

The Effect of Limestone Aggregate Paths on Peat in the Yorkshire Dales

1. Purpose of this Report

The purpose of this report is to provide a technical background document to support the use of limestone in the construction of an engineered bridleway (the Pennine Bridleway) over peat. This is in response to a number of questions that have been raised as part of the Pennine Bridleway applications to create new bridleways at Garsdale and Selside by floating a limestone aggregate path over peat at these sites.

It is recognised that a floated aggregate path, is only one type of construction method available, but it is the most appropriate at these locations given the various site factors¹.

2. Introduction

The Authority is delegated Highway Authority on behalf of the county councils. Most of the rights of way engineering work undertaken by the Authority is part of its duties to maintain and improve the 'highway' under the Highways Act and is permitted development. However where a new path is engineered, ahead of a right of way being 'created' then this does require planning permission.

Paths over extensive areas of peat create a number of challenges – particularly if it is a new creation. The need to create the path has to be weighed up against the effect on biodiversity and the visual impact a path will have. Finding an appropriate path surface that blends sympathetically with this environment can be difficult. Peat is waterlogged organic matter with a very delicate hydrology, by definition there is little visible stone or naturally occurring 'aggregate' within it, so material to create the path must be 'imported'. This means the path material will be 'alien' even if it comes from bedrock present only 1 to 2 metres beneath the peat, or outcropping in the locality. Yet without this type of intervention, peat can withstand only light use and is quickly damaged. This is the dilemma that faces the Pennine Bridleway in creating a route in this environment.

About this report

The need for this report has come about following the Authority's recent planning decision no R/48/134A. Where grounds for refusal were stated to include:

'the use of limestone aggregate in the construction of the track across non-limestone areas would be inappropriate in terms of its visual appearance and its impact on the acid ground conditions'.

To this end the report looks at the geology, ecology, chemistry and soil science as well as the landscape impact, behind the use of limestone on peat and it questions the premise by

¹ For a full discussion of available options including stone flagging of footpaths on peat, or inverted paths please see Davies and Loxham (1996) and BTCV footpath handbook on line

some that limestone shouldn't be used on peat for path maintenance or creation. In summary it will show that:

- The geology of the Yorkshire Dales means that, areas of limestone outcrop within areas of peat, and/or limestone rich groundwater in the form of springs are often found within peat;
- Whilst limestone is alkaline and peat in the uplands usually acid, the quantity of limestone introduced through path construction in relation to the amount of hydrogen ions present in the peat means that any pH change within the soil will be minimal;
- In addition the weathering of limestone, that is dissolving of the limestone into solution through contact with the hydrogen ions in groundwater or surrounding soil (which leads to breakdown of the limestone releasing calcium and bicarbonate) is a slow and complex process;
- The construction of aggregate paths across peat does change the hydrology of the peat, but this is the primary purpose of path maintenance and construction - to dry out wet areas, so that they provide a suitable surface for their intended use and prevent users trampling a wider area with the inevitable deterioration in biodiversity and visual impact this creates beyond the linear route of the path.
- The main factors determining the species composition of the vegetation cover that becomes established on a path after construction or maintenance, is (a) the seed bank present and (b) secondary treatment in the way of seeding and soiling (c) whether this vegetation is resistance to trampling.




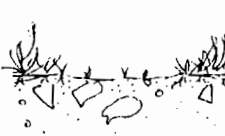
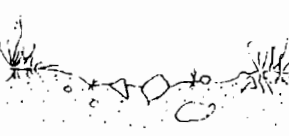
Before looking at these findings in more detail, it is necessary to understand the principles of path erosion and best practice in terms of path construction and maintenance over peat. The Yorkshire Dales, in the mid-80s, had some of the worst path erosion in peat environments in the country. The then National Park Committee set up the Three Peaks Project, a partnership with the Countryside Agency and Nature Conservancy Council to tackle this problem, and the Institute of Terrestrial Ecology (ITE) to research and monitor the outcomes (see appendix 1). A large body of knowledge was built up that has since helped develop 'best practice' elsewhere in the country.

3. Some Principles

Path erosion

Soils vary greatly in their resistance to wear. Surfaces with a high proportion of coarse particles (rocks or stones) are generally least affected by recreational use, and clay and peat soils most affected in that they show the greatest erosion of soil material and changes in soil structure. Most soils have lower resistance to wear under wet ground conditions because water acts as a lubricant, displaces any air pockets, and allows soil particles to rub together and soil compaction occurs.

Peat is extremely vulnerable to damage as a direct result of its water content and low structural resistance, and the peat surface is held together by the vegetation growing upon it. This vegetation is particularly sensitive to trampling, and is quickly lost through low levels of use. In addition the trodden areas often become wider over time, as users seek to avoid particularly waterlogged sections along the original path, leading to further loss of vegetation over a wide area.

Use	Unused	Very light use	Light use	Moderate use	Heavy use
					
Vegetation impacts	None	Reduced height along route	Reduced species diversity Invasion by trample resistant species	Low plant cover on path. Few species remaining	No vegetation on path Bare zone gets wider
Soil impacts		Slight soil compaction	Comminution of plant litter. Moderate compaction	Loss of plant litter Severe compaction/structural damage	Erosion of surface and exposure of subsoil

Source: Bayfield and Aitken (1992)

The factors that influence path deterioration are many, and include soil and vegetation characteristics and type as well as intensity of use, as shown opposite.

How to minimise erosion?

Research undertaken (Bayfield and Aitken, 1992), shows that for minimal path deterioration the path surface needs to be dry, smooth and steep slopes avoided where possible. Bayfield advocates planning ahead, rather than a 'stitch in time', that is designing and constructing a path so that it has minimal potential for erosion, rather than wait for erosion to occur and then undertake emergency repairs after the damage has already been done, and may be harder to control.

For example in implementing the Pennine Bridleway across the Yorkshire Dales there are two approaches available:

1. Engineer a route before opening the route that will have minimal future erosion and require relatively little maintenance. This means capital costs are met at start up (100% grant from Natural England), and planning permission for engineering works is required (as the legal right of way created is first dependent on the path being physically created). Over peat soils this means engineering a grass/gravel path (suitable for bridleway use) with some loss of biodiversity along the linear strip; or
2. Open the route, without undertaking any engineering work, and see if it deteriorates which based on experience means possible loss of biodiversity, over a wider area than the width of the path itself. Then find the money (75% grant from Natural England 25% Authority) to maintain the route, which over peat will mean using an engineered solution to create a grass/gravel track. In this context it is important to remember that eroded peat that has lost its vegetation cover has no biodiversity and also oxidises readily releasing carbon dioxide into the atmosphere. Undertaking engineer work at this stage does not require planning permission as the route is already legally created and the work falls within the Authority's delegated statutory Highway Authority duties.

1. is good practice, to plan ahead and get planning permission to engineer the route.

Path construction – what are the established techniques?

Path erosion has been the subject of detailed study since the 1970s, when increased leisure time, and encouragement of recreation in the countryside lead to the phenomenon. Experimentation in path construction and maintenance techniques followed and the Three Peaks Project lead the way in establishing techniques that are now widely accepted and used in other National Parks.

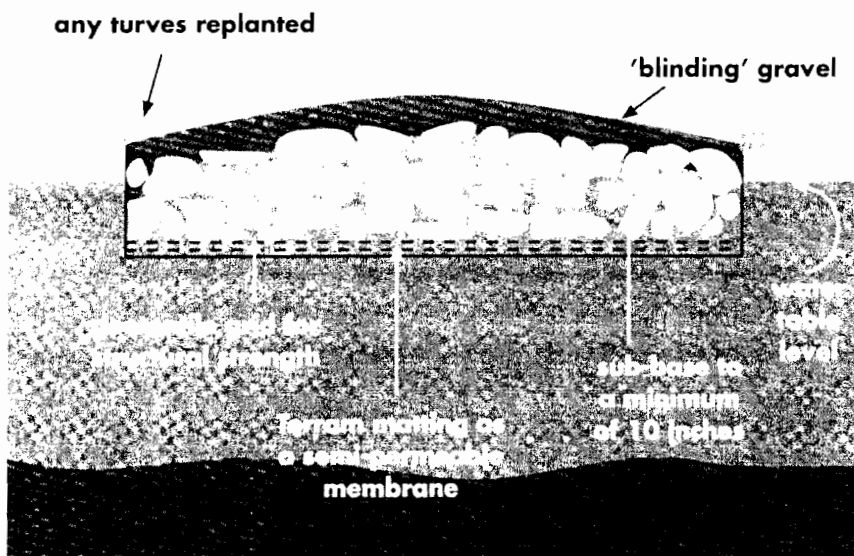
Constructed paths typically have three layers: sub-base, base and surfacing. Whether or not all three layers are needed will depend on the natural sub-grade, drainage, expected use, and the type of material being used to make the path. The type of material used is:

- 'Soft' stone, such as limestone, which shatters when crushed and binds to form an almost solid surface. (NB Hard, angular stone should be avoided if possible as it is difficult to bind together).
- Stone with clay or minute particles called 'fines', which bind when rolled and set to form an almost solid surface.
- Material without fines, which should be graded and laid in layers. .

If material without fines, is simply thrown in together, or a hard angular stone is used, a structurally weak and uneven surface will result that doesn't bind, and vegetation will fail to establish because the movement of the stones damages the plants trying to grow.

The base is the main load-bearing part of the path, and usually comprises the bulk of the material used in construction. 'Cut and fill' is common where the simple excavation of a path eg thin layer of peat or soil (A and B horizons) leads to a firm sub-base, and this 'cut' is then filled in with appropriate aggregate material.

Cross section of a floated aggregate path over peat



(Source: Davies and Loxham 1996)

Over very soft ground such as deep peat, geotextiles membranes used in civil engineering, are often used for the sub-base. The geogrid and aggregate in effect float

over the structurally weak peat, creating a 'raft path'. An aggregate path laid directly on soft ground will soon fail, as the stone gets 'punched' down into the sub-grade, and fine material from the sub-grade is 'pumped' upwards by the action of passing users creating a mud or bog bath. The geotextile keeps the aggregate separate from the peat, and by keeping the aggregate all together, gives structural strength to the path without the need for a thick supporting base layer (see diagram above).

Geotextile fabrics are permeable, the permeability dependent on the exact material used. High permeability is needed on wetter ground to allow ground water to move upwards, preventing the path from moving under pressure from water below. The exact type of geotextile chosen depends on the load bearing capability of the ground, and the maximum loading the path will have to take. In nearly all cases the maximum loading will be exerted by vehicles used during construction, (see photos below during construction along the right of way at Newby Head) and not by its end use, in this case a bridleway.

Floating a limestone aggregate path over peat - an example at Newby Head



Geotextile rolled out over the moor, aggregate is then placed over it. A drainage ditch is created alongside, turfs removed are placed along the edges of the geotextile to blend it into the surroundings. NB Tracked vehicles are used during construction to minimise pressure on, and compaction of the peat below.



The path appears 'raw' until the limestone aggregate weathers and the grass sward becomes established. NB visual impact of the path is minimised, as far as possible, by careful positioning within the landscape, and avoidance of straight lines through the introduction of curves.

A stable path soon re-vegetates (note green edges of path shortly after completion). The limestone aggregate above has peat mixed in it. Re-vegetation is also encouraged through seeding the path with an appropriate native grass seed mix. Trials were undertaken by the Three Peaks Projects in the 1980s on similar aggregate floated paths to find the best methods. (See appendix 1 for more information about these trails and Appendix 2 for list of species that usually colonise after path construction). Many factors including altitude, aspect, and amount of rainfall affect the rate of re-vegetation.

An example of maintaining a damaged path - the 'Highway' - Wensleydale



User damage to the peat surface of the right of way creates pools of standing water and loss of vegetation over a widening area, as users seek to avoid these wet areas.



As part of the maintenance aggregate is imported to the site, and the track surface raised above the surrounding water table. Note also drainage ditch on left

Track is seeded with a native seed mix to encourage vegetation to re-establish.



Two years later the aggregate surface has almost disappeared and the path narrowed through the colonisation of native grass species, and encroachment of soft rushes along the edges of the track and drainage ditch.

The finished surface is ideally a trample resistant, well established, grass sward of native species in keeping with the surrounding habitat, which is comfortable to walk/ride on, and free draining (so usually has a slightly raised surface, to shed water, and/or ditch alongside). The end result should be users preferring to keep to the path in preference to trampling the surrounding vegetation.

Type of Aggregate

In practice there are sources of two types of stone in the area:

- Carboniferous limestone available from Swinden, Horton, Leyburn, Wensley or Pateley Bridge (Greenhow). (Giggleswick quarry will close in the next month or so). This is theoretically available in light to very dark grey, although that may depend on which part of the quarry is being worked.
- Lower Palaeozoic greywackes and siltstones (also referred to as gritstone) available from Arcow, Dry Rigg, Ingleton and Roan Edge. These are more consistently dark grey and neutral pH.

There are no commercial source of reasonable quantities of Carboniferous sandstone without travelling much further a field.

The strength and binding properties of limestone, together with the locally available variation in colour (pale to dark grey) which weather well, make it a superior material to any other, particularly as a base material for rights of way work in the Yorkshire Dales. Unlike other rock types such as sandstone and shales, limestone has the ability to dissolve in water yet retain mechanical strength. This contrasts with porous rock type such as sandstone that absorb water, then become friable, losing their strength so if used require more ongoing maintenance than limestone. Whilst harder metamorphic rocks also maintain their strength when wet, they can be difficult to bind to form a stable surface, and therefore re-vegetation can be problematic.

In selecting a suitable aggregate for peat paths it is noted that the 'Repairing upland path erosion best practice manual' stated guidelines include:

- Aggregates for surfacing should be locally derived and unsorted/ungraded where possible;
- imported aggregates should match locally derived material in colour, texture, mixture of fragment size and shape and geological origin;
- imported aggregates must be geologically inert and have no potential adverse effects on the pH or nutrient balance of adjacent ground...

Elsewhere it states in an example 'not limestone chippings in acidic habitats'. Similarly The BTCV online footpath handbook states: 'limestone aggregates should not be used on acidic soils as water leaching through it may locally raise the pH and alter the flora'.

It is significant that this uses the word 'may' locally raise the pH and alter the flora, as in relation to using limestone on peat in the Dales, this appears to be a 'perceived' wisdom. To date, no research can be found to supports this statement. It would appear to be based on the fact that limestone is alkaline and dissolves in acid water, but without any

actual consideration of the rate or chemical reaction that actually occurs (see section 4 below).

Significantly no reference could be found to the effect of aggregate type in the available ITE Three Peaks Project reports. Though a review called 'managing the impacts of recreation on vegetation and soils' produced by Bayfield and Aitken in 1992, for the then Countryside Commission, and English Nature amongst others has a section on 'floated' aggregate paths on soft ground or peat. The report states:

The long term performance of floated paths has so far only received limited monitoring although many paths have now been laid apparently successfully, in difficult conditions on soft peat and clay.

The Review then illustrates this point in fig 7.2, which has the caption:

'building a 2.5m wide limestone aggregate path on a geogrid over deep peat at Ribbleshead (Yorkshire Dales)'.

It is suggested that use of limestone on peat was already accepted practice, and did not need further comment.

4. Factors that could influence vegetation establishment on paths in the Yorkshire Dales

The main factors, based on observation, that have been found to influence the type of vegetation that is established, in the Yorkshire Dales, following engineering work on peat, are the native species present in the seed bank adjacent to the path, and whether these are resistance to trampling, and prefer the drier hydrological regime that path repair work inevitably creates. Aggregate paths created over 20 years ago, by placing limestone aggregate on top of peat have not been found to have any different vegetation on and alongside the path to that in the surrounding wider area. This isn't surprising when the geology of the area, and chemistry of limestone solution are considered.

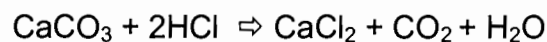
Geology and Soil Type

The solid geology of the National Park is a combination of limestone, sandstones, shales and gritstones, with glacial till. In all areas of the Park limestone and shales outcrop in differing measures, with the Great Scar limestone being most obvious towards the south of the Park, and gritstone outcropping east and further south still. The Three Peaks and central moors and fells are dominated by rocks of the Yoredale Series, a cyclic sequence of limestones, shales and sandstones lying over 300m deep above the Great Scar Limestone. This is characterised by alternating bands of soft shale with harder sandstones and limestones. Where the Yoredale Series rocks have been eroded away the Great Scar Limestone becomes exposed. The northern moors and fells are characterised by millstone grit overlaying the Yoredale Series rocks. Here the limestones are set far apart with thick intervening shales and sandstones. The Yoredale limestones form small pockets of limestone scenery within the surrounding mass of sandstones and shales, with occasional scars and scree slopes.

In summary this means that most areas of the Park have a mosaic of limestone and sandstone/shales within relatively small distances, and rock type can change markedly along a path as it passes between the valley bottom and on to the surrounding fells.

Chemistry of limestone solution

Limestone (CaCO_3 , the primary constituent) is an alkaline agent with the ability to partially neutralize strong acids eg hydrochloric acid. The neutralization process occurs when strong acids, in contact with the limestone, form water, carbon dioxide and calcium salts:



calcium carbonate + hydrochloric acid yields calcium chloride carbon dioxide and water

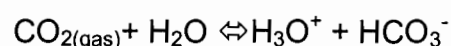
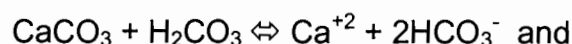
In this scenario, because of the liberation of CO_2 , (resulting in the formation of carbonic acid) limestone does not have the ability to raise the pH of the solution above 7.0. A high surface area is also important, as is sufficiently long contact time, as the reaction is not instantaneous.

Limestone solution (weathering) in the natural environment is a more complex process than a simple equation of acids in the soil/peat releasing calcium bicarbonate or other salts – a number of equilibria have to be maintained including that between CO_2 dissolved in the water and in the soil atmosphere.

$\text{CO}_{2(\text{gas})} + \text{H}_2\text{O} \Leftrightarrow \text{H}_2\text{CO}_3$ (carbonic acid) or more correctly, carbonic acid dissociates with water to become $\text{H}_3\text{O}^+ + \text{HCO}_3^-$.

Carbonic acid is a weak acid and the expected acidity of rainwater is pH 5.4. Additional acidity comes from organic activity in the soils. As micro-organisms metabolise organic materials, they form CO_2 as a by product of metabolism (this assumes oxygen is available to support metabolism). CO_2 can also be produced by inorganic oxidation of organic materials. As a result partial pressure of CO_2 in those environments can be high. As rainwater infiltrates the soil, it reacts with this soil CO_2 and the pH decreases again. In addition, there are dissolved organic acids in the soil (e.g. phenolic acid) which also contribute to acidity. The end result of all of these acid producing reactions is that the pH of water in the soil can be between 3 and 5.

When the acidic water reaches limestone, the following reaction takes place:



This yields hydronium ion, the source of acidity², and bicarbonate ion. As the hydronium ions are “used up” in the reaction, the carbonates dissolve away and the pH can rise to between 7 and 7.5. This leaves a void where the carbonate molecules used to be and the more insoluble (non-carbonate) salts are left as a residue.

² See <http://en.wikipedia.org/wiki/Hydronium> for further explanation of this concept

Limestone solution is a very slow process. Limestone solution rates have been estimated at 50mm per 1000 years (Sparks, 1979) and that the solution of limestone varies with pressure and temperature because these effect the amount of dissolved carbon dioxide present. This slowness is a result of a number of factors not least salts coating the limestone surface preventing further reaction of the CaCO_3 with any acid present.

To put this into context it means a piece of limestone aggregate of approx 150mm diameter, (used in path construction), could take 3000 years to weather (dissolve) away as a result of the acid environment in which it sits acting upon it.

Soil pH

Soil pH is dependent on the interaction of mineral type, climate and vegetation, and under natural condition plants have adapted and evolved to the prevailing soil pH. In the Dales loamy, often shallow, free draining neutral or alkaline soils are found over limestone with a characteristic grass sward. Whilst peaty, poorly drained acidic soils occur primarily (with the exception of drift deposits over limestone) over sandstones and gritstones and are typically ericaceous species such as heather with sphagnum in wet areas.

It has been suggested above that adding limestone to peat, eg a limestone track across a peat moorland will have an adverse effects on the soil pH and therefore the vegetation adjacent to the route. This is based of the premise that the weathering of the limestone will release sufficient HCO_3^- anions to neutralise the H^+ or Al^{3+} cations present in the peat and thereby raise the pH, as a direct result the surrounding ericaceous vegetation will be replaced by lime loving plants uncharacteristic of the surrounding flora.

Where paths have been constructed over peat the volume of limestone present at any one point is small, compared to the surrounding volume of peat. In addition the size of the limestone aggregate will vary from 150 mm down to dust, but the surface area of limestone taken as a whole being acted upon by the available acid ground water is small, and the process slower compared to say 'liming', when ground calcium carbonate is applied in powder form to raise the pH of acid soils. (It is this practice that may have lead to the general premise mentioned above?)

Biodiversity

There is a negative physical impact on biodiversity from a new path across peat land (effectively the function of the peat is lost under the path) regardless of material used. Where this crosses acid grassland the impact on the biodiversity is low but if it crosses dwarf-shrub heath or blanket bog it is a net loss of high quality habitat along the line of the path. This loss of biodiversity should be 'factored' in as part of the decision making process when planning new paths. However, it is important to note that where an existing path across peat is badly eroded there are generally positive biodiversity benefits of a new surface as it invariably reduces the width of the eroding area allowing vegetation either side of the path to recover - again regardless of path materials.

In the Dales some of the areas richest biodiversity are found where spring lines supplying water, rich in calcium and other basic minerals from the underlying limestone geology,

come to the surface through an area of peat. This can create a species rich alkaline flush within an area of acid grassland or moorland where no limestone outcrop may be visible.

This phenomenon of the local geology aside, it is important to recognise that in areas of heather or sphagnum the re-established vegetation is likely to appear different to that present before any erosion of the route or engineering work occurred. Unlike acid grassland, these vegetation types cannot withstand anything other than light trampling, or grazing pressure. Grasses, and soft rushes, usually present within this moorland habitat are less obvious, but do withstand trampling so it is these species that tend to dominate along the path after repair/construction work (see appendix 3).

In addition peat's amorphous structure has very sensitive hydrology and its fragile soil capillaries and pipe structures within it are easily damaged and compressed through trampling. This changes the hydrology and creates standing pools of water (see Highway example above). A right of way across peat that is damaged, can usually only be 'repaired' (in Highway Act terms) by providing a firm relatively dry surface, such as an aggregate path. It is this firm dry surface, through wetter ground that provides the more ideal habitat for grasses, and can lead to the appearance of a grass route through the heather vegetation fringed by soft rushes.

Visual Impact

The visual impact of path construction and maintenance, when in progress and immediately afterwards, is always an issue, and the Authority follows guidelines drawn up by the House of Commons Select Committee (see Appendix 4) to ensure this is minimised.

Given the concern about this effect a number of studies have been commissioned to help assess whether the need for construction work did outweigh the landscape impact it had. The most comprehensive study was that undertaken by Julie Martin Associates (2007) who were commissioned by the Pennine Bridleway Project to look specifically at the landscape and visual impact of the engineering works undertaken as part of the implementation of the route. This included Gorbeck and the Highway where limestone aggregate paths were created over peat. The conclusions were:

There is a high degree of consistency in the findings across the five route sections:

- In all cases there appears to have been a clear improvement in track condition as result of the works, and this was confirmed by re-survey in late winter.
- The impact on the appearance and character of the wider landscape has been beneficial or neutral for all route sections, and benefits may increase further over time, as the grass gravel track re-vegetates.
- The works have generally made a positive contribution to natural beauty, by improving the landscape quality and condition of the routes and their landscape settings. These benefits are usually localised, but for Lady Anne Highway and Gorbeck Road they are more widespread, reflecting the wider extent of the original damage.
- Access to all the routes for walkers, horse riders and cyclists (and also for 4x4 vehicles in the case of Gorbeck Road) has been significantly improved,

and all routes are passable with greater ease and enjoyment as a result of the works.

In thinking about ways to minimise impact of dominant landscape elements can be grouped into four categories, colour (both vegetation and rock/soil), linear elements such as vegetation boundaries, walls and horizons, texture (surface vegetation and soil) and land form or terrain. Route selection and materials aim to minimise visual disruption of these elements by following natural curves of the land and visual boundaries. Sympathetic materials are used wherever possible. Dark matt materials are generally best, eg dark grey limestone, and mixing the limestone with some of the peat, excavated as part of the creation of the drainage ditch, helps to tone down the immediate stark appearance. In some instances a limestone path has been topped of with a layer of sandstone to help it fit better in the landscape.

The 'rawness', immediately following completion, soon mellows once the vegetation becomes established.

5. Conclusion

Creating a new path over peat is always going to be a balancing act between the need for the path, and minimising any impact it has. The perfect path should be visually attractive, have low visual intrusion within the wider landscape, have low impact on biodiversity and be easily maintained with minimum future liability of erosion. A medium term view will need to be taken, as paths look 'raw' when first constructed.

Over the past 20 years, the limestone aggregate paths built over peat, as part of the Three Peaks and other projects have been very successful in re-establishing native species over what was once a wide quagmire of eroded peat with little or no vegetation cover. In addition the techniques of using geotextiles to float an aggregate path are now used throughout the British Isles.

Whilst some path management text books advocate, understandably, that as a general rule materials should have geological and colour compatibility with the surroundings there is a belief that limestone aggregates should not be used on acidic soils. This is on the basis that water leaching through it may locally raise the pH and alter the flora. However there is no evidence of this having occurred in the Yorkshire Dales and it has been suggested that this is unlikely for the reasons outlined above. Any changes in flora that are observed are likely to be a result of the change in hydrology and resistance to trampling. Furthermore the juxtaposition of peat and limestone has created part of the biodiversity and natural beauty of the Dales.

Kathryn Beardmore BSc MA DipCM MRTPI
Access and Recreation Manager

6 June 2008

Bibliography

(Conscious some of these references are a bit old now, but they are my undergraduate text books which were to hand – happy to discuss anything if things have moved on or you think I have got things wrong!)

Bayfield NG and Aitken R (1992) managing the impacts of recreation on vegetation and soils A review of Techniques Institute of Terrestrial Ecology. Banchory, Kincardineshire.

BTCV (2008) footpath handbook online see
<http://handbooks.btcv.org.uk/handbooks/index/book/86> Internet

Davies P and Loxham J (1996) Repairing Upland Path Erosion - A best practice guide LDNPA, National Trust and English Nature

Digital Analysis Corp (2008) the use of limestone for pH adjustment see
<http://www.phadjustment.com/Limestone.htm> internet

Martin J, (2007) Pennine Bridleway: Assessment of the Landscape and Visual Impacts of Construction and Ongoing Recreational Use Julie Martin Associates

RHS (2008) Lime and Liming Soils see
<http://www.rhs.org.uk/advice/profiles1104/limingsoils.asp> Internet

Sparks, B.W. (1979) Geomorphology. Longman

White, R.E. (1979) Introduction to the principles and practice of soil science. Blackwell

Yorkshire Dales National Park Authority (2008) - Yorkshire Dales Geology see
www.yorkshiredales.org.uk/gtga_np_display_page_news.htm?ID=3350 Internet

<http://inst.santafe.cc.fl.us/~jklein/Cave/cave4a.htm>

The Three Peaks Project

The 'Three Peaks Project ran from 1986 to 1991. The aim of this project was to find solutions to some of the worst footpath erosion in the country with £1 million funding. It involved experimenting with new techniques and was instrumental in establishing many of the techniques used by the Authority today. Importantly the outcomes of the project were properly monitored and evaluated by the Institute of Terrestrial Ecology (ITE).

ITE produced 12 reports over the five years as follows: a survey of the path network (Report 1); transplanting trials (Reports 2 and 4) a monitoring handbook, (Report 3) studies of vegetation reinforcement by addition of fertilizer (Reports 6 and 7); and of the potential use of soil seed banks for reinstatement purposes (Reports 5, 9, 10). The last report was concerned with seeding trials on both peat and mineral soils.

Interestingly no reference could be found in any of these reports to the use of limestone and the effect this had on re-vegetation – even though the key issue ITE were asked to monitor was how best to re-establish native species along eroded paths particularly after engineering works. The only reference can be found in a Review produced by ITE and significantly Bayfield (who had also been involved in the ITE reports commissioned by YDNPA see below). The Review called 'managing the impacts of recreation on vegetation and soils' was produced in 1992, for the then Countryside Commission, English Nature amongst others. The Review has a section on 'floated' aggregate paths on soft ground or peat. The report states:

The long term performance of floated paths has so far only received limited monitoring although many paths have now been laid apparently successfully, in difficult conditions on soft peat and clay.

The Review then illustrates this point in fig 7.2, which has the caption 'building a 2.5m wide limestone aggregate path on a geogrid over deep peat at Ribbleshead (Yorkshire Dales)'.

Over 15 years on, the limestone aggregate paths built over peat, as part of the Three Peaks project have been very successful in re-establishing native species over what was once a wide quagmire of eroded peat, with little or no vegetation cover.

ITE Reports commissioned by the Yorkshire Dales National Park Authority as part of the 'Three Peaks Project' (in numerical order)

BAYFIELD, N.G. & McGOWAN, G.M. (1986) Footpath survey 1986. The Three Peaks Project. Tm Report No. 1. institute of Terrestrial Ecology, Banchory, Kincardineshire.

BAYFIELD, N.G. & MILLER, CR. (1986) Reinstatement Tnals 1986. The Three Peaks Project. ITE Report No. 2. Institute of Terrestrial Ecology, Banchory, Kincardineshire.

BAYFIELD, NC. (1988) Monitoring Handbook. The Three Peaks Project. ITE Report No. 3. Institute of Terrestrial Ecology, Banchory, Kincardineshire.

BAYFIELD, N.G. & MILLER, G.R (1987) 1987 Progress Report: Revegetation Trials. The Three Peaks Project. ITE Report No. 4. Institute of Terrestrial Ecology, Banchory, Kincardineshire.

MILLER, G.R. & BAYFIELD, N.C. (1988) Seed Banks of Organic Soils at the Three Peaks. The Three Peaks Project. ITE Report No. 5. Institute of Terrestrial Ecology, Banchory, Kincardineshire.

BAYFIELD, N.G. & MILLER, G.R. (1988) 1988 Vegetation Reinstatement Trials. The Three Peaks Project. ITE Report No. 6. Institute of Terrestrial Ecology, Banchory, Kincardineshire.

BAYFIELD, N.G., MILLS, D., MCGOWAN, G.M. & PATERSON, I.S. (1990) Vegetation reinstatement trials: 1986-89. The Three Peaks Project. ITE Report No. 7. Institute of Terrestrial Ecology, Banchory, Kincardineshire.

BAYFIELD, N.G., MCGOWAN, G.M. & PATERSON, I.S. (1990) Restoring Native Plant Cover by Seeding and Live Mulching: Trials in the Three Peaks Area on Peat and Mineral Soils 1986-1989. The Three Peaks Project. ITE Report No. 8. Institute of Terrestrial Ecology, Banchory, Kincardineshire.

MILLER, G.R., BAYFIELD, N.G., PATERSON, I.S. & MCGOWAN, G.M. (1990) Re-establishment during 1989 of Natural Vegetation from Seed Banks in Organic Soils. The Three Peaks Project. ITE Report No. 9. Institute of Terrestrial Ecology, Banchory, Kincardineshire.

MILLER, G.R., BAYFIELD, N.G., PATERSON, I.S. & MCGOWAN, G.M. (1991) Restoration of Natural Vegetation from Buried Viable Seeds, The Three Peaks Project. ITE Report No. 10. Institute of Terrestrial Ecology, Banchory, Kincardineshire.

MCGOWAN, G.M., BAYFIELD, N.G. & PATERSON, I.S. (1991) Restoring Native plant cover by Seeding and Live Mulching: Progress of Trials on Peat and Mineral Soils to 1990. The Three Peaks Project. ITE Report No. 11. Institute of Terrestrial Ecology, Banchory, Kincardineshire.

BAYFIELD, N.G., MCGOWAN, G.M., & PATERSON, I.S. (1991) Monitoring of Seeding Trials in the Three Peaks. The Three Peaks Project. ITE Report No. 12. Institute of Terrestrial Ecology, Banchory, Kincardineshire.

Three Peaks Project – Outcome of Seeding Trials

The ITE last report produced for the Three Peaks Project (Monitoring of Seeding Trials in the Three peaks, 1991) looked at seeding trials on peat and mineral soils initiated in 1986-1989 that were monitored to examine long-term changes in vegetation cover and species composition:

- At the two sites at Simon Fell, the species composition on seeded plots after five years showed a strong resemblance to that of adjacent ground. Both sites had a substantial seed bank, which contributed to the final species composition. Species such as mat grass that do not form a seed bank were mainly only present where they had been sown.
- Comparison of seeded and unseeded ground indicated that seeding could produce cover in a single season that would require 4-10 or more seasons of natural colonization.
- Extensive trials of seeding at 16 sites were hampered in the first season by dry ground conditions. The “commercial” mixture gave more than 50% cover in the first season, but the “native” mixture only reached this level in the second year. Colonization was most complete at low altitude wet sites, and least complete at high altitude, dry sites.
- The commercial mixture was more successful than the native mixture at difficult sites.
- Seeding at a mineral soil site or Whernside gave generally good (>50%) cover in the first season. On grazed plots, cover then declined over the three years of observations, whereas on ungrazed ground cover increased.
- Terrabind and live mulch were beneficial to vegetation establishment.
- Three different seeds mixtures produced broadly similar amounts of vegetation cover after three years, although there were substantial differences in the first year.
- Yorkshire fog, sown as a nurse crop did not provide any special benefits and appeared to reduce the cover of some species.

Native Grass Species and Recolonisation

(from Davies and Loxham 1996 - based on findings of the Three Peaks project and survey work elsewhere)

In general terms the native species composition of a newly constructed or maintained path across moorland returns in the following order, (if left alone to recolonise naturally). There will always be exceptions to the rule as there are a myriad of factors affecting the re-vegetation of a moorland, but this is intended as a guide.

- | | |
|-----------------------|--|
| 1 Annual meadow grass | Usually at its highest concentration (<i>Poa annua</i>) in the middle third of the path i.e. the engineered section. |
| 2 Wavy hair grass | Towards the edges of the (<i>Deschampsia flexuosa</i>) engineered path and into the surrounding area. |
| 3 Matt grass | At first small patches on the edges (<i>Nardus stricta</i>) of the engineered path, gradually takes over the peaty edges of the path once the ground has stabilised. |
| 4 Black sedge | Certain small areas at the path (<i>Carex nigra</i>) edge which are wet and peaty allow Black sedge to establish extremely well. |
| 5 Soft rush | Tends to re-establish very well (<i>Juncus effusus</i>) from existing isolated colonies, which merge into one over time. Can create a 'corridor effect' of high vegetation along an engineered path. |

6 Other moorland species:

- Heath rush (*Juncus squarrosus*) once a sward has established it will start to take over.
- Sweet vernal grass (*Anthoxanthum odoratum*) Generally colonises the path edges on remnant soils.
- Creeping bent (*Agrostis stolonifera*) This will grow on aggregate if untrampled.
- Tufted hair grass (*Deschampsia caespitosa*) Only on virgin ground, or formally eroded but stable peat.
- Yorkshire fog (*Holcus lanatus*) On formally eroded peat but not the engineered path.
- Purple moor grass (*Molinia caerulea*) On formally eroded peat but not the engineered path.
- Rare sedges & rare rushes May possibly return to eroded peat in time, provided water content levels are reinstated.

Repair of Upland Route Erosion– Guiding Principles

Before any repair work is agreed the question should be asked; 'Is there a better solution?' Where repair and maintenance of a route is necessary, for environmental or recreational reasons, it should be subject to the following considerations:

- Repairs are necessary to prevent or ameliorate visual intrusion and/or environmental damage;
- Works should be of a high standard of design, having minimal impact on setting and character, and
- implemented, where possible, using indigenous materials, sympathetic in colour and texture to the immediate surrounding area, and employing traditional techniques. Uniformity of construction should be avoided, e.g. regular or geometric steps;
- Techniques used should protect existing vegetation and, normally, only locally occurring plant species should be used in restoration. Nonlocal species will be acceptable only where necessary as a nurse crop and where natural succession will rapidly result in their disappearance;
- The more remote the route, the more stringently this criteria for repairs should be applied. This will be a matter of judgment but in general, the more remote or wild the location the less acceptable an obviously engineered route will be;
- Repaired routes should be suitable to the route's use and constructed on a scale appropriate to the route's status as a footpath, bridleway or byway (BOAT).

These are based on guidelines accepted and adopted by the House of Commons Environment Select Committee (1995) as best practice guidelines, and are included in the Yorkshire Dales National Park Authority's Integrated Access Strategy (2005).