The project

The Proactive Earthwork Management on Hadrian’s Wall (PEMW) World Heritage Site project is an European Heritage Laboratories project funded by the European Union’s Raphael Programme and supported by English Heritage, The National Trust, Countryside Agency, Northumberland National Park and Cumbria County Council. Started in January 2000 and due to finish at the end of July 2002, the project aims, for areas under grassland or woodland management, to:

- improve effective and efficient conservation of the Hadrian’s Wall World Heritage Site (WHS) by the establishment of effective management regimes for earthwork archaeological sites under pressure or likely to come under pressure from visitors or from agricultural stock;
- develop proactive and innovative management systems for the management of archaeological earthworks based on partnership between owners, professionals and statutory agencies;
- through experience gained on Hadrian’s Wall and a review of best practice elsewhere, produce consolidated guidance on the management of archaeological earthworks to be disseminated through seminars and regular bulletins during the project and the publication of a guidance manual at the end of it.

Hadrian’s Wall World Heritage Site

The Hadrian’s Wall WHS, stretching from South Shields in the east to Ravenglass on the Cumbria Coast (Figure 1) was inscribed as a World Heritage Site in 1987. It consists of 188 to 200 Roman military or related Scheduled Ancient Monuments that are associated with the development of this curtain frontier work. Surrounding the monument is a buffer zone, known as the Setting, designed to ensure through local authority controls that development is sympathetic to the landscape of Hadrian’s Wall.

![Map of Hadrian's Wall World Heritage Site](image)

*Figure 1. Hadrian's Wall World Heritage Site. © English Heritage. © Crown copyright. All rights reserved.*

Although it is the visible masonry elements of the Wall and its forts that the public perceives as the Hadrian’s Wall WHS, the site includes a large number of well preserved and outstanding earthworks (Plate 1). The main components that form the Hadrian’s Wall WHS and may express themselves on the surface as visible earthworks are the countercap mound, ditch, wall, military way, vallum (Plate 2) and the forts, milecastles, turrets and camps spread along its length.

In addition to these there are other components, which are important to our understanding of the evolution of the Hadrian’s Wall WHS landscape (Plate 3). These include components that are contemporary with the Roman period such as the settlements (vici) that lay outside each of the forts, spur roads leading from the military way to the milecastles and Romano-British native
settlement. There are many other components that either pre or post date the Roman period, and include prehistoric boundaries, medieval sheltering, enclosures, bastles and post-medieval farmsteads. Many of these too survive as visible earthworks.

**Conservation of the Hadrian’s Wall WHS**

The conservation of the Hadrian’s Wall WHS involves an understanding of the causes of change to the monument. These include environmental influences acting upon the monument, the types and mechanisms of damage, and the vulnerability of the archaeological deposit to damage.

Environmental influences include soil, geology, topography and climate. With a WHS that stretches across Northern England and along the Cumbria coast the Hadrian’s Wall landscape is actually a series of landscapes; urban in Newcastle and Carlisle, lowland arable in East Northumberland, upland permanent pasture in the Northumberland National Park, improved cultivated pasture in lowland Cumbria and estuarine and coastal on the Cumbria coastline. Therefore, as each of these landscapes has a variety of soils, geology, topography and climates, the environmental influences affecting the WHS are numerous. However, despite this soils within the WHS are commonly affected by seasonal waterlogging. The dominant soil is surface-water gley soils, which cover about 49% of the land along the length of Hadrian’s Wall and are associated with glacial and fluvo-glacial deposit. These are characterised by being slowly permeable and subject to seasonal waterlogging. In addition soils from other major groups that account for a further 12% of the land along the length of Hadrian’s Wall display seasonal waterlogging characteristics. When this is combined with the shift in recent years to milder and wetter winters the susceptibility of the monument to poaching from stock, vehicle and recreational use is high and increasing (Plate 4).

Such a diversity of landscapes also means that there are examples of damage to the monument from all the potential processes listed below:

- disturbance by the action of burrowing animals;
- disturbance by the action of tree, scrub and bracken growth.

An understanding of these processes is required for effective management of archaeological earthworks. It is an aim of this project to build upon previous work within the Hadrian’s Wall WHS and on work from elsewhere in the United Kingdom and Northwest Europe. Such works include turf-wear management on Hadrian’s Wall Path National Trail (see McGlade; Lazzari this publication) and at Stonehenge (see Cathesides this publication), alternative path construction on the Pennine Way National Trail (see Cutts this publication) and at Housesteads Roman Fort (see...
Stockdale this publication), burrowing animal control (see Bapty this publication; Dunwell and Trout, 1999), and control of vegetation such as bracken (Rees and Mills, 1999) and scrub development.

Animal and human poaching on and near archaeological sites has been dealt with by many of the papers contained within this publication. These are two of the principle damaging impacts on Hadrian’s Wall WHS. Two others, which have a very significant impact on the archaeology, are the burrowing activity of rabbits and scrub development. When one considers the burrowing activity of the rabbit, which can be up to 4.5 m deep and every hole can represent up to 8 m of burrow length (some 1.6 m$^3$ of excavated material) and that the abandoned burrows can be utilised by badgers and foxes (Dunwell and Trout, 1999) then the need to control rabbit populations on archaeological monuments becomes paramount. However, the eradication of rabbits on sites, either archaeological or not, has proved notoriously difficult and an alternative approach may be to control populations to limit disturbance to those parts of monument already highly disturbed by rabbit activity.

Likewise, the removal of scrub from a monument may not always be necessary. Scrub damages a monument through root action, and by associated stock damage either through providing shelter, rubbing posts (Plate 5) or creating pinch points for movement around a site. An appropriate approach to scrub management on archaeological sites may be to remove newly developing scrub and scrub that causes associated stock damage. This method would allow the retention of scrub that has nature conservation value through the retention of established scrub, and through the removal of specific areas of scrub it creates a multi-age scrub that, in general, enhances nature conservation value whilst ensuring limited disturbance to the archaeology.

The level of survival, form and composition of archaeological earthworks affect their continued survival. As visible earthworks are always trying to reach equilibrium with their surroundings through natural slope processes, the cultural heritage manager is at very best attempting to slow the decay of upstanding archaeology to only these natural processes. The proactive cultural manager is therefore assessing the potential vulnerabilities to the monument from other causes. Figure 2 shows how the varying state of survival for the vallum affects its susceptibility to poaching. Poaching on the slopes of upstanding and ditch cut features will lead to enhanced erosion through the action of slope wash and slumping. Therefore where the survival is good and the slope angles greater then the potential vulnerability is higher. The impact of poaching decreases with a decrease in survival and slope angles. On flat areas poaching is commonly limited to the surface of the soil.

Composition of the monument will affect its vulnerability. Lighter, better drained deposits such as the turf wall (Plate 6) are more susceptible to burrowing activity than other parts of the monument. In addition once bare ground is exposed lighter, drier soils are more susceptible to erosion be wind and rain-wash.

**Condition assessment**

The first stage of any management is to assess the present state of the monument, against which any future change can be measured. On Hadrian’s Wall the baseline condition assessment forms the fundamental record of the present survival, condition, stability, vulnerability of the monument. In addition any management issues are recorded and photographed to show their present extent, and an estimate of the amount and causes of damage for each section is made. On this information management recommendations are made.
The field-based exercise can be supported by gathering additional information from a variety of sources including historical and natural heritage information. Historical information such as previous field monument warden visits, scheduling documentation, sites and monuments records, old photographs and provide a view of how the survival and landuse on a monument has changed. Natural heritage information such as the presence of designated habitats, presence of protected species, local bio-diversity action plan targets and habitats of nature conservation value like those on the National Grassland Inventory and National Heathland Inventory will affect the detailed prescription of any management recommendation.

The management recommendation forms the preferred solution to a management problem. Depending on its nature this may involve one-off actions such as the repair of an erosion scar or the creation of livestock sheds to over winter livestock and prevent damage through poaching. It may equally involve the establishment of management agreements to effect a certain management regime where the problems would remain recurrent such as the control of burrowing animal infestations.

Once a management agreement is in place or one-off actions have taken place then it is important to continue monitoring to assess the effectiveness of the action, the results of which can then be used to improve future actions. It is also important to monitor parts of the monument where no action has been taken to better understand the processes acting on the monument and to emphasise the merits of taking actions.

Conclusions
The effective management of the Hadrian’s Wall WHS archaeological resource, as with any archaeological resource, requires:

- an assessment of its present and changing condition;
- an understanding of the nature of the archaeological deposit;
- a knowledge of the environmental setting of the monument;
- and a knowledge of the various causes of loss to the archaeological resource.

Once this is attained the limits to acceptable change for a monument can be predicted and indicators can be used to monitor if, when and what action is required to improve the condition and management of the monument.

References
Rees, T. and Mills, C. 1999 Bracken and Archaeology. Technical Advice Note 17, Historic Scotland: Edinburgh
Introduction

Initial survey of the archaeological sites on National Trust properties in the Northumbria Region in the 1980's identified a number of sites where erosion of archaeological earthworks was a cause for concern. Working with the Trust's warden staff and volunteers, 'low tech' earthwork repair projects have been successfully carried out on a variety of sites during the last decade.

Ros Castle Hillfort, Chillingham, Northumberland

Ros Castle is a Scheduled Ancient Monument (Northumberland 109). It lies at about 1034 feet/315 metres, at the summit of a steep sandstone hill about 10 miles/16 kms inland from the Northumberland Coast. The soil is a thin layer of peat over an impoverished mineral soil and the vegetation is of moorland species, predominantly old heather, which is left unburned on the property to provide a contrasting habitat to the adjoining burned moorland. The site is a popular viewpoint and is situated on a waymarked route for one of Forest Enterprise's Hepburn Woods circular walks.

The steep terrain (Plate 1) and vulnerable vegetation and soils had led to erosion and where this had become severe, and was threatening known archaeological remains, the decision was taken to undertake some simple repairs. Where paths were braiding this would be discouraged by restoration and temporary diversions with the bulk of walkers directed to use the original hillfort entrance. A broad mown strip was cut in the old heather by the Forestry Commission around the shoulder of the hill to encourage people to use the hillfort entrance and avoid a steeper eroding path.

The site was surveyed, at the National Trust's request, by the Royal Commission on the Historic Monuments of England in 1990 to provide a record of condition/aid interpretation and to provide a basis for planning erosion repairs. An application for Section 24 Grant aid for management of the site was made to English Heritage, which provided 40 per cent of the costs.

At the point where the principal footpath crossed the hillfort rampart, resulting in considerable erosion of the rampart, it was proposed to form a flight of steps to carry the path over the rampart and to restore the eroded profile of the rampart with imported sympathetic material to that surviving on each side of the breach.

The steps (Plate 2) were to be constructed using substantial side timbers (old telegraph poles) secured by heavy transverse timbers (old railway sleepers) laid onto the existing ground in the manner of a sill beam and then filled around with fell sandstone rubble (obtained from field clearance some miles away) and topped with fines.
The alignment of the steps was discussed on site with the Inspector of Ancient Monuments from English Heritage and they were to be about one metre wide. The risers of the steps were timber (Elm boards) with the treads formed by an infill of broken sandstone rubble subsequently topped with fines. The main timbers were also anchored by 3 inch diameter steel pins to ensure the stability of the structure. A French drain was formed in the rubble fill to ensure adequate drainage for water from within the hillfort, which was running down the path scar at times of heavy rainfall. The aim was to provide a lasting all-weather footpath surface with as much of the structure as possible hidden from view by the restored rampart profile.

The path from the top of the proposed steps to the topograph on the hilltop was braided for part of its course and the lesser route was covered with heather brash to encourage reseeding and visitors encouraged by simple routed signs to follow the main path.

The modern walker’s cairn developed on the old beacon platform near the topograph was dismantled and the material used in the erosion repairs and a necessary rebuild to a large collapse of the Chillingham Park Wall which forms one side of the property.

Where the path from the hilltop leaves the northern side of the hillfort a substantial gully had developed alongside the Park Wall. Here a further set of steps (Plate 3) was formed within the gully and the rest of the eroded area was filled with imported sandstone rubble. It was necessary to take back about 20cm of the rampart at this point to achieve a reasonable width for the steps. This work was agreed with English Heritage as part of the project and carried out as an archaeological excavation with the partial section through the rampart being recorded.

At the exit point for the footpath leading south over the hillfort rampart large blocks of sandstone were pitched in the existing erosion scar to prevent further erosion at this point and walkers were discouraged by simple signing and restoration of the approach path by heather seeding.

At all the points where work was undertaken photographs were taken to record the present condition of each location before work started and on completion of each operation.

The work was carried out by members of an Employment Training team and/or groups of volunteers under the supervision of the National Trust’s Northumberland Coast Wardens. Those tasks with a specific archaeological involvement were supervised in addition by the Trust’s Archaeologist.

Care was necessary when bringing material onto the hilltop by vehicle and trailer, particularly through the original hillfort entrance. Traffic was kept to a minimum and was restricted to a dry time of the year to keep damage to a minimum - not least because it involved crossing a neighbour’s moor for some distance.

Lessons
1. Transporting materials on to the site was quite a challenge – a good local agricultural contractor was invaluable and the regional National Trust Volunteer Group, who took most of the heavy timberwork up the hill and sorted the field clearance stone, still talk about their work day!
2. The value of appraising the whole site and its immediate surroundings - a feature of the site is the very narrow site boundary owned by the National Trust. The lack of vehicle access required close liaison and cooperation with other landowners in order to obtain access for vehicles and materials. Likewise it was necessary to liaise with the Forestry Commission to arrange an adjustment to and scaling down of the waymarking on the promoted self-guided route over and around the site.
3. The need for subsequent “gardening” or stitch in time maintenance to tidy up edges of construction, further work to cut up heather brash, seed braided paths and, importantly, to top up surfaces after the first winter.
Catcherside Camp, Wallington, Northumberland

This is a small later prehistoric hillfort with only the northern defences surviving to full height. Situated on Catcherside Farm, Wallington, the site is rough fell grazing at just over 600 feet (183 metres) above sea level and about 20 miles/17kms in from the coast. The soils are derived from boulder clay over Fell Sandstone.

A number of hollows had developed, particularly in the south-facing slope of the surviving rampart of Catcherside Camp as a result of scraping/rubbing by sheep (Plate 4). These were first noted in 1988 and were subsequently monitored on a regular basis. The distribution and extent of the scrapes were plotted in 1990 and this plan, showing the location of scrapes to be infilled, formed the basis for an application for Scheduled Monument Consent.

It was proposed to infill the sheep scrapes with imported topsoil and then seed or turf over (with turf from outside the Scheduled area) – in practice the areas were left to seed in naturally. The work was carried out by the Wallington site wardens.

Care was needed as the access for vehicles was difficult, particularly with heavy soil filled trailers, the work had to be undertaken in the late summer when the route across adjoining farmland was driest.

In order to protect each site temporary fences of posts and sheep netting (Plate 5) were required until the grass had become established. A site visit with the Inspector of Ancient Monuments from English Heritage established precisely the number of posts required for the temporary fencing around each site and the scrapes where treatment was appropriate were further defined. The posts were to be driven to a depth not exceeding 0.5 metres.

‘Terram’ matting was laid in each scar before infilling to provide a demarcation between original and imported material. Photographs were taken of each area to be treated before, during and after the works.

Lessons

It may seem obvious, but care is needed when sourcing material for repairs to archaeological earthworks. The topsoil, imported from the National Trust’s lowland Wallington estate, introduced some non-local plants including Snowdrops and Foxgloves! The same care should be taken to ensure that the soil source does not introduce exotic archaeological material (pottery/clay pipes or worse still older material which might be confused with that belonging to the site). The ideal is to find material close by - providing that winning material does not damage other sites of archaeological or nature conservation interest - or start erosion elsewhere!
Lindisfarne Castle Limekilns, Holy Island

It was necessary to restore the eroded path on the slope adjacent to the north end of the eastern facade of the battery of limekilns to the east of Lindisfarne Castle, just above sea level, on the north Northumberland Coast. The site is very exposed!

The original access from the working area adjacent to the charging floor at the top of the kilns to the kiln foot was by a simple flight of stone steps set into the artificial slope of soft lime ash, and other waste from the kilns, which had been built up around the masonry structure. This alignment was the most direct route and, although it was steep and not easily negotiated, most visitors to the kiln area seem to descend to the kiln foot by this route. As a consequence the path had widened by over a metre in places and the steps were in danger of being lost through undercutting. In addition burrowing rabbits were very active in the bank below the steps.

One possible solution to the problem was to provide a wider flight of stone steps but there was concern that these would prove visually intrusive and be out of scale with the kilns and their surroundings.

The initial proposal was to restore the present steps to the existing width and repair the erosion scar giving careful thought to the sourcing of material in a generally sensitive archaeological area, also undertake a degree of visitor management. The latter involved a short run of low fencing at the top of the slope with signage directing the visitor to the easier and safer route to the kiln foot via the gentle gradient of the old tramway. Access to the restored steps would be retained because they help to explain how the site operated but by offering a better alternative route it was hoped that the load on the steps route would be reduced to an acceptable level.

The limekilns are a Scheduled Ancient Monument (Northumberland 555) and the proposed work required Scheduled Monument Consent as archaeological layers and structures associated with the kilns would be affected, as would the setting of the monument.

In practice the decision was taken, based on the Ros Castle experience, to form a flight of timber steps following the existing path line (Plates 6 & 7). Some 40 steps were required, the timber risers being secured with timber pegs and secured to the side timbers and each step filled with Whinstone rubble and finished with a binding of Whin dust. Where the eroded path extended beyond the new steps the scar was filled with rubble/soiled over and seeded.

The work was supervised by the National Trust’s archaeological field officer and photographs were taken to record the progress of the works. The works were carried out by the National Trust’s Northumberland Coast wardens; volunteers and an Employment Training Scheme. The cost of the works to this Scheduled Ancient Monument were forty per cent grant aided by English Heritage.

Conclusions

A number of general themes suggest themselves as a result of our experience in this region.

1. Regular monitoring is repaid as it enables problem areas to be identified and responded to before major works are required to prevent loss of archaeological material.

2. Detailed large scale mapping of archaeological earthwork sites is valuable as a means of locating and monitoring challenges and planning projects.

3. Care and attention to detail is paramount when thinking through the whole process of planning larger projects to ensure that all the operations are covered by consents (e.g. fencing to secure the work site/footpath diversions/ temporary notices/vehicle access routes) and the impact of works on the wider landscape/other archaeological sites is considered.

4. Good early liaison with statutory agencies can speed up consent procedures and avoid delaying the start of a project.
The Restoration of the Grassland Setting at Stonehenge

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Introduction

Stonehenge (Plate 1) is arguably the most well known ancient monument in this country, possibly the world. It has always been reasonably well known and the subject of 'tourist' visits - writing of a visit in 1768 Gilbert White in his 'Natural History of Selbourne' describes it as 'that amazing work of antiquity' and comments on its use of by jackdaws who nested at the top of the upright stones which were tall enough to 'secure those nests from the annoyance of shepherd-boys who are always idling round that place'. The jackdaws remain, doubtless relieved that the shepherd boys do not! During the following centuries visitors continued to come and our first photographic record of visitors is dated to around 1870 (Plate 2).

Had visitor numbers continued at this level there would not have been a problem, however, much to the pleasure of our business managers, visitor numbers have risen dramatically and by 1999 the annual figure had reached 870,000 (Plate 3). These increasing numbers unfortunately led to major problems with the grass surface surrounding the stones, on what is actually a remarkably small area - the stone circle is only about 30 metres in diameter and the surrounding ditch and bank about 120 metres diameter. After access to the centre circle was stopped in 1978 all visitors, on leaving the tarmac pathway which cuts across part of the site, were directed around the outside of the encircling ditch and bank, on the grass to the fence by the Heel Stone and because of the extremely sensitive archaeology of the Avenue area - back again - thus doubling the wear on an area estimated at only 4,000 sq.m. This continued until the walkway across the Avenue (Plate 4) was installed in 1995 - thus reducing the wear problem on one side but greatly increasing it on a previously unused section.

Why do visitors cause such a problem?

At this stage I think it is worth digressing briefly to cover some aspects of basic plant biology as there are a number of people now involved in site management who come from a leisure or tourism background rather than a biology or horticulture/agriculture background and consequently do not have the knowledge of basic plant science that many of us take for granted.

Grass has the same basic structure as most plants, with green leaves above ground connected to sub-surface roots.
In grasses the leaves grow from around (usually) horizontally growing stems and consist of two parts - the ‘leaf sheath’ which clings closely to the stem and the ‘leaf blade’ which is free from the stem. The leaf blade grows upwards from the leaf sheath and continues to grow even when the ‘free’ end of the blade is cut or eaten. The roots are fibrous and shallow, rarely extending down more than 75 - 100 mm.

As a much simplified explanation, these leaf blades harness the sun’s energy by using photosynthesis to produce energy and sugar for growth from the raw materials of water and carbon dioxide. Water is provided by the roots and carbon dioxide absorbed directly by the leaves. Leaves and roots have evolved complex structures and mechanisms for ensuring that there is sufficient movement of water and air into and out of the plant in a controlled way so that life can be supported without being threatened.

For the leaves and roots to grow and function properly they need to respire and respiration requires ready access to oxygen. Leaves very rarely have problems with obtaining sufficient oxygen for respiration as it makes up approximately 21% of the surrounding air and is also a by-product of photosynthesis within the leaves. In most soils there are innumerable air spaces between soil particles which provide sufficient oxygen for roots to respire. Specialist plants which grow in soils deficient in these air spaces have evolved specialised methods of obtaining oxygen for roots such as the pneumatophore’s or ‘knee roots’ on a Swamp Cypress *Taxodium distichum* (Plate 5).

Having explained these basics, I can now return to the question posed above - why do visitors cause such a problem? the answer is simple - their feet!! Thousands or hundreds of thousands of pairs of feet walking over grass can cause damage in four ways:

- by crushing grass blades, damaging their delicate internal structure, disrupting photosynthesis and possibly causing excessive moisture loss by damaging the external surfaces;
- by tearing leaves and stems as the foot ‘kicks back’ as it is lifted - especially when wearing deeply indented soles;
- by smearing mud over the leaf surface during wet weather, reducing the amount of sunlight which can penetrate into the leaf blade;
- by compaction of the soil, destroying the soil structure and greatly reducing the amount of air spaces between soil particles. This inhibits root respiration, makes physical root growth difficult and interferes with the movement and availability of water in the soil.

**Wear pattern**

Returning to Stonehenge, the increasing number of visitors caused a decline in the quality of the grass surface. This occurred rapidly and in what can now, with 20/20 hindsight, be seen as a predictable fashion. The first indications are yellowing caused by damage to the leaf blades (Plate 6), followed by brown and patchy areas with some damage to stems and leaf sheath (Plate 7).

For those involved in the concept of ‘limits of acceptable change’ I would venture that this stage is the absolute limit at which recovery of the existing turf is possible - if the source of wear is removed.

If nothing is done at this stage the spiral downwards continues with large areas becoming bare, indicating complete loss of stems and leaf sheaths (Plate 8). Partial recolonisation can occur during off peak periods (Plate 9) but generally only by broad-leaved and annual species with no wear tolerance (Plate 10). Areas of wear spread (Plate
11), further and further until the loss of vegetation leads to large areas of bare earth (Plate 12). By 1987 the entire grass pathway (Plate 13) was bare chalk or mud for most of the year and by 1988 the situation was so bad that calls to extend the tarmac path right round were becoming increasingly insistent (Plate 14).

**Road to success**

For both archaeological and aesthetic reasons an extension of the tarmac path was strongly opposed. Following studies of grass wear at a number of sites, commissioned by English Heritage and carried out by Land Use Consultants, Andy Wimble, then Chief Landscape Architect for English Heritage, was permitted to introduce some trial areas of turf...
re-inforcement materials. (They have been previously described at the Seminar at Birmingham in 1992 and are contained in the publication resulting from this - Berry & Brown (eds) (1994) 'Erosion on Archaeological Earthworks - its prevention, Control and Repair'). These were partially successful and provided a number of useful lessons on combating erosion. More importantly, they led to an acceptance within English Heritage that, given an appropriate management regime, it was possible to maintain a good quality grass surface at Stonehenge.

A decision was taken to re-turf the damaged area using more wear tolerant grass species, implement a programme of high intensity sportsfield maintenance and to strictly manage the flow of visitors over the area. The success of this management regime was immediate and has remained successful to the present day, visitors to Stonehenge now walk on grass not mud (Plate 15).

Management regime used at Stonehenge

There are 3 key turf management elements in the successful prevention of erosion at Stonehenge.

1. The use of wear tolerant grass species. The whole area regularly used by visitors was re-turfed using 100% Ryegrass. To retain this homogeneous cover, any repairs are made using Ryegrass cultivars recommended for use on heavy wear areas of sportsfields e.g. goalmouths and regular overseeding of the whole area is carried out. From two photographs taken in January it should be apparent the difference between the natural grass cover and the stronger growing ryegrass (Plates 16 & 17).

2. Continuous maintenance. The area is subject to a sportsfield style maintenance regime consisting of:
   • regular cutting: to encourage a low, dense sward; cutting is carried out using cylinder mowers and arisings are removed to help reduce the build up of a thatch layer;
   • aeration (or spiking): using a solid tine spiker this is carried out regularly to relieve compaction, and improve aeration and drainage;
   • regular fertilising: carried out in spring and summer with high nitrogen fertilisers to encourage strong leaf growth and in autumn with fertiliser’s low in nitrogen, but high in phosphorus and potassium to encourage root growth and slower, hardier leaf growth for the winter;
   • light harrowing is carried out when necessary to disperse any worm casts or similar and prevent mud being smeared over the leaf surface;


Plate 16 - Natural sward in January. © Alan Cathersides.

Plate 17 - Ryegrass sward in January. © Alan Cathersides.

Plate 18 - Molehills awaiting removal. © Alan Cathersides.
- autumn restoration: this consists of scarifying to remove any thatch, followed by aeration, over seeding and top dressing, carried out over the whole area;
- pest control: when necessary and especially the removal of any molehills before these become spread out, smothering grass and providing seed beds for weeds (Plates 18 & 19);
- weed killing: to remove broad-leaved weeds (which have very low wear tolerance) is carried out whenever necessary. It is interesting to note that all the preceding measures have served to maintain a very dense, healthy grass sward which has prevented weed establishment - no weed killing has been necessary for the last 6 years;
- watering: the very thin soil at Stonehenge and the open, exposed nature of the site make it very susceptible to drying out - grass recovering from a period of wear is watered during dry spells - something of a problem on a site with very low water pressure. Because of the low water pressure at Stonehenge ordinary sprinklers are ineffective and soaker type hoses are employed;
- early repair: any wear early is repaired as quickly as possible to prevent it spreading and becoming further eroded.

Management of visitor flow: To spread wear and compaction the area is divided into a number of walkways. Individual walkways are marked out using unobtrusive low level ropes and visitors are encouraged to keep within the designated walkway. There is room for approximately 10 individual walkways on the maintained area and these are alternated regularly, at the first sign of wear - this may be daily during peak periods or every 2-3 days off-peak. Walkways in use are shown in Plate 20.

I indicated above that the introduction of a walkway across the Avenue (Plate 4), whilst alleviating some problems and creating others. This is because the area opened up by the walkway was never prepared as a sportsturf and is only wide enough for 4 alternating pathways. So far we have managed to keep a permanent (re-inforced) path close to the fence for the winter season - shown at the right of Plate 11. This results in a regular dead area at the start of the summer season which needs to be re-seeded each year. Ideally this re-inforced path would be used for 2/3 years while the remaining area was worked on, but the massive masses of 'wands' (audio tour equipment) prevents this and we have to carry out intensive work in the autumn/winter each year - time will tell if this will be sustainable.

The walkway itself was designed so that it can be relatively easily moved, but because of the limited number
of positions available which join up the grass pathways on either side, a series of pinch-points have developed. At these points we have introduced a non-invasive type of grass re-inforcement which can be installed over an existing grass surface (Plate 22) with minimal fixing (and therefore minimal archaeological disturbance). The grass can then grow through the re-inforcement material, which is designed to protect the growing point. This will increase the wear tolerance to some extent, but it will also provide a sacrificial layer to prevent erosion becoming continually worse, even if the grass does die off.

Taken individually, any of these measures would help to reduce wear on turf and delay the onset of erosion to some degree. The success at Stonehenge, with such high visitor numbers, is due to the combination of them all - on this site any measure taken in isolation would not suffice to control the wear.

General principles

Every site, like every erosion problem, is different and the regime described above may not be physically or financially possible on other sites, or even desirable in some cases! So what general principles can be suggested for dealing with turf wear? I would suggest the following -

- Always remember the basic requirements for good grass growth - good soil structure, undamaged roots/leaf blades and leaf blades not covered by mud - and try to provide these.
- In areas of high wear, spread the wear wherever possible, giving some areas respite before wear becomes serious, carrying out repairs if necessary.
- In areas of high wear consider turf re-inforcement, even if only as a sacrificial layer.
- Where possible introduce more wear tolerant species of grass, such as Ryegrass and reduce levels of wear susceptible grass and broad-leaved species. (The ecological value of the site in question must be considered here - obviously in a SSSI, the introduction of sportsgrass cultivars might be unacceptable).
- Carry out as much ‘sportsfield’ maintenance as possible on susceptible areas.
- Where funds are limited choose the most beneficial maintenance that can be afforded - as a guide spiking which relieves compaction and improves aeration and drainage is by far the most beneficial operation. Because of the archaeological implications and shallow nature of the topsoil at Stonehenge aeration is carried out using standard spiking equipment designed to give approx. 100mm penetration. Where there is a greater depth of topsoil and subsoil, and no archaeological implications, much greater benefit can be obtained by annual or biannual use of a ‘deep penetration spiker’ or ‘verti-drain’ (Plate 23) whose 300 - 400mm penetration and ‘kick-back’ action results in major drainage and aeration improvements.

Conclusion

The very nature of Stonehenge and the sheer numbers of visitors it attracts cause problems, but also helps with some of the solutions. Staff are required on site to prevent misuse of or damage to this important monument and because such large numbers of visitors require a support infrastructure. Having these site based staff allows us to ensure walkways are used properly and rotated regularly. Large numbers of visitors undoubtedly cause wear and tear on the turf, but their entrance fees help to ensure that funds are more readily available to carry out the intensive maintenance necessary to reduce this problem.

So while the sun may set every midsummer at Stonehenge (Plate 24) let us not allow it to set over our efforts to control erosion!!

References

A Hard Surfacing Solution for the Devil’s Pulpit Area of Offa’s Dyke in Gloucestershire

Jan Wills
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Summary
In 1995-6 an archaeological survey of Offa’s Dyke in Gloucestershire was undertaken in order to record the form and condition of the monument and to assess management problems. The survey identified that significant erosion was being caused by the use of the Offa’s Dyke National Trail which is situated on the monument for much of its course in Gloucestershire. Since 1997 a number of the survey recommendations have been implemented in order to improve the management of the Dyke and to address the erosion problem. Along one of the most heavily eroded stretches, over a distance of about 30m, an experimental hard surfacing solution has been tested. The surface has been in place since August 1998 and has now generally been accepted as successful in fulfilling the objective of protecting the monument from further visitor erosion without itself having an adverse impact on the nationally important earthwork.

Introduction
The linear earthwork known as Offa’s Dyke crosses the English and Welsh borderland from Treuddyn, near Mold, in the north, to Sedbury on the River Severn estuary in the south. The earthwork is thought to have been constructed ‘from sea to sea’ by King Offa of Mercia (757-796AD) and it was so described in Asser’s 9th century Life of Alfred. It may therefore have had an important strategic role during the struggle for control of the borderland between the English midland territory of Mercia, controlled by Offa, and the Welsh kingdoms to the west. The monument has been referred to as Offa’s Dyke from the twelfth century onwards but, despite these attributions, it may have had a more complex origin than its name implies.

The Gloucestershire section of Offa’s Dyke (Figure 1) consists of about 15km of earthwork, divided into five discrete sections within which there are smaller gaps, some of which may be original. It is located near the western edge of the county, generally at the break in slope between the high ground of the Forest of Dean and the steep-sided valley of the River Wye. The form of the monument varies considerably along its length but it generally consists of a bank, ranging in height from a few centimetres to c. 3m, with a ditch to the west. In places a berm separates the bank and ditch, and a counterscarp may be present at the western lip of the ditch. Quarries are sometimes found to the east of the bank. In places there is no ditch and the appearance of the monument is more like a terrace.

Management issues
Given the extent and the fame of the dyke, surprisingly little archaeological research and survey has been undertaken on the monument. Antiquarian observations of the nineteenth century were followed by the first major survey by Cyril Fox in the 1920s and 1930s (Fox and Phillips 1931; Fox 1955), with further research by Frank Noble (Gelling 1983). A programme of survey and small-scale excavation begun in the 1970s is continuing under the direction of David Hill of the University of Manchester.

As a result of a perceived increase in management problems affecting the dyke - ranging from visitor erosion to small-scale development - the Archaeology Service of Gloucestershire County Council undertook a survey of the monument in Gloucestershire during 1995-6 (Hoyle and Vallender 1997). The survey was funded by English Heritage and it examined the extent of the dyke, documented its form and assessed its condition. Numerous management problems were apparent. These ranged from the inadequacy and inconsistency of the scheduling (for example, 72% of the length of the monument is scheduled as an ancient monument but the protected area generally includes only the bank rather than the whole of the monument), through the problems of landuse (almost 80% of the monument is situated in woodland with a range of consequent management issues), to the widespread and sometimes extremely damaging active erosion of the monument. The response to the last of these issues forms the subject of the rest of this paper.
The two most significant causes of erosion identified by the survey were visitors using the Offa’s Dyke Path National Trail, which follows the bank or the line of the ditch for much of its course, and animals, principally badgers, for whom the bank appears to be an ideal habitat. In contrast with other counties, little of the Gloucestershire monument (c. 14%) is situated in agricultural land and so the impact of cultivation or erosion by stock is comparatively limited.

Organisations with responsibility for, or an interest in, the management of Offa’s Dyke are numerous – a management problem in itself – and therefore the local group established to tackle the erosion consisted of representatives of a wide range of organisations: the County Council (archaeology and public rights of way), Forest Enterprise, the Offa’s Dyke Path Management Service, the Forest of Dean District Council, English Heritage, the Wye Valley AONB, English Nature and the Countryside Agency. The initial focus of the group’s activities was tackling the erosion on the stretch of the Dyke managed by Forest Enterprise – an area comprising almost 40% of the monument in Gloucestershire, including some of the most eroded sections.

Two approaches to the erosion problem were considered: re-routing the national trail and establishing a protective surface on top of the dyke. The option of moving the national trail off the dyke completely had considerable advantages from the
archaeological point of view. Some of the concerns about breaking the association between the path and the dyke raised by this proposal diminished as it became clear that re-routing the path alongside the dyke (well outside the monument) instead of along the top of the bank would in some areas offer the visitor a better view of the monument than that obtained by walking along the bank. Accordingly, one short diversion of the path was successfully identified and implemented. However, in the stretches where erosion was at its worst, diverting the path was extremely difficult since no viable alternative routes were available and these stretches of the dyke arguably represented some of the best places for visitors to gain access to the monument. It was therefore agreed to pursue the option of creating a protective surface on top of the bank of Offa’s Dyke to protect it from further damage.

The experimental surfacing

The trial area chosen is situated near to the Devil’s Pulpit, a well-known viewpoint in an area of wooded landscape on high ground overlooking the Wye valley (NGR - ST 3428 9951, 5km south of St Briavels, Figure 1). The Devil’s Pulpit itself is an outcrop of rock immediately adjacent to the monument and probably the best views of Tintern Abbey across the River Wye are obtained by standing on Offa’s Dyke at this point (Plate 1). The accessibility of this part of the dyke from a nearby English Heritage carpark where the path to the monument is signposted, from local paths and from the viewpoint itself, adds considerably to the ‘normal’ visitor pressure from long distance walkers.

Here the dyke consists of a bank with quarries to the east and the very steep slope down to the River Wye on the west. Visitor erosion since the designation of the national trail in 1955 has been particularly severe; the surface of the bank has been denuded of all vegetation revealing the stone and earth core from which (judging by the exposed bases and roots of trees growing on the monument) a considerable amount of material has been lost. Woodland cover exacerbates the situation by concentrating visitor traffic along the national trail into a narrow strip, while the trees shade the ground discouraging any regeneration of ground cover (Plate 2).

The form of the monument in this area exemplifies the difficulties to be faced in surfacing it. The profile of the eroded bank is convex; this, together with the adjacent steep slopes, presented a significant problem for the proposed surfacing project since surfacing material would need to be physically retained to prevent it from migrating rapidly down-slope, an objective difficult to achieve without anchoring retaining structures into the monument itself.

On behalf of the management group, the County Council commissioned consulting engineers Halcrow to research a surfacing specification which could be implemented as an experiment on a section of the dyke about 35m in length but which could be applied more widely if the trial section was successful. The brief was to design a durable low maintenance surfacing which would not need to be physically anchored into the monument and which could be constructed without causing any damage or disturbance to it.

The design put forward (Figure 2) involved the protection of the monument with a geotextile membrane placed on the uneven crest of the bank. On the western edge of the bank (ie the edge of the steep slope) a concrete wedge placed on the membrane would provide a stable platform for large edging stones (about 25-50kgs in weight) fixed together with a lime mortar. Where the shape of the bank made it necessary similar stone edging would be placed along its eastern edge. The channel thus created between the edging stones was to be infilled with a variable depth of...
sub-base (minimum thickness 150mm), topped with a finer dust (<3mm in size, to a minimum depth of 10mm) compacted by rolling. All materials were to be local limestone derived from the nearest quarry. A methods statement was also prepared, setting out how the works were to be undertaken, in order to prevent damage during construction.

Initial reactions from the management group to the specification included concern about the stability of the proposed surface since it has no ground fixings, and the impact that the new surface would have on the appearance of the monument. Wide consultation was therefore undertaken with local and amenity groups including the parish councils and the Ramblers’ Association, representatives of whom were invited to a presentation and site visit. There was no dissent from the view that action needed to be taken to protect the monument although at least one consultee expressed concern about the change in the character of the monument, and therefore of the walking experience, that would result from the proposed works.

Scheduled Monument Consent was obtained for the work. Construction was then undertaken by a local contractor (Plate 3), monitored by the engineer who had designed the surfacing and by the Archaeology Service. The most difficult problem encountered was access to bring material to the site. Stone was delivered to this remote location along a forestry track and then conveyed by powered wheelbarrow to the dyke. Construction was carried out according to plan and the main objective of the project - creating a protective surface without damage to the monument through its design or construction method - was achieved. Unsurprisingly, the newly constructed surface had a very stark and artificial appearance in its woodland setting.
Assessment

The surface was laid in August 1998. It was agreed that its condition should be monitored, and the success of the project assessed no earlier than a year after construction to allow wear and weathering to take place. Early in 2000 the working group therefore re-visited the trial section to examine its appearance and condition after about 15 months of wear. (Plates 4 & 5) Archaeologically the project appeared to have been successful; most of the potential problems had lain in the design and construction phases and no new difficulties were apparent. From a practical point of view the surface is generally very stable although there has been some very slight movement of surface material caused by rainfall on sloping stretches of the path. No other deterioration had taken place and it appears to be a low maintenance solution. Some beneficial weathering of the stone had taken place, with vegetation growth along the sides of the new surface, moss growth on the mortar and leaf fall generally over the area helping the new materials to blend in with the surroundings.

Less successful aspects of the project include the significant change to the appearance of the dyke and the nature of the national trail which has resulted from the works (although no adverse reaction from users of the trail has been received). Access to the trial section was difficult and this would probably be an insurmountable difficulty in many areas of the monument. Finally, another significant issue arising from the project is the cost. The budget for the trial section was £4000 for the construction of about 35m of path i.e. c. £114 per metre.

Following the assessment of the trial surfacing the working group has now agreed that this method is suitable for dealing with the sections of severe erosion where the national trail cannot be moved to a better route. Design work is now in progress in preparation for surfacing a further stretch of path adjacent to the trial area and the Devil’s Pulpit viewpoint itself. This will be carried out in conjunction with the implementation of a broader management plan (Hoyle 2000) for the large section of the dyke in Forest Enterprise land which will also address other issues such as the management of the woodland cover and the interpretation of the monument.

References

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The Pennine Way Research Project

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Introduction

The Pennine Way Research Project was set up in 1998. The core aim of the project is to maintain existing vegetation where possible and encourage the growth and persistence of new vegetation on any new ‘built’ path surface. The project is funded 100% by the Countryside Agency and supported by the three northern authorities on the Pennine Way; Durham County Council, Cumbria County Council and Northumberland National Park.

Most of the surface issues on the Pennine Way are related to the deep peat over which much of the National Trail passes. The vegetation associated with peat and the peat itself is very intolerant of trampling. The heather stems are brittle and the lack of structure in the peat allows the bare peat to wash away causing erosion scars and very unpleasant walking conditions. Not only does this cause visual intrusion but it also has an economic cost in terms of loss of grazing and a reduction in the quality of the visual amenity.

The serious erosion problems on the Pennine Way were first highlighted in the Countryside Commission Management Project report by Mollie Porter (Porter 1990). This was the first attempt to quantify the damage and extent of the work needed on the Pennine Way to restore it to a ‘long green trail’ as envisaged by Tom Stephenson in 1935.

A brief review of techniques used

Flagstones or slabs

The first and most widely known technique has been the use of re-cycled mill flooring flagstones from Yorkshire woollen and Lancashire cotton mills. These are laid directly onto the peat to form a hard and sustainable walking surface. Although effective, they can be unforgiving to the feet of walkers feet and can become monotonous if used for long stretches. The longest stretch of flagging on the Pennine Way is over Featherbed Moss in the Peak District National Park which stretches for nearly 4 km. The use of flagging has allowed the natural vegetation to recover exceptionally well reducing the path width in some areas from greater than 30 metres down to the width of the flag path. Some walkers have complained that the use of flagstones removes the navigational challenge on high moorland paths although previously they would have been able to follow the line of erosion. The listing of more old mill buildings is reducing the domestic supply. There are reports that some are being imported from India to meet demand. Alternatives are now needed (Plate 1).

Board walks

This is a technique that has traditionally been used to cross wet sensitive ground. There are various board walk designs with either linear ‘planks’ forming the walking surface supported on piers or the more usual planks laid across ruts supported by stobbs into the peat.

Board walks are an effective way of removing the pressure of recreational use from areas of fragile vegetation. They are visually very intrusive and, due to their wooden structure, can have a high maintenance cost. Without careful and frequent inspection they can quickly become a hazard to users if planks become loose or the structure slumps. They are a short term and expensive solution at best when it comes to long stretches of moorland path over deep peat.
The linear design, as can be seen on the Offa’s Dyke Path near World’s End in Denbighshire, will have a longer life span but still represents quite a visual intrusion in an open moorland setting. Many long stretches of board walk on the Pennine Way have now been replaced by flags (Plate 2).

Machine paths

The other widely used technique is the soil inversion path or machine (hymac) path. This aims to create a sustainable walking surface by using the mineral soils from beneath the peat. The new walking surface ‘floats’ on the peat and the extraction trench alongside the path acts as a drain. As the material used for the path is from local sources there are no problems of pH incompatibility and the stone extracted for the path surface soon blends in with other exposed rock local to the area.

The resulting surface has a ‘natural’ feel and does not require the importation of large quantities of material for its construction. The surface is built using one operator and one machine, this makes it the most cost effective technique currently available. The cost of a machine path can be as low as £8 per metre depending on access and peat depth on site. On some sections of the Pennine Bridleway the machine went down through 3 metres of peat to find suitable substrate for the path surface.

Other techniques

Many other approaches to moorland path design have been experimented with including the use of polystyrene as a raft for a floating path and chestnut fencing or palings as a walking surface. Neither of these techniques have proved to be of any use.

The need for vegetation on the Pennine Way

Vegetation is desirable on the path for two main reasons, firstly for practical management considerations. The action of water on a surface with loose material can be very destructive, however, if you can get vegetation to grow, the root system will hold the path together. The resulting resistance to water damage will reduce long-term management costs as surface material will remain on the path surface and not be washed away. The only factor that lets the machine path down is the difficulty experienced in getting vegetation to establish with success on the path surface.

The other consideration is more of an aesthetic one that ties in to the 1935 ‘Tom Stephenson’ aim of a long green trail. A green path is more pleasant to walk and looks more acceptable in an open landscape than a bare, eroded strip.

Getting the grass to grow and persist is the problem, most of the machine paths are at altitudes in excess of 1000 feet, as such they are exposed to harsh climatic conditions and consequently have a very short growing season. Add to this the fact that they are subjected to a high level of use in the middle of that short growing season and you can begin to appreciate some of the problems with getting the grass to grow (all this without mentioning sheep and farm ‘ATV’ traffic).
How to combat this problem?

There are physical, biological and chemical factors that will affect the surface vegetation of a machine path. When looking at a number of machine paths one can begin to see a pattern in the vegetation and the surface structure. It soon becomes clear that in order for vegetation to be able to establish the path surface must have at least two physical characteristics:

1. it must not become too compacted;
2. the vegetation must have some mechanical protection from the walker’s boot, the horse’s hoof or the bike or quad wheel (Plate 3).

These two do go hand in hand. The physical shelter afforded to the vegetation by the stone in the path surface also helps to prevent compaction in the root zone. This is vital for the health of the plant. There must be pore space in the soil or the plant root will not be able to function and survive. In a compacted anaerobic environment the plant root will die.

The root zone should also have healthy microbial activity. Without this microbial population the root will not function efficiently. One of the suspected problems with the sub-soil path is a lack of microbial life. As previously stated the material is brought from a depth of up to 3 metres below the surface, an anaerobic environment where no such organisms can survive.

Several approaches to the establishment of vegetation have been experimented with over the years. Various path managers in different parts of the country have undertaken their own trials but often without the time or resources necessary either to record their results properly or communicate them to other practitioners. There is now a large resource of anecdotal evidence on the best solutions to some of these problems. It is the anecdotal nature of these solutions that are being addressed by the Pennine Way Research Project.

In an attempt to address some of the issues raised above two sets of trial plots are now established and running in Northumberland and Cumbria. Early results indicate that with the right management and modifications to the path surface, vegetation can be established on the machine path with only a relatively low additional expenditure on top of the initial construction cost.

The seed mix used on machine paths

The choice of seed mix may be a crucial factor in the successful establishment of vegetation on the machine path surface. Many different Perennial Rye Grass cultivars have been tried in the past, not in any controlled manner but usually as a result of seed merchants not having the first choice cultivar in stock. Designers of schemes often ‘inherit’ seed mixes rather than scientifically arrive at them.

For the purpose of the project’s experimentation the following seed mix was used. There is a good opportunity to investigate other seed mixes on machine path work, however, to undertake this investigation is beyond the scope of the current research project.

The seed mix used

The seed mix used on the machine paths within the research project is designed to persist for only 5 years during which time local grasses should move into the sward. A point quadrat survey will be undertaken to analyse the extent to which this is happening on the project’s paths. There may well be a variation from plot to plot depending on the nutrient state of the substrate after the various treatments have been applied.

Components of the seed mix

(Basic seed mix as supplied by Rigby Taylor)

- 40% Mondial Perennial Rye Grass
- 19.5% Angrams Chewings Fescue
- 15% Crystal Hard Fescue
- 15% Sheep’s Fescue
- 7.5% Highland Browntop
- 1.5% Carmen Creeping Bent
- 1.5% Wavy Hair Grass

For a full explanation of the characteristics of the following grasses refer Hubbard (1980).
Perennial Rye Grass *Lolium perenne*
A loosely to densely tufted perennial, 10 - 90 cm high.
This grass has been cultivated in Britain for over 300 years. Over this time many different strains have been selected from short lived stemmy types to more persistent leafy types. It flowers from May to August.
Perennial Rye Grass is a valuable grazing and hay grass in lowland settings. It is prominent in old pasture and meadows. It has been extensively sown in the British Isles for the formation of new grazing, it can also be found on waste ground and as a roadside ‘verge’ grass.

Angrams Chewings Fescue *Festuca rubra*
A densely tufted perennial, 20-60 cm high, without rhizomes.
Widely sown in Britain as a lawn species. In a wild state it has been recorded in many English counties, especially in the south. It occurs on well drained chalky, gravelly or sandy soils. It is to be found in open grassland, road verges and waste ground.
Chewings Fescue is a drought resistant species which makes it particularly suitable for upland path work. Most of the seed for Chewings Fescue is now imported from the United States and mainland Europe. The name comes from Mr. Chewings who first sold the seed in New Zealand.

Crystal Hard Fescue *Festuca longifolia.*
A densely tufted perennial, 15-70 cm high, without rhizomes.
Probably introduced from Germany in the 1800’s. Used widely as an amenity species and sown on road verges and railway embankments, also sown as a lawn species. It is generally uncommon to rare. Flowering from May to June.
Another drought resistant fescue, Crystal Hard Fescue is now naturalised on well drained soils in central and southern England.

Sheep's Fescue *Festuca ovina*
A densely tufted perennial, 5-60 cm high, without rhizomes.
Widely distributed within the British Isles on poor thin soils. Sheep's Fescue can tolerate acidic or basic conditions. Often to be found in upland environments it can withstand heavy grazing and poor weather. Often the dominant grass at up to 4,000 feet.
Sheep's Fescue is another very drought resistant species, in flower from May to July. It has a low foliage yield but forms a vital food for upland stock.

Highland Browntop *Agrostis tenuis*
A densely tufted perennial, 10-70 cm high, with short rhizomes and stolons.
Common Bent is widely distributed throughout the British Isles. A lover of poor acidic soils, Common Bent will dominate grassland up to 4,000 feet. Another drought resistant species it will also cope with heavy wet clay soils.

Carmen Creeping Bent *Agrostis stolonifera*
A tufted perennial, 8-40 cm high, spreading by leafy stolons and forming a close turf.
This is a very variable grass species. Found in environments from salt marsh to upland swards at 2,500 feet. It is frequent to very common in the British Isles, flowering from July to August.

Wavy Hair Grass *Deschampsia flexuosa.*
A loosely to densely tufted perennial, 20-100 cm high. Sometimes with slender rhizomes.
A widespread grass in Britain occurring from Cornwall to 4,000 feet in Scotland. Mainly on sandy and peaty soils, it prefers dry conditions but can also be found in wetter areas. Abundant on moors and heath and in open woodland. It has also been used as a lawn grass on very acidic soils.
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A loosely to densely tufted perennial, 10 - 90 cm high.

This grass has been cultivated in Britain for over 300 years. Over this time many different strains have been selected from short lived stemmy types to more persistent leafy types. It flowers from May to August.

Perennial Rye Grass is a valuable grazing and hay grass in lowland settings. It is prominent in old pasture and meadows. It has been extensively sown in the British Isles for the formation of new grazing, it can also be found on waste ground and as a roadside 'verge' grass.

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Experimental sites

Three sites have been established at two locations; Padon Hill on the Pennine Way in Northumberland; the Pennine Bridleway at Kirby Stephen in Cumbria.

Some initial observations on path construction:

- seed and fertilise before compaction;
- hand finish surface to specification if needed so as to incorporate a wearing course;
- hand finish drainage where wet patches are likely and monitor closely to avoid slumping and wash out;
- fertilise twice a year and over seed each spring;
- incorporate some organic matter or topsoil.

The draw back with all of the above, especially the incorporation of organic material such as live mulch, are the additional costs involved. One of the key features of machine paths is their low cost, ease and speed of construction. By adding new elements into the construction the technique may become too costly. However, if one bears in mind the cost difference between machine paths and flag paths, there is some justification for additional expenditure during establishment so as to achieve better vegetation cover in the long run.

Measuring success in vegetation cover

At present the survey of Padon Hill shows an average vegetation cover of 15-20% based on a basic visual assessment of each section. Against this there has to be an agreed threshold where re-vegetation is considered to have been a success. At present such cover is set within a range, with 60% as the lowest acceptable and 100% as the ideal, a realistic figure to aim for will be around 70%. This figure may be revised after further consultation although it is the criterion used by both the Institute of Terrestrial Ecology and by the Three Peaks Project as a measure of success. It is unlikely that a figure in excess of 70% can be sustained through wet winters and dry summers.

Machine path treatments

The final design of the treatment plots was finalised in early March 1999 after consultation with the supervisory team in the Environment Department, University of Central Lancashire, who are supervising the research. The initial proposals were immediately judged to be too ambitious, the number of proposed treatments and the length of the plots would have produced far too much data. It was suggested that the treatment plots be limited to four.

Having reviewed the previous work undertaken on upland re-vegetation, composted seaweed was seen to be a potentially very useful way of adding both nutrient and organic material, as well as microbial activity, to the path surface. Composted seaweed is available as a product called Alginure. It is used extensively in the horticultural industry as a soil improver.

The list of machine path treatments is as follows:

1. Seed + Stone
2. Seed + Stone + Fertiliser
3. Seed + Stone + Alginure
4. Seed + Stone + Alginure + Fertiliser

The revised list of treatments is a lot simpler. The main aim of the trial plots is to assess the value of the addition of stone as a wearing course and that of adding Alginure and fertiliser. Each plot has two replicates and each is 4 metres long.

There are 12 plots plus 4 control plots making a total of 16 plots per path.

Each plot is separated by a 1 metre buffer, in total, 100 metres of each path is used for the trial plots.

100 metres of each path were identified with a poor surface strength as indicated by a lack of a wearing course, vegetation and with a clay dominated substrate. This coincides with a level section of path so as to avoid water borne cross contamination.
The Establishment of the machine path experimental plots

The work on each path took four days to complete. Labour was drawn from the relevant authority, the Northumberland National Park Authority field service and East Cumbria Countryside Project.

The stone to be used for the wearing course was bagged off site and bought in by trailer. This enabled it to be moved by Quad bike and trailer along the path with a minimum of handling or damage to the machine path surface. A total of three tonnes of stone was used on each path to cover 100 metres.

Implementation

The length of path, once identified, was broken down into plots using a tape measure and survey pins.

Each 4 metre plot has a yellow topped survey pin at the left hand corner, one pin being used for each plot. Each plot was then treated as per the set of treatments outlined above.

The treatments were laid out in a south to north order, reflecting the pattern of the majority of recreational use being from south to north. The fewer treatments per plot were located at the southern end of the set of plots to help avoid transfer contamination by walkers’ feet.

The surface of the plots were raked when wet with garden forks so as to break up the surface pan and provide a key for the various treatments and to allow the applications to penetrate into the substrate. The seed and the stone were the standard applications.

Application rates

- The seed was sown at a standard rate of 35g m².
- The Alginure was applied at a rate of 70g m² as recommended by the manufacturer.
- The Planting Plus (fertiliser) was spread at a rate of 35g m².

Once the applications had been applied according to the treatment plan, the stone was added as a top dressing. The stone was poured onto the centre walk-line of the path and spread to a uniform depth (one stone deep) by using garden rakes. Care was taken to not drag the surface treatments with the movement of the stone. With the stone now spread as an even layer on the path surface, the Whacker plate was used to ‘ram’ the stone into the machine path surface.

The work must be done when the path surface is thoroughly wet. The nature of the clay is such that if the surface was dry the stone would not be successfully incorporated into the path surface (Plate 4).

As the path surface was wet, the Whacker plate pumped the clay up to form a matrix of stone and soil. This has helped to fix the stone into the path surface.

After establishment of the experimental plots the paths were still open and subject to use from day one of the trials.

User levels

The passage of feet over the trial plots will need to be accurately recorded so as to assess the impact of trampling on the successful establishment of grasses in the path surface.

The usage levels will be monitored with automatic people counters of the sort used on other National Trails. These are a British Waterways design supplied by JT systems in Llangollen, which sense the passing of body heat. One of these units has been installed at each of the experimental plot locations.

Weather record

The weather conditions are an important factor in the growth and sustenance of a sward on machine paths. The temperature records will allow an assessment of the length of growing season required for establishment. A record of precipitation is also essential, if it is too high the surface becomes water logged and squirm and the clays cannot provide any mechanical protection for the young grasses. If it is too little and the grass desiccates and the clay within the path surface hardens to form a pan through which the young grasses will struggle to penetrate.
Weather stations have been installed to record rainfall, soil temperature and air temperature. These are electronic units that need downloading on a monthly basis. The data that they produce can be imported into MS Excel for analysis (Plate 5).

Conclusion

The machine path research work will be monitored over the next three years. This will provide the project with a large amount of data from which to draw conclusions on the re-vegetation of upland machine paths.

The findings produced by the Pennine Way Research Project will be drawn together in a publication designed to inform good management practice. This will be available as a Countryside Agency publication.

Other areas of research

Experimental path design.

In an attempt to reduce dependence on flags and other hard surfacing options where deep peat is encountered, this element of the research is looking to develop a fully vegetated engineered path surface that will sit on deep peat soils.

The design was arrived at after looking at the old miners' routes in the North Pennines. These paths appear to retain a full covering of vegetation whilst at the same time being able to withstand quite a high level of use from both walkers and cyclists.

The work on the development of the experimental path design is progressing well. There are initially two locations where the design has been tested. A location on Hadrian’s Wall Path National Trail at Cockmount Hill, within a Scheduled Monument Area, will follow later in 2001.

The two sites currently established are:

- Wark Forest, a non Pennine Way location;
- Upper Teesdale near to Low Force.

More details of this work will follow although if you would like any information relating to any areas of research outlined please contact me at the Countryside Agency, North West Regional Office.

Wark Forest

The first of these locations to be implemented was the Wark Forest site. The work was assisted by Forest Enterprise and the Northumberland County Council Forest Trails Project. Using the Forest Enterprise estate site for the experimental design provides a challenging set of ground conditions such as tree root plates and deep peat, in an absorptive environment.

The work within Wark cost £5,000 to complete and has provided the Forest Trails Project with a 300 metre stretch of 3 metre wide bridleway. This equates to a cost of £16 per metre.

Upper Teesdale

There are two locations in this area. The first section of experimental path will aim to use the experimental path idea in a slightly different way. The badly eroded river bank of the Tees is in a biological Site of Special Scientific Interest and is a candidate SAC. The work here will aim to raise the path surface back to its original height, covering exposed tree roots and outcrops of whin stone that have been exposed by on going erosion.

The second area of work in Upper Teesdale is further north past High Force. It is a 15 metre section of the ‘contract path’. At this point the path ascends a slight incline. The wet weather and poor design of the contract path have led to the migration of the whin stone aggregate down the slope leaving Geo-textile free to blow in the wind. This section will be excavated and re-built to the experimental design.
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Understanding the Dynamics of Physical Change on Historic Earthworks: Analysing Patterns of Long-Term Erosion on Offa’s Dyke

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Introduction

The great 8th century linear earthwork known as Offa’s Dyke, which runs for 129 km through the Welsh borders from Treuddyn (near Wrexham in north east Wales) to Sedbury Cliffs (on the Severn estuary in southern Gloucestershire), is Britain’s longest archaeological monument, and one of Europe’s most impressive ancient structures. The dyke typically consists of a massive earthwork bank associated with a deep western ditch, and is generally considered to have been built as a defensive barrier and territorial line between Offa’s kingdom of Mercia and the independent British (Welsh) Kingdoms then existing in what is now Wales. As it survives today, the combined geographical scale, archaeological sensitivity and modern landscape context of this remarkable monument presents a unique conservation challenge.

Much of the modern archaeological analysis of Offa’s Dyke and its significance is based on the work of Sir Cyril Fox, who undertook the first systematic field survey of the earthwork between 1925 and 1932 (Fox 1955). Although Fox was primarily interested in developing the academic understanding of the dyke, he was among the first to recognise the ongoing erosion threats to the monument, and saw the potential importance of his work as a record of what may disappear in the future. Fox was particularly aware of the increased scale of development pressures in the mid 20th century landscape, noting of the Welsh border dyke systems in general that ‘the overmastering need for extending arable and ley farming and . . . the power of the machines available for these purposes is likely to seriously reduce in height and breadth, or even completely remove, hundreds of yards of these earthworks ’ (Fox 1955, page xxi).

Half a century on the conservation problem has, if anything, become more difficult. The kinds of direct threats which Fox perceived, though still very real, are in some degree now managed through procedures such as Scheduled Monument designation and PPG16 (England) and Planning Guidance (Wales) provisions. Perhaps the greater worry today, on Offa’s Dyke as in the historic landscape in general, are more gradual processes of cumulative earthwork deterioration, which are typically the result of the complex interaction of a number of individually small scale causes. That situation is further complicated by the fact that specific archaeological management concerns at a given location are often more than matched by those of wider environmental and wildlife conservation on the same site, and by the strong emphasis on enabling full public access to this collective historic landscape resource (Berry and Brown 1995).

So a particular cause of physical erosion on Offa’s Dyke - such as walkers on the Offa’s Dyke Path National Trail, tree shading effects or agricultural activity - in another way represents part of the wider contemporary value of the earthwork.

Evolving lasting management solutions against this background requires a sophisticated understanding of how ancient earthworks interact with wider environmental processes, and how patterns of erosion on such monuments work in detail. It is probably the case that practical solutions do exist to most commonly encountered problems of earthwork damage (e.g. Berry and Brown 1994, and see papers in this volume). However, unless those solutions are founded on full comprehension of how erosion change in earthen structures actually happens in the first place, it is less clear that they will necessarily be the most sustainable long term management options, and the best way to resolve competing conservation aims.

Management issues on Offa’s Dyke

Offa’s Dyke occupies a rural and largely pastoral landscape. Of the 60 km of the dyke in Wales, 47% is in primary agricultural management (mainly improved pasture). Other landuses - woodland (18%), hedgerow (7%), other boundary (11%) and road/path (10%) - reflect the same countryside context, with only 7% in the built environment (Burnham 1992). The pattern is comparable on the English stretches of the monument (Leigh 1996), and throughout its length the dyke is a prominent and locally distinctive landmark often serving as a modern national, parish, ownership or field boundary. In addition, the Offa’s Dyke Path (one of Britain’s premier ‘National Trail’ long distance footpaths) directly follows 55 km of the earthwork. Much of the particular landscape character of the dyke as it now exists stems from its complex relationship to this modern setting.
The dyke’s preservation and condition varies greatly from a barely visible earthwork to a massive structure some 8 metres high from the base of the ditch to the top of the bank, and the dyke is now breached by many larger and smaller gaps. It is all too clear that the processes which have created this partially eroded and destroyed earthwork are not just historical phenomena. Recent research (Burnham 1992) to quantify the state of Offa’s Dyke in Wales found that 32% of the extant dyke was suffering ongoing deterioration, and that message has further been driven home by further qualitative condition surveys of the dyke in Montgomery and Radnorshire (Burnham 1997 and 1998). The picture is similar in England, with detailed analysis of the 15.2 km of surviving dyke in Gloucestershire revealing that 20% (by area) of the earthwork in the county is subject to active erosion processes (Hoyle and Vallender 1997).

The degradation of the dyke is the result of a range of specific processes. The principal issue is agricultural activity, which is calculated to have resulted in erosion (historical and recent) on 34% of the dyke in Wales (Burnham 1992). Other cumulative causes of damage noted in Wales - transport routes (12%), woodland management (6%), burrowing (7%) and development (8%) - appear less significant in terms of the percentage amount of dyke affected, but have been and continue to be very serious in local circumstances, as the Gloucestershire case in particular demonstrates (Hoyle and Vallender 1997, and see Wills this volume) and as survey linked to the Offa’s Dyke Path has also shown (Cutts 1998).

Offa’s Dyke as a dynamic earthwork

If the statistical picture outlined above defines something of the broad scope of the management problem which Offa’s Dyke presents, then it is the detailed appearance and character of the dyke earthworks which begins to reveal the real complexity of the conservation challenge.

At the most basic level, it is evident that the profile of even the best preserved sections of the dyke is as much shaped by 1200 years of erosion as by the efforts of the dyke builders (Plate 1). The ditch is everywhere at least partly in-filled, and the rampart is rounded and softened from what is presumed to have been the sharply defined and imposing appearance of the original structure. The faces of the bank typically show a complex of interlocking soil creep ridges, and larger slump features of uncertain age can often be observed in the re-stabilised shape of the earthwork.

It is apparent that, given enough time, these fundamental processes of change and weathering will – even without help from more immediate human pressures – eventually succeed in filling the ditch and levelling the bank, so reducing the dyke to a flat surface. Of course, ‘enough time’ is a very long time indeed, and there might not seem to be much useful insight to be gained here with respect to conservation of the monument within reasonably foreseeable human timescales; earthwork monuments at least four times older than Offa’s Dyke survive in the British landscape. Indeed, earthwork decay experiments have shown that newly created bank and ditch structures quite rapidly assume a stable condition of repose, and thereafter only change and erode at a very slow rate (Bell et al 1996). That conclusion too is borne out in the ditch fill stratigraphic sequences which have been recovered in archaeological excavation of Offa’s Dyke (e.g. Allen 1988) and many other comparable earthworks.

Yet even in the more immediate time frame of a notional ‘present’, it is clear that Offa’s Dyke is not a stable structure; it is a dynamic earthwork interacting with a range of processes in its surrounding environment, and it does so in ways which are often difficult to understand and predict. A good example would be the many thousands of ‘animal scrapes’ which exist along the pastoral sections of the dyke. These features are typically observed immediately beneath the cusp of the dyke bank, and consist of a vertical back
face, sometimes up to a metre deep, with a crescent shaped down slope eroded area beyond (Plate 2). At their worst they are a serious erosion problem destroying significant areas of the monument. While there is an evident association between scrapes and a combination of sward degeneration and mechanical erosion linked directly to trampling by grazing/sheltering animals - and therefore to the stocking levels and seasonal grazing patterns in place at a given location - such features would also seem to be influenced by a number of other factors. These include tree shading and root damage, drought effects on the dyke bank, exceptional climatic conditions, the local micro-environment of a particular site, and the added impact of other damage processes such as burrowing activity and walkers on the Offa’s Dyke National Trail. In some circumstances scrapes will re-vegetate and stabilise (Plate 3), and it is common to see various stages of this ‘life cycle’. Yet there is no certain pattern here; it seems that some scrapes may persist and enlarge, while others remain stable or disappear.

The same is true of many other kinds of erosion features and processes present on the dyke. Sections of the earthwork which have evidently recovered after significant incidents of past damage (Plate 4) are frequently observed, though it is equally usual, of course, to see areas where such ‘self-healing’ does not seem to be taking place. What is obviously important in conservation terms is to understand how those processes work, and what kind of timescales are relevant in managing their effects.

70 years of earthwork evolution on Offa’s Dyke

It is here that Sir Cyril Fox’s records and photographic archives are invaluable. The 45 published photographs of the earthwork (and a further 13 photographs of the nearby Wat’s Dyke) offer a 70 year old fixed point photographic survey of the dyke allowing, by comparison with the state of the monument as it now survives at the same locations, a direct insight into the development of the earthwork over that time.

The first thing to note on Fox’s photographs (Plates 5, 7, 9 and 11) is simply that they nearly all show a range of active erosion processes closely similar to those acting on the dyke today. This is no great surprise - Offa’s Dyke must have been subject to damage and erosion almost since the moment of its completion - but it does emphasise the point that the contemporary threats the dyke faces are not just a consequence of recent changes in land management patterns, significant though those have unquestionably been (Burnham 1992).
What is most striking in the comparison of Fox’s archive with the present state of the earthwork is actually how little some parts of the monument have changed in the last 70 years. Plates 5 and 6 offer a typical example, showing a well preserved length of dyke bank and ditch near the Kerry Ridgeway, which survives in 2000 much as it did in 1929, and also retains the same improved grassland management regime. The 1929 photograph shows commonplace erosion features, including lateral scars beneath the crest of the bank, and an animal scrape on the end of the rampart adjacent to the later entranceway. These features are easy enough to explain in general terms as a combination of root damage caused by the mature hedgerow which surmounts the bank, degradation of the sward as a consequence of shading and soil compaction, direct mechanical erosion by animal trampling, and additional background weathering and soil creep effects. The assumption would be that, left without positive remedial management, the damage would have got worse over the last 70 years, causing accelerated deterioration of this stretch of dyke. In fact, the most obvious visual difference today is that the hedgerow has matured to leave fewer trees on the monument. Almost exactly the same patterns of erosion are present on the earthwork, and in so far as can be superficially judged have not dramatically increased in scale, nor led to observable new loss in dyke fabric.

This counter intuitive state of affairs sometimes holds true even where the dyke is found in what might seem potentially less stable management contexts. Plate 7 shows the dyke as photographed by Fox in Mellington Woods, where the earthwork exists in mixed broadleaf woodland of 19th century origin. Bare surfaces are everywhere visible, the dyke ditch is subject to ongoing weathering by the stream which runs in the base of it, and tree cover on the earthworks poses ongoing root damage and wind-throw threats. Erosion beneath the root plate of a tree on the terminus of the secondary earthwork which adjoins the main dyke at this point appears particularly damaging, with the potential for the tree to fall and carry a large piece of bank fabric with it. It is, then, interesting to discover that the same earthworks viewed 70 years later (Plate 8) actually illustrate remarkable stability. The now somewhat larger tree is still in place, with comparable erosion around the root plate and the bank surfaces even show better ground flora cover than existed in Fox’s time. Of course, some amount of decay will have taken place since Fox’s photograph. For example, uncontrolled under-storey regeneration is now very much in evidence compared to the more managed appearance of the pre-war woodland, and this must be linked to increasing root damage of sub-surface archaeological horizons.

In many cases, the fate of the monument has not been so good, and very clear degradation in the condition of the dyke over the last 70 years is apparent. Yet even here, the
complexity of the erosion systems at work is emphasised, and the patterns of change are not necessarily those one might have predicted from the state of the earthwork as seen by Fox. Plate 9 shows a well preserved section of the dyke rampart, with significant badger burrowing activity when recorded in 1929. The same site today (Plate 10) clearly reveals loss in height and change in profile of the dyke in the vicinity of the old sett, representing collapse of internal burrows and the spread and subsidence of bank material. However, the dyke has survived as a tangible earthwork in this area. At some point the burrowing has stopped, the shrubs have been removed, and the site has re-vegetated and stabilised. A new focus of erosion in 2000 is under the large tree on the crest of the dyke. This situation can be linked to a number of now familiar circumstances; tree shading, soil compaction, and probably poor moisture retention on the bank top all contributing to the initial deterioration of the sward, with those processes exacerbated by domestic animal trampling and general weathering. It may be that the significant growth of the tree is one of the reasons why this new problem has come into being since Fox’s visit.

In some places, notable shifts in land-use have occurred since the 1920s. In 1928 the fine stretch of bank at Ruabon (Plate 11) was contained in a pocket of improved pasture in a predominantly industrial area, with an access track running along the base of the dyke ditch. Today (Plate 12), the heavy industry is long gone, and the dyke now occupies an unmanaged corridor with woodland re-generation in progress. In some ways the change has been beneficial for the monument. Erosion features such as the bare area down-slope from the old tree stump have now disappeared, and it is possible to make a close comparison between the profile of the dyke in 2000 and its condition 72 years earlier. On the other hand, tree growth poses erosion dangers of its own, and the dyke is now lost as an immediately visible feature.

At other locations recorded by Fox which have subsequently developed tree and shrub cover (e.g., Fox 1955, plate XIXb, not reproduced here), visible new damage to the dyke is often not so much linked the presence of woody vegetation in itself, as it is to ancillary erosion effects such as increased burrowing activity and the congregation of domestic animals in such areas. Similarly, where deliberate woodland creation has occurred on or in the vicinity of the earthwork (e.g., Fox 1955, plate XXa, not reproduced here), it would seem to be woodland management procedures which have been more obviously detrimental than the actual trees themselves, although that partly reflects the degree to which the serious consequence of root damage to buried archaeological deposits may not be immediately apparent on the surface of the monument.

Interpreting long-term erosion patterns

Fox’s photographic archive only covers a tiny percentage of Offa’s Dyke, and the contrast with the condition of the dyke today in any case offers no understanding of exactly why particular parts of the earthwork have or have not altered in the last 70 years. Nonetheless, the patterns which emerge are collectively instructive.

Perhaps the most obvious insight is simply the comparatively small amount of change which has impacted on some parts of the monument despite their continuing context in the actively managed landscape, and despite the presence of some ‘active’ erosion features on the earthwork. Plainly, this should not be taken to mean that the dyke will somehow look after itself indefinitely, and the more general incidence of significant deterioration in the dyke as a whole since Fox’s time cannot be disputed. But what it does demonstrate is that the processes which are contributing to that deterioration are more complicated than they may first appear. Not every erosion feature will become a major erosion problem, and in this sense erosion and weathering are part of the dynamic nature of the monument, and indeed part of the very historical character of the dyke.
The development of the dyke over the last 70 years also emphasises that, while it is possible to make general judgments about the causes of ongoing damage to the dyke, it is much more difficult to accurately predict how the monument viewed at a given point in time will then alter in the future, even given little alteration in surrounding land management systems.

Of course, it would also be wrong to somehow use this evidence to make the conservation challenges faced on a monument such as Offa's Dyke seem even more complicated than they already are. There are many sites on the earthwork today suffering severe and rapidly advancing erosion where major management intervention and repair is unequivocally and immediately necessary (see Wills this volume) without too much need to pause and consider whether such work may somehow be appropriate. If Fox's archive throws up some questions regarding our understanding of the conservation problem on Offa's Dyke, it also directly affirms many assumptions about the kinds of change which will certainly be detrimental to the monument. For example, radical transformation in the land management regime incorporating the dyke has in almost all cases led to observable deterioration, and deliberate woodland creation has been a particular culprit here. Similarly, there is no way to escape the commonsense fact that repeated mechanical erosion processes – such as animal burrowing or the action of human feet – will, even in short timescales, significantly erode the monument.

Re-phrasing approaches to earthwork management?

How does this 70 year perspective on patterns of earthwork change on Offa's Dyke inform the way in which conservation approaches to this and other ancient earthworks should be developed?

At the most basic level, a clear message is that heritage managers must engage in a properly sophisticated way with the erosion processes which act on ancient monuments. That requires an understanding that historic earthworks are, by their very nature, dynamic features. A structure such as Offa's Dyke will change with time, and it is a fundamental part of its character and relationship to the historic and contemporary landscape that this is so. Ancient monuments are living parts of an integrated modern environment, not just fossilised elements of a static 'historic landscape'.

In this sense, it is evident that the function of earthwork management should not be to prevent change per-se; it should rather be to manage the processes which are acting on a particular monument in the most effective way to secure the long term survival of that structure. That may mean, in practice, that a minimum intervention conservation strategy, doing no more than maintaining an existing land management regime, will sometimes be the right approach even where apparently 'active' erosion is ongoing. Management should not be too precious with the archaeological resource. What survives from the past made it to the present time without any help from modern conservationists, and in some circumstances it may be able to similarly survive into the future with less help than contemporary managers might tend to assume.

It also follows that if some degree of change in the fabric of the historic landscape is inevitable, then it is crucial to record as completely and accurately as possible the state of ancient structures as they now exist. Offa's Dyke is a major national monument, but only a tiny percentage of it has been recorded either photographically, or at the level of measured survey and detailed recording of its micro-profile. This means that any perceived loss is absolute, with no way of establishing what that loss really represents. An emphasis on recording should be seen as a legitimate and integral part of monument management projects, not a tacit admission that conservation is in some way failing, or likely to fail in the future.

Aside from recording what survives today, then the apparent unpredictability of erosion change indicates that it is equally important that effective monitoring of the ongoing condition of the monument is developed as a core element of the management process. Only with good monitoring information will it be possible to effectively identify and target the most vulnerable sites, and determine if subsequent management has been successful. The development of Offa's Dyke over the last 70 years would suggest that it is how and if a site changes - not the superficial nature of its current condition - which is significant in making such judgments.

Plainly, agreed parameters of change must be at the core of the management process. What is not implied by focusing on the dynamic nature of ancient earthworks is a tacit acceptance that sustained loss of archaeological fabric on a monument such as Offa's Dyke is somehow acceptable. The notion of setting 'limits of acceptable change' is one widely current in modern heritage conservation thinking (see McGlade, this volume), and offers a way of making explicit judgments about the degree of alteration which may occur before particular management intervention is deemed appropriate. The decisions here will not necessarily be easy ones, and will involve mediation between different management objectives as well as relative assessment of purely archaeological values. Indeed, it may be that
no change is the limit – although, as Offa’s Dyke indicates, achieving that outcome most effectively will still involve working with the dynamic processes which mould the continuing evolution of earthworks and landscapes.

Underlying all of this is the fundamental need to be explicit about what the management objectives actually are, and to be clear about the timescales those objectives will be achieved within. There is no final solution to the problem of conserving Offa’s Dyke which will simply ensure that it is there for ever. Management is influenced by the historical context in which it is developed as well as by the physical problems conservation nominally seeks to resolve, and present aims may not even fit comfortably with the real nature of the physical processes which ultimately shape ancient monuments. What is important is that there is a stated objective for current management efforts, and that in our own timescales and terms, it is clear how and when that end will be reached.

Conclusions

The conservation insight which a long term analysis of change in ancient earthworks such as Offa’s Dyke suggests is ultimately a simple one; effective and sustainable management approaches must be similarly long term in design and execution, and based as much on regular monitoring and small scale intervention, as on large scale restoration and stabilisation works. The challenge which emerges here is perhaps more organisational than practical, requiring the realisation of management systems which extend beyond the constraints of the short term funding packages and particular project schemes which provide the immediate framework for most conservation initiatives. There will be no easy way to achieve this, and perhaps the message is that ‘sustainability’ – and the no less often quoted ideas of ‘partnership’ and ‘public involvement’ which go with it – really do need to be grasped as developed components of the management process.

How such an approach will be realised on Offa’s Dyke itself is still very much part of the development work underway within the auspices of the present Cadw: Welsh Historic Monuments and English Heritage funded ‘Offa’s Dyke Initiative’ (Bapty 2000). The aim must be that a future comparison of the Dyke 70 years from now will not only find the physical condition of the monument little changed from that in the year 2000, but will also be able to draw on a very much more detailed resource of information within which to make such an assessment.

Acknowledgements

Sir Cyril Fox's photographs are reproduced by kind permission of the Cambrian Archaeological Association and the National Museum of Wales.

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