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Mapping extent of burn management in the North Pennines: Review of extent year 2001-2003

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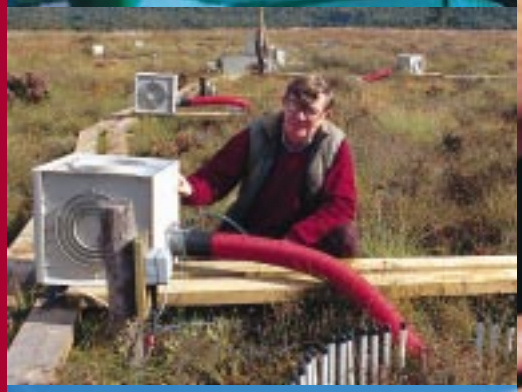

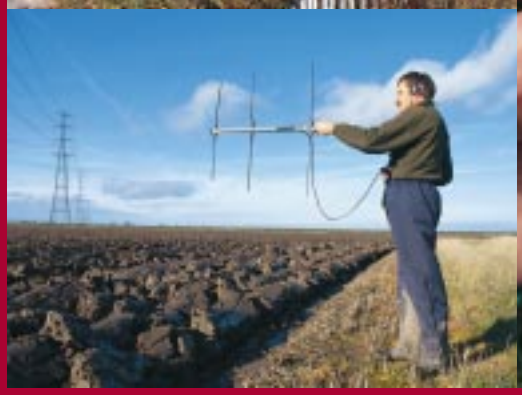

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Mapping extent of burn management in the North Pennines:
Review of extent year 2001-2003

Dr Adrian R Yallop
Dr J Thacker
Mr B Clutterbuck

Cranfield UNIVERSITY
Silsoe

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Project officer	Alistair Crowle, Terrestrial Wildlife Team Alistair.crowle@english-nature.org.uk
Contractor	Dr Adrian R Yallop Cranfield University Silsoe MK45 4DT a.r.yallop@cranfield.ac.uk www.silsoe.cranfield.ac.uk

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Executive summary

English Nature commissioned an analysis of the extent of management by burning within areas of Upland Heath and Bog in the North Pennines AONB (Area of Outstanding Natural Beauty).

Existing UK Perspectives imagery for this area was supplied by English Nature.

The primary deliverables of this project were digital data and these are included together with printed outputs from a summary analysis

The quality of the imagery supplied has limited the precision of image interpretation.

The proportions of the AONB currently burned are striking and raise concerns about possible adverse affects on the biodiversity status of large areas of the North Pennines.

Contents

1 Introduction

1.1 Background to the project

Management by fire in ericaceous-dominated communities is now virtually ubiquitous in the English Uplands (Yallop and others 2006). The primary drivers for the use of fire in this way are to improve sheep *Ovis aries* grazing and habitat for red grouse *Lagopus lagopus*, reared for game shooting. Management for sheep is rarer and usually executed as large but infrequent burns whereas management for grouse tends to be more frequent and executed as smaller patches to create a mosaic of differing aged stand of heather.

While burning has a history of 100's to perhaps 1000's of years and is frequently cited as a traditional method of managing heather, in many areas there has been a significant increase in the extent and frequency of its use over the past 30 years (Yallop and others 2005). As burning has a number of adverse biodiversity consequences (Tucker 2003) and inappropriate (usually excessive) burning management is now cited as the second largest reason for condition failure in the upland SSSIs in England (English Nature 2006) such an increase raises significant ecological concerns.

1.2 Brief synopsis of the ecological impacts of burning

1.2.1 Heather moor

The effect of burning on the communities of plants and animals present on moorland is complex. In general terms, burning prevents or reverses successional processes that would eventually result in reforestation of moorland, but the specific outcome of a burning regimen depends on many factors, notably the frequency of burning and the age of heather when it is burnt.

Heather passes through a series of growth phases over the course of thirty years or so (Gimingham, 1959). Vegetative regeneration of heather following burning declines in vigour in the mature phase of its growth and is absent in the degenerative phase, when regeneration is solely from seed (Hobbs & Gimingham, 1984). If vegetative regeneration of heather is vigorous, then the heather will quickly come to dominate burnt areas, while if it is weak or absent, these areas may become dominated by mat-grass *Nardus stricta*, wavy hair-grass *Deschampsia flexuosa*, moor grass *Molinia caerulea* or bracken *Pteridium aquilinum*, depending on conditions (Miles, 1988; Ross, Adamson & Moon, 2003). Too-frequent burning favours rapidly colonising, fire-resistant species like moor grass and bracken, and may result in conversion of dwarf-shrub heath to acid grassland or monocultures of bracken. In contrast, too-infrequent burning can also lead to the decline in dominance of the dwarf-shrub community where over-mature or degenerate stands of heather are burnt and regeneration is by seed (Hester & Sydes, 1992).

The effects of burning are inextricably linked with those of grazing. Burning promotes young growth for grazing, but excessive grazing can eliminate regeneration completely, leading to the loss of dwarf-shrub heath and the spread of *Molinia* grassland on wetter sites or *Nardus/Deschampsia* on drier ones. This is because heather regrowth on newly-opened habitat after a burn is preferentially chosen as food by grazing livestock. Heather that is regrowing from seed after over-mature stands have been burnt is unlikely to survive this

selective grazing. Short-cycle burning can have a similar effect due to the elimination of mature plants.

1.2.2 Bogs

On heather moorland *Calluna* will, if unburned, proceed through the phases of pioneer, building, maturity and degeneration, which might ultimately lead to the succession of birch wood. In bogs, on the other hand, *Calluna* does not pass into the degenerate phase because of the continuous layering of the stems as they are buried under bog-moss (Macdonald and others 1995). The immediate effect of burning bog vegetation is to destroy the above-ground woody tissues of the shrubs (*Calluna*, *Erica tetralix*, and others), the bog-moss surface, and any species sensitive to fire. One of the first species to recover is *Eriophorum vaginatum*, whose tussock-bases are protected from the fire, the new growth of which is useful forage. In contrast to the situation on heather moorland, it may take many years for Calluna to become the dominant species in the plant community after burning. Over time this may lead to a loss of diversity, with an increase of *Eriophorum, Molinia* and *Juncus squarrosus* at the expense of other plants (Hobbs, 1984; Shaw and others 1996). It is generally accepted that burning of bogs is undesirable (Stewart and others 2004)

The extremely low nutrient status of bogs raises concerns about the long-term outcome of burning regimes. Whilst moorland burning results in a flush of nutritious young growth, burning of bog vegetation has a less beneficial outcome because the growth of *Calluna* would not have been impeded by degeneration of individual plants, so burning may not generate any more young growth of heather than would be produced in its absence, so this kind of management is of no benefit for grouse (Hobbs, 1984). Edible species like *Eriophorum* may temporarily replace *Calluna* after burning, providing forage for sheep. It is generally accepted that burning has a negative impact on species of *Sphagnum* moss, although direct evidence is lacking, frequently because degradation of bogs is caused by grazing and draining at the same time as burning. Pearsall (1950) noted that bogs in good condition may have more than 12 species of vascular plant in a square metre, while degraded, *Eriophorum*- dominated bogs may have only 3-4 species in a square metre.

1.2.3 Animal communities

Moorland, whilst low in plant diversity, supports a large community of invertebrates. Usher & Thompson (1993) quantify this for the North York Moors, which have 2.2% of British vascular plant species, but 15% of carabid beetle species and 20% of spider species. The diversity of these polyphagous predators depends on the mosaic structure of upland heathland, and simplification due to large-scale burning and heavy grazing will inevitably lead to a loss of species. Medium-rotation, small-scale burning therefore favours generalist invertebrate predators because it maintains the complex mosaic of different-aged stands of heather.

Too-frequent burning and heavy grazing, in converting dwarf-shrub heath and bog into acid grassland, also impacts on phytophagous insects. Many more species of phytophagous insect are associated with the woody plants of moorland and bog than with the grasses, sedges, and rushes of moorland and acid grassland. Around 34 species of phytophagous insect are associated with *Calluna vulgaris*, 10-29 with *Vaccinium myrtillus* and *V. vitis-idaea* and 13-18 with *Erica tetralix* and *E. cinerea* species. In contrast, plants like *Eriophorum spp*., *Nardus*, *Molinia* and *Juncus squarrosus* are extremely species-poor, with around 3-6 species

of phytophagous insect found on each. The shift from shrubs to grass-like plants caused by a combination of heavy grazing and burning therefore leads to an inevitable loss of invertebrate diversity. Some moorland insects are associated only with mature or degenerate heather plants, and for this reason Usher & Thompson recommend that some areas of dwarf-shrub heath are left permanently unburnt.

Although the principal purpose of burning on grouse moors is to increase the population density of red grouse by increasing the availability of high-quality forage, other species of birds are known to nest at higher density on patch burnt rather than moorland not managed in this way. These include curlew, golden plover and lapwing (Tharme and others 2001). Relaxation of burning regimes may have a beneficial effect on densities of meadow pipit, and in turn, hen harriers (Smith and others 2001).

1.3 Project rationale

Despite the large-scale application of burn management within the upland areas of England, and the potential for considerable biodiversity impacts from its use, information on the location, spatial extent and approximate age of moorland burn is lacking in many areas and the activity is poorly monitored.

As part of a possible larger project, English Nature decided to map burning activity within the upland areas of the North Pennine AONB. The exact area to be mapped is defined as portions of the English Nature Digital datasets ' Blanket Bog v1.2' and 'Upland Heath v 1.2' that lie within the north Pennines AONB. As frequent monitoring of large areas is expensive a sample based approach to estimating the extent of burns was adopted. These data were summarised at a series of scales appropriate to field, regional and national office requirements.

nb. This project uses an existing national aerial imagery dataset gathered by UK Perspective. Such national projects are flown at different periods throughout a 'campaign' period and from these a national dataset of images is generated. This requires the merging of images to create a complete mosaic. Any scene image may thus be a mosaic of aerial photographs gathered at different times. The area covered in this project was photographed in 2001 and 2003 and it is impossible to establish exactly when each portion of the North Pennies AONB was flown within this period. Hence the reported figures for burn extent are presented as representing the status of burning during an inclusive period covering the years 2001 to 2003, rather than an individual year.

2 Methods

2.1 Process

1 All features within the datasets 'Blanket Bog v1.2' and 'Upland Heath v1.2' that lie wholly or partially within the North Pennines AONB defined by English Nature 'Natural Areas' digital dataset as supplied to Cranfield University were selected for study.

2 The subsets of both these habitat classes where then merged to form an integrated sampling area for the AONB. To create datasets of a size readily useable during the classification process this was divided into three approximately equal areas covering the NE, NW and S of the AONB respectively.

3 A systematic sampling grid with a spatial separation of 35m between points was created within a GIS and overlain the imagery for each of these areas.

4 A visual interpretation of the habitat and evidence burn each point was made and a value assigned according to the following classes:

0: No visual presence of ericaceous shrub

> Habitat unlikely to be managed by burning ie *Eriophorum/Poa*-dominated bog/moor. This class included all areas with evidence of agricultural activity and other habitat/land cover types spuriously included in the English Nature digital data.

1: New burn – within approx. 0–4.6 years

2: Recent burn – within approx. 3-7 years

3: Visually closed canopy – estimated age 6-15 years

4: Mature, degenerate areas of ericaceous shrub, hereinafter referred to as dwarf-shrub heath (DSH)– greater than 15-25 years or unmanaged

These are the same classes as those used and defined in Yallop and others 2006.

nb. The imagery supplied for most of the North Pennines AONB was of poor quality. This impaired the ability to successfully assign land cover into these classes. Following discussion with English Nature it was decided to add 2 new classes. The first of these was defined as 'new burn' and in essence combines Class 1 and 2 above. The second was 'no visible burn' and is comprised of Class 0, 3, and 4 above. These new classes allows discrimination of recently burned areas (0-7 years old) from areas not burned within the last 7 years and were felt to produce a more reliable, albeit less precise, estimate (see accuracy statement below).

5 Following classification the point files for the three working areas were merged into a single file covering the area of the North Pennines AONB (see deliverables). Points in this file were then selected according to their presence within the original Upland Heath or Bog habitat classes and extracted to form two files of Upland Heath classified points and Bog classified points respectively.

Note that the original 'Blanket Bog v1.2' and 'Upland Heath v1.2' files supplied to Cranfield contained considerable areas of commonality, ie polygons that appeared in

both datasets and therefore the sum of extracted points for two habitat files separately will sum to a greater value than the number of points in the combined Upland Heath and Bog classified point file.

6 An initial analysis of the datasets has been executed and summary files produced show the intensity of new burn as averaged at 100m and 1km OS squares (see deliverables).

2.2 Accuracy statement

As the imagery supplied for this review was produced between 2001 and 2003, and the interpretation exercise was undertaken during early 2006, ground-truthing of burn interpretation was not possible. To assess the consistency of the interpretation following the classification of all sample points, 1000 points were selected at random from within the original set and these were then reinterpreted. Table 2.1 shows the summary results from this exercise. This shows clearly the consequences of the poor imagery available for this area. The original attempt to classify to four burn classes has produced poor overall compliance. However, the use of 2 classes, effectively new burn and 'not new burn' has produced much higher repeatability. These are shown in Table 2.2. Please note as these are not ground truth results these cannot be described in terms of accuracy. They are rather a measure of compliance by the observer.

Table 2.1 Results of observer compliance: Five original classes

		no of points in second interpretation						
	Class	**0**	**1**	**2**	**3**	**4**	**Total**	**Accuracy %**
no of points in first interpretation	**0**	564	1	11	20	8	604	93.3
	1	1	55	7	0	0	63	87.3
	2	8	20	89	4	0	121	73.6
	3	23	1	14	166	8	212	78.3
	4	0	0	0	0	0		
	Total points	596	77	121	190	16	1000	
	Accuracy %	94.6	71.4	73.6	87.4			

Overall accuracy
87.4

Table 2.2 Results of observer compliance: Revised classes

		no of points in second interpretation			
	Class	**1&2**	**no burn**	**Total**	**Accuracy %**
no of points in first interpretation	**1&2**	789	27	816	96.7
	no burn	13	171	184	92.9
	Total points	802	198	1000	
	Accuracy %	98.4	86.4		

Overall accuracy
96.0

3 Results

Although it is not the primary intention of this project to present a formal or comprehensive analysis or review of the impact of burn management in the North Pennines AONB a number of analyses have been undertaken to inform English Nature about the current extent of this practice within this area.

3.1 Burning within the North Pennines AONB

The use of fire management in both bog and upland heath habitats within the North Pennines AONB is extensive. The observed estimates for new burn classes, summarised for the entire area of the AONB, are shown in Table 3.1 *below*.

Table 3.1 Summary estimates of percentage of area in each class by habitat in North Pennines AONB

	Upland Heath & Bog	Bog	Upland Heath
Area of habitat km^2	1026	689	353
Class 1 burn %	7.2	6.6	9.4
Class 2 burn %	13.5	12.6	18.2
Cl 1 & 2 burn *combined* %	20.7	19.2	27.5

It is important to consider that these represent overall figures for burn extent for each habitat within the AONB.

Note the method used here to determine the 'envelope' against which proportions burnt are estimated differs from that presented in Yallop and others 2005 (ENRR 667) and Yallop and others 2006. In these earlier studies a large area comprising upland Broad habitat classes (defined by Centre for Ecology and hydrology) were examined and the proportions of burn classes were expressed against an overall extent estimate of 'ericaceous dominated' habitat (as determined within the aerial photographic interpretation) in which management by burning might be expected. In this work on the North Pennines AONB each burn class is expressed as a proportion of the total area within English Nature defined Bog and Upland Heath. Therefore these are different treatments and the results are not directly comparable.

3.2 Estimation of repeat times within the North Pennines AONB

Although estimates for a single year are only available it is still possible to derive simple estimates for repeat times (the time for an entire area to be burnt). Estimates of repeat times for upland heath and bog habitats for sample square kilometres with at least 100 sample points (1069 square kilometres examined for bog, and 668 square kilometres examined for upland heath) indicate a wide variation in the intensity within which moors are burnt, from extremely intensively managed areas with repeat times of less than ten years to large areas that are apparently unmanaged (some 39% of sample squares of bog and 17% of sample squares of heath have no visible management). Figure 3.1 shows the distribution of repeat times of all sample squares of bog and heath in which some evidence of burning was noted.

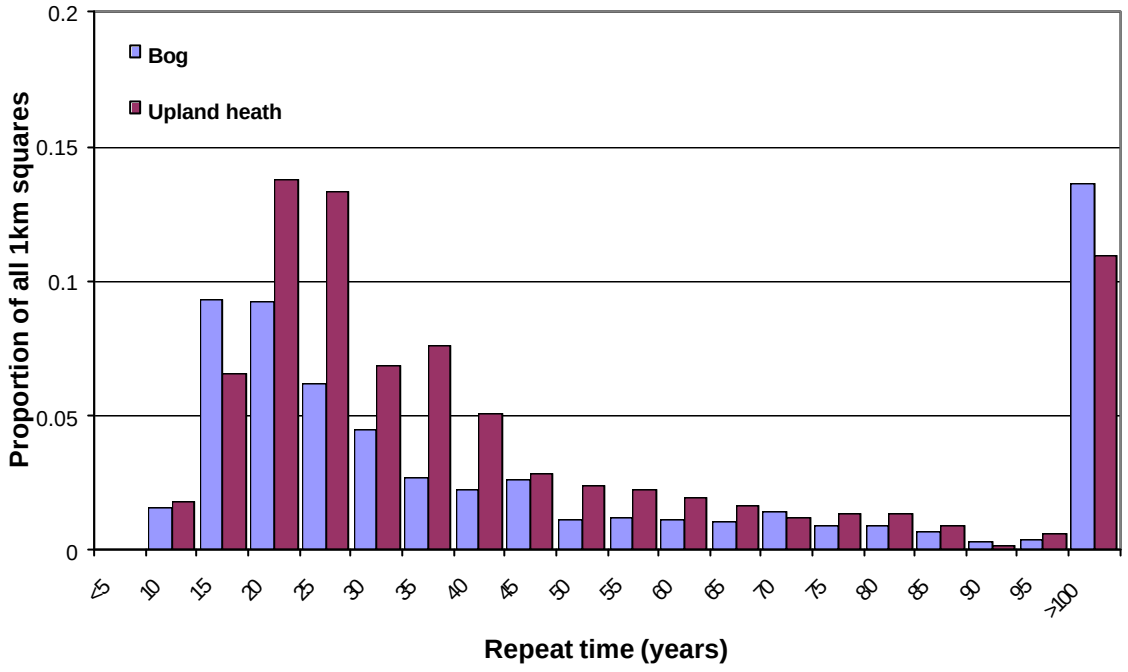

Figure 3.1 Estimated repeat times in bog and upland heath managed by burning in North Pennines AONB. Note that figures shown are for 1km squares with visible evidence of burning. 38% and 17% of 1km squares containing bog and upland heath respectively showed no evidence of such management.

Figure 3.1 clearly shows that whilst about half of the area of bog (50% of km squares) is effectively unmanaged (ie a return period of >100yrs or contain no visible evidence of burning), more than 20% is managed by burning with repeat times of under 20 years. Furthermore, management of bog by fire is frequently more intense than that of upland heath, although the proportion of bog unmanaged is greater than that of upland heath.

3.3 Estimates of burning within North Pennine SSSIs

SSSIs cover a significant area of the AONB, and provide the greatest opportunity for regulation of burning activity. It may be therefore be of interest to consider the application of burn management in these areas. The figures for extent of burning within SSSIs are presented in Table 3.2 *below.*

Table 3.2 Summary estimates of percentage of area in each class by habitat in North Pennines AONB within SSSI designated areas

	Bog	Upland Heath
Proportion of habitat within SSSI	67.6	81.2
Class 1 burn	7.6	10.3
Class 2 burn	14.7	19.4
Cl 1 & 2 burn *combined*	22.3	29.7

Table 3.2 clearly indicates that, burning is a highly significant feature of land in SSSIs, including SSSI bog habitat. The proportion of burn management and repeat times, is summarised by upland SSSIs within the AONB are shown in Table 3.3. Note that it is frequently on bog habitat that it is most intense (5 of 9 SSSIs where significant burning of both habitats occur show more intense burning on bog than upland heath). The bog habitats of four of these sites have repeat times below 20 years.

Table 3.3 Percentage (by bog and upland heath habitat types) of area of SSSIs showing burn management.

	Bog		Upland Heath	
SSSI	**New burn** (%)	**Repeat time** (yrs)	**New burn** (%)	**Repeat time** (yrs)
Bollihope, Pikestone	19.8	39.0	33.6	22.9
Burnhope Burn	0.0	nvm	0.0	nvm
Pow Hill Bog	0.0	nvm	0.0	nvm
Mallerstang-Swaledale	0.0	nvm	0.0	nvm
Arkengarthdale, Gunn	0.9	>100	0.0	nvm
Appleby Fells	4.6	>100	1.3	>100
Geltsdale & Glendue	51.6	14.9	49.0	15.7
Moor House & Cross F	11.3	68.1	1.0	>100
Upper Teesdale	14.2	54.2	22.0	35.0
Allendale Moors	4.8	>100	6.1	>100
Hexhamshire Moors	21.2	36.4	26.2	29.4
Cotherstone Moor	21.7	35.6	10.5	73.3
Teesdale Allotments	0.0	nvm	27.1	28.5
Whitfield Moor, Plen	39.1	19.7	30.1	25.6
Muggleswick, Stanhope	26.6	29.0	29.9	25.8
Lune Forest	39.2	19.6	32.7	23.6
Bowes Moor	42.3	18.2	27.1	28.4
Foster's Hush	15.4	50.1	n/a	n/a
The Bog	0.0	nvm	n/a	n/a
Heatheryburn Bank	N/A	n/a	0.0	nvm
Close House Mine	N/A	n/a	0.0	nvm
Fairy Holes Cave	0.0	nvm	0.0	nvm

Repeat time estimated on basis of new burn visible for 7.71 years. nvm: no visible burn management; N/A: none of that habitat type present in SSSI; >100: repeat time calculated to be more than 100 years.

4 Discussion

The protocols for defining the overall statistics differ between this study and ENRR 667 and Yallop and others (2006) with which it is temping to draw comparison. Without calibrating the two methods it would be unwise to make detailed comparison. However, it should be noted that, as the earlier work reports estimates expressed as a proportion of visibly ericaceous-dominated habits, and the figures presented here are estimates as proportions of bog and upland heath habitat (including sedge/grass dominated areas) they will effectively under-report proportions burned relative to the figures for the North Pennines AONB. This probably means that although the overall figures for Class 1 and 2 burns are remarkably close to that cited in both earlier reports, the actual intensity of burning in the North Pennines determined in the present study is considerably higher than those national estimates. In fact, of the area studied in ENRR 667, only 25% fell into the 'likely to be burned' group of habitats against which the proportion burned was reported. The Bog and UH priority habitat envelope for the AONB studied here will also include large areas of essentially sedge and grass dominated moorland that are unlikely to be at present managed by burning. The figure of 20.7% in Class 1 and 2 combined includes these areas, hence it is entirely possible that the figure for areas actually or likely to be managed in this way is far higher.

Upland Heath. Differences in protocol aside, the actual levels of burn management observed in Upland Heath within the North Pennines AONB is startling. Overall 30% of the upland heath falls within Class 1 and 2, defined in Yallop and others (2006) as most likely to have been burned within the last 6-8 years. This equates to between 3.76% and 5% of this habitat being burned annually, or a repeat time of 20 to 26.7 years respectively. As the base figures used here for this habitat undoubtedly include large areas of grass/sedge dominated moor, in which no burning is expected, it is extremely likely these figures underestimate the actual intensity of burning occurring in habitat types where there is sufficient shrub presence to make it worthwhile. While a repeat time of this order, or less, may be appropriate in intensively managed grouse moor, it should be understood the figures here give a repeat time for the entirety of Upland Heath in the North Pennines AONB. As such it indicates that few areas of unmanaged ericaceous moorland, as proposed by Usher & Thompson (1993), are presently being left.

The proportion of Upland Heath being burned within SSSIs is slightly higher still. To what extent these observed levels arise as a consequence of English Nature guidance, or despite it, is however unclear. However, presumably this activity has been consented.

Bog. The figures for burning within the areas defined as Bog are particularly noteworthy. Burning management of any kind may be detrimental to these habitats (Shaw and others 1996; Stewart and others 2004) and there is a presumption against burning in these habitats as outlined in the 'Heather and Grass Burning Code' issued by DEFRA. Application for consent for such activity within SSSIs should also be made in writing and consented by English Nature. The extent of new burn classes within this habitat may therefore be considered remarkable, as they are similar to those for UH in which routine burning might be expected.

It is unlikely this level of activity is in any way ecologically sustainable and must give rise to concern on biodiversity grounds as well as the Rio Convention on Biodiversity (CBD) or European Habitat and Species Directive (HSD) obligations. Paradoxically perhaps, given the concerns about burning of bog, the intensity of burning observed in SSSIs, and presumably

consented, is again considerably higher than the overall observed levels. Assuming the same range of 6-8 years duration for the observed Class 1 and 2 this represents between 4% and 3% of this habitat being burned per annum (equivalent to return periods of 25 and 33 yrs respectively). At least 30% of the bog in upland SSSIs in the AONB is under intensive burning regimes with repeat times of less than 20 years (the bog of four SSSIs, amounting to 33.6% of the area of bog in SSSIs, have repeat times this short).

This interpretation assumes that burn signatures are visible in bogs for the same length of time as they are on heath. There is however, clearly a wide spectrum of plant communities defined as both upland heath and bog, from ericaceous shrub-dominated to grass/sedge–dominated types and a more accurate assessment of repeat times, would require more detailed knowledge of both the distribution of community types and the duration of visibility of burn signatures. However, it is considered unlikely the results gained by such considerations would be greatly different.

Summary. Both the extent and repeat times of burn management within the North Pennines AONB would appear to be at variance with biodiversity interests. They are certainly greater than the national averages observed by Yallop and others (2006). While the repeat times for upland heath are within guidelines, the extent values are an overall average for the entirety of this habitat within the AONB. Such a high average value therefore indicates that very little of this habitat is not under intense burn management. However, while the extent of burning in upland heath habitat is alarming, it is the figures for bog habitat that give reason for particular concern. This is a habitat in which there is a presumption against the use of fire as a management tool yet in many places it is being burned more frequently than upland heath. It is not the purpose of this review to pass particular comment about the appropriateness or otherwise of management observed. However, we consider it likely that such intense use of fire is potentially severely detrimental to biodiversity interests.

We also feel a need to raise concerns about the potential confusion arising from the fact that many authorities are working from restricted visions of upland management. The creation of dense, essentially mono-stands, of *Calluna* by frequent burn management may be appropriate and bring biodiversity benefits on upland shallow peat or mineral soils. However, it is destructive to areas of deep peat which should be predominantly saturated and covered in diverse and sparse bog vegetation including abundant bryophyta. Yet the application of burn management paradigms, appropriate to only some restricted areas appears, appears in many places to be being applied almost universally. Much of the area of bog in question can be seen in the photography to be heavily modified, both by burning and extensive gripping. Ongoing burn management is unlikely to improve the condition of such habitats.

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