ASSESSING THE EFFECT OF MINE SUBSIDENCE ON DWARF SHRUB ERICOID HEATH COMMUNITIES WITHIN A SITE OF NATIONAL IMPORTANCE [1]

by

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Abstract. Planning consent was applied for in 1997 to extract coal from the Stanley Main seam beneath Skipwith Common, North Yorkshire in the United Kingdom. The 293ha Common is of national importance for its dwarf shrub ericoid heath communities, and has statutory protection under UK law as a Site of Special Scientific Interest (SSSI). Current planning guidance requires the effects of the mining proposals to be rigorously examined. The distribution of the heath vegetation is largely determined by the surface topography and sub-surface clay features, these determine relative site wetness. The ground surface and clay sub-surface layer were modelled to predict the potential effect of subsidence on drainage, and hence soil wetness and heath vegetation. Up to date topographical, soil and vegetation surveys were undertaken. This data was used in conjunction with the mining company's subsidence predictions to model the effects of the mining of the previous and deeper Barnsley seam, as well as the proposed extraction of the Stanley Main seam. Overall, the model predicted there would be no adverse effect of subsidence from the mining of the Barnsley seam or cumulative effects following the extraction of the Stanley Main seam on the site features which determine relative wetness and heath distribution. The prediction for the Barnsley seam was tested using past and current vegetation and soil wetness records. On a broad scale, there was no field evidence that the previous mining has resulted in a reduction in the extent of ericiod heath communities within the SSSI. On a local scale, there was some evidence for a very small effect at the one location where a potential effect was predicted. As the principal physical changes to the SSSI are induced by the previous mining of the Barnsley seam, no further effects were predicted for extracting the Stanley Main seam. The modelling approach has proved to be valuable, both technically and as a means of explaining the potential effects of mining on a nationally important nature conservation site to various interested parties, including the regulatory bodies.

Additional Key Words: soil wetness, topography, catchments, *Calluna vulgaris*, *Erica tetralix*.

Introduction

Skipwith Common, near Selby, North Yorkshire, United Kingdom is a site of national importance for its extensive dwarf shrub ericoid heath communities, and associated ornithological and entomological interest (Ratcliffe, 1977). The 293 ha site was originally notified as a Site of Special Scientific Interest (SSSI) in 1958 under Section 23 of the National Parks and Access to the Countryside 1949 Act, and later re-notified in 1986 under section 28 of the Wildlife and Countryside 1981 Act (as amended). The SSSI is also a Grade 1 Nature Conservation Review Site (Ratcliffe, 1977).

RJB Mining (UK) Ltd made a planning application in 1997 to extract coal from the Stanley Main seam which occurs within a relatively confined area to the east of Selby. The company is currently mining the underlying and wider occurring Barnsley seam under a current planning consent granted in 1972. The new proposal would use the existing infrastructure of Riccall Mine, which is part of the Selby Complex (the UK's largest producing deep mine).

Whilst the SSSI lies within the general working area of the Barnsley seam, only the northern half of the SSSI lies within the proposed area of

[1]Paper presented at the 15th National Meeting of the American Society for Surface Mining and Reclamation, St. Louis, Missouri, May 16-21, 1998.

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Proceedings America Society of Mining and Reclamation, 1998 pp 409-417

DOI: 10.21000/JASMR98010409
https://doi.org/10.21000/JASMR98010409

extraction for the Stanley Main seam (Figure 1). The rest lies outside, but still within the zone of potential subsidence.

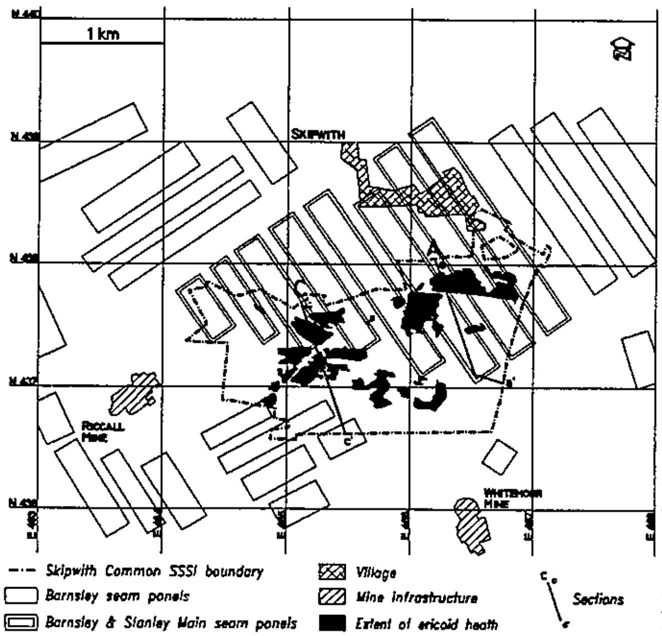


Figure 1. Location of Barnsley and Stanley Main seam extraction panels.

Under the Town and Country Planning (Assessment of Environmental Effects) Regulations (UK Government, 1988) mining companies are required to submit an environmental assessment of the proposals with their application to the planning authority (in this case the North Yorkshire County Council) for consent. Current planning guidance on nature conservation requires development proposals which potentially affect the statutory protected SSSIs to be "....subject to the most rigorous examination...." (Department of the Environment, 1994). Humphries Rowell Associates (HRA) were commissioned by RJB to prepare an in-depth assessment of the effects of their proposals, and this was incorporated into and appended to their Environmental Statement and planning application (RJB Mining, 1997).

This paper describes the approach, methods and results of the impact assessment of extracting both the Barnsley and the Stanley Main seams on the key dwarf shrub ericoid heath communities within the SSSI.

Site History

The ericoid heath on Skipwith Common is the remnant of a previously much larger area extending over the locality, the rest having been reclaimed for arable agriculture over past and more recent times (MAP Archaelogy Consultancy, 1994). Up to the 1914-18 War it was grazed under common rights by sheep and cattle. With the advent of the 1939-45 War grazing all but ceased with the establishment of the Riccall Military Airfield (Thompson, Smith and Jefferson, 1987; Fitzgerald, 1995). This relaxation of grazing, coupled with the decimation of the resident rabbit population by myxomatosis, resulted in rapid succession to birch (*Betula* sp.) and willow (*Salix* sp.) scrub and woodland over much of the site. Some of the site was planted with Scots Pine (*Pinus sylvestris*) in the mid 1800s, and although much of this has been felled, the species has also been a successful coloniser of the heathland (Fitzgerald, 1995). Since the late 1970s management has been undertaken by the statutory agency (Nature Conservancy Council (now English Nature)), the local voluntary trust (Yorkshire Wildlife Trust) and the land owner (Escrick Estate). This has included scrub and tree removal, and the reintroduction of sheep grazing. As a result, the encroachment of scrub and woodland has been arrested, and remnant heathland areas have been restored (Fitzgerald, 1995).

The extraction of the Barnsley seam under and around the SSSI was begun by RJB's predecessor (the British Coal Corporation) in 1992 and was largely completed in 1997. A programme of hydrological and vegetation monitoring was established by the Nature Conservancy Council (NCC) in 1979. This continued up to about 1990, but was abandoned before mining started.

Nature Conservation Issue

The principal concern of the statutory nature conservation agency, English Nature, was there should be no net loss of the ericoid heath communities and habitat; this being the prime reason for the site's designation as an SSSI. The other vegetation and habitats were of secondary concern. This paper therefore only considers the potential impact on the ericoid heath vegetation and habitat.

Types of Heath Communities

Two types of ericoid heath have been described on the Common, a dry and a wet type. The dry type was classified by Weston and Littler (1994) as an extremely species poor lowland variant of the *Calluna vulgaris - Deschampsia flexuosa* (H9c) sub-community (sensu Rodwell,1991). The wet type was classified as a typical *Erica tetralix - Sphagnum compactum* (M16) community (sensu Rodwell, 1991), and is also a species poor lowland variant of its type (Weston and Littler, 1994).

Distribution of Heath Communities and Site Factors

There are extensive areas of the wet heath vegetation characterised by the ericoid cross-leaved heath (*Erica tetralix*) in the central, north east and southern parts of the SSSI. The wet heath typically inter-grades with cotton-grass (*Eriophorum angustifolium*) dominated mire vegetation or soft rush (*Juncus effusus*) or purple moor-grass (*Molinia caerulea*) types of marshy grassland. Within the areas of wet heath there are, particularly in the south, patches of dry heath dominated by the ericoid, heather (*Calluna vulgaris*). Both site conditions and management are acknowledged as factors determining their distribution (Goode, 1964; Newson, 1985; Fitzgerald, 1995). Shade and relative soil wetness are the principal site physical factors.

Neither ericoid species are tolerant of deep shade, and do not persist under scrub or woodland for any significant period of time (Gimmingham, 1960; Bannister, 1966). Hence, the heathland communities are associated with the open areas, and scrub or woodland which remain relatively open or where canopy closure is recent.

The heather dominated dry heath is typically associated with unsaturated soil conditions, although short periods of inundation are tolerated (Gimmingham, 1960; Bannister, 1964 a & b). The cross-leaved wet heath is typically associated with winter and spring to early summer soil saturation, often with short periods of winter inundation and summer unsaturated conditions (Bannister, 1964a & b, 1966). Persistent saturation and summer inundation is associated with wetland vegetation such as cotton-grass mire and soft rush marshy grassland (Philips, 1954), or even reed swamp (Haslam, 1970 & 1972).

Soil wetness within the SSSI is partly due to the inherent physical properties of the soil profiles and the occurrence of a cohesive lacustrine clay layer within 1 to 3m below the ground surface. Although the soils are fine wind blown (aeolian) sands (Furness and King, 1978), they are typically organically enriched sands, these peaty/humic sands have a relatively high water retention capacity, and typically are poorly draining (being saturated for much of the year) without agricultural improvement (Furness and King, 1978). The underlying clay layer acts as an aquiclude causing a perched water table typically within 1 to 2m of the surface (Newson, 1985).

In general, the permanently saturated soil profiles are associated with topographic low spots, seasonally saturated profiles with mid-topographical positions, and unsaturated profiles with topographic high spots.

Hence, the dry heath is typically associated with the higher ground or steeper and convex slopes, whilst the wet heath is associated with the mid- and concave slopes.

Mining Proposals and Potential Effects

The Stanley Main proposal would only extract coal from within the 'foot-print' of certain panels of the previously mined deeper Barnsley seam within the area shown in Figure 1. Within the working areas for the Barnsley seam, the maximum subsidence was predicted to be about 0.9m in the northern half of the SSSI, and up to a maximum of 0.3m in the southern half. Following the extraction of the 2m thick Stanley Main seam, the pattern of subsidence is predicted to be the same and results in a further maximum 0.9m in the northern half of the SSSI, but with little additional subsidence in the southern half of the SSSI. Within the working area the maximum combined subsidence is predicted to be about 2m.

The potential effects of the subsidence will be manifest largely through the lowering and/or tilting of the land and the effect this has on surface and subsurface drainage, and relative soil wetness, and consequently on vegetation and habitats. However, subsidence does not have an effect on the intrinsic physical properties of the soils, and their potential for drainage remains unaffected.

The Approach

In view of the prime interest of the SSSI being the ericoid heath communities, a vegetation-habitats approach was adopted whereby the ground surface and subsurface clay were modelled to predict the potential effect on drainage, and hence relative soil wetness. This approach was accepted by the conservation agency, English Nature, who considered it also adequately dealt with the associated flora and fauna interest.

Methods

An up to date topographical ground surface survey was undertaken by RJB using standard 'total-station' equipment and techniques in March and April 1997 before full canopy leaf expansion had occurred. The survey was carried out on an almost regular grid of about 25m with additional points taken to record local features such as ditches, breaks in slope etc. The principal ditches within and around the site were also mapped and surveyed during the topographical exercise. HRA prepared computer generated contours maps from the data. The 3-D model was based upon a 5m grid to which the data was interpolated using a standard geo-statistical method. These were tested at two locations against surveys at a regular grid of 5m. Overall, the 25m grid proved to be reliable in capturing both general trends and the larger scale micro-topographical features.

A deep auger survey was carried out by HRA over the SSSI at thirty three locations between April and June 1997 to determine the thickness of the sand layer and the depth to the clay aquiclude, each point being fixed by survey. From this data a sub-surface contour map of the clay layer was prepared by HRA by interpolation to a 50m grid.

Together with RJB's subsidence prediction data, which had been checked by the British Waterways Board, an independent authority, the above survey data was used to model in three dimensions (x-y-z) the ground and clay surfaces for the post mining senarios for the Barnsley and the Stanley Main seams. In the absence of a comprehensive set of pre-mining contours, a pre-mining of the Barnsley seam scenario was also reconstructed; the results agreed well with the limited pre-mining data available.

The Results

Surface and Sub-Surface Topography

The SSSI lies across the water-shed of two catchments, the River Ouse and the River Derwent. Prior to mining, the surface was very gently sloping with ground levels between about 8.5 and 10m AOD. A characteristic of site was its subdued wind blown (aeolian) sand dune landscape, with a very varied and patterned surface topography comprising shallow and often inter-connected 'humps and hollows' at various scales. In contrast, the lake formed clay sub-surface was largely a uniform and almost level plain, with surface levels typically ranging between 7.25 and 7.5m.

Whilst the ground and clay surfaces will be lowered in absolute terms, particularly in the area of extraction, the relative position and extent of their surface features are predicted to remain unchanged by the subsidence caused firstly by the current Barnsley workings, and subsequently by the Stanley Main (Figure 2). The relationship between the surface and the clay layer also remains unchanged.

Gradients

The overall gradients of the ground surface and sub-surfaces prior to mining were typically very shallow and within the range of 1: 1000 to 1: 3000. Locally, steeper and slacker gradients occurred.

Both inside and outside the area of working no significant changes in gradients were generally predicted, this included the two main internal and most site boundary drainage ditches. At the limit of working, the subsidence contours are at their steepest and there is a potential for a change in both direction and degree of slopes in this 'boundary zone'. The SSSI lies across the southern limit of the proposed mining, and so some of the site is within this zone.

Owing to the largely flat, although locally varied, ground surface no significant local changes in gradients could be detected within the boundary zone. Potential surface changes in the zone were assessed to be insignificant for drainage because of the relative small change in gradients and the attenuating effect of the varied ground surface. Where the eastern boundary ditch crossed the limit of working there was the potential for a local reversal in direction of flow with the mining of the Stanley Main seam.

There was only one potential effect on the clay layer gradient predicted following the working of the Barnsley seam; a steepening of the gradient of a central area towards the east. Overall, no further significant effects were detected on extracting the Stanley Main seam, except for the potential reversal of slope at one location within boundary zone in the south east, and the potential steepening of the previously affected central area. In reality these effects on the clay surface gradient is likely to have a minor effect as the main transmissible layer within the profile is restricted to a

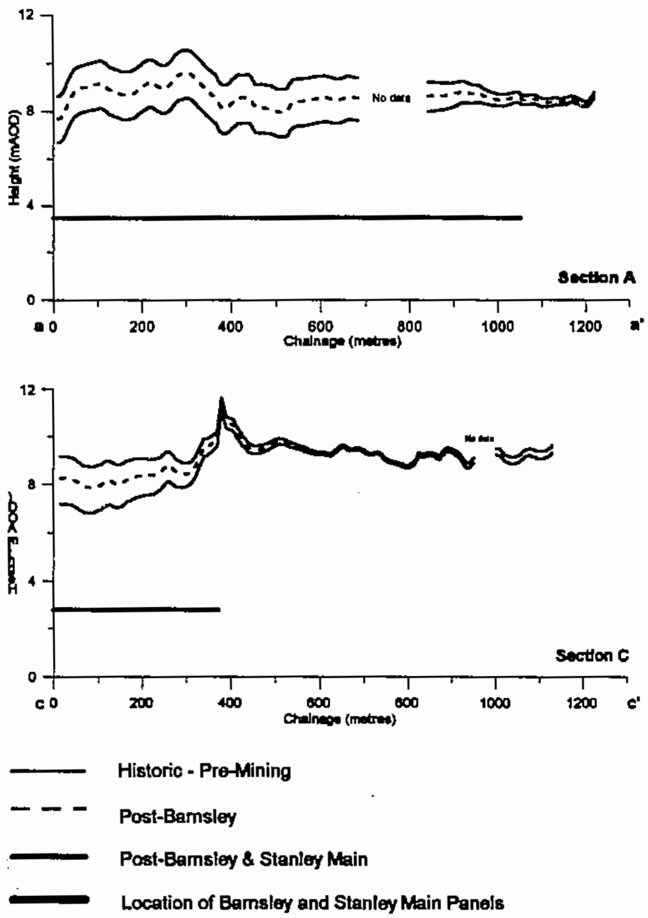


Figure 2. Effect of subsidence on surface topography.

(<20cm) coarse sand layer above the clay. Hence, the potential effect of a significant increase in gradient is likely to be manifest as a small increase in summer wetness.

<u>Sub-catchments</u>

Although the surface topography of the SSSI is extremely variable, surface drainage does occur, especially at times of flooding. Most of this is by over-land flow. In addition, there are two internal ditches which serve to drain surface water from within the central and eastern parts of the SSSI. Three distinct sub-catchments were identified to have been present before mining, with the larger central-eastern sub-catchment having four components (IIIa-d, Figure 3a).

The extraction of the Barnsley seam was predicted to result in the coalescence of two of the surface sub-catchments (IIIa & c) within the boundary of the working area and their separation from the two outside to the south (IIIb & d). No further major changes were predicted from the extraction of the Stanley Main seam.

The ericoid heath within catchments I and II, and the two southern components (IIIb & d) are not associated with any significant changes. A central and major area of wet and dry heath is associated with the coalesced IIIac catchment.

Seven subsurface catchments were identified to be present prior to mining in the clay layer, and three (1, 2, 7) are predicted to remain unchanged by the mining of either seam (Figure 3b).

In the central part of the SSSI, sub-catchment 3 (outside the working area) would slightly increase at the expense of 4 (largely inside), and in the east, sub-catchment 5b (inside) would increase at the expense of 6 (outside) with the mining of the Barnsley seam. No further major changes were predicted to occur through the extraction of the Stanley Main seam; although there was a slight increase in catchment 5b at the expense of 6.

3a. Surface catchments

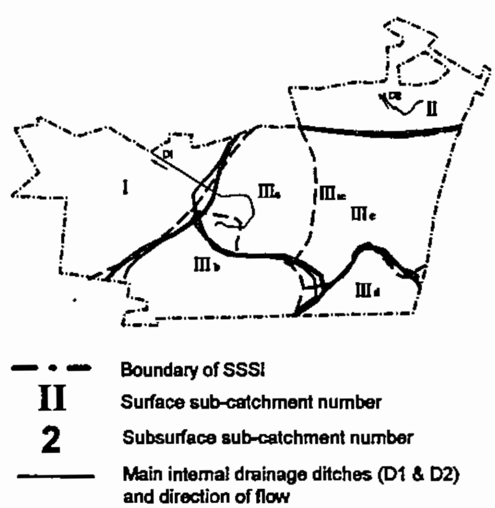


Figure 3. Effect of subsidence on catchments.

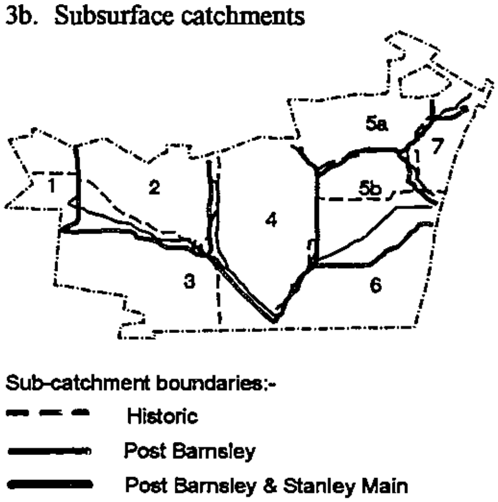
As a result of the potential change in the eastern subsurface catchment 5b by the Barnsley workings, a greater proportion of subsurface water could potentially drain further northwards towards the central and major area of heath. In view of the relative thinness of the coarse sand layer above the clay, the change is unlikely to affect winter wetness, but mightincrease the extent and duration of summer wetness at that location. There are no significant changes in subsurface catchments associated with ericoid heath elsewhere.

Predicted Effects on Heath Communities

Overall, the topograhically based model predicted that there would be no effect of subsidence from the Barnsley seam or the cumulative effect following the extraction of the Stanley Main seam on the site features which determine relative wetness (soil physical properties, thickness of sand cover, topography, gradients, and catchments) and influence the distribution of heathland.

The model predicted that there was a potential for an increase in wetness at one low lying location in the north east and next to an area of heath with the extraction of the Barnsley seam. Here, the effect of subsidence is predicted to be relatively small and localised (Figure 4).

3b. Subsurface catchments



Vegetation

Aerial photograph derived pre-mining vegetation maps for the SSSI were available for 1985 and 1991, and HRA prepared an equivalent 1997 post-mining map from a 1996 aerial flight and field surveys in 1997.

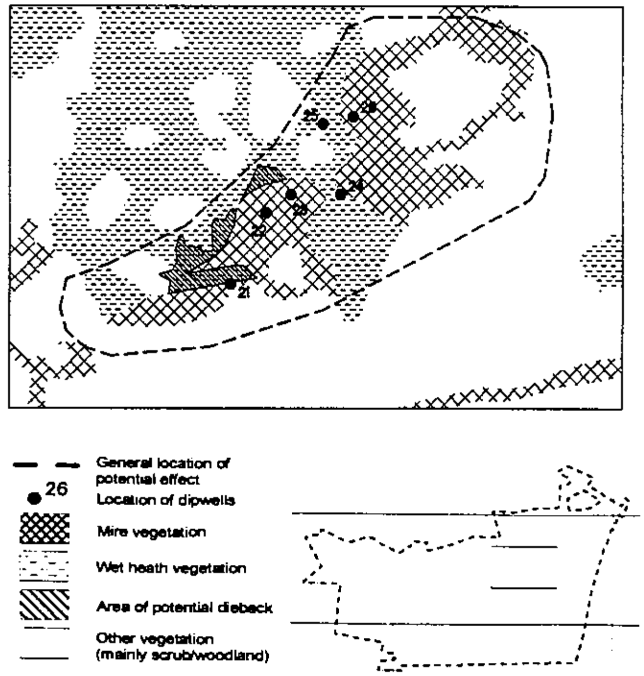


Figure 4. Local increase in wetness following extraction of Barnsley seam.

Vegetation data is also available from long term monitoring plots for 1980, 1982 and 1990. The plots had been deliberately placed by the NCC across heathland boundaries at sensitive locations throughout the SSSI. All 21 were relocated by HRA in 1997 and recorded in the same way.

Comparison of the vegetation maps indicated a significant reduction in heathland between 1985 and 1991, whereas between 1991 and 1997 there had been an increase. These changes were due to apparent woodland and scrub encroachment, and retreat respectively. Between 1985 and 1991 there was also an apparent expansion of wet heath at the expense of dry heath. These changes coincided with the introduction of a programme of scrub and woodland clearance, and then grazing by sheep as a means of controlling scrub re-development.

These observed broad scale changes in type of heath across the SSSI are likely to be anthropogenic, (ie management induced by man), as the relative dominance of the heather and crossed-leaved heath is sensitive to the grazing regime (Gimmingham, 1960; Bannister, 1966). Also and importantly, the changes occurred before mining took place, and have continued with the further expansion of areas under grazing. Hence, there is no evidence for these large scale changes to be due to the mining of the Barnsley seam.

The results for the long term plots confirmed the pre-mining trend from dry to wet heath. However, there was evidence at three plots (nos. 7, 20, 26) for a local change from wet heath to a wetland mire type (Table 1).

Soil Wetness

There were also pre-mining records of soil wetness for the long term monitoring plots; in the form of point measurements of depth to free water in shallow (<1m) 'dip-wells' (wide-bore piezometers). Seventeen of those relocated in the heathland were refurbished and read by HRA from April to August in 1997. Comparable rainfall in the springs of 1982 and 1997 enabled comparisons of summer wetness to be made between the readings for the month of July. The dip-well data for July 1982 and 1997 were converted to soil water regime equivalents (ie permanent and seasonal saturated, and unsaturated soil profiles) (Hodgson, 1976).

The majority (13) of the heathland plots had the same summer water regime in 1997 as in 1982. Of the others, four were wetter, but only in one (Plot 7) was there a wetter regime and a change to a non-ericoid heath vegetation type (Table 1). Plot 7 is associated with a slight hollow in to which surface water now drains and collects as a result of a failure to maintain a boundary ditch. The three other plots (16, 43, 44) were associated with areas recently cleared of scrub and woodland. An increase in wetness would have been expected as these soils had been drier than expected for wet heath vegetation whilst under scrub and woodland. In Plot 20, whilst there was no change in wetness regime, a slight increase in inundation was detected (Table 1). Here, the increase is linked to the deliberate damming of the main central ditch in the early 1990s to retain flood water in that part of the SSSI.

There was no historical data to confirm an increase in wetness in association with the vegetation change recorded at Plot 26. The plot records for 1982 and 1990 show that there was a high proportion of mire species present prior to mining. Subsequently, the area was excluded from grazing and this change in management is the likely cause of the increase in the dominance of cotton-grass at the expense of the ericoid crossed-leaved heath.

Table 1. Vegetation types and soil wetness regimes in long term monitoring plots.

Plot no.	1982		1990	1997	
	Veg Type	SWR	Veg Type	Veg Type	SWR
2	DH	d	DH	WH	d
3	WH	d	WH	WH	d
4	DH	d	WH	WH	d
5	WH	d	DH	WH	d
6	DH	x	DH	WH	s
7	MG	d	WH	CM	p
9	DH	d	WH	WH	d
12	DH	d	DH	DH	d
16	WH	d	WH	WH	s
19	WH	x	x	WH	s
20	WH	p	MG	CM	p i
24	WH	p	x	WH	p
25	WH	p	WH	WH	p
26	WH	x	WH	CM	x
37	WH	s	WH	WH	x
41	WH	d	WH	WH	d
42	WH	d	WH	WH	d
43	WH	d	WH	WH	p
44	WH	d	WH	WH	p
46	WH	d	WH	WH	d
47	DH	d	WH	WH	d

KEY: Vegetation / SWR

DH	Dry heath	d	unsaturated profiles
WH	Wet heath	s	seasonally saturated
MG	Marshy grassland	p	permanently saturated
CM	Cotton-grass mire	i	increased inundation
x	No data		

However, there was supporting evidence in the field for a slight increase in wetness to the west of Plots 21-23 in the form of deeper and a corresponding greater extent of summer inundation (covering a further 0.3ha) along the northern edge of the cotton-grass mire (Figure 4). In this narrow band of wet heath some die-back of heather and self set birch and pine was evident in 1997; their die-back being a good indicator of increase in inundation.

This local change in vegetation and wetness at the local (plot) scale may also be management linked with an increase in run-off following the local removal of trees and scrub. At the local scale, the data and field observations indicate that if there have been effects of extracting the Barnsley seam, they are both very localised and small scale, and are almost undetectable within the backgound effects of standard site management practices.

Conclusions

On a broad overall scale, there is no field evidence that the mining of the Barnsley seam has resulted in the reduction in the extent of ericoid heath communities within the SSSI. On a local scale there is some evidence for a minor increase in summer inundation at one location. Both location and scale of the effect were predicted by the habitats and surface topography modelling approach adopted in the environmental assessment for the Stanley Main proposals.

The model also predicted that the principal physical changes to the SSSI are induced by the extraction of the Barsley seam, and only minor further changes result from the mining of the Stanley Main seam. The subsidence due to the extraction of the Stanley Main seam are therefore predicted to have no further significant effect on the wetness of the site and its ericoid heath communities, for which the Common has been given statutory protection.

If planning permission is granted, a monitoring programme will be implemented, as a precautionary measure, whereby any required mitigation can be properly designed and implemented. There is ample scope for mitigation through the reinstatement of the derelict ditch network within the Common as current off-site drainage will be maintained as part of mitigation for subsidence effects outside the SSSI.

The Value of the Approach

The topographical approach is likely to be applicable to a wider range of circumstances than that described at the Skipwith site, especially where the principal effect of subsidence is the potential modification of relative wetness. We have used it successfully in this context for an internationally important wetland site for wintering birds and flood/inundation grasslands.

A number of important benefits of the approach became apparent during the project. Technically, not only did the topographical model provide a useful visual description (2D & 3D) of the potential and sequential changes to the SSSI that could occur due to the extraction of the two seams of coal, but importantly it enabled the re-construction of the pre-mining landscape. It also enabled the integration of various related site data (vegetation, topography, hydrology, management history, etc).

Secondly, and significantly, the visual representations enabled all parties, the mining company, the planning authority, the statutory nature conservation agency and the voluntary wildlife groups to understand the potential and scale of changes to the SSSI. This much aided the discussions between these parties, and the reaching of agreement about the effects of the mining proposal.

However, the approach is dependent on there being an adequate amount of appropriate data. Fortunately, there was sufficient pre-mining data in the case described above, and this enabled the verification of the model used. It is essential, as for all models, that adequate pre- and post-event data is collected.

Finally, this is the first time such an approach has been used in the UK to assess a nature conservation issue and mining subsidence effects in an Environmental Asssessment. We anticipate that it could be adopted more widely in the future for important sites.

Acknowledgements

We thank RJB Mining for permission to publish this study, and any opinions expressed are those of the authors and not necessarily those of RJB. We are grateful to RJB Mining for their logistical support and encouragement, in particular C. Bennett (Minerals Manager), I. Johnston (Chief Surveyor), M. Johnson (Planner) and J. Kirby (Ecologist). We also thank T. Dixon of English Nature, the Yorkshire Wildlife Trust, and the Escrick Estate for providing site historical information and access. M. King is thanked for her help in the preparation of this manuscript.

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