Rose *et al*, 2000) and a considerable database on the extent and composition of heathland in Dorset has been built up. Two of the main causes of loss of heathland habitat in Dorset have been land use change and inappropriate management or lack of management. Land use changes such as urbanisation, afforestation or agricultural improvement are major changes that may or may not be reversible. Inappropriate management or the lack of management is more likely to result in the habitat becoming temporarily unsuitable. However, continued unsuitable or insufficient management may lead to a permanent loss of heather. This may be to grassland, by intensive grazing, or by natural succession to scrub invasion and woodland.

The silver-studded blue butterfly is a particularly suitable species to study the effects of habitat fragmentation. Data for habitat requirements and dispersal distances for the butterfly have been published for North Wales (Thomas, 1985), East Anglia (Ravenscroft, 1990) and Devon (Read, 1985). These show that it has relatively poor powers of dispersal and it occurs only when the vegetation is in an early stage of development. The silver-studded blue is also reasonably abundant in Dorset (Webb & Thomas, 1994). This is important in this type of study because it is difficult to characterise the range and optimum habitat for a species if there are few examples on which to base any analysis. Indeed some rare species are likely to be persisting only in poor quality habitat and their real habitat requirements are unknown.

Background

The implications of heathland fragmentation in Dorset for rare species have been discussed by Moore (1962), Bullock & Webb (1995) and in association with climate change by Thomas *et al* (1999). However, these analyses were either done at a crude scale (selected individual heaths) or using habitat definitions from other areas.

The aims of this study were to describe the total stock and composition of heathland vegetation within the study area and define those areas that were inhabited by the butterfly. Then, by using these data, to construct a habitat definition for the butterfly in Dorset. This definition could then be applied to existing data covering the whole of the Dorset landscape at three time points over an 18 year period. These findings were then used to assess the spatial and temporal continuity of habitat within the landscape and the probability of occupancy of heathland fragments of differing size and habitat quality.

Methods

To investigate the effects of habitat fragmentation on the silver-studded blue, data has been used from the CEH Dorset Heathland Survey database in combination with data from a survey of the distribution of the butterfly in Dorset. The Dorset Heathland Survey is a complete census of all the heathland in Dorset. It has been done 3 times, in 1978, 1987 and 1996 by the Institute of Terrestrial Ecology (now Centre for Ecology and Hydrology), and was helped in 1996 by the RSPB. The survey covered a total of 15,840 ha of land (of which about 7,300 ha are heathland). This land was divided up into 3,960 sampling units that were 200 m x 200 m (4 ha) in area. The extent of the survey is shown in Figure 1. Within each sampling unit 180 different attributes were recorded. This included patches of vegetation as small as 20 m x 20 m. In this way the following features of each sampling unit (square) were recorded.

- The area of each of the heathland vegetation types (dry heath, humid heath, wet heath and peatland (valley mire)).
- The area of non-heathland vegetation types (woodland, improved and unimproved grassland, arable, open water, bare ground, urban and industrial sites etc).
- The age and structure of the heathland vegetation (pioneer or post-burn, building, mature and degenerate age phases).
- Topographic features such as slope and aspect.
- Other land features such as roads, tracks, ditches, hedges etc.

The butterfly data were collected at the same spatial scale (200 m x 200 m square) as the Dorset Heathland Survey using similar recording methods. The recording was on a presence or absence basis and was done during the main flight period for the silver-studded blue (the end of June until early August). Surveying was only done when the weather conditions met butterfly monitoring scheme guidelines. Thus the following parameters were considered:

- temperature (> 14°C)
- sunshine (sunny if a shadow is cast)
- wind speed (< slight breeze = leaves and twigs in slight motion)
- time of day (between 10.00 and 16.00).

The search method was based on that described by Thomas (1983) and the search time within each square was a minimum of 30 minutes.

Results

Using the two sets of data it is possible to build a habitat definition for the butterfly. To analyse these data the statistical technique of Binary Logistic Regression was used. The attributes with a statistically significant and positive effect (that is, those favoured by the butterfly) were used. All factors including topographic features, heathland and non-heathland vegetation and land use were considered. From this analysis the habitat definition was based on the vegetation type and age (structure). Four habitat types were identified. These were:

- humid heath in the building phase
- humid heath in the mature phase
- wet heath in the building phase
- peatland in the building phase.

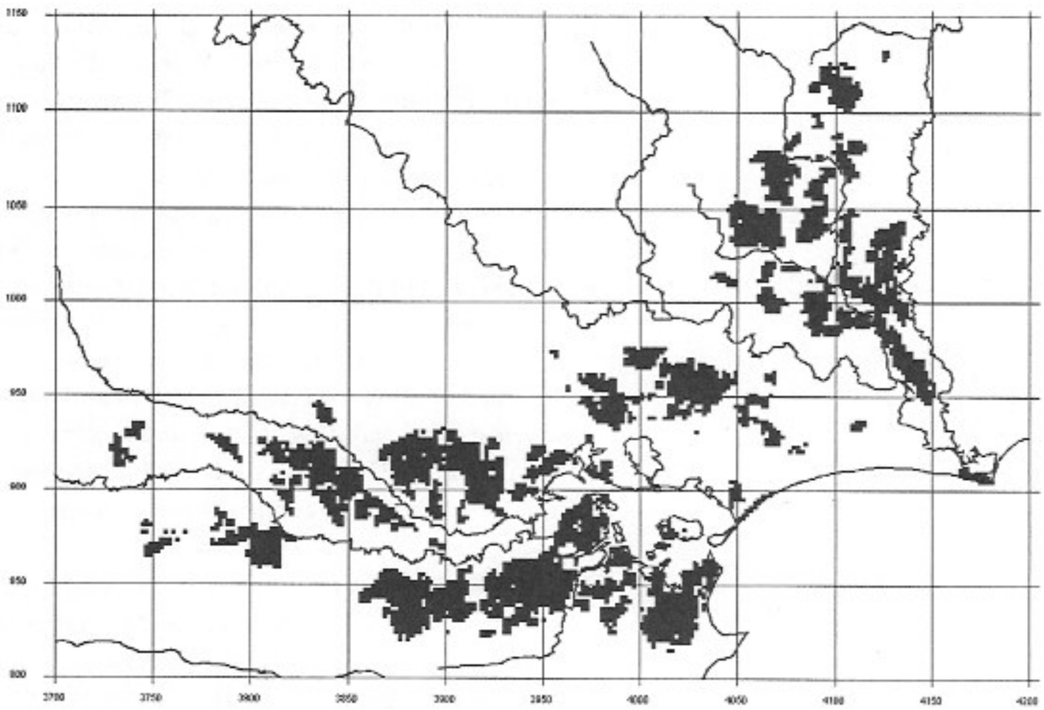

Figure 1. The Dorset Heathland Survey Area

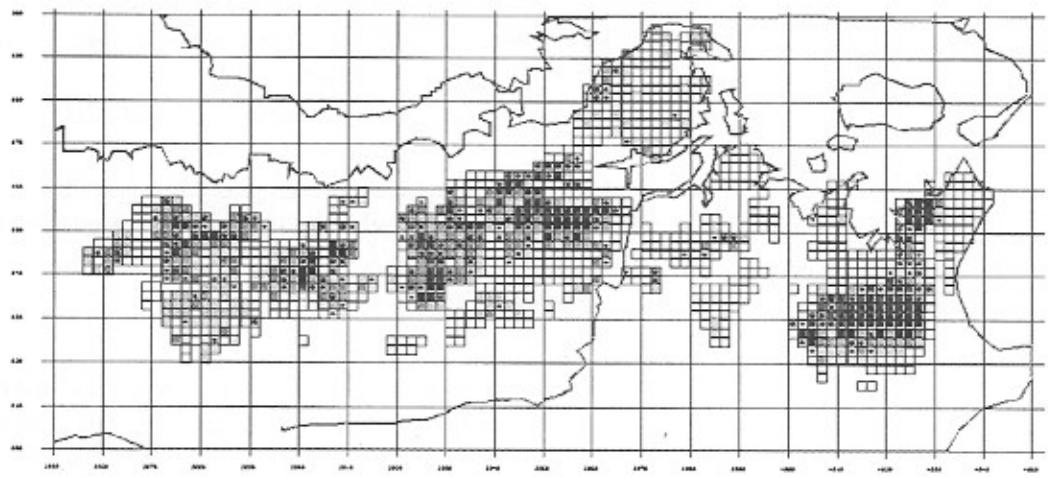

Figure 2. Silver-studded blue heathland habitat suitability. Open squares represent unsuitable heathland, shaded squares show predicted occupancy (occupancy predictions: palest grey: p = 0.1 – 0.3; intermediate grey: p = 0.3 – 0.5; darkest grey: p = 0.5 – 0.7; black: p = > 0.7).

Therefore we can say that in Dorset the silver-studded blue is a species of wetter heaths that are in the mid-succession stages of the normal heathland management cycle. This habitat definition is different to those published for the silver-studded blue in East Anglia, North Wales and even Devon where it is found in drier and shorter

Table 1. Silver-studded blue habitat constancy

	Total number of squares 3,960		
1 Not always heathland		1,494 (37.8%)	
2 Heathland but never with a habitat suitability ≥ 0.5		1,714 (43.4%)	
	1978	1987	1996
3 Habitat suitability ≥ 0.5 in one survey only	33 (0.8%)	224 (5.6%)	232 (5.8%)
4 Habitat suitability ≥ 0.5 in two consecutive surveys	47 (1.2%)		146 (3.7%)
5 Habitat suitability ≥ 0.5 in all three surveys		33 (0.8%)	

heathland vegetation. Therefore we must be aware that local habitat preferences may differ over surprisingly short distances (Thomas *et al*, 1999). This is important when using information from other regions

Having defined the habitat in terms of vegetation types and age, the definition was further refined by including the following parameters.

- Habitat area. The data show that increasing the area of habitat increases the chances of the species being present.
- Habitat isolation. The more suitable the habitat in the surrounding area, the greater the chances of a site being inhabited. Habitat up to 1 km away has been shown to have an influence, but for regular recolonisation a 600 m distance is more appropriate.
- Habitat persistence. The longer a site has been suitable habitat the more likely it is to be inhabited.

These findings were used to produce a probability of species occurrence for each heathland square in Dorset. A sample area of the Dorset heaths showing the area of heathland and its habitat suitability is plotted in Figure 2. These probabilities can be used in a number of ways to look at how the populations of silver-studded blue butterflies fluctuate, how long they may persist in one place and how best to manage heaths for them in the future.

It is possible to estimate the number of squares occupied in Dorset in each of the survey years by summing all the probabilities of silver-studded blue occurrence. The results calculated by the above method are given in Figure 3. This figure shows that in 1978 the population size was smaller than in the subsequent survey years. This survey followed the extensive heathland fires in 1975 and 1976. During the period after these fires there were large areas of bare ground and pioneer phase heather. Thus there was less suitable habitat for the silver-studded blue. By 1987 much of the burnt heath had revegetated to the building phase and by 1996 was in the building/mature phase.

Table 2. Silver-studded blue habitat patches

Survey year	Total number of patches	Number of single square patches	Number of patches with < 10 squares	Number of patches with > 10 squares	Maximum number of squares
1978	74	16	33	25	381
1987	58	9	26	23	456
1996	56	10	23	23	440

A hypothetical situation with no heathland management (nor accidental fires) between 1996 and 2005 predicts a sharp down turn in the number of sites occupied (Figure 3). This is due to many areas becoming mature wet heath and peatland and degenerate humid heath that is unsuitable silver-studded blue habitat. This highlights the need for heathland management to maintain a proportion of mid-succession aged vegetation.

The persistence of suitable habitat within any one square can be tracked between the three survey dates (Table 1).

Table 1 shows the dynamic nature of the Dorset heathlands. Line 1 of the table shows that 37.8% of squares have not been continuously classified as heathland throughout the 18 year study period. These squares are generally on the edge of heaths with small areas of heath within them that either become scrubbed over or have been cleared. Alternatively they are a part of plantation forestry that has been felled or areas within heathland re-creation schemes where 'new' heathland is being formed. Line 2 shows that a further 43.4% of squares are of poor habitat quality for the silver-studded blue. This leaves only 18.8% of the heathland area in Dorset having been classified as high quality habitat at some time during the study period. Lines 3 to 5 indicate that very few squares maintain high quality habitat status between surveys. This suggests that many populations are surviving in low quality habitat that will eventually become unsuitable. Therefore, it is important that there is suitable habitat within the dispersal range (< 600 m). This will enable individuals to track from one patch of suitable habitat to another to maintain populations.

The data can also be analysed spatially. Squares of suitable habitat can be grouped into clusters between which butterflies can move. This can be done to create habitat patches (that is squares that are within 600 m of each other). Table 2 shows that there are varying numbers and sizes of habitat patches between survey years.

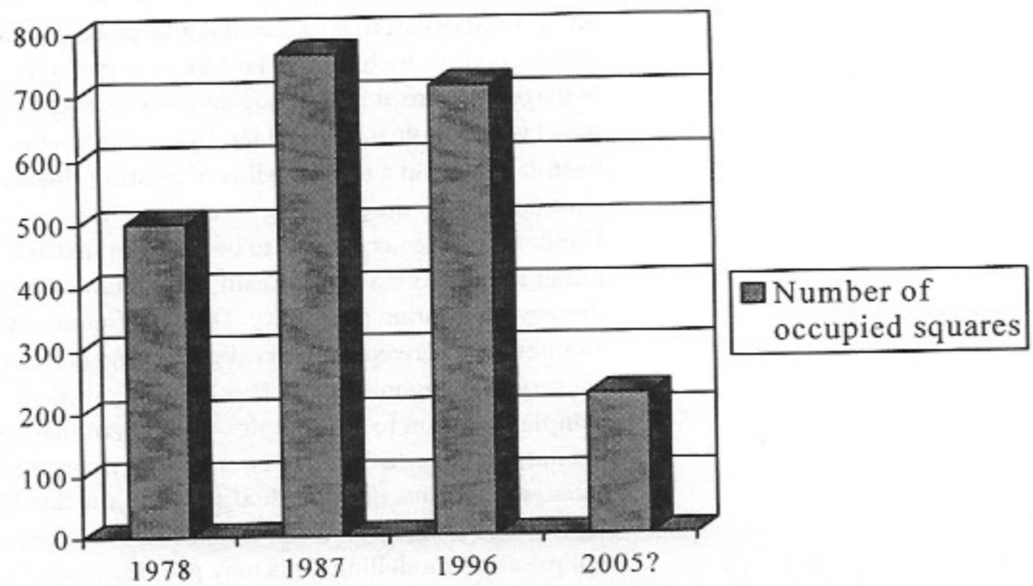

Figure 3. Silver-studded blue predicted population size

The single square and small patches (< 10 squares) are likely to require detailed and intensive management if they are to maintain populations of the silver-studded blue because there are likely to be few colonies and areas of potentially new habitat. The larger patches are likely to be more stable with more sites offering greater potential for recolonisation and options for management.

Conclusions

Given that silver-studded blue populations have been shown to fluctuate between surveys and that most individual patches of vegetation have only a temporary period of suitability, it is important to plan where, when and how management should be done. This must include sufficiently long-term planning to target areas for management several years in advance of a site becoming suitable for colonisation. This is relatively simple when a single species is involved but the silver-studded blue is only one of a number of species of conservation interest on heathlands. The challenge is to manage heaths for different species that have different habitat requirements. Therefore, what every heathland manager is trying to do is to maintain suitable habitat for a number of species. This is when the planning involved becomes more complicated.

A balance needs to be struck between conservation aims for different species. This has to be done by considering the different habitat requirements, viable population sizes and dispersal distances of all the species of conservation interest. There are a number of possible conflicts; Dartford warblers require more gorse scrub on a heath while sand lizards require less, the frequent burning of wet heath encourages marsh gentians but is detrimental to bryophytes and so on. It is important that the habitat and management requirements are understood for each species and that the plans for conservation management are at the appropriate scale for each species. This scale may be the whole heathland landscape for Dartford warblers, heathland within a 600 m radius of existing sites for the silver-studded blue to much smaller scales for the more sedentary species. Habitat management needs to be co-ordinated across the landscape rather than within a single heath to maintain habitat patch and thereby population continuity. This will frequently require co-operation between conservation managers from different conservation organisations. This idea of 'joined-up management' is a complex solution to the complex problem of managing fragmented habitats. A balance needs to be struck between the different conservation aims of individual sites and the heathland landscape as a whole. One method of analysis that could be used as a decision tool is optimisation modelling. This may provide a solution to how much of each habitat to conserve, and where to conserve it, to maintain viable populations of all species of conservation interest.

References

Bullock, J M & Webb, N R (1995) Response to severe fires in heathland mosaics in southern England. *Biological Conservation*, 73, 207-214.

Moore, N W (1962) The heaths of Dorset and their conservation. *Journal of Ecology*, 50, 369-391.

Ravenscroft, N O M (1990) The ecology and conservation of the silver-studded blue butterfly *Plebejus argus* on the Sandlings of East Anglia, England. *Biological Conservation*, 53 (1), 21-36.

Read, M (1985) *The silver-studded blue conservation report*. MSc thesis. Imperial College, London.

Rose, R J, Webb, N R, Clarke, R T & Traynor, C H (2000) Changes on the heathlands in Dorset, England between 1987 and 1996. *Biological Conservation*, 93, 117-125.

Thomas, C D (1985) The status and conservation of the butterfly *Plebejus argus* (Lepidoptera, Lycaenidae) in North-east Britain. *Biological Conservation*, 33 (1), 29-51.

Thomas, J A (1983) A quick method for estimating butterfly numbers during surveys. *Biological Conservation*, 27, 195-211.

Thomas, J A, Rose, R J, Clarke, R T, Thomas, C D & Webb, N R (1999) Intra-specific variation in habitat availability among ectothermic animals near their climatic limits and the centres of their ranges. *Functional Ecology*, 13 (Suppl. 1), 55-64.

Webb, N R (1990) Changes on the heathlands of Dorset, England between 1978 and 1987. *Biological Conservation*, 51, 272-286.

Webb, N R & Haskins, L E (1980) An ecological survey of heathlands in the Poole Basin, Dorset, England in 1978. *Biological Conservation*, 17, 281-296.

Webb, N R & Thomas, J A (1994) Conserving insects habitats in heathland biotopes: a question of scale. In: P J Edwards, R M May and N R Webb (eds) *Large Scale Ecology and Conservation Biology*, pp 129-151. Blackwell Scientific Publications, Oxford.

The impact of human disturbance and urban development on key heathland bird species in Dorset

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Introduction

Human disturbance of wildlife has recently become an issue of concern for conservationists. With the passage of the Countryside and Rights of Way (CRoW) Act (2000), which will grant open access to many heathland sites in the UK, there is a real need for a thorough understanding of how human disturbance can impact on birds. Here we present an overview of studies of human disturbance, and then present recent analysis we have conducted on three heathland bird species in Dorset. This analysis examines the effect of urban development surrounding heathland sites on the numbers of birds present on each site. It therefore addresses human disturbance, but also a number of other associated effects of urban development.

Overview of disturbance

Human access in the countryside occurs in a number of forms, such as kite flying, 4x4 vehicles and dog walking. Each form may have its own impacts on birds and each is difficult to measure (for example a total count or rate of visits of people to a site will not cover the range and types of activities those people may be involved with).

Disturbance is therefore difficult to quantify, and its impacts to birds, in terms of stress or survival, are also difficult to measure. Despite these problems, there have been many studies published in the scientific literature that address the impact of disturbance. Most, however, consider a specific aspect, such as foraging behaviour, and very few actually determine the extent to which human disturbance may impact on population size.

A further feature of most studies is that they focus primarily on wetland or coastal breeding species, and no studies have been published that specifically address any heathland species. From the published literature, mechanisms by which disturbance may have an impact on birds can be identified and used to consider the likely risks of an impact on any species (Table 1).

Table 1. Selected examples of studies of the impact of human disturbance on birds
Adapted from published reviews of disturbance (primarily from Anderson, 1990; Hockin *et al*, 1992; and Liley, 1999)

Mechanism	Effect	Examples of species	Reference
<u>All types of access</u>			
Complete avoidance of areas with high access levels	Suitable habitat supporting no birds	Kentish plover	Schulz & Stock (1993)
		Ringed plover	Liley (1999)
Lower densities in disturbed areas	Number of birds correlates with a measure of disturbance	8 species of woodland bird,	Van der Zande *et al* (1984)
		variety of species, both passerines and non-passerines	Tydeman (1977)
Accidental dislodgement of eggs caused when adults are flushed from the nest	Reduction in breeding success	Guillemot	Schauer & Murphy (1996)
Eggs predated because adults not present (disturbed)	Reduction in breeding success	Guillemot	Schauer & Murphy (1996)
		Ducks and geese	Strang (1980)
Increased rates of nest predation (eg because repeated flushing of adults from the nest site reveals the nest location to predators)	Reduction in breeding success	Adelie penguin	Giese (1996)
		California gnatcatcher	Sockman (1997)
Chicks or eggs dying from exposure (adults kept away from the nest)	Reduction in breeding success	Herring gull	Hunt (1972)
		Brown pelican	Anderson & Keith (1980)
Increased mortality of young due to reduced feeding time/brooding	Reduction in breeding success	Golden plover	Yalden & Yalden (1990)
		Piping plover	Flemming *et al* 1988
Abandonment of eggs or chicks	Reduction in breeding success	Brown pelican	Anderson & Keith (1980)
		Auks	Rodway & Montevecchi (1996)
Young separated from parents	Possible reduction in breeding success	Brown pelican	Anderson & Keith (1980)
		Great blue heron	Burger *et al* (1995)
Trampling of eggs by people	Reduction in breeding success	Ringed plover	Liley (1999) and Pienkowski (1984)
Birds disturbed while feeding	Feeding rate reduced	Brent goose	Riddington *et al* (1996)
		Piping plover	Burger (1994)
Birds flushed	Increased time spent in flight	Common tern	Burger (1998)
Close proximity of people	Increase in stress, resulting in elevated metabolic rate	Kittiwake	Huppop (1995), Huppop & Gabrielsen (1998)
		Adelie penguin	Regel & Putz (1997)
<u>Dog walking</u>			
Predation of eggs/chicks by dogs	Reduction in breeding success	Killdeer	Nol & Brooks (1982)
		Ringed plover	Pienkowski (1984)
<u>Off-road vehicles</u>			
Nests driven over	Reduction in breeding success	Hooded plover	Tulp (1998)
		Ringed plover	Liley (1999)

There are a variety of different disturbance effects, ranging from nests being crushed by vehicles to increased predation rates from natural predators. It is therefore difficult to highlight a species that may be particularly vulnerable to a certain type of disturbance. However, it is perhaps during the breeding season that any impacts may be most apparent, and ground-nesting species are likely to be the most vulnerable. Species nesting in habitats which attract high numbers of people (such as on beaches) are likely to be especially at risk, for example coastal breeding waders. A large proportion (33%) of this group are listed as being of global conservation concern (Collar *et al*, 1994) and disturbance is cited as the cause of this threatened status for most of these. Studies such as Strauss & Dane (1989), Loegering & Fraser (1995), Schulz & Stock (1993) and Liley (1999) provide evidence for the impacts of disturbance on this group.

Dorset heathlands: key bird species and urban development

Many heathland sites within Dorset are located close to, or adjacent to, large areas of urban development, especially the Poole/Bournemouth conurbation. There are a variety of ways in which urban development can impact on the conservation interest of a heathland site. These are described by Haskins (2000), and include diverse effects such as increased human disturbance, increased fire risk, pollution and predation from domestic cats.

In this study, the amount of developed land within a 500 m radius of heathland sites in Dorset was used as a measure of urban development and used to determine whether such development has an impact on the numbers of three Annex 1 bird species (nightjar, woodlark and Dartford warbler) which occur on the Dorset Heaths.

Data sources and methods

Distribution and extent of heathland in Dorset

The survey of the Dorset heaths conducted in 1996 by the Institute of Terrestrial Ecology was used to define heathland patches (for background and methodology see Webb & Haskins 1980; Chapman *et al*, 1989; Webb & Vermaat, 1990; Rose *et al*, 2000). The survey was based on a recording unit of a 200 m x 200 m grid square based on the Ordnance Survey National Grid. All such squares containing heathland-associated vegetation within Dorset were surveyed. Contiguous squares were grouped as patches. Only patches greater than 10 ha in total were included in this analysis (51 patches in total). For each patch, the area of heathland vegetation and whether public access was in any way restricted (for example Ministry of Defence (MOD) sites) was used in the analysis.

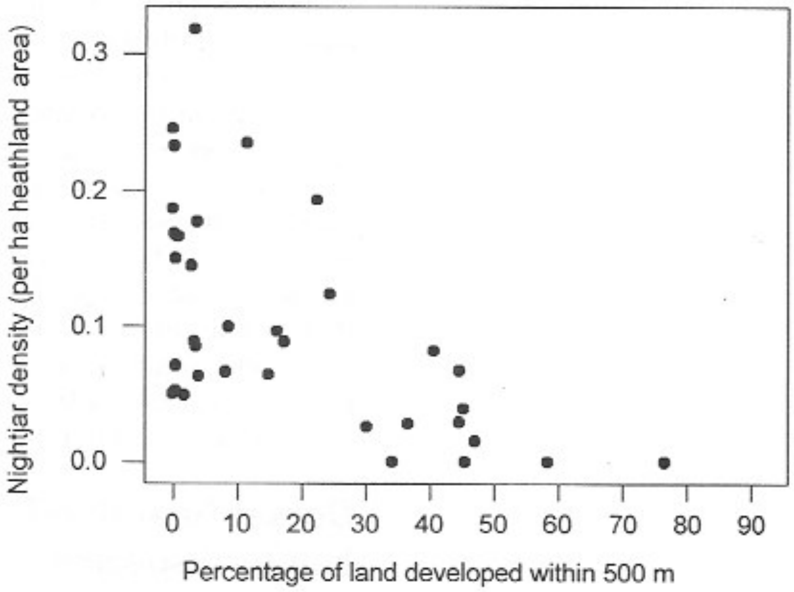

Figure 1. Correlation between nightjar density (per ha of heathland per patch) and the percentage of developed land within the 500 strip

The correlation is significant: Pearson correlation coefficient = -0.61, p = < 0.001, n = 36 patches.

Degree of developed land surrounding each heathland patch
The individual patches were taken as the basic sampling unit for analysis. For each patch a 500 m wide strip was drawn round the outside of the site, and then using orthorectified aerial photographs of Dorset (taken in 1997) as a base layer, the urban area within each 500 m strip was measured using GIS software. Developed areas included all buildings, warehouses and main roads.

The numbers of three key Annex 1 species (nightjar, woodlark, Dartford warbler) within each patch
These data were primarily from the RSPB/BTO data set from the national surveys conducted for each species (in 1992, 1994 and 1997 respectively). A further, more detailed spatial analysis of nightjar territory centres was conducted, using recent surveys by the RSPB Dorset Heathland Project (unpub). Theses surveys involved a minimum of two, pre-dawn visits, recording all nightjar activity at a site. Territories were then identified using the standard CBC type methodology.

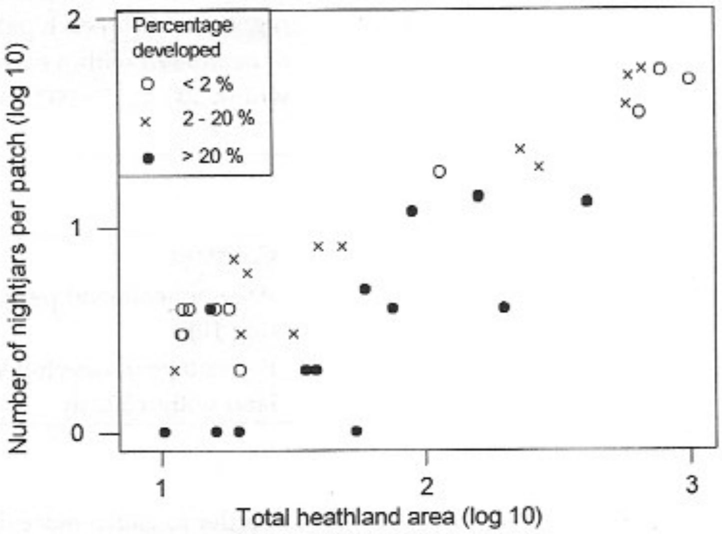

Figure 2. Relationship between number of nightjars per patch and total heathland area

A trendline is not illustrated in order not to obscure the different points, but the relationship is significant:

log number of nightjar = - 0.46 + 0.71 log heathland area,

$r^2 = 72.0\%$, $n = 36$, $F = 91.04$, $p < 0.001$.

Results

Nightjars

There was a significant negative correlation between nightjar density and the percentage of developed land within the 500 m strip (Figure 1).

The relationship shown above was further tested by using the numbers (rather than density) of nightjars per patch in a regression analysis. The area of heathland per patch provided a very good predictor of the numbers of nightjars with an approximately linear relationship between the logarithm of the number of birds on a patch and the logarithm of the area of heathland (all logarithms to base 10, denoted log 10). This relationship is shown in Figure 2, with sites categorised according to three levels of development in the surrounding 500 m.

Adding the percentage of developed land within 500 m as an additional variable in the regression, relating log numbers to log heathland area gives a statistically significant ($p < 0.001$) improvement in predictive ability. This factor explained two-thirds (65%) of the variation in log nightjar numbers on a patch that was not explained by log heathland area (Table 2).

Table 2. Multiple regression results predicting the (log 10) numbers of nightjars within each patch using two variables, namely the total area of heathland within each patch and the percentage of developed land within 500 m, $r^2 = 90\%$, n = 36 sites

	Regression coefficient	t value	p
Constant	-0.24	-2.74	0.010
Area of heathland per patch (log 10)	0.70	15.69	< 0.001
Percentage of developed land within 500 m	-0.011	-7.91	< 0.001

In order to gain a more detailed insight into the distribution of nightjar territories on heathland sites, a separate analysis was conducted, comparing the location of nightjar territories with random points. Nine sites were selected, representing a range of different degrees of surrounding development. The centre of each territory was plotted, using GIS software, on aerial photographs. Within each site, random points were plotted, using the same number of random points as the number of territories identified for the same site. At each point (nightjar territory centres and random points) the following variables were recorded using 1997 aerial photographs at a zoom level of 2,000 m:

- distance to the nearest edge of the site
- distance to the nearest house
- distance to the nearest road
- number of paths within a 100 m radius of the point.

With points for all sites combined (n = 93 for both random points and territory centers), there was no significant difference between nightjar territory centres and random points in the distance to the nearest edge of the site (Mann Whitney test W = 8348, p = 0.34), nor the distance to the nearest road (W = 8980, p = 0.44). However, nightjar territory centres were located significantly further away from houses than random points (W = 9574, p = 0.017). Territory centres also differed from random points in that there were fewer paths within 100 m of the territory centers (W = 9970, p = 0.003).

Woodlarks

There was no significant correlation between woodlark density and the amount of developed land within the 500 m strip (Pearson correlation coefficient = -0.11, p = 0.49, n = 44 patches). Although no woodlarks were recorded on the four patches with the highest degree of urban development, this was not unexpected in that woodlarks were recorded on less than 40% of all patches.

As with nightjars, heathland area per patch was found to be a good predictor of the number of woodlarks per patch (Figure 3).

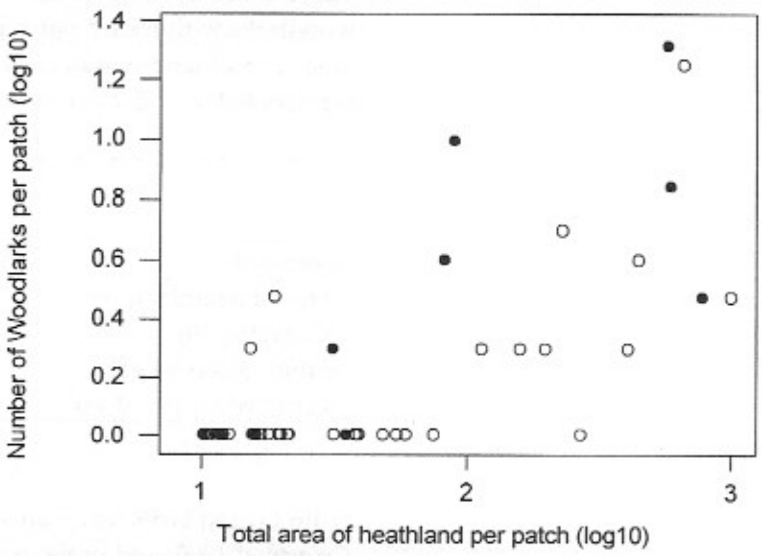

Figure 3. Number of woodlarks per patch for sites with public access restricted (filled circles: n = 12) and where public access is not restricted (open circles: n = 32).

A trendline is not illustrated in order not to obscure the different points, but the relationship between heathland area and the number of woodlarks is significant: log number of woodlarks = - 0.49 + 0.42 log heathland area, $r^2 = 49.7\%$, $n = 44$, $F = 43.57$, $p < 0.001$.

The amount of developed land within the 500 m strip, when included as an additional variable, was not significant. However, the public access variable was a statistically significant ($p < 0.05$) predictor for woodlark numbers and the amount of variance explained increased from 50% (Figure 3) to 55% (Table 3).

Dartford warblers

There was no significant correlation between Dartford warbler density and the amount of developed land within the 500 m strip (Pearson correlation coefficient = 0.11, p = 0.51, n = 36 sites). Similarly, in a multiple regression, the area of heathland was a very good predictor of the number of birds present per patch ($r^2 = 82\%$), but neither the amount of developed land nor the public access variable were significant when included.

Conclusions

A clear relationship was identified between the numbers of nightjars and the percentage of development surrounding the heathland patch, with patches surrounded by a high degree of developed land supporting fewer nightjars. The reasons for this effect cannot be directly determined from such an analysis, but it is possible to infer likely causes. A feature of the nightjar's ecology is that they will often leave the nesting areas to feed, with studies in Dorset showing that

Table 3. Multiple regression results predicting the numbers of woodlarks within each patch using two variables, namely the total area of heathland within each patch and whether or not public access is restricted, $r^2 = 55.2\%$, n = 44 sites

	Regression coefficient	t value	p
Constant	-0.33	-2.67	0.011
Area of heathland per patch (log 10)	0.41	6.87	< 0.001
Public access to site restricted (1=yes, 0=no)	-0.20	-2.47	0.018

radio-tagged birds travel an average of 3.1 km to forage (Alexander & Cresswell 1990) and prefer to forage in semi-natural habitats (Alexander & Cresswell 1990; Sierro *et al*, 2001). It is therefore possible that lower densities of nightjars on urban heaths could result from a loss of suitable feeding areas, in particular deciduous woodland or orchards around the heathland perimeter (Cresswell 1996).

Nightjars nest on the ground in the open. Ground-nesting species have been shown to be vulnerable to a range of disturbance effects, such as predation of eggs, or chicks, by dogs (Nol & Brooks, 1982; Pienkowski, 1984; Liley, 1999). The comparison between nightjar territory centres and random points shows that territory centres are located in areas with fewer footpaths and away from houses. This would suggest that there could be an effect of human activity.

Woodlarks, unlike the other two species, are not restricted to heathland, and are known to breed in a variety of habitats, including farmland and conifer plantations (Sitters *et al*, 1996; Wotton & Gillings, 2000). They are associated with areas of bare ground or very short grass (Bowden, 1990; Wotton & Gillings, 2000), and nest on the ground, typically in tussocks of grass (Cramp & Simmons, 1977), often alongside paths and firebreaks (J Mallord, pers comm). As such open habitat is likely to be patchily distributed, it is perhaps not surprising that the relationship between the numbers of woodlarks on a given site and the area of heathland is less strong than for the other two species. Thus sites such as Arne or Hartland Moor, which contain large tracts of mature heather, support very few woodlarks. Hence, there is a large variation in the density of woodlarks, and in order to predict more accurately the numbers of woodlarks on a site a better habitat measure than heathland area would be necessary.

A significant effect, however, was found for woodlarks when the public access variable was included in the regression. Sites were categorised as having restricted access when a major part of the patch had restricted public access, for example at Arne RSPB Reserve or MOD sites. The result should be viewed with caution dues to the fact that some MOD sites contain good woodlark habitat, created by tank and vehicle driving, and hence this may explain the higher numbers of woodlarks. However, given woodlarks' preference for nesting on the ground, close to paths, and feeding in areas of open ground or short vegetation, where dogs are likely to be running freely, it might be expected that woodlarks are sensitive to disturbance. This is an area where more detailed research is required, ideally starting by identifying and mapping areas of suitable woodlark habitat.

Dartford warblers are perhaps the species for which an effect of disturbance is least expected. Unlike the other two species, the nest is located off the ground, and in dense vegetation, often gorse or tall heather (Bibby 1979) where people and dogs are less likely to venture. The population size is also rapidly increasing. The population in 1994 had increased four-fold from the previous survey in 1984 (Gibbons & Wotton 1996) and there has been further spread since, with areas such as Suffolk, where the species last bred about 80 years ago (Gibbons & Wotton 1994) being recolonised. Given such a population increase it is likely that even poor quality territories will be occupied.

The analysis presented here does not address the mechanisms by which urban development does have an impact. Thus the true cause of the relationship between nightjars and the amount of surrounding development can only be speculative. Such mechanisms require further, more detailed research. However, the analysis does reveal the importance of considering a heathland site in a wider, landscape context, with issues outside the heathland boundary being of importance for the species within.

References

Alexander, I & Cresswell, B (1990) Foraging by Nightjars *Caprimulgus europaeus* away from their nesting areas. *Ibis*, 132, 568-574.

Anderson, P (1990) *Moorland recreation and wildlife in the Peak District.* A report to the Peak Park Planning Board, Bakewell. Penny Anderson Associates, Stockport.

Anderson, D W & Keith, J O (1980) The human influence on seabirds nesting success: conservation implications. *Biological Conservation*, 18, 65-80.

Bibby, C J (1979) Breeding biology of the Dartford Warbler *Sylvia undata* in England. *Ibis*, 121, 41-52.

Bowden, C G R (1990) Selection of foraging habitat by Woodlarks *Lullula arborea* nesting in pine plantations. *Journal of Applied Ecology*, 27, 410-419.

Burger, J (1994) The effect of human disturbance on foraging behaviour and habitat use in Piping Plover. *Estuaries*, 17, 695-701.

Burger, J, Gochfield, M & Niles, L J (1995) Ecotourism and birds in coastal New Jersey. *Environmental Conservation*, 22, 56-65.

Burger, J (1998) Effects of motorboats and personal watercraft on flight behaviour over a colony of Common Terns. *Condor*, 100, 528-534.

Chapman, S B, Clarke, R T & Webb, N R (1989) The survey and assessment of heathland in Dorset for conservation. *Biological Conservation*, 47, 137-152.

Collar, N J, Cosby, M J & Stattersfield, A J (1994) *Birds to Watch 2: the world list of threatened birds*. Birdlife International, Cambridge.

Cramp, S & Simmons, K (1977-1995). *Birds of the Western Palearctic*. Oxford University Press, Oxford.

Cresswell, B (1996) Nightjars – some aspects of their behaviour and conservation. *British Wildlife*, 7, 297-304.

Flemming, S, Chiasson, R D, Smith, P C, Austin-Smith, P J & Bancroft, R P (1988) Piping Plover status in Nova Scotia related to its reproductive and behavioural responses to human disturbance. *Journal of Field Ornithology*, 59, 321-330.

Gibbons, D W & Wotton, S (1996) The Dartford Warbler in the United Kingdom in 1994. *British Birds*, 89, 203-212.

Giese, M (1996) Effects of human activity on Adelie Penguin breeding success. *Biological Conservation*, 75, 157-164.

Haskins, L (2000) Heathlands in an urban setting – effects of urban development on heathlands of south-east Dorset. *British Wildlife*, 11, 229-237.

Hockin, D, Ounsted, M, Gorman, M, Hill, D, Keller, V & Barker, M A (1992) Examination of the effects of disturbance on birds with reference to its importance in Ecological Assessments. *Journal of Environmental Management*, 36, 253-286.

Huppop, O (1995) Störungsbewertung anhand phsiologischer Parameter. *Der Ornithologische Beobachter*, 92, 257-268.

Huppop, O & Gabrielsen, G W (1998) Energetic consequences of human disturbances. Proceedings of the 22nd International Ornithological Congress. *Ostrich*, 69, 171-172.

Hunt, G L Jnr (1972) Influence of food distribution and human disturbance on the reproductive success of Herring Gulls. *Ecology*, 53, 1051-1061.

Liley, D (1999) *The consequence of human disturbance, predation and sea-level rise on Ringed Plover population size*. PhD thesis, University of East Anglia.

Loegering, J P & Fraser, J D (1995) Factors affecting Piping Plover chick survival in different brood-rearing habitats. *Journal of Wildlife Management*, 59(4), 646-655.

Nol, E & Brooks, R J (1982) Effect of predator exclosures on nesting success of Killdeer. *Journal of Field Ornithology*, 53, 263-268.

Pienkowski, M (1984) Breeding biology and population dynamics of Ringed Plovers in Britain and Greenland: nest predation as a possible factor limiting distribution and timing of breeding. *Journal of the Zoological Society of London*, 202, 289-295.

Regel, J & Putz, K (1997) Effect of human disturbance on body temperature and energy expenditure in penguins. *Polar Biology*, 18, 246-253.

Riddington, R, Hassel, M, Lane, S J, Turner, P A & Walters, R (1996) The impact of disturbance on the behaviour and energy budgets of Brent Geese. *Bird Study*, 43, 269-279.

Rose, R J, Webb, N R, Clarke, R T & Traynor C H (2000) Changes in the heathlands in Dorset, England between 1987 and 1996. *Biological Conservation*, 93, 117-125.

Rodway, M S & Montevecchi, W A (1996) Effects of investigator disturbance on breeding success of Atlantic Puffins. *Biological Conservation*, 76, 311-319.

Schauer, J H S & Murphy, E C (1996) Predation on eggs and nestlings of Common Murres at Bluff, Alaska. *Colonial Waterbirds*, 19, 186-198.

Schulz, R & Stock, M (1993) Kentish Plovers and tourists – competitors on sandy coasts? *Wader Study Group Bulletin*, 68, Special Issue: Disturbance to Waterfowl on Estuaries. Davidson & Rodwell (eds).

Sitters, H P, Fuller, R J, Hoblyn, R A, Wright, M T, Cowie, N & Bowden, C G (1996) The Woodlark *Lullula arborea* in Britain: population trends, distribution and habitat occupancy. *Bird Study*, 43, 172-187.

Sierro, A, Arlettaz, R, Naef-Daenzer, B, Strebel, S & Zbinden, N (2001) Habitat use and foraging ecology of the Nightjar *Caprimulgus europaeus* in the Swiss Alps: towards a conservation scheme. *Biological Conservation*, 98, 325-331.

Sockman, K W (1997). Variation in the life-history traits and nest-site selection assects the risk of nest predation in the Californian Gnatcatcher. *Auk*, 114, 324-332.

Strang, C (1980) Incidence of avian predators near people searching for waterfowl nests. *Journal of Wildlife Management*, 44, 220-222.

Strauss, E & Dane, B (1989) Differential reproductive success in a stressed population of Piping Plovers in areas of low and high human disturbance. *American Zoologist*, 29, 42-48.

Tulp, I (1998) Nest success of White-fronted Plover and Kittlitz's Plover in a South African dune field. *Wader Study Group Bulletin*, 87, 51-54.

Tydeman, C F (1977) The importance of the close fishing season to breeding bird communities. *Journal of Environmental Management*, 5, 289-296.

Van der Zande, A N (1984) Impact of outdoor recreation on the density of a number of breeding bird species in woods adjacent to urban residential areas. *Biological Conservation*, 30, 1-39.

Webb, N R & Vermaat, A H (1990) Changes in vegetational diversity on remnant heathland fragments. *Biological Conservation*, 53, 253-264.

Webb, N R & Haskins, L E (1980) An ecological survey of the heathlands in the Poole Basin, Dorset, England, in 1978. *Biological Conservation*, 17, 281-296.

Wotton, S R & Gillings, S (2000) The status of breeding Woodlarks *Lullula arborea* in Britain in 1997. *Bird Study*, 47, 212-224

Yalden, P E & Yalden, D W (1990) Recreational disturbance of breeding Golden Plovers. *Biological Conservation*, 51, 243-262.

Whither heathlands?

Do Dorset's urban heaths have a future?

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The recent history, current management and future prospects for the urban heaths around Poole

The recent history of the heaths around Poole

The decline in the extent of Dorset's heathlands over the last few centuries is well documented (Webb & Haskins, 1980). The recent growth of Poole and nearby towns has reduced the once extensive heathlands and changed the character of the remaining heaths. However, despite these losses, a considerable area of heathland remains.

Heathland requires active management and committed or sympathetic owners. In recent years urban heathlands around Poole have increasingly come under the control of local authorities or conservation bodies and active management has been introduced. Private land owners have also entered into management schemes. The effects of these changes can be seen in Table 1.

It is believed that the proportion of these sites now under active conservation management has increased from around 1% in the mid-1980s to approximately 86% now.

Table 1. Estimates of the changes in ownership/management of the main urban heaths around Poole

Site	Area (ha)	Area (ha) with conservation management scheme c 1985	Proportion with conservation management scheme c 1985	Area (ha) with conservation management scheme 2001	Proportion with conservation management scheme 2001
Canford Heath	411	0	0%	411	100%
Upton Heath	214	9	4%	118	55%
Bourne Valley	73	0	0%	62	85%
Corfe Hills	103	0	0%	90	87%
Ham Common	32	0	0%	32	100%
Totals	833	9	1%	712	86%

Table 2. Effects of urban development on heathlands in south-east Dorset based on Dorset Wildlife Trust (1999) and Haskins (2000)

Reduction in size and fragmentation	Target species have only small populations, which are vulnerable to loss or extinction eg reptiles, silver-studded blue butterfly. Smaller heathlands have fewer characteristic species and more non-characteristic species
	Long boundaries with other habitat types – invasion by non-heathland (including non-native) species likely
	Sites may be too small for sustainable management eg grazing schemes
Loss of supporting habitats	Some key 'Heathland' species use other habitats for feeding (eg the nightjar) Reduction in management options eg back-up land for grazing
Water issues	Disruption to hydrology and pollution
Impact of roads	Changes to vegetation eg spread of common gorse, producing an increased fire risk and enrichment of soils from pollution, leading to change in vegetation
	Barrier to dispersal of heathland species
	Death of heathland species from collisions with vehicles (some species eg Dartford warblers may be attracted to nest near roads; nightjars may feed near roads)
	Increased noise, may disrupt sensitive species eg nightjars
Service infrastructure	Construction and maintenance of pipes/cables etc leads to damage to vegetation, soil disturbance and alteration of drainage
Public access	Trampling/cycles/horseriders and motor bikes leads to erosion (although bare ground has value, species using it, eg the sand lizard, may be damaged)
Disturbance	Disruption to behavior and success of sensitive species; worse for some species than others, eg the woodlark and nightjar (rather than the Dartford warbler)
Enrichment	Changes to vegetation (eg dog fouling and dumping of garden and other waste)
Predation	Loss of species (eg sand lizards by cats)
Fire	Direct destruction of plants and animals
	Long-term damage to habitat eg changes to vegetation
Public perception	Concern about removal of trees and grazing
Cost	Management costs may be up to 100 times that of rural heaths

The special problems of urban heaths

Despite this positive trend, urban heathlands have additional problems due to their location and to the proximity of large numbers of people. These problems, based on work by a local heathland expert (Dorset Wildlife Trust, 1999; Haskins, 2000) are summarised in Table 2.

The problems are mainly due to two factors: (1) the small size, fragmented distribution and location of urban heaths and (2) the direct impact of the human population. Tables 3 and 4 give examples of measures taken to overcome both types of problem.

Table 3. Mitigation measures to counter effects of size and distribution of remaining heathlands

Factor	Possible mitigation and limitations	Examples
Reduction in size and fragmentation	Create heathland corridors links – opportunities limited and costs high.	Alderney Recreation Ground, bank linking two areas within Bourne Valley SSSI across amenity grass area (bank c. 75 m x 10 m).
		Proposed heathland re-creation as part of Talbot Village Trust development.
	Manage more intensively to prevent invasion of scrub and garden plants – may be fighting a losing battle?	Most urban sites resourced at higher levels (and good potential supply of volunteer labour).
	Integrate management with other sites and schemes – expensive in time and money.	Corfe Hills – use of grass field for back-up winter grazing and hay cut from urban grassland as winter feed.
		Mobile grazing flock (East Dorset District Council).
Loss of supporting habitats	Influence management of non-heathland areas nearby – supply of undeveloped land limited (and continual development pressure as heathland itself more protected).	Proposals for Talbot Village Trust land will leave some meadow land and retain some mature oak trees near to heath.
Water issues	Maintain quantity and quality of ground water supplies – likely to be altered by nearby development even if heathland remains.	Proposals for Talbot Village Trust land include 'sustainable urban drainage systems' eg swales and reedbed filters.
	Introduce measures to control existing pollution – difficult to alter existing drainage patterns.	Bourne Valley Stream Partnership developing 'retro' fitting of reedbed filters to existing watercourses.
Impact of roads	Manage vegetation more intensively – expensive (road safety precautions).	Road management along Canford Heath road – 'management' plan for road verge.
Service infrastructure	Route new build away from most sensitive areas; ensure installation/replacement carried out sensitively.	Transco pipeline in Canford Heath area – route planning; reptile rescue/exclusion; vegetation removed and replaced by 'macro' turfing to allow pipe laying.

Two of the more intractable problems of urban heaths – fire and public perception – are discussed in greater detail below, together with the higher management costs associated with urban heathlands. Ultimately, the future of Dorset's urban heaths depends on how successful such measures are, and on the extent to which the effort required is deemed worthwhile.

Table 4. Mitigation measures to counter effects of human population on urban heathlands

Factor	Possible mitigation and limitations	Example
Public access	Control access – fencing, barriers, wardening; encourage revegetation.	Work done at Ham Common, Canford Heath ('Route E') and Alder Hills (aerial photos show dramatic reduction in eroding bare areas over last 10 years).
Disturbance	Create 'sanctuary areas' with little or controlled public access. Not likely to be effective on desire lines or areas with long tradition of use. For some disturbance problems eg ground-nesting birds by dogs – limited disturbance at key times may have major effect, education.	Heathland area at Hatch Pond rarely accessed, despite nearby development. Interpretation and education projects at most urban sites.
Enrichment (eg dog fouling and dumping of garden and other waste)	Education, disposal facilities, bye-laws and enforcement.	Increasingly applied on most sites.
Predation (eg by cats)	Limiting access fencing/barriers and numbers (covenants) on new developments, education. Potential perception and enforcement problems (banning domestic pets seen as over-restrictive); difficult/impossible to apply to existing developments.	Various measures proposed for new development near Talbot Heath.
Fire	Reduce numbers of fires (education/enforcement); reduce size and impact of fires (fire breaks/access/equipment).	See detailed discussion below.
Public perception	Education, consultation and involvement.	See detailed discussion below.

The fire problem on urban heaths

Heath fires are the most dramatic direct human impact on the heath (the incidence of fires starting naturally is thought to be extremely low). Fires can spread rapidly, covering large areas. A major heath fire at Canford Heath in June 1996 covered 45 ha and required the attendance of over half the available units of the Dorset Fire and Rescue Service. Nearby residents were evacuated from approximately 25 properties and around 12 properties were damaged (Martin, pers comm). Fires are the direct cause of the death of important species and may also encourage the spread of bracken or scrub.

Table 5. Estimates of the extent of heath fires for Canford Heath from 1990 to 2000 (total area of site 411 hectares)
Note: fire recording more systematic in later years so data probably more accurate.

Year	No of recorded fires	Area burnt (ha)	Proportion of site burnt (%)
1991	7	2.67	< 1
1992	9	1.17	< 1
1993	19	1.84	< 1
1994	19	2.58	< 1
1995	55	25.48	8
1996	39	54.08	16
1997	14	12.49	4
1998	15	1.23	< 1
1999	18	1.06	< 1
2000	12	0.80	< 1
Total	207	103.40	31

During the 1990s there were often hundreds of individual heath fires each year in south-east Dorset (mainly in the urban areas) and fires occurred throughout the year, though more frequently during March to September, probably the most damaging time for wildlife (Tantram *et al*, 1999). The number of heath fires was described as 'astonishingly high' in an on-the-spot appraisal of the Dorset Heathlands on behalf of the Standing Committee for the Convention on the Conservation of European Wildlife and Natural Habitats (de Molenaar, 1998).

The frequency and size of fires means heather is unlikely to reach maturity on parts of some urban heaths and in some cases the same area may be burnt twice in one year (Martin, pers comm). Estimates of the numbers and extent of heath fires for Canford Heath from 1990 to 2000 are given in Table 5 and figures for other key heathland sites in Poole for 1995 (a 'bad' year for fires) are given in Table 6. As conservation management has been extended to urban heaths, measures have been taken to reduce the impact of fires including the improvement of fire access, establishment of fire defendable lines, provision of fire maps and a system to assess the lèvel of fire risk. Education work (with the aim of convincing young people of the value of heathland) through schools and more generally in the community, eg by events such as heathland fairs, have been organised by local authorities, conservation bodies, the Police and Dorset Fire and Rescue Service acting together under the slogan 'Action for Heaths'.

Table 6. Estimates of the extent of heath fires on key urban sites during 1995

Site	No of recorded fires 1995	Estimated area burnt (hectares) 1995	Total area of site (hectares)	% of site burnt in 1995	Theoretical maximum age of vegetation (years) if fires evenly distributed across site and fire rate maintained
Bourne Valley	35	8.95	48	19	5
Canford Heath	69	26.72	333.4	8	12
Corfe Hills	17	0.27	30	< 1	111
Ham Common	30	1.39	24.5	6	18
TOTAL	151	37.33	435.9	9	12

However, heath fires are not a new phenomenon. Excavation of a buried soil beneath a Bronze Age barrow on Canford Heath suggested that the heath type vegetation had been burnt off at the time of the construction of the barrow, around 1100 BC (Horsey & Shackley, 1980). Old newspaper reports contain periodic references to heath fires and it is clear that large fires occurred. It is also well known that burning, accidental or deliberate, has contributed to the control of scrub (Moore, 1962). Urban heath fires often occur at the most damaging times and can affect critical areas such as reptile foci, which might be deliberately left un-burnt under a conservation management regime. It is also possible that climate change could, in future, exacerbate the problem of heath fires with summer droughts and higher winds (Anon, 2001). In international conservation terms it has been noted that 'very decisive action needs to be taken to avoid further degradation of heathlands that are frequently set on fire' (Standing Committee for the Convention on the Conservation of European Wildlife and Natural Habitats, 1998).

In addition to precautions to deal with fires when they occur, inter-agency co-operation (eg via 'Operation Heathland') has resulted in a better understanding of the pattern of fires and a greater willingness to pursue those responsible for the deliberate setting of fires. Reports of heath fires made to the Dorset Fire and Rescue Service are now passed by pager to site managers. This information can also be used to monitor the pattern of fires in relation to rainfall (Figure 1) and also to compare the distribution of fires at different times of the day, during school holidays and between sites. Figure 2 shows how the number of fires in each month at key sites varied in 2000. For example, fires in the Bourne Valley peaked in March and August with a relatively quiet period in June-July.

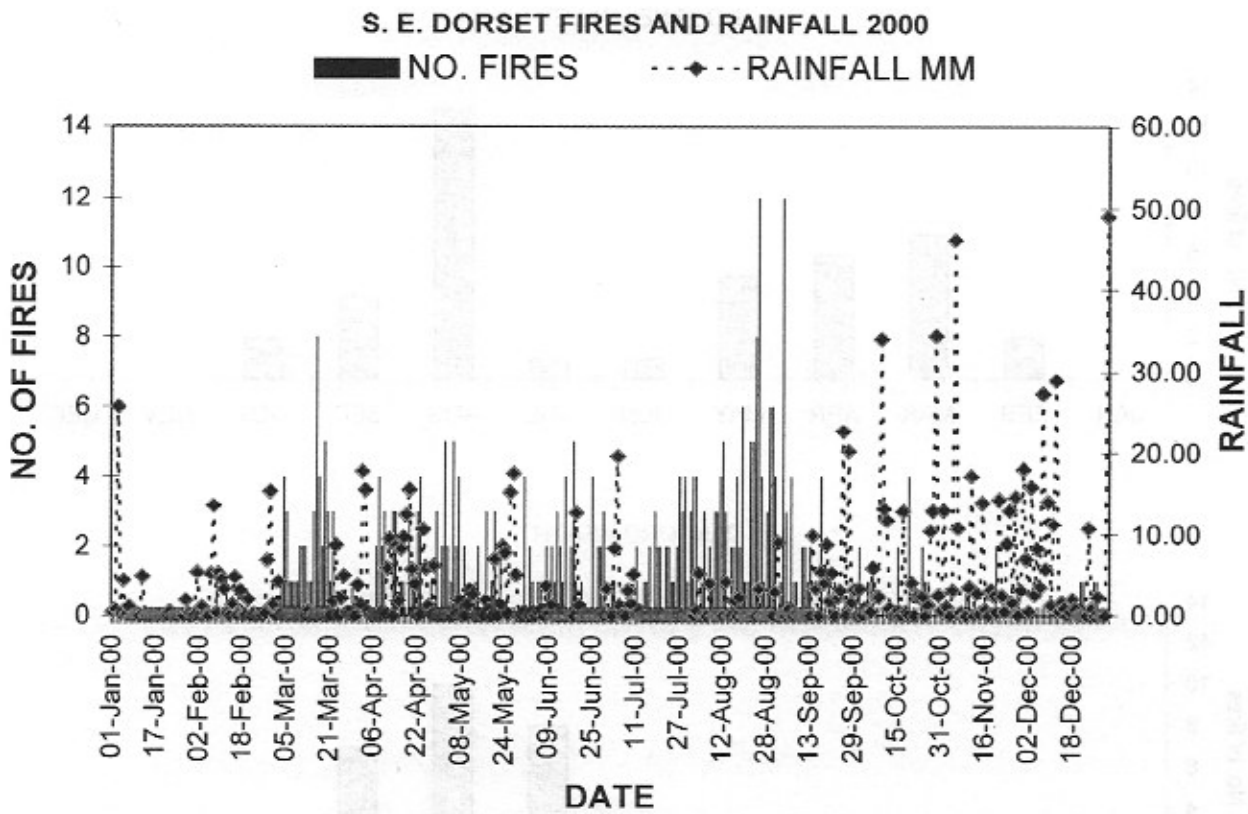

Figure 1. Reported heath fires in south-east Dorset and daily rainfall in Poole in 2000

In contrast, the numbers of fires in the Canford Heath area and on Upton Heath showed one main peak, but at different times of the year. It is hoped that this approach will lead to a better understanding of the occurrence of fires, the targeting of resources to problem areas and the monitoring of the effectiveness of the action taken. In this context Figure 3 shows daily rainfall, the total number of recorded heath fires and the number occurring in the Bourne Valley area (ie Bourne Valley SSSI and Turbary Common SSSI) for July and August 2001. These sites are all close together and a police operation against individuals suspected of anti-social behaviour (including arson) resulted in three arrests towards the end of July. The graph suggests a reduction in the number of fires (and the proportion of the total number of fires) occurred on these sites following the police action. More accurate and accessible data could help target resources for prevention and detection, as has been done for crime in general by Hampshire Police through the 'PROphecy' Geographical Information System (Ordnance Survey, 2001).

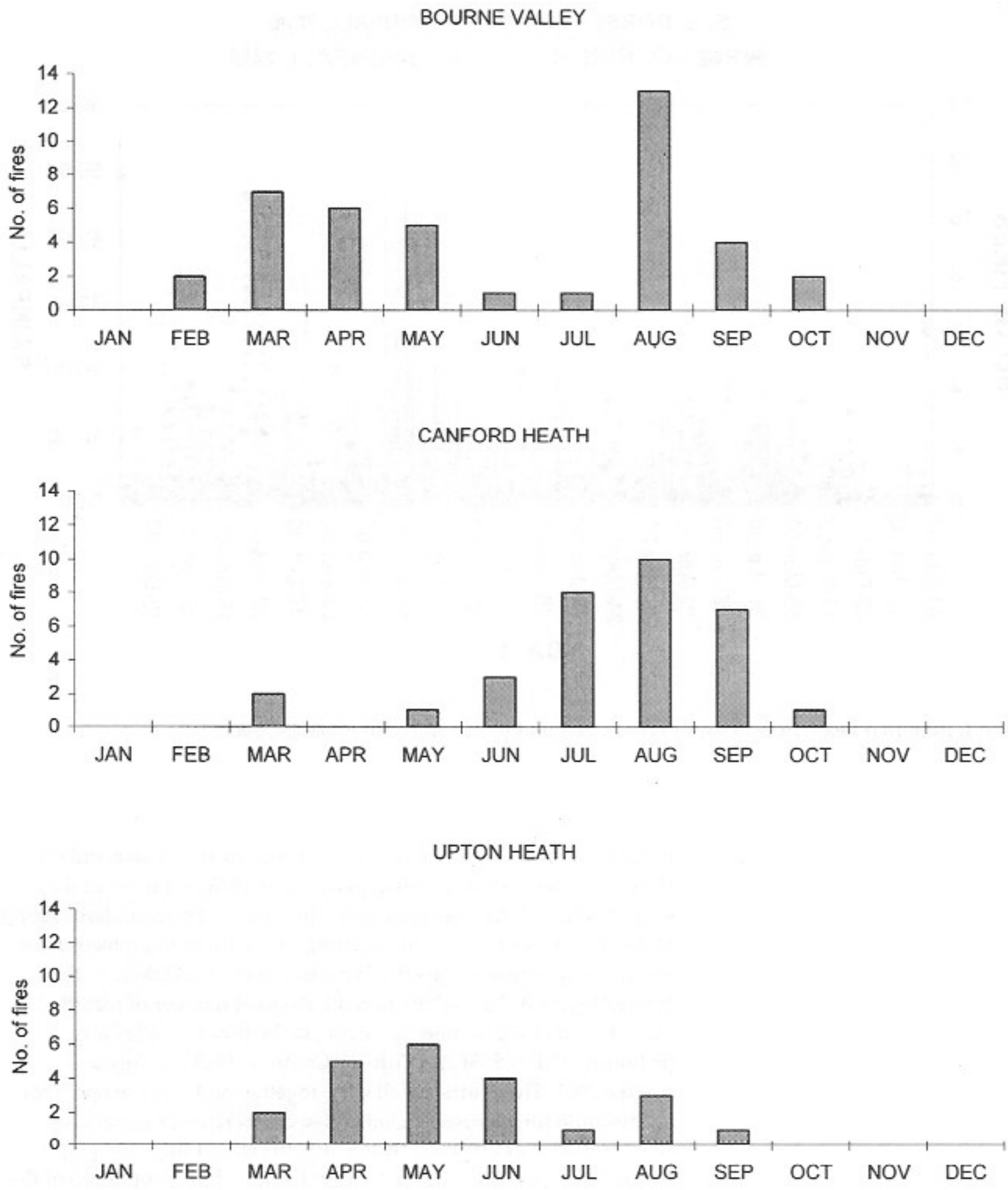

Figure 2. Number of reported heath fires in 2000 for three areas in Poole by month

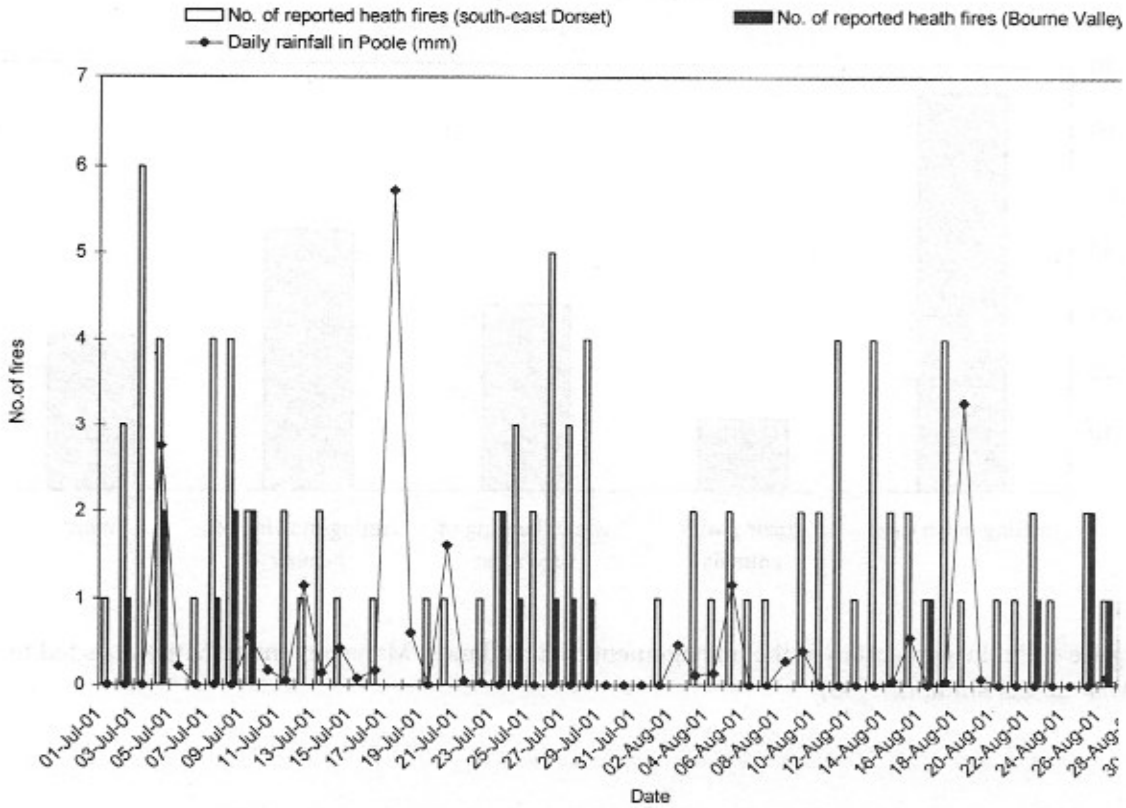

Figure 3. Number of reported heath fires on sites in the Bourne Valley/Wallisdown area, all reported heath fires in south-east Dorset and daily rainfall (Poole) for July/August 2001

Public perception

Public perception influences urban heaths in a number of ways. Most obviously, perhaps, through public concerns about tree felling and the danger posed by heathland fires. Recent local paper headlines such as *'Outrage as woods axed'* (Bournemouth Echo, Feb 3rd 2000) and *'Heath blaze ordeal'* (Bournemouth Echo, June 12th 2000) illustrate the impression heathland issues may make. Indirectly too, public perception may have an influence through the use of public funds for heathland management, the support for conservation organisations and, ultimately, planning policies.

Objective information on perception of heathland is harder to obtain. English Nature commissioned work in 1995, which sought to investigate perception of heathland (Atlantic Consultants, 1996). When asked 'Would it matter if heathland were lost?' 98% of those who responded in the Dorset sample (around Canford Heath) said 'yes' (similar figures were also returned for other areas). There was clearly an appreciation of the value of the heath. However, the need for management is apparently less well understood and Figure 4 shows that the cutting down of trees was the management activity objected to by the highest number of respondents in all three areas.

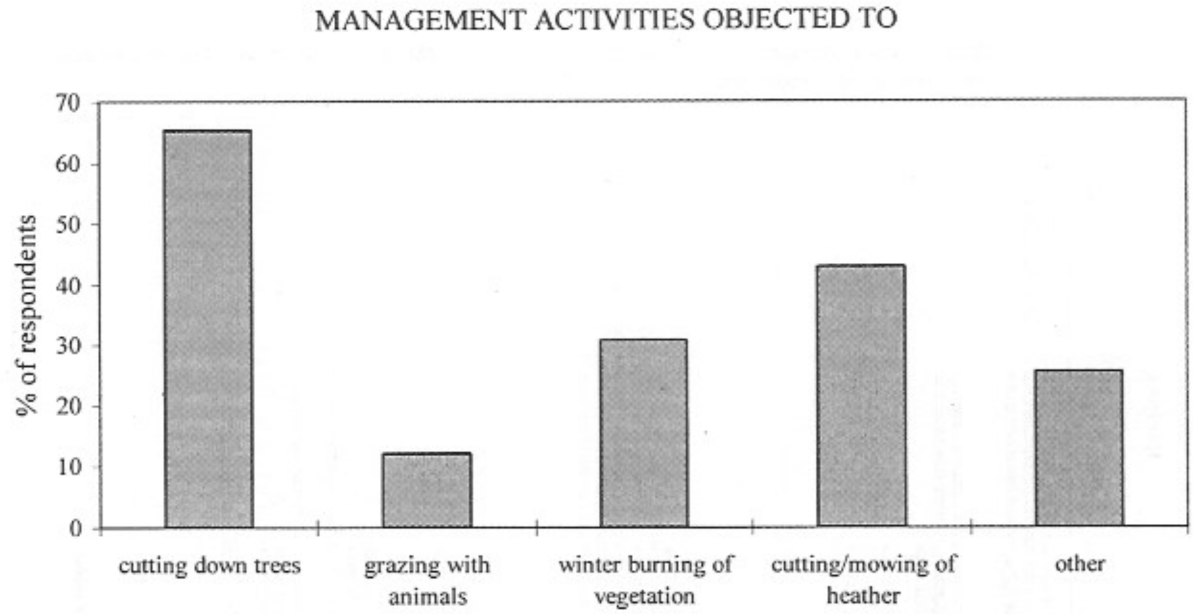

Figure 4. Public perception of the management of heathlands. Management activities objected to (Atlantic Consultants, 1996)

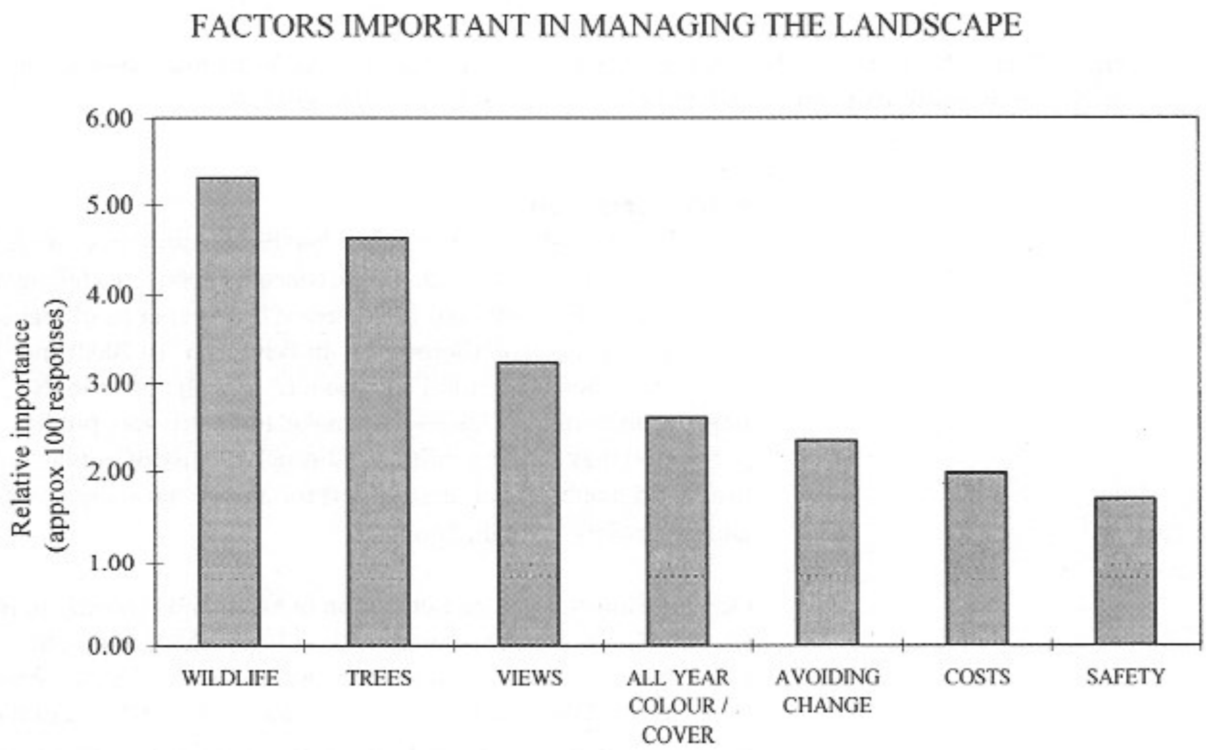

Figure 5. Importance of various factors in managing the landscape around Poole (relative importance based on 109 questionnaires completed at events in Poole 1994-2001)

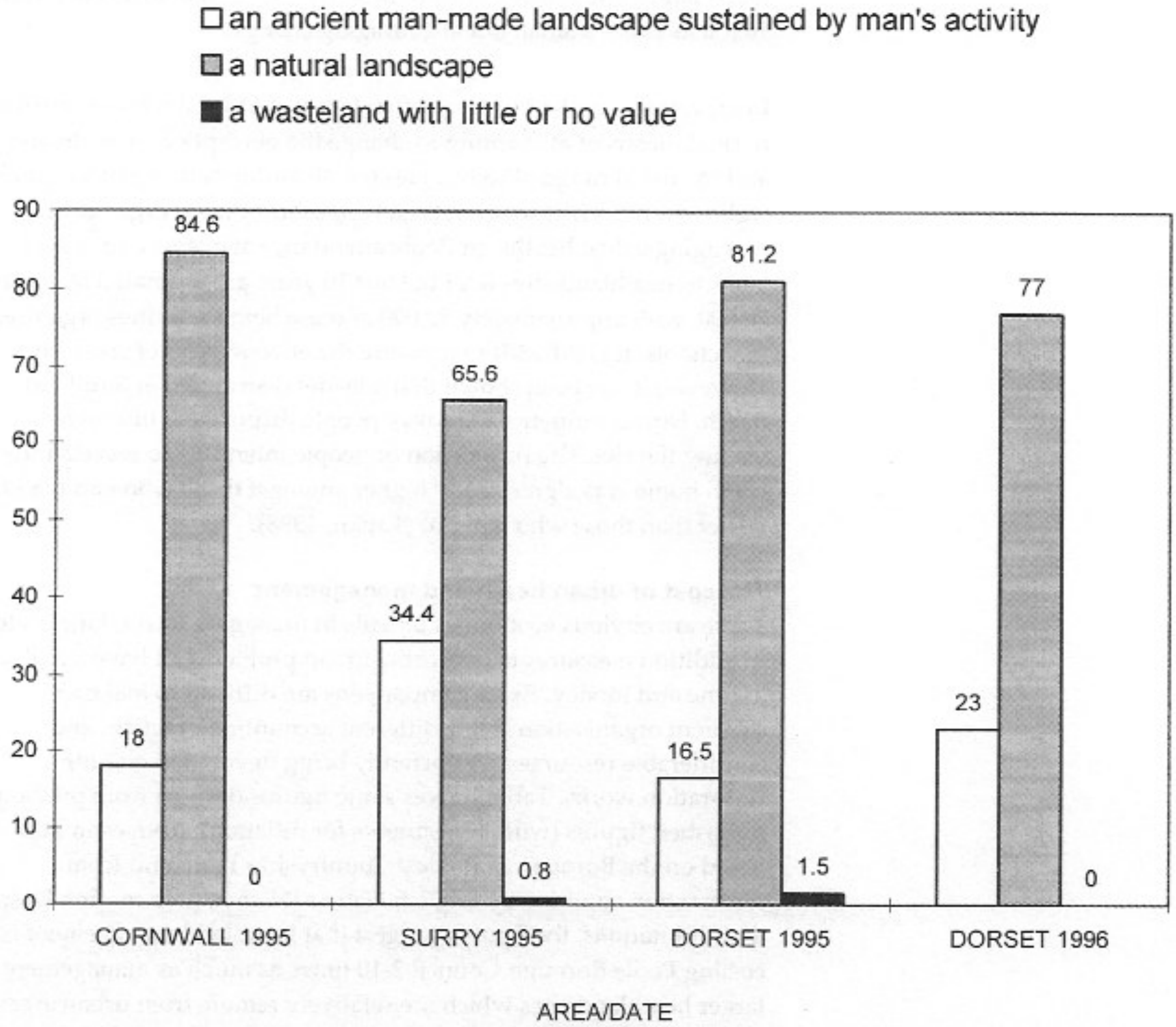

Figure 6. Public perception of the value of heathlands. Response to a postal questionnaire survey (Atlantic Consultants, 1998)

This may reflect the high profile given to the environmental importance of trees in recent years as illustrated in Figure 5, which shows the results of a questionnaire on local landscapes used in conjunction with a mobile display. When asked to rank in order of importance various factors to be taken into account in managing the landscape, people score 'wildlife' very highly. However, 'trees' (ie 'encouraging tree growth') comes a close second. Figure 6 may help to explain this contradiction (from a heathland management perspective). The 1995 English Nature study shows that whilst few people regard the heath as 'a wasteland of little or no value', the majority see it as 'a natural landscape' rather than 'an ancient man-made landscape sustained by man's activity'. This suggests that the emphasis of interpretation programmes should be to encourage understanding of the need for management. Figure 6 also shows the result of a repeat study (Atlantic Consultants, 1998) for Dorset. This shows that the proportion of respondents seeing the heath as a man-made landscape rather than a natural landscape had increased from 16.5% to 23% – a small but encouraging change.

Interpretation and education (often targeted at local schools) are the normal means of attempting to change the perception of heathland and the usual range of techniques (on site information panels, guided walks, events, visits to schools etc) are used by most organisations managing urban heaths. In Poole attendance at events and school visits to heathland sites over the last 10 years are estimated at around 20,000, with approximately 12,000 of these being activities organised for schools. It is difficult to measure the effectiveness of such work. However, it has been shown that a leaflet distributed at Studland Beach, Dorset influenced the way people disposed of litter when visiting the site. The proportion of people intending to recycle litter taken home was significantly higher amongst those who had read the leaflet than those who had not (Taylor, 1998).

The cost of urban heathland management

There are obvious economies of scale in managing fewer, larger sites. In addition measures to overcome urban problems all have a high cost in time and money. Exact comparisons are difficult to make as different organisations have different accounting practices and considerable resources are currently being devoted to one-off restoration works. Table 7 gives some figures derived from previously published figures (with adjustments for inflation), from estimates based on the Borough of Poole's Countryside Team and from information supplied by English Nature (Nichol, pers comm). Despite their limitations, the figures suggest that heathland management is costing Poole Borough Council 2-10 times as much as management of larger heathland sites which are relatively remote from urban areas. This factor of 2-10x is less than the maximum 100x that has been suggested (Haskins, 2000). It could, however, be argued that the Borough of Poole could input even more resources into these issues. The current level of management has not fully resolved the urban problems.

Ultimately, it may be more important to ask 'What are urban heaths worth (to those who provide the resources to manage them)?' than 'How much does management cost?' The estimates given in Table 7 suggest that, currently, Poole's 'expensive' heathlands cost significantly less per unit area to manage than its Country Park or its major urban park (Poole Park).

Can the problems of urban heathlands be overcome?

Problems due to the fragmentation and isolation of small blocks of heath are inherently difficult to deal with in an urban setting; restoration of forestry or farmland is relatively easy by comparison. Similarly, the difficulty of establishing sustainable grazing schemes in urban areas is likely to be difficult to overcome. Opportunities could arise in the future eg by diversification on urban fringe farms into farm tourism/rare breeds. The draft Borough of Poole Open Space Strategy (Borough of Poole, 2001) contains a proposal to *investigate alternative management regimes such as 'conservation farming' of semi-natural areas* in order to achieve sustainable management of open spaces. However, it is unlikely that such problems could ever be fully overcome.

Problems due to physical damage to urban heaths through past misuse and present recreational use leading to erosion may be easier to control. Mitigation measures to reduce the impact of the maintenance and construction of services are possible. Disturbance may be overcome by better education and visitor management, but very sensitive species (eg ground-nesting birds) may always be vulnerable to the actions of a minority. Similarly, the unprecedented efforts to tackle problems of misuse such as fires could achieve considerable success, although constant vigilance will be necessary as the actions of one or two individuals can have an adverse effect out of proportion to their actual numbers.

Ultimately, public perception may be of over-riding importance. A negative perception may make conservation management difficult, and only with the co-operation of local people can behaviour be modified to reduce problems such as enrichment and disturbance. Resourcing the extra costs of urban heath management will also require a positive public perception, whether such resources are provided via European bodies, national or local government or via conservation organisations either financially or in volunteer time.

The future for Dorset's urban heaths – conclusion

In south-east Dorset a major initiative started in July 2001 to tackle specifically urban problems on the heathlands. The Urban Heaths LIFE Project ('Combating urban pressures degrading European Heathlands in Dorset') is a four-year joint project between the local authorities, voluntary conservation bodies, the Dorset Police, Dorset Fire and Rescue Service and English Nature. Fifty percent funding from the European Union means that approximately £1.17M will be provided by the EU, to match the resources being applied to these problems by the partner organisations. The range of actions covered by the project is outlined in Table 8.

Only time will tell how successful the Urban Heaths LIFE Project will be. However, it is probably realistic to assume that the many problems associated with urban heaths will never be fully overcome and such sites will always be more difficult (and expensive) to manage than more rural sites. Whether or not urban heaths have a future will depend on the value put on such sites and, from a conservation point of view, whether the benefits possible for conservation are worth the additional costs involved.

Table 7. Estimated costs for heathland maintenance and management and management costs for a Country Park and formal park
Note: accounting practices (eg for apportionment of overheads) are likely to vary between organisations. Figures generally exclude support costs.

Details of assessment/source	Estimate of total annual cost	Total area (ha)	Cost per ha per year	Notes
'Heathland maintenance' – low estimate from 1990 heathland conference (Auld, 1991)			£69	Original figures (£50-£70 per hectare) – adjusted for inflation at 3% per annum. Assumed to be figure for basic habitat management.
'Heathland maintenance' – high estimate from 1990 heathland conference (Auld, 1991)			£97	Original figures (£50-£70 per hectare) – adjusted for inflation at 3% per annum. Assumed to be figure for basic habitat management.
Rural heathland: English Nature – lowland heathland National Nature Reserves (NNR) in Dorset – 1995/6 (Rayment, 1997)	£140,000	1,738	£96	Original cost estimated at £81 per annum – figure adjusted for inflation at 3% per annum.
Rural heathland: English Nature – lowland heathland National Nature Reserves in England – 2001/02 (Nichol, pers comm)	Not given	Not given	£135 * £143**	Figure for financial year 2001/2 based on projected expenditure. Provided by English Nature's NNR Management Unit. (Nichol, pers. comm.) * includes income ** excludes income
Rural heathland: RSPB – expenditure on lowland heathland reserves excluding capital expenditure – assumed to be 1994/5 (Rayment, 1995)	Not given	Not given	£207	Original figure (£168 per hectare) adjusted for inflation at 3% per annum.
Urban heathland: Borough of Poole – all sites – budgeted expenditure for 2001/2	£219,000	446	£491	Approx. costs – (based on 75% of Countryside Management budget) after purchase of additional 273 ha at Canford Heath (figure is projected expenditure).
Urban heathland: Borough of Poole – projected expenditure for 2001/2 without land purchase of additional land on Canford Heath	£195,000	173	£1,127	Approx. costs (based on 75% of Countryside Management budget) prior to purchase of additional land at Canford Heath. Includes only the Council's original 60 ha of Canford Heath. Figure is projected expenditure without the economy of scale provided by including such a large site, which is atypical of urban heaths.
Upton Country Park – equivalent costs for Country Park consisting of gardens, parkland, woodland and shoreline budgeted expenditure for 2001/2	£108,760	41	£2,653	Excludes internal support, internal asset rentals, premises costs and senior management costs.
Poole Park – equivalent costs for Victorian town centre park including lakes, gardens, play facility and amenity areas budgeted expenditure for 2001/2	£284,530	50	£5,691	Includes estimate for one parks officer and one ranger. Excludes internal support, internal asset rentals, premises costs and senior management costs.

Table 8. Urban Heaths LIFE project: summary of proposed actions (within each section of project)

GENERAL – MONITORING AND STRATEGY WORK
Condition monitoring of site following action undertaken during the project (F5)
Public perception surveys (F2)
Site user monitoring (F3)
Fire monitoring (F4)
Provision of heathland wardening strategy (A3)
Provision of education strategy (A2)
PUBLIC ACCESS – EROSION CONTROL
Erosion control measures (C6)
Improved access control/fencing (C5)
FIRE – PRECAUTIONS AND EQUIPMENT
Heathland wardening service covering all major urban sites (D1)
Heathland fire fighting and prevention guide (E4)
Training courses – fire fighting (E5)
Volunteer fire warden service (E15)
Standardised fire plans for urban heathlands (A5)
Fire fighting equipment (C1)
Improved water supply (Dry Riser Main) (C4)
Improved fire vehicle access (C3)
Creation of new firebreaks within the heathland candidate SAC (C2)
Maintenance of existing firebreaks within the heathland candidate SAC (D2)
PUBLIC PERCEPTION – COMMUNITY BASED
Community education program (E11)
Project publicity (E3)
Junior heathwatch program (E14)
LIFE project information boards (E2)
Mobile interpretative displays (E7)
LIFE heathland website (E12)
PUBLIC PERCEPTION – EDUCATION (SCHOOL) BASED
Schools heathland education program (E10)
Electronic educational resources (E13)
Exhibition trailer/mobile classroom (E6)
Training courses – creation of key/lead teachers (E8)
Training courses – partnership staff involved in education for heathland (E9)

It is felt that the experience in the Poole area over the last 10 or so years demonstrates that such efforts are effective (to a certain extent), and worthwhile; urban heathlands should have a future for the following reasons.

(i) Urban heaths can (and do) contribute to conservation objectives (though realistic objectives and targets may need to take account of the character of such sites).

(ii) A considerable effort is now being made to counter the problems of urban heaths and, hopefully, we are getting better at tackling such problems (within the limits that can be reasonably expected).

(iii) Urban heathlands are not simply a small part of a national or international resource. Each site forms part of the distinctive landscape and history of an area, has a cultural value (potentially at least) to the people who live in that area and can sustain some recreational use.

(iv) All, or at least most, heaths are dependent on human intervention. At present for most heaths external resources are required to achieve this. Finance from government or the Heritage Lottery Fund and time/money given by volunteers reflects the attitude of society to heathlands in particular and conservation in general.

Given the proximity to large numbers of people, the urban location of some of our heathlands could legitimately be regarded as a positive opportunity as well as a threat.

References

Anon (2001) UK Climate Impacts Programmes, Climate Change Impacts in the UK, 1998. Reported in *Environment Action* (published by the Environment Agency, June 2001).

Atlantic Consultants (1996) *Attitude survey of the value of heathlands.* Report to English Nature, Peterborough.

Atlantic Consultants (1998) *Repeat attitude survey of the value of heathlands.* Report to English Nature, Peterborough.

Auld, M H D (1991) A Heathland Project – starting and running. Proceedings of Heathland Conference II: History of Management of Lowland Heaths. In M H D Auld, B P Pickess & N D Burgess (eds) *RSPB Southern Heathlands Project.* pp 91-97. The RSPB, Sandy.

Borough of Poole (2001) *Draft Open Space Strategy for the Borough of Poole.* Report to Environment and Prosperity Policy Advisory Group, Borough of Poole, Dorset.

de Molenaar, H J G (1998) *On-the-spot appraisal of the Dorset heathland (United Kingdom)*. Report to the Standing Committee of the Convention on the Conservation of European Wildlife and Natural Habitats. IFNR, Wageningen.

Dorset Wildlife Trust (1999) *Heathlands in the urban setting – an examination of the effects of urban development on the heathlands of south-east Dorset*. Report to the Dorset Heathland Forum, Dorset.

Haskins, L E (2000) Heathlands in an urban setting – effects of urban development on heathlands of south-east Dorset. *British Wildlife*, 11, 229-237.

Horsey, I & Shackley, M (1982) The Excavation of a Bronze Age Round Barrow on Canford Heath, Poole, Dorset (SZ01889586). *Proceedings of the Dorset Natural History and Archaeological Society*, 102, 33-42.

Moore, N W (1962) The heaths of Dorset and their conservation. *Journal of Ecology*, 50, 369-391.

Ordnance Survey (2001) *Staying ahead of the Criminals* http:/www.ordsvy.gov.uk/media/studies/07-v1-rf-0500.htm

Rayment, M (1995) *Nature Conservation, Employment and Local Economics*. Report to the RSPB, Sandy.

Rayment, M (1997) *Working with Nature in Britain: Case Studies of Nature Conservation, Employment and Local Economies*. Report to the RSPB, Sandy.

Standing Committee for the Convention on the Conservation of European Wildlife and Natural Habitats (1998) *Recommendation No. 67*. Adopted 4 December 1998.

Tantram, D A S, Boobyer, M G & Kirby, J S (1999) *Monitoring heathland fires in Dorset: Phase 2*. Report to DETR Wildlife and Contryside Directorate. Terra Environmental Consultancy, Northampton.

Taylor, R E (1998) The role of interpretation in changing attitudes and behaviour towards nature conservation. *Customer Relationship Management*, Vol 1 No. 1, 1998.

Webb, N R & Haskins, L E (1980) An ecological survey of the heathlands in the Poole Basin, Dorset, England in 1978. *Biological Conservation*, 17, 281-296.

Posters

Local patterns of distribution and habitat usage by the heath grasshopper *Chorthippus vagans*

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Background

The heath grasshopper *Chorthippus vagans* is an RDB3 (Rare) species in the UK, and has only ever been recorded on the mainland from heathland sites in Dorset and the New Forest. The ecology of *C vagans* is poorly understood, but it has been suggested that the species feeds readily on heather, enabling it to exploit grassless areas of heath unsuitable for other Orthoptera (Marshall & Haes, 1988). During summer 1998, 4 x 4 grids of 2 m^2 quadrats were established, three on Holt Heath NNR and one on Sopley Common DWT Reserve, in Dorset. Data collected from each quadrat included percentage cover of dominant plant species and numbers of *C vagans* observed during standardised searches.

Results

The most striking result of this study was the clear association identified between *C vagans* and dwarf gorse *Ulex minor*. Yates corrected χ^2 tests showed a statistically significant spatial association of the grasshopper with *U minor* ($p < 0.01$) and *Erica cinerea* (bell heather, $p < 0.01$) but not with other plants. These associations were confirmed by Spearman Rank correlation analyses, which furthermore showed a highly statistically significant negative relationship between mean *C vagans* numbers and heather *Calluna vulgaris* cover ($R = -0.41$, $p < 0.001$).

T-tests on mean numbers of *C vagans* found in quadrats with and without *U minor* or *E cinerea* showed statistically significantly greater numbers of grasshoppers where *U minor* was found, but no such difference in numbers associated with *E cinerea* presence/absence.

Conclusions

Despite the suggestion that heather is an important food plant for *C vagans*, this study shows a strong negative correlation with *C vulgaris*, and no evidence of aggregation on *E cinerea*. In contrast, the grasshopper shows a very strong positive association, in local distribution and abundance with *U minor*. In casual observations made throughout the study, *C vagans* was never recorded feeding on ericoids, but was seen to feed on *U minor*.

Webb & Thomas (1994) recognised a need for small-scale management of heathland habitat patches, to benefit invertebrate species with specific requirements in relation to the ericoid development cycle, ie pioneer, building, mature and degenerate stages. *C vagans* may fall into this category – *Ulex minor* appears to thrive in gaps that exist in the pioneer and degenerate stages, becoming suppressed while the ericoid cover is closed.

References

Marshall, J A & Haes, E C M (1988) *Grasshoppers and Allied Insects of Great Britain and Ireland*. Harley Books, Colchester.

Webb, N R & Thomas, J A (1994) Conserving insect habitats in heathland biotopes: a question of scale. In: *Large Scale Ecology and Conservation Biology*, The 35th Symposium of the British Ecological Society. P J Edwards, R M May & N R Webb (eds), pp 129-151, Blackwell Science, Oxford.

Distribution patterns of the large marsh grasshopper *Stethophyma grossum* in the New Forest

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Background

CABI Bioscience is conducting research towards the conservation of the large marsh grasshopper *Stethophyma grossum*, a UK BAP priority species and the largest of the British grasshoppers. The species used to occur in open wetland habitats across the south of England. It was lost from the Thames valley in the late 19th century and from East Anglia in the 1960s. It now appears to be extinct in Surrey (last record 1991) and the Somerset Levels (last record 1995). *S grossum* is currently known to persist only in Dorset and the New Forest.

S grossum distribution in the New Forest – comparing habitat distribution patterns

A recently published map (Ordnance Survey, 1996) shows 242 one km squares within the New Forest, of which 203 contain wetland symbols, with 94% of these in open areas. Between 1997 and 1999, sites within 88 of these one km squares were visited, of which 28 sites (32%) yielded records of *S grossum*.

Away from the coast, open wetland habitat in the New Forest may be broadly classified as mire or wet heath. Where it occurred, *S grossum* was invariably found within mire. Although the two habitat types often formed a mosaic, the site (1 km square) scale data revealed *S grossum*'s habitat affinity (Yates corrected χ^2 tests of association: mire, $p < 0.01$; wet heath, n.s.).

Despite the clear association of *S grossum* with mire habitat in the New Forest, not all mires here support the species. Studies are investigating the finer habitat characteristics that influence *S grossum* distribution. Historic records are also being examined, to characterise habitat where the species formerly occurred in the UK (eg the Norfolk Broads, Cambridgeshire Fens).

S grossum distribution in the New Forest – comparing previous surveys

Brown & Searle (1974) derived *S grossum* distribution data from surveys in 51 of 126 New Forest tetrads, whilst Welstead & Welstead (1989) collated data from 165 one km squares (≡ 76 tetrads). Our own 1997-99 data cover 43 tetrads. Numbers of occupied tetrads increase across the 3 surveys (17, 21 and 22 respectively). However, this may not represent a genuine increase in numbers of *S grossum* colonies, as all surveys were only partial in coverage, and our own were guided by knowledge of historic records. Combined, the surveys reveal 33 tetrads with *S grossum* records. Remarkably, however, only 7 occupied tetrads are common to all 3 surveys. This is partly due to differences in coverage between surveys, but could it also indicate a dynamic process of extinction and colonisation across localised sites?

Surveys are on-going, to complete the picture of *S grossum* distribution in the New Forest, providing a basis for future monitoring.

References

Brown, A J & Searle, C A (1974) The Native Orthoptera of the New Forest. *Entomologist's Gazette*, 25, 285-292.

Welstead, A R & Welstead, N I (1989) *Orthoptera of the New Forest and its Environs.* Privately published.

Ordnance Survey (1996) *Outdoor Leisure 22, The New Forest (1:25,000).*

Mechanical means for removing rhododendron and aerial bracken spraying on lowland heath: techniques used at the RSPB's Arne Reserve, 1999-2001.

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Introduction

One of the objectives under Arne's current Management Plan (2000-05) is: 'To maintain the area dominated by ericaceous dwarf shrubs and their associated species in the dry, humid and wet heath (300 ha)/valley mire systems (6 ha) by managing the heather structure and removing invasive species, to benefit a wide range of heathland species.' This objective will be partly achieved by the prescription to: 'Remove invasive species from the heath by reducing pine/birch (scattered over the site or in small clumps) to a maintenance level; eradicating rhododendron (3.5 ha); and substantially reducing bracken (dense stands 26 ha, thickly scattered areas 37 ha, thinly scattered areas 32 ha).'

Rhododendron

The battle against rhododendron at Arne began in the early 1980s with major clearance carried out at Shipstal between 1983-86. Periodically, since then, small areas have been removed. By 1998, there was still an estimated 10-12 ha spread around the reserve. Under a successful Countryside Stewardship application in 1998, 1 ha was to be removed annually between 1998/99 and 2007/08.

Over the winter of 1998/99, 1 ha was removed by hand, the work being largely carried out by Arne Conservation Volunteers – a total of 1,651 man-hours were spent clearing this area. This tied up a lot of manpower and other methods of removal were investigated. Attending local machinery demonstrations introduced us to Morley Yeandle at Perry Plant Hire in 1999. Generous grants from SITA Environmental Trust and a rescheduling of Countryside Stewardship enabled us to remove 6 ha in 1999/2000 and a further 1.2 ha in 2000/2001 using Perry Plant Hire.

There still remain small pockets of rhododendron spread across the reserve, which will have to be removed by hand. It is, however, envisaged that by the end of the Tomorrow's Heathland Heritage project, in 2005, rhododendron will have been virtually eradicated from the reserve.

Bracken

Bracken has been sprayed at Arne with Asulox since the 1970s. A number of areas are now largely bracken-free and only require minor spot treatment periodically. A survey carried out in the summer of 1998 looked at the extent of the remaining bracken at Arne; the results showed that it covered about 100 ha, a third of the open heath.

Four criteria were used for assessing bracken density:

- present but negligible
- sparsely scattered (1-5 fronds per m^2)
- thickly scattered (6-20 fronds per m^2)
- dense (> 20 fronds per m^2).

Bracken dominates the areas where tree cover has been removed from the dry heath, and needs to be removed to allow the heather to establish. Historically Asulox has been applied by knapsack, micron-ulva and tractor-mounted boom sprayer. These methods will continue but an alternative was investigated and used in 2000: application by helicopter.

The advantages of using a helicopter are:

- a large area can be treated in one go
- it is very cost effective (at less than £100/acre)
- applied under optimum conditions, there is a virtual 100% kill-rate.

It will be important to ensure that sufficient time and resources are available to carry out follow-up spot treatment after the initial aerial spraying.

Contractor Costings	Oct 1999/Sep 2000		Oct 2000/Sep 2001	
	Ha	Cost £/ha	ha	cost £/ha
Bracken#	19	211	20.2	225
Rhododendron##	6	2,500	1.2	2,750

spraying in July 2001 was funded under the Tomorrow's Heathland Heritage 'Egdon Heath Project'

project funded by a grant from SITA Environmental Trust

The Hampshire Grazing Project

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Grazing of conservation sites such as chalk downland, heathland and unimproved grassland is becoming more difficult due to long-term and more recent changes in agriculture. Hampshire holds significant proportions of the total UK resource of these nationally important habitats.

The Hampshire Grazing Project is a joint Hampshire County Council and English Nature initiative, which aims to encourage the appropriate grazing of conservation sites throughout the county with suitable livestock. It is a pilot Local Grazing Scheme in association with The Grazing Animals Project (GAP), which is developing conservation grazing at a national level.

The project provides advice on grazing, and assistance in locating suitable stock and graziers. Through capital grants, the project can also help make sites suitable for grazing through scrub removal, fencing or water provision.

To date the project has been involved in some 40 sites varying in size from a few, to hundreds of acres. It works with private landowners, local authorities, volunteer groups and other organisations managing land of conservation interest. Some £4,000 of grants have been paid so far and demand is anticipated to increase in the next year.

The project has developed an extensive network of land managers and graziers spanning the whole county. It has amassed a wealth of information and experience of grazing and the suitability of different stock and breeds within Hampshire. This knowledge base helps the project to deliver appropriate grazing on conservation sites.

However, the project is working against a background of successive crises in the livestock sector, which have serious implications for conservation grazing. Experience from the pilot project will help develop measures and future projects that will work to address more strategic issues affecting the long-term viability of conservation grazing in Hampshire.

The re-discovery of the nail fungus *Poronia punctata* in Dorset, England, UK

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Conservation status and UK distribution

Introduction

Nail fungus *Poronia punctata* is one of the rarest fungi in Europe and is included in the UK Biodiversity Action Plan (UK Steering Group, 1995). It is also included in the provisional Red Data List of endangered British fungi (Ing, 1992). In recent years, it has been largely confined to the New Forest.

Description

In Britain nail fungus occurs on the dung of ponies and horses, although in Europe it has also been recorded from cattle dung (Whalley and Dickson, 1986). The fruiting bodies or stromata are shaped like a broad-headed nail, hence their common name. The dark coloured stalk is attached to the dung and a flattened, whitish, upper surface is dotted with black ostioles, small pores opening into spherical cavities termed perithecia. When the stromata are mature, they give a distinctive 'peppered' appearance. The perithecia contain numerous asci, which are cylindrical sacs containing ascospores, and once the spores have been ejected they adhere to vegetation surrounding the dung pile due to their gelatinous coat. Ascospores ingested with vegetation by grazing herbivores germinate to form a mycelium within the dung, and new stromata develop from the mycelium. The ascospores are produced sexually but asexual spores, or conidia, are produced as a dry powder over the surface of young fruiting bodies (Cox, 1999). Reid (1986) recorded that stromata could occur at any time of year, but in Dorset, October-December have been the principal months.

The Dorset discoveries and surveys

Nail fungus was re-discovered in Dorset in early November 1999 on Hartland Moor National Nature Reserve (NNR) and the RSPB Stoborough Heath Nature Reserve. Shortly afterwards it was also found on Stoborough Heath NNR and Hartland Moor SSSI. Pony grazing had been introduced to these sites in the mid-1990s. All four of these locations were extensively searched for the presence of the fungus on pony dung piles. Table 1 shows the number of infected dung piles and the number of stromata, per deposit, found during 1999 and 2000.

Table 1. Numbers of dung deposits bearing *Poronia punctata* together with numbers of stromata per dung deposit on Stoborough and Hartland Heaths during 1999 and 2000

Number of *Poronia* stromata per dung deposit	RSPB Stoborough Nature Reserve		Stoborough Heath NNR		Hartland Moor NNR/SSSI		Totals	
	1999	2000	1999	2000	1999	2000	1999	2000
1-10	7	68	-	1	11	20	18	89
11-25	5	47	1	1	10	25	17	73
26-50	3	30	2	2	4	15	8	47
51-75	3	26	-	1	2	3	5	30
76-100	-	9	1	1	5	3	6	13
101-150	3	12	1	-	7	2	11	14
151-200	-	5	1	-	6	2	7	7
201-300	-	-	-	-	7	2	7	4
301-400	-	-	-	-	-	1	-	1
401-500	1	-	-	-	2	-	3	-
501-600	-	-	-	-	-	1	-	1
Total numbers of dung deposits bearing *Poronia*	22	197	6	6	54	74	82	279

Habitat

In order to classify the vegetation on which dung supporting *Poronia* were deposited, a total of 51 2 m x 2 m quadrats were recorded, centred on *Poronia*-bearing dung on Hartland Moor NNR/SSSI and Stoborough Heath NNR. All vascular plants, mosses and lichens were recorded and their percentage cover within the quadrats estimated by eye. The vegetation within each quadrat was classified according to the National Vegetation Classification (Rodwell, 1991). The results are presented in Table 2.

Possible sources of *Poronia* on the Dorset sites

The ponies that graze Hartland and Stoborough originated from the New Forest, which currently is the only area in Britain where *Poronia* is known to persist. It is suggested that the most likely arrival of this fungus in Dorset is through transfer of spores, in the gut, by animals that had eaten *Poronia* infected vegetation in the New Forest. This is not certain, however, as it is not known how long the spores may persist in the gut, and the ponies, before being turned out on the

Table 2. National Vegetation Classification communities of vegetation within 51 2 m x 2 m quadrats centred on pony dung supporting *Poronia punctata*

National Vegetation Classification Community	Number of Quadrats	Percentage
H2 *Calluna vulgaris – Ulex minor* heath	33	65%
H3 *Ulex minor – Agrostis curtisii* heath	9	17%
U3 *Agrostis curtisii* grassland	5	10%
M16 *Erica tetralix – Sphagnum compactum* wet heath	2	4%
Non-NVC (recent *Ulex europaeus*-clearance areas)	2	4%

Dorset heaths, were wintered away from heathland. There are still many questions to be answered concerning this rare fungus, not least will it persist in Dorset?

References

Cox, J R (1999) *The Biodiversity of Animal dung*. Hampshire and Isle of Wight Wildlife Trust. Unpublished.

Ing, B (1992) A Provisional Red Data List. *Mycologist*, vol 124-128.

Reid, D A (1986) A collection of *Poronia punctata* from Surrey. *Bulletin of the British Mycological Society*, 20, 58-59.

Rodwell, J S (ed) (1991) *British Plant Communities Volume 2: Mires and Heaths*. Cambridge University Press, Cambridge.

UK Steering Group (1995) *Biodiversity: The UK Steering Group report. Volume 2: Action Plans*. HMSO, London.

Whalley, A J S & Dickson, G C (1986) *Poronia punctata* – a declining species? *Bulletin of the British Mycological Society*, 20, 54-57.

Hardy's Egdon Heath Project

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Executive summary

The Dorset Heathlands are one of the most important areas for wildlife in Britain. They are the largest and biologically the richest of any of the heathlands within the Tomorrow's Heathland Heritage Project. These heaths also have a rich archaeological heritage and significant cultural associations, particularly through the novels of Thomas Hardy.

Over 80% of Dorset heathland has been lost since the early 19th century, replaced by agricultural and urban development and forestry. The once continuous Egdon Heath is now in fragments, but nevertheless there are still places left within the remaining 7,000 ha of heathlands and associated habitats where Hardy's stunning, open, treeless, heathland landscape can be experienced.

These remaining heaths are valued for their ecology, landscape and archaeology and their importance is recognised through a host of national and international designations. Although Egdon Heath now covers only 15% of its former area, it still remains one of the most important areas for the conservation of heathland biodiversity in this country, mostly due to the outstanding range of habitat types and the large number of associated species. However because the traditional uses of the heathland that helped to sustain it have ceased, large areas have become degraded and are rapidly losing their heritage value through the invasion of trees and scrub.

Hardy's Egdon Heath – Return of the Native Dorset Heathland aims to reverse the decline in the quality and extent of Dorset's heathland, over a five-year period which began in October 2000, through a major restoration programme. This includes removing extensive areas of scrub and secondary (recently developed) woodland, and prioritising the re-creation of heathland from conifer plantation, thereby reducing heathland fragmentation. In addition, bracken control measures will be required for both extensive areas of open heathland and for cleared areas. The extension or introduction of grazing schemes is also needed to, in the first instance, restore heathland vegetation structure, and thereafter to further the sustainable management of the restored heathland in the future.

The whole programme of habitat management is backed up by a series of specific projects aimed at increasing public understanding and appreciation of the ecological and cultural heritage of Egdon Heath. New permitted access routes to previously closed areas of heath will be established. Access to heathland will be further increased by small-scale heathland re-creation on land that is currently used for commercial forestry plantations. The project includes specific provision for promotion and monitoring.

By reversing the alarming decline of Dorset heathland through the major restoration works proposed during the five years of the project and by ensuring future long-term, sustainable management practices, the outstanding wildlife richness of Hardy's Egdon Heath with its atmospheric open landscapes will be maintained for future generations to enjoy.

The project partnership comprises 13 organisations, led by English Nature, which together manage most of the heathland. Project partners include: Borough of Poole, Bournemouth Borough Council, Christchurch Borough Council, Dorset County Council, Dorset Wildlife Trust, East Dorset District Council, English Nature, Forest Enterprise, Herpetological Conservation Trust, Holton Lee, Ministry of Defence, National Trust and the RSPB.

Summary of targets

Habitat restoration through:

- clearance of over 1,000 ha of heathland by tree and scrub clearance
- bracken control over an area of 450 ha of heathland
- gorse control, by coppicing/clearance of 80 ha
- extension and introduction of heathland grazing schemes covering an area of 1,500 ha of heathland
- creation of suitable habitat for herpetofauna and invertebrates where appropriate
- heathland re-creation within forest plantations covering an area of 94 ha.

Promotion/education:

- a project launch ceremony was held in Summer 2001
- project promotional leaflets

- mobile display boards and site specific display/information boards
- newsletters to be distributed to the general public
- a structured programme of walks and talks
- slide pack, updated halfway through the project to be used at talks
- promotion of THH and the project during an annual Heathland Fair week
- Landrover 'safaris' and guided walks to be arranged on sites where access is restricted
- local groups to be encouraged to take an active part in scrub management through volunteer tasks.

The Canford Estate, Dorset

Peter Traves

The Canford Estate includes 500 ha of land in south-east Dorset that has SSSI or Site of Nature Conservation Interest (SNCI) designation. Of this, 300 ha is lowland heath, distributed across six separate sites located around the urban-fringe of the Poole/Bournemouth conurbation, while 200 ha forms part of the inter-tidal mud flat on the north-western edge of Poole Harbour.

General management of the Canford Estate is undertaken by FPD Savills and where appropriate, areas of SSSI heathland have been leased to the Herpetological Conservation Trust and the Dorset Wildlife Trust. The Trusts are currently implementing a significant amount of heathland restoration work within the Tomorrow's Heathland Heritage programme. A second major initiative, a LIFE project, commenced in 2001 with the aim of reducing the incidence of malicious fire damage to the heaths of south-east Dorset.

Issues affecting the management of urban-fringe heaths

Landscape

At present, heathland SSSIs are managed primarily to enhance their value as a habitat for designated species. Vegetation management is the principal method of achieving this, and large-scale clearance work required to alleviate years of scrub invasion has a fundamental effect on the character of the landscape. Addressing public concern about the impact of tree clearance is therefore a key issue. The historical background to the creation of the heath and how this was maintained by human activity should be explained to visitors. This will clarify the reasons for the current intervention and how this aims to re-create historical use.

Recreation

Areas of open heathland form a backdrop to urban areas, providing quiet areas for informal recreation. Freedom to use the open space is highly valued by local people. Many heaths are regarded as being 'owned' by the local community, even when, like the Canford Estate holdings, they are in private ownership. Informing the public of the need to impose restrictions on access in order to reduce excessive erosion and protect reptiles or ground-nesting birds is another important aspect of site management.

Education

Heathland is a valuable study resource for a wide range of topics including ecology, archaeology and cultural heritage. The Canford Estate is encouraging educational use of heaths in its ownership. Upton Heath has been used for project work with the co-operation of the DWT and Bournemouth University propose to commence a number of studies that will expand our ecological and archaeological knowledge.

The future management of the urban-fringe heaths

It is apparent that to achieve comprehensive management of urban-fringe heathlands, a number of key functions that they fulfil in addition to nature conservation must be carefully considered. Conveying the history of the heaths to the public and encouraging further use for educational purposes will assist in ensuring the heaths and the management of them is appreciated by the wider public, now and into the future.

Lowland heath to pine woodland to lowland heath, the Grip Heath Project

Bryan Pickess

The RSPB, c/o Syldata, Arne, Wareham, Dorset BH20 5BJ

On the aerial photographs of the early 1950s this area was shown as heathland, with invading Scots pine *Pinus sylvestris*. By the mid 1980s the site had become a dense pine woodland, with an understorey of bracken *Pteridium aquilinum* and where some light reached the woodland floor odd plants of ling *Calluna vulgaris* and bell heather *Erica cinerea*. The restored site covers about eight hectares and with the exception of a scattering of pines left for visual amenity, the area was clear felled during the winter of 1990/1991. Photographs illustrated the results of the actions and results of the project.

Photographs shown with the poster:

Photo 1	1990	November: 35-45 year old self-sown pine before felling
Photo 2	1991	March: chipping top and lop after removal of pine logs
Photo 3	1991	Vacuuming humus litter after removal of lop and top
Photo 4	1992	Cleared site covered in dense bracken
Photo 5	1992	July: ling and bell heather seedlings appearing under the bracken
Photo 6	1992	July: spraying bracken with a tractor-mounted boom sprayer
Photo 7	1993	August: dead bracken fronds and emerging heath vegetation
Photo 8	1995	August: establishing heath vegetation
Photo 9	1996	August: 5 years after the site was vacuumed
Photo 10	1998	August: the heath in full flower
Photo 11	1998	September: decaying pine stump and heath vegetation
Photo 12	2000	August: the heath 10 years after felling

Countryside Stewardship – helping heathland

Mike Pearce & James Phillips

What is Countryside Stewardship?

Countryside Stewardship (CSS) is a DEFRA agri-environment scheme that makes payments to land managers to improve the natural beauty of the countryside by:

- conserving landscape, wildlife and archaeology
- helping people to enjoy the countryside
- offering capital and land management payments
- helping government meet biodiversity targets.

- It is available to all eligible land managers.
- It is part of the England rural development programme.
- 14,000 farmers and land managers already have agreements.
- £500 million is available over the next 6 years.

What can Countryside Stewardship do for heathland?

- Conservation of existing heathland
  £20 per hectare to prevent deterioration through tree or scrub invasion and to create firebreaks.

- Enhancing existing heathland
  £50 per hectare to improve heathland by providing grazing or mowing (including fencing and water).

- Re-creating heathland
  £275 per hectare to revert improved land back to heathland, through natural regeneration or spreading heathland seed, and for the correct aftercare.

What has Countryside Stewardship achieved for heathland conservation so far?

The following data use figures up to September 2001.

- 108,127 ha of heathland conserved in England since 1991 at a cost of £2,381,439.

- 39,935 ha of heathland conserved in the SW region since 1991 at a cost of £708,303.
- 9,165 ha of heathland conserved in Dorset since 1991 at a cost of £184,778.
- 10,931 ha of heathland re-created in England since 1991 at a cost of £2,929,459.
- 3,072 ha of heathland re-created in SW region since 1991 at a cost of £836,422.
- 1,518 ha of heathland re-created in Dorset since 1991 at a cost of £414,660.

The archaeological importance of heathland

E M Wilkes & Iain Hewitt

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The poster presents the four key reasons for the archaeological importance of heathlands: preservation of earth, stone, and turf monuments; preservation of environmental indicators; retention of landscape integrity; and rights of access enhancing amenity and educational value of heathland sites. Contrasted against these are the main threats to heathlands that also threaten the archaeological resource: conversion of heathland to other uses; animal and natural erosion; visitor erosion; and mining and quarrying activities. Detail is also given of human exploitation of the heathland resource from early Neolithic to post-medieval times, including land improvement schemes, drawing on excavation and other evidence from our case study site at Holton Lee on the edge of Poole Harbour, Dorset.

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