EYES ON THE BOG

IUCN National Committee United Kingdom

Peatland Programme

Long-term monitoring network for UK peatlands

The science of peat bog research may seem beyond the scope of the interested public, but there is an important role for citizen science

International environmental treaties and national land-use policies are devoting increasing attention to the benefits that peatlands provide to global society in terms of long-term carbon storage, ecosystem services and maintenance of biodiversity. The science underpinning this interest is often viewed as dauntingly technical, the exclusive preserve of academic researchers. It is therefore understandable that community groups wishing to engage in some useful way with a local peat bog may feel that there is little they can contribute in terms of gathering valuable scientific data and monitoring the health of the site.

By using a combination of simple methods and modern everyday technology, citizen groups can gather immensely valuable information about their local peat bogs. Indeed, one of the world's longest-established peat bog monitoring projects can be regarded as a community science project.

The Holme Fen Post – one of the world's oldest community science projects

In 1848 an iron pillar from the Crystal Palace Exhibition was sunk to its cap in a raised bog called Holme Fen in Cambridgeshire at the instigation of a Mr William Wells because there was widespread concern about the rate of ground subsidence caused by drainage of the surrounding peat-dominated Fenlands. The cap of this pillar now stands more than 4 m above the ground surface as a result of peat shrinkage and oxidation, the pillar having been tended and maintained by the local community for much of the intervening period. **The Holme Fen Post is one of the oldest markers of peat shrinkage in the world and is particularly valuable because it provides an indisputable measure of change despite the relative simplicity of approach.**

Simple technology and modern everyday technology offer great opportunities

The Holme Fen Post provides an example of a straightforward approach to peatland monitoring which can be applied more widely. Modern everyday items now make it possible to extend the principle embodied by the Holme Fen Post to a suite of monitoring methods having the capacity to generate valuable data for use by scientists, land managers and society as a whole.

Features readily amenable to monitoring

In the case of peat bogs and small-sedge fens, the range of features lending themselves to ready measurement or recording may come as something of a surprise (tall-sedge fen peatlands and sedge-fen swamps pose a different set of challenges and are not considered here). Using a combination of readily-available materials and modern everyday technology, it is possible to gather useful monitoring information about:

- peat subsidence and carbon loss;
- carbon capture;
- general behaviour of the water table;
- condition of the peat;
- vegetation composition;
- surface structure/microtopography;
- historical context of change and possible current trajectories.

Peat accumulation and carbon capture or peat subsidence and carbon loss

Peat consists of semi-decomposed dead plant material which accumulates because the material is waterlogged. Oxygen, needed for rapid decay, cannot penetrate effectively in waterlogged conditions. If the material were not waterlogged it would decay rapidly just like most dead plant material. Under conditions of waterlogging, therefore, carbon is captured by plants and then a proportion is preserved as semi-decayed plant matter that eventually becomes peat.

On the other hand if a peatland is drained, the semi-decomposed plant material which comprises the peat soil will begin to decay, causing the soil itself to steadily disappear into the atmosphere as carbon dioxide or be washed out of the system into local watercourses as various forms of dissolved or particulate organic carbon. This alone will cause the ground level to subside, but because peatlands are so waterlogged (peat typically contains less solids and more liquid by weight than milk), the matrix of peat particles is normally suspended within the volume of water held in the body of peat. Drainage causes some of this water to be lost, reducing the total volume of the peatland, causing the particles of peat to collapse more closely together and thus causing the ground surface to subside.

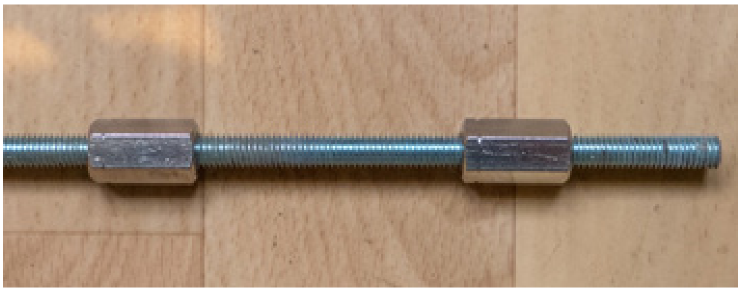
Monitoring peat depth - 'Surface-level rods'

It is a combination of these two processes that explain why the cap of the Holme Fen Post now sits more than 4 m above the present peat surface, and the method adopted back in 1848 at Holme Fen points to an approach which can be adapted simply and cheaply to the modern recording of such phenomena using what we shall term 'Surface-level rods'.

Importance of surface-level rods

Surface-level rods are important because they indicate the condition of a peatland – is it accumulating peat as a natural 'active' peatland, or is it degraded and losing carbon? In relation to this latter question, surface-level rods are particularly important because the effect of drainage on a peatland is two-fold. Drainage lowers the water-table to an extent but it also results in surface subsidence and it is the combination of these phenomena which can result in widespread impacts across a peatland. Traditional hydrology, however, focuses only on measuring the effect of drainage on the water table, not the effect on the peat surface, but it **is essential to measure both water-table and surface movement for a full picture of drainage effects on a peatland.**

In lieu of a pillar from the Crystal Palace Exhibition, zinc-coated steel threaded rod of various diameters and lengths is relatively cheap and widely available. It is also possible to buy stainless steel rod, but if zinc coated rod is purchased it can be used either for surface-level rods or for 'rust rods' (see below) without the potential for confusion between the two.



Typically it comes in 0.5 m or 1m lengths and is often coded as M6 or M8 meaning that it is 6 mm or 8 mm diameter respectively. Stainless steel connectors are used to join lengths of rod together and are also fairly readily available and inexpensive. The M6 diameter rods are sufficiently stiff to push easily through most peat soils, though M8 is less prone to bending when inserted into dense peat.

Equipment:
- Zinc plate steel threaded rods (M6 x 1000mm)
- Threaded rod connecting nuts (M6)
- Large metal washers
- Medium metal washers
- Small metal washers
- Bare steel (not copper) wire
- 'Noxyde' inert blue paint

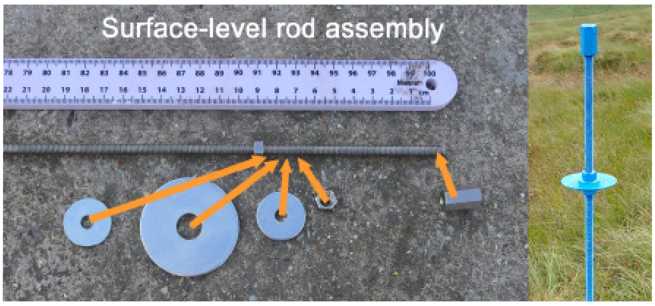
Tools:
- Paintbrush
- Small folding foot-stool
- Metal detector
- Snow shoes

Preparation of surface-level rods

In advance of going out on site, the top-most section of rod can be prepared. An M6 nut is positioned approximately 10 cm from one end of a 1m length of M6 rod (or two connected 0.5 m lengths). A medium-sized metal washer is then slid down the rod until it is prevented from further travel by the nut. The largest possible off-the-shelf washer is then slid down the rod until it sits on top of the medium washer. A further medium washer is then slid down the rod to sit on top of the large washer, and the whole thing is then locked in place by threading another nut down onto the washer assembly. Finally, another connector is added at the very top of the rod. The whole assembly is then painted with inert blue 'Noxyde' paint leaving some 2-3 cm unpainted at the bottom to allow an M6 connector to be added. This pre-painted assembly is then taken out to the site.

Use of inert paint

Blue 'Noxyde' paint is specifically manufactured to be biologically non-toxic, highly weather resistant and quick-drying. Standard paint will not suffice because it will leach metal ions into the surroundings, while the blue version of 'Noxyde' is the most inert of the colours available.



Positioning of surface-level rods

Having decided on a location within the site for inserting a surface-level rod, the first step involves determination of the peat depth at the precise location where the rod will be positioned. Threaded rods are inserted into the peat, length-upon-length, until the mineral soil or bedrock beneath the peat is reached. At this point either solid or markedly-increased resistance is encountered. The depth of peat will thus have been determined, but can be confirmed if desired by using a peat corer should one be available from a local university or statutory environmental agency. The 'bog surface' should be taken either as the top-most surface of a moss layer, if present, or the level of the solid peat surface if no moss layer is present (i.e. push aside any overhanging leaves of vascular plants such as cotton grass, purple moor grass or heather to reveal the peat surface).

In the case of solid resistance from the mineral base the sound is often important. A harsh 'metal-on-stone' sound indicates that bedrock or hard sediments have been encountered. A hollow 'wooden' sound may indicate that a buried tree-stump has been encountered and it may therefore be advisable to move 1-2 m away from this initial point before testing the depth again. In the case of increased resistance rather than a dead stop, a sandy base sends a 'gritty' vibration back up the rods and will soon resist further penetration. Soft clay, on the other hand, will simply provide increasing resistance. In this case, when the rods are removed it is generally possible to determine how far the basal rod penetrated the clay because clay particles will be caught and retained in the thread.

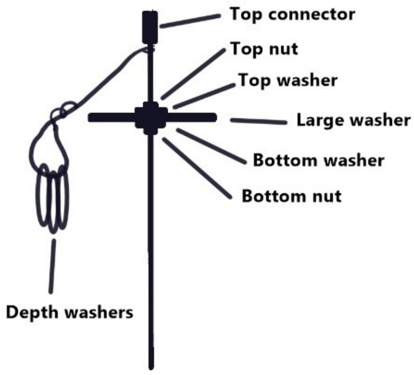
Two useful tips when measuring the depth of peat in this way: (1) Never pull the rods out of the ground as a single connected length because they will bend, distort and subsequently be unusable. Disconnect the rods as they come out of the ground, ensuring that the last lengths are held firmly so that they do not slip back down the hole to be lost forever. (2) Never count the rods as they go into the peat because it is easy to lose count. As the rods come out of the ground, disconnect them and lay them side-by-side on the ground. Only when the last rod has emerged and been disconnected should the rods be counted and the depth of peat calculated.

Having established the depth of peat at this precise location (peat depths can vary significantly less than 50 cm away from a given point), it is necessary to calculate the number of rods that must be added below the top-most rod that was prepared off-site earlier, such that when the entire assembly is sunk into the peat the large washer will sit at the bog surface. Usually this means that the bottom-most length of rod must be cut to length using bolt-cutters or using a small hacksaw (a small plastic folding foot-stool can make a reasonably stable work-bench for this). The entire assembly is then constructed length-upon-length, starting with the bottom-most rod, steadily inserting the rods into the peat until the large washer sits flush with the bog surface.

Robust means of recording peat depth

It is important to record the depth of peat below the washer in a robust way that will resist the passage of time and events such as fire. Metal tags for gardening and horticulture use offer one option, with the peat depth punched into the label using a set of metal number punches, these tags are, however, generally aluminium and could be lost in the event of a fire.

A better option to ensure that there is a permanent record of the original depth involves preparing a number of large, medium and small washers beforehand by coating them with 'Noxyde' paint. Wind a length of general purpose galvanized wire (approx. 1mm diam.) that has previously been dipped in 'Noxyde' paint round the rod just beneath the washer assembly, then slide a number of the pre-painted washers onto the wire – the largest representing metres, then the medium washer represents tens of centimetres and the smallest washer represents units of centimetres. Finally the loose end of the wire is wrapped around the rod again to form a large loop holding the washers in place. The 'peat-depth washers' on their wire loop can be buried in a small slit made alongside the washer assembly and finally a rubber gardening 'cane-cap' is slipped onto the uppermost connector to provide added protection and reduce the possibility of damage to the hooves of deer or other passing animals. The position of the surface-level rod is recorded using a GPS.



Avoiding perching birds

The rod extends only 10 cm above the surface in order not to encourage perching birds, who would add seeds and guano to the immediate area. The top-most connector is added simply as protector to the top-most threads.

Subsequent recording of surface-level change

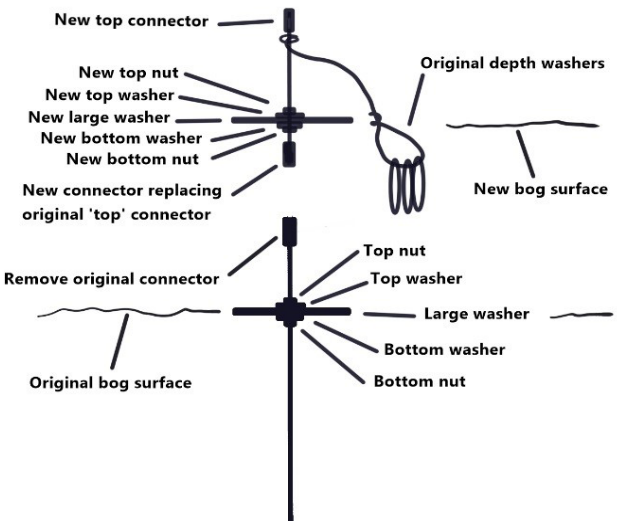
(1) If the surface-level rod is buried – i.e. there has been carbon capture

In subsequent visits, the first challenge might be finding the surface-level rod as it may have become buried beneath vegetation or even fresh peat. Enlisting the help of a local metal-detectorist may be worth considering, though £100 will purchase a perfectly serviceable metal detector. If the surface-level marker is not immediately visible, the immediate vicinity of the GPS position should be searched by only one person using a metal detector in order to minimise trampling damage. The combination of metal rod, level-washer and depth-washers should give a sufficiently strong signal to ensure that finding the assembly is an easy task. Should they be available, snowshoes are useful in minimising trampling damage.

The level of the moss or peat layer is then noted in relation to the large surface-level washer. If this washer is deeply buried, gently expose the top-most connector and slide a length of threaded rod down alongside the buried rod until it hits the large washer. Note the depth of burial.

If the top connector is buried by more than 4-5 cm or so, remove it using two pairs of pliers – one on the connector, one on the rod below to stop the rod unscrewing from lower connectors – in order to expose clean thread at the top of the rod.

Prepare a short section of rod having a length that, once attached to the top of the existing surface-level rod, will stand proud of the present bog surface by around 10 cm. Attach a connecteor to one end; this will be screwed onto the tip of the existing surface-level rod. Using M6 nuts above and below to lock them in place, position two small washers and a large washer between them at the position that will mark the new bog surface once the assembly is attached to the existing surface-level rod. Attach this assembly to the existing surface-level rod, then add a connector to the top of the new assembly. Attach the depth-washers with wire to the rod just beneath the top-most connector. Paint everything with Noxyde paint. If necessary gently press the moss/peat layer back around the rod without lowering the new moss/peat surface once the paint is dry (1 -2 hours).



(2) If the surface has subsided – i.e. there has been at least some carbon loss

If the peatland surface has subsided in the manner of Holme Fen, the surface-level marker will be standing proud of the surface and may attract perching birds or the attention of deer, sheep or other passers-by. It will then be necessary to note the height of the surface-level washer above the present moss/peat surface, then detatch the 'depth-washers'. Remove the whole original rod but immediately place a spare length of rod into the vacant hole, with a large washer attached in order to prevent the rod from being lost down the hole, thereby temporarily marking the exact location of the original rod. A whole new surface-level rod should be constructed as above and inserted into the peat down the original hole, attaching the original depth washers as a record of the former peat depth.

Water-table behaviour – 'rust-rods'

Monitoring of water table behaviour in a peat bog can be achieved using a variety of techniques but several of these require specialist equipment and technical expertise to establish and interpret.

Dip-wells: The most commonly-used simple method involved dip-wells, consisting of plastic pipes (typically standard plumbing down-pipes) with a series of slots cut in them to allow water inflow and outflow, set into the peat. The water level in these pipes is measured on a regular basis to build up a picture of water-table behaviour. One key disadvantage of this method is that the measurement can be affected by the weather immediately preceding or during the measurement.

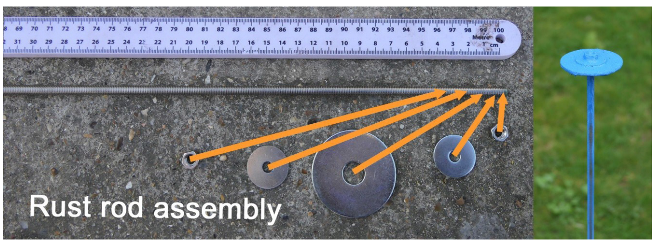
Another issue is that the number of readings obtained depends on the number of occasions that someone is willing to visit the dip-well array.

Walrags: another relatively simple method for recording the behaviour of the water table over longer time periods than is typically obtained for dip-well arrays is what is known as a Walrag – an acronym for 'water-level range gauge'. This consists of a long plastic drainpipe sunk into the peat, inside which is a float made from a drinks bottle. Attached to the float is a rod which forces two markers (often a piece of closed-cell foam) either up or down along a fixed measuring tape. The lower marker indicates the lowest point reached by the water table between readings, the upper marker indicating the highest point reached by the water table.

A Walrag is relatively cheap to construct and can be left to record between readings for as long as is convenient or interesting. It gives a good measure of the lowest and highest water tables experienced by the peatland and thus provides a valuable picture of the extremes – which is often of considerable value when assessing the condition of a peat bog.

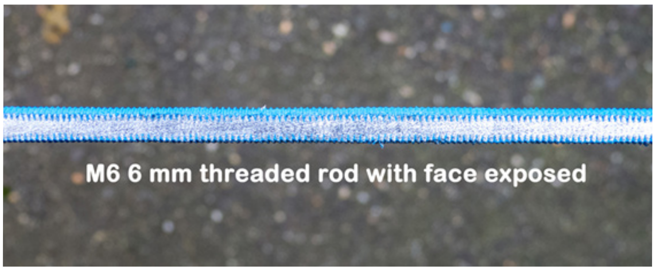
The main restriction influencing the use of Walrags is that even if a 'hedgehog' of spikes is added to the cap to prevent birds perching, they are still fairly prominent features within the bog landscape and thus tend to attract attention from, and potential damage caused by, deer, livestock and human passers-by. It is also true that installing a considerable number of these across a site would be an arduous task.

Rust rods: In the same vein as a Walrag but offering the potential to install a considerable number of recording devices across a site at relatively little cost and with limited effort, 'Rust rods' make use of the fact that metal will rust within the zone of water-table fluctuation but remain bright in the oxygen-free zone of permanent waterlogging. Using zinc-coated steel threaded rod rather than stainless steel threaded rod, a 1 m length of M6 rod has a connector or nut fitted almost at the top of the rod. A washer assembly as described for the surface-level rods is fitted above the nut, then a further nut or connector is screwed down tight onto the tip of the rod to hold the washer assembly in place. The entire assembly and length of rod is then painted liberally with inert Noxyde paint.


Rust rod assembly

Grinding a bright face to record rust level

In order to produce a bright face on which to record the rusting process, an angle-grinder or a dremmel is used to grind a flat face along the length of the rod (use eye protectors, face-mask and ear defenders). The aim should be to grind away the threads down one side of the rod to create a flat face but not grind away so much metal that the rod loses its rigidity.


M6 6 mm threaded rod with face exposed

Installation of a rust-rod adjacent to a surface-level rod

Once constructed, it is a simple matter of inserting the rod into the peat until the washer assembly sits flush with the moss/peat surface. Ideally every surface-level rod should have a rust rod adjacent so that the combined picture of water level and surface movement is obtained, but the rust rods can be distributed much more widely across a site if desired because they are cheap and easy to install. It may well be that these markers become overgrown with vegetation, or even peat, over time, but with a GPS record of their position and use of a metal detector they should be relatively easy to find even under these conditions. After measuring the rust level the face can be cleaned with sandpaper and the rod replaced, or, if the rusting is too severe, it can be readily and cheaply replaced.


Rust rod & surface-level rod

A minimum of a 3-month period will show the mean lowest water level

To 'read' the rust rod on a subsequent visit it is necessary to clean off the peat from the ground face. In the field, use a pot of water and a decorating brush to brush the ground face clear, or use a plant spray set to 'jet' rather than 'mist'. If taking the rod home before reading, wrap it in cling-film to keep it wet, otherwise the whole rod may rust before the reading is obtained. Studies have shown that a fairly clear boundary can be identified between the bright metal and the rusted face after approximately 3 months in the peat. This will indicate the general depth to which the water table falls regularly, with the completely bright section indicating the zone into which the water table never (or hardly ever) falls. The water-table difference between a healthy and a degrading peat bog mostly lies in the depth to which the water table frequently falls. A healthy 'active' bog will rarely see a water table fall as far as 30cm whereas a peat bog in hydrological difficulty will see falls of 40-50 cm or even more.

Rust-rods can reveal whole-site hydrology

The cheapness of these rust rods, their relative ease of construction and installation, plus the fact that they can be left for a year or more to gather their patina of rust, means that they have the potential to help build up a whole-site-scale picture of water-table behaviour within a modest budget of time and money.

Peat condition: The von Post field test for peat soils

The more degraded a peatland becomes the smaller the fibres of semi-decomposed plant material become. In a healthy 'active' peat bog dominated by *Sphagnum* bog moss, the peat will be extremely fibrous and 'springy' whereas in a highly degraded bog the plant material will have decomposed much more, the fibres will therefore be small (more 'humified') and the peat will squeeze through small gaps. This is the basis of a long-established, field-test for peat soils known as the von Post test (*see image below*).

The test is very simple. Dig wrist deep into the peat and take a sample of peat somewhat larger than a golf ball. Squeeze it hard in a clenched fist. The amount of material squeezing out between the fingers and the amount remaining when the palm is opened, gives a value of H0 to H10 on the von Post scale. For those interested in using the full range of the scale it is possible to find many versions of this test on the internet. For a very quick and approximate assessment of peat condition, however, it is possible to divide the scale into a simple 3-point version:

- no material, only brown water, squeezes out between the fingers (H0-H4)
- around half squeezes out and half remains in the palm (H5-H7)
- most of the peat squeezes out between the fingers (H8-H10)

The higher the von Post value (usually) the more degraded the peat

If the peat falls onto the H0-H4 range then the peat bog is likely to be fairly healthy, at least at that point on the site. If the peat is H8-H10 then the peat at that location on the site is likely to be highly degraded.

A word of caution however. If the bog consists of ridges of peat consistently giving von Post values of H0-H4 and there are pools or hollows which cannot be safely trodden on also distributed across the bog, the ***soft*** peat in these pools or hollows will tend to give high von Post values simply because peat in pools tends naturally to be more decomposed ('humified') than the peat of ridges and hummocks.

On the other hand, if the whole base of what looks like a bare-peat 'hollow' is ***solid*** and gives a von Post value of H8-H10, this is unlikely to be a true hollow and is more likely an erosion gully, or micro-erosion gully running between hard tussocks of cotton grass, deer grass or purple moor grass.

A picture of von Post values obtained from across a site will help to give a valuable picture of the condition of a peatland over time, particularly if this can be aligned with data obtained from rust-rods and surface-level rods.

Vegetation and 'hummock-hollow' recording

Many plant species of peat bogs are considered difficult to identify, particularly the *Sphagnum* bog mosses but also the various 'feather mosses which may be found particularly on drier, somewhat damaged bogs.

Technology, however, can replace specialist knowledge to a useful degree, and increasingly so with modern technology.

Use of smartphones

Photography is more than 150 years old so can hardly be described as 'modern' but the fact remains that a photograph is a moment frozen in time, recording fairly objectively whatever is captured in the frame. Modern smartphones are the equal of many cameras nowadays, being quite capable of producing high-resolution images of the general vegetation at a particular location, and also for close-ups of any moss layer and other associated plant species. Some smartphones will even take panorama photographs, giving a 180 degree or 360 degree view of the site from that particular spot. Importantly, many smartphones with GPS technology can now geo-tag the location of a photograph so that the exact location can be pinned to social media or on websites such as Google Maps and Google Earth.

Value of time-stamping and geo-tagging

The value of such photographs should not be under-estimated. Being time-stamped and geo-tagged, they hold a record of what exactly was at a particular location on a particular date. The quality of the photographs is now so high that a specialist can often subsequently determine with a degree of certainty the precise species in the photograph, even if they include one of the more 'difficult' mosses such as *Sphagnum*.

Species identification via smartphone

Above: Smartphone photographs allowing identification of *Sphagnum magellanicum*, *S. fuscum*, great sundew and bog asphodel at specific locations on a site on a specific date, being geo-tagged and date-stamped.

Potential to create 'big-data' archives

Such photographs can be taken in a moment, without unduly disturbing other activities, and can help to build up an immensely valuable record over time – assembling 'big data' archives. Indeed there is a strong argument to say that site managers could be building up just such an archive of data during their normal rounds of a site without taking any time from their normal activities.

Clear evidence of change over 11-year interval

The value of a photographic record over time, whether of individual species, vertical shots of the immediate vegetation, or panoramic views, can be illustrated by the pair of photographs shown below. They are of exactly the same view but 11 years apart. It can be seen that the heather stimulated by drainage of this small-sedge fen has almost completely vanished and been replaced by purple moor grass and other more typical fen species. It took less than 10 seconds to photograph each view, the only additional requirement being that a permanent marker (it could have been a rust-rod or a surface-level rod) was in place to provide a consistent location from which to take the photograph.

Virtual Reality offers new opportunities for recording

The rise of Virtual Reality (VR) has also provided new opportunities to record the vegetation and, to some extent, the surface morphology, of a peatland. Cameras costing between £300 and £400 can now take 360 degree views of entire scenes which, when viewed in even cheap devices such as Google Cardboard, can give a sense of standing in the middle of the peatland, allowing the viewer to look at the vegetation immediately at their feet or to view everything to the far horizon. Such views are, to repeat, irreplaceable records of a specific place at a specific time and can be used in years to come as a wholly objective record of what once existed at that location.

Stereo VR

A further opportunity now being offered by the latest technology is the ability to record the surface morphology – often referred to, albeit somewhat incorrectly, as 'hummock-hollow topography' – of a peatland. The technique goes back as far as the beginnings of photography but only now is it becoming re-invented through developments in modern technology. Stereo (3D) photographs were all the rage in Victorian times but fell out of fashion with the rise in popularity of the mono (2D) Box Brownie camera and its descendants. Virtual Reality headsets are now introducing a whole new generation to the possibilities offered by stereo photography.

Importance of stereo for recording surface morphology

The importance of stereo views to the monitoring of peat bog systems cannot be over-stated because the surface morphology of a peat bog is one of its most characteristic features and one of the most useful means of judging its condition. This morphology is almost completely invisible in a 2D photograph but becomes immediately evident in a 3D image. VR cameras offering 180 degree stereo views are already on the market for little more than £300. As the market develops and viewers become less cumbersome it can be expected that such cameras will become even cheaper and enter the mainstream – with even smartphones offering true 3D stereo. The opportunities for everyday monitoring using stereo VR video will then become truly remarkable.

The 'trampling issue' – extreme sensitivity of peatlands to trampling

The regular or semi-regular visiting of fixed-points on a peatland raises the issue of trampling, which can be a significant problem for the vegetation, and the more natural the vegetation the more sensitive it becomes to trampling. Even yearly visits can eventually create a path to, and a patch of bare peat around, a fixed marker point. Flat-plate snowshoes (rather than the 'tennis-racquet' type) are helpful in the absence of a fixed, raised boardwalk. In the absence of either, temporary boardwalk may be placed beside a marker to be measured. In the case of photographs, if fixed-point photography is used it may be sufficient simply to stand in the same general vicinity of the fixed point rather than at exactly the fixed point each time.

Some peatland nature reserves have boardwalk, allowing for fixed point locations to be created along the boardwalk where people can record their photographs and perhaps be shown examples of previous views on information signs. QR codes are small and can be regularly updated on signage, allowing visitors access previous views via their smartphones.

Monitoring 'back' as well as forwards

The term 'monitoring' is most often understood to mean monitoring forward in time, but technology is also making it increasingly possible to monitor back in time, putting a site into the context of its trajectory of change over the past half-century or so. This context is important because present-day management interventions may not result in expected changes but this may occur because the site was already on a trajectory of change that was established 30, 40 or 100 years ago.

Use of historical maps

Various information sources can shed light on past conditions, allowing us to 'monitor back in time'. In the UK, the First Edition 6" Ordnance Survey maps contain a wealth of detail, including the original extent of many lowland bogs, plus drains cutting across these systems, while subsequent OS map series reveal the nature of at least some of the changes to which these sites have subject. Such historical maps are increasingly being made available via the internet, providing the opportunity to map at least the changes in mappable features over time.

Aerial photography

The development of aerial photography during World War 1 and its increasing sophisticated development during World War 2, combined with the desire to photograph large areas for military purposes, generated a large archive of aerial photography for many parts of the globe. This strategic mapping by aerial photography continued after WW2 and many countries now have a rolling programme of aerial survey which underpins the updating of national cartographic maps.

Internet-based map resources

A further recent development has been the addition of aerial imagery to on-line resources such as Google Maps, Google Earth, Bing Maps and What3Words. At full zoom, the 'satellite' view is predominantly very high ground resolution (12.5 – 50 cm) aerial photography or pansharpened satellite imagery. There are still a few areas of the globe where these data are not available for a variety of reasons, and lower resolution (10 – 30 m) Landsat or Sentinel satellite data are presented there. Significantly, where high resolution imagery are available, Google Earth is beginning to present historical imagery for as far back as the 1940s, though this typically only goes back two or three decades, and is not available for everywhere in the UK, for example.

Aerial-photo archives

Focusing on the UK, extensive national archives of historical aerial imagery are managed by Historic England, Historic Environment Scotland (HES), The Royal Commission on the Ancient and Historical Monuments of Wales (RCAHMW), and The Public Record Office of Northern Ireland (PRONI). All archives contain a range of both military and commercial photography and are continually expanding. There is some overlap between the archives, and of wider interest, the National Collection of Aerial Photography (NCAP) run by HES is one of the largest international collections, reported to hold over 26 million aerial photographs covering places throughout the World.

Methods of accessing aerial photo archives

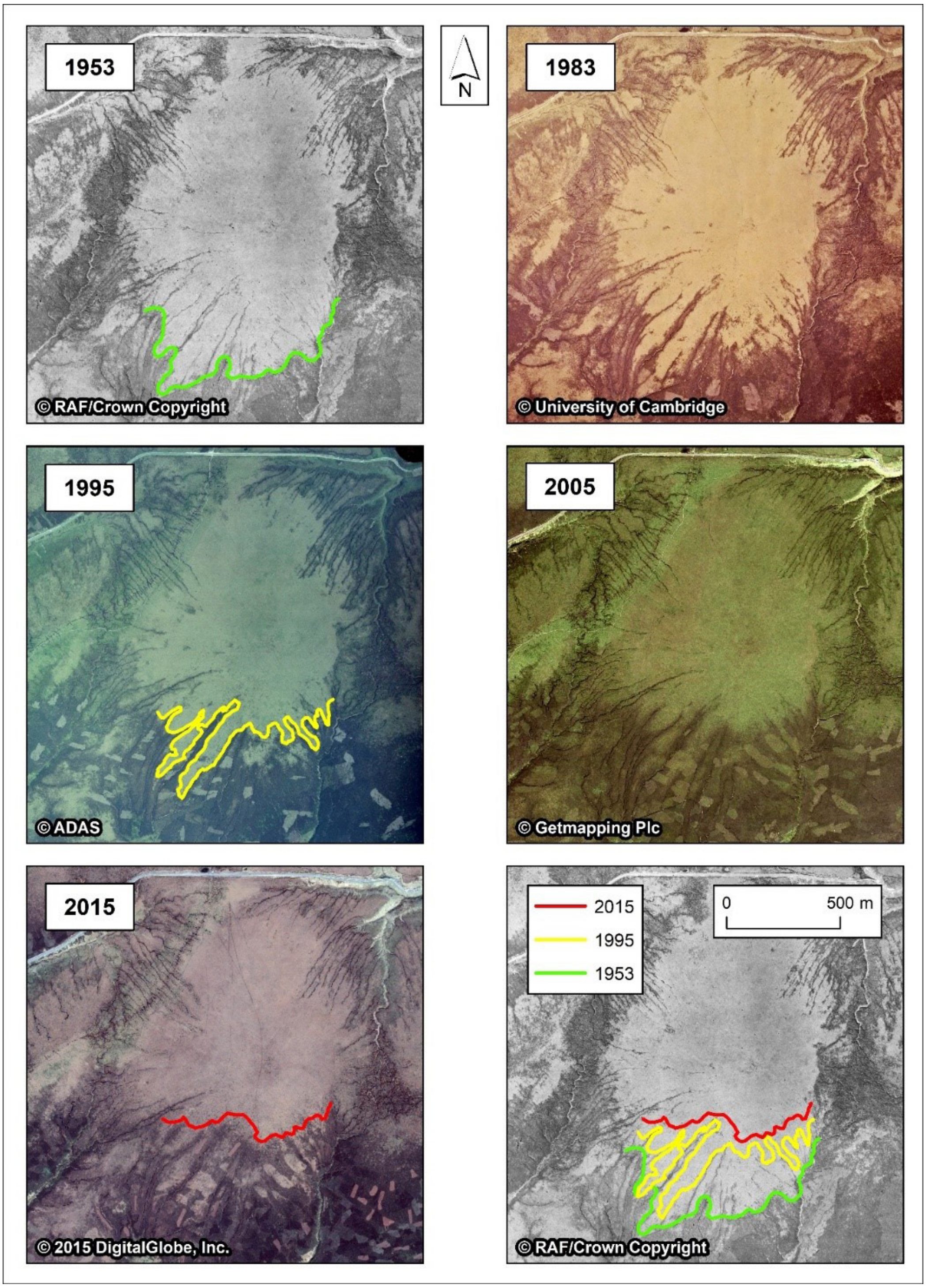
Image archives are making increasing use of computer mapping (Geographical Information Systems; GIS) to facilitate image searches and all archives noted here have online search tools. Scans of images are continually being added to the GIS databases and it is possible to view low resolution 'quickviews' for many images online. Advanced searches can be performed by the archive curators to reveal the full record available for an area, often at no cost. Purchase of imagery is as simple as most online or telephone transactions, and the dominant form of image delivery is in digital format made available for download. High resolution scans of individual frames from national archives range from £25-50, although if image quality or cloud cover is uncertain, some archives, such as Historic England, can provide a photocopy of an image for £2 (costs as of 2018).

'Monitoring back' at Featherbed Top - a worked example

The benefits of using historical aerial imagery as part of a monitoring programme are highlighted here for Featherbed Top, a dome of blanket bog in the Peak District National Park. Erosion gullies are visible on all sides of the dome and have the potential to compromise the integrity of the peat body, reduce the height of the water table in the bog and ultimately influence surface vegetation. The historical appearance of the bog has been reconstructed using aerial imagery dating from 1953. A high-resolution scan of an aerial photograph captured by the RAF in 1953 was purchased from Historic England. The ground resolution (i.e. pixel size) is c.25cm, equivalent to the resolution of the majority of colour aerial photography today. The image highlights that at this time the majority of the peat dome was covered by cotton grass-dominated vegetation and that heather dominated vegetation was present on the lower slopes on the south side.

The reconstruction of Featherbed Top from historical imagery demonstrates that since 1953 the heather on the south side of the dome has increased in extent by at least 100 m upslope and in places by over 300 m.

From the historical data the rate of spread of heather (and perhaps an indication of drying of the peat Moss) can be determined, thereby allowing prediction of where the heather may be in 30 years' time. If, in 30 years, heather has not increased as predicted (i.e. the rate of change has slowed or even begun retreating), this may be indication that blocking of erosion gullies on the south side of the dome undertaken by the National Trust in the early 2000s is having a positive impact beyond the area of intervention. Such overall trajectories of change can only be identified through the use of 'monitoring backwards' as well as conventional monitoring forwards.



Further reading

This document has been produced following a major process of review and comment building on an original document: Lindsay, R. 2010 'Peatbogs and Carbon: a Critical Synthesis' University of East London. Published by RSPB, Sandy. http://www.rspb.org.uk/Images/Peatbogs_and_carbon_tcm9-255200.pdf, this report also being available at high resolution and in sections from: www.uel.ac.uk/erg/PeatandCarbonReport.htm

More information on Eyes on the Bog is available at https://www.iucn-uk-peatlandprogramme.org/get-involved/eyes-bog

The International Union for the Conservation of Nature (IUCN) is a global organisation, providing an influential and authoritative voice for nature conservation. The IUCN UK Peatland Programme promotes peatland restoration in the UK and advocates the multiple benefits of peatlands through partnerships, strong science, sound policy and effective practice.

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Peatland Programme

EYES ON THE BOG

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