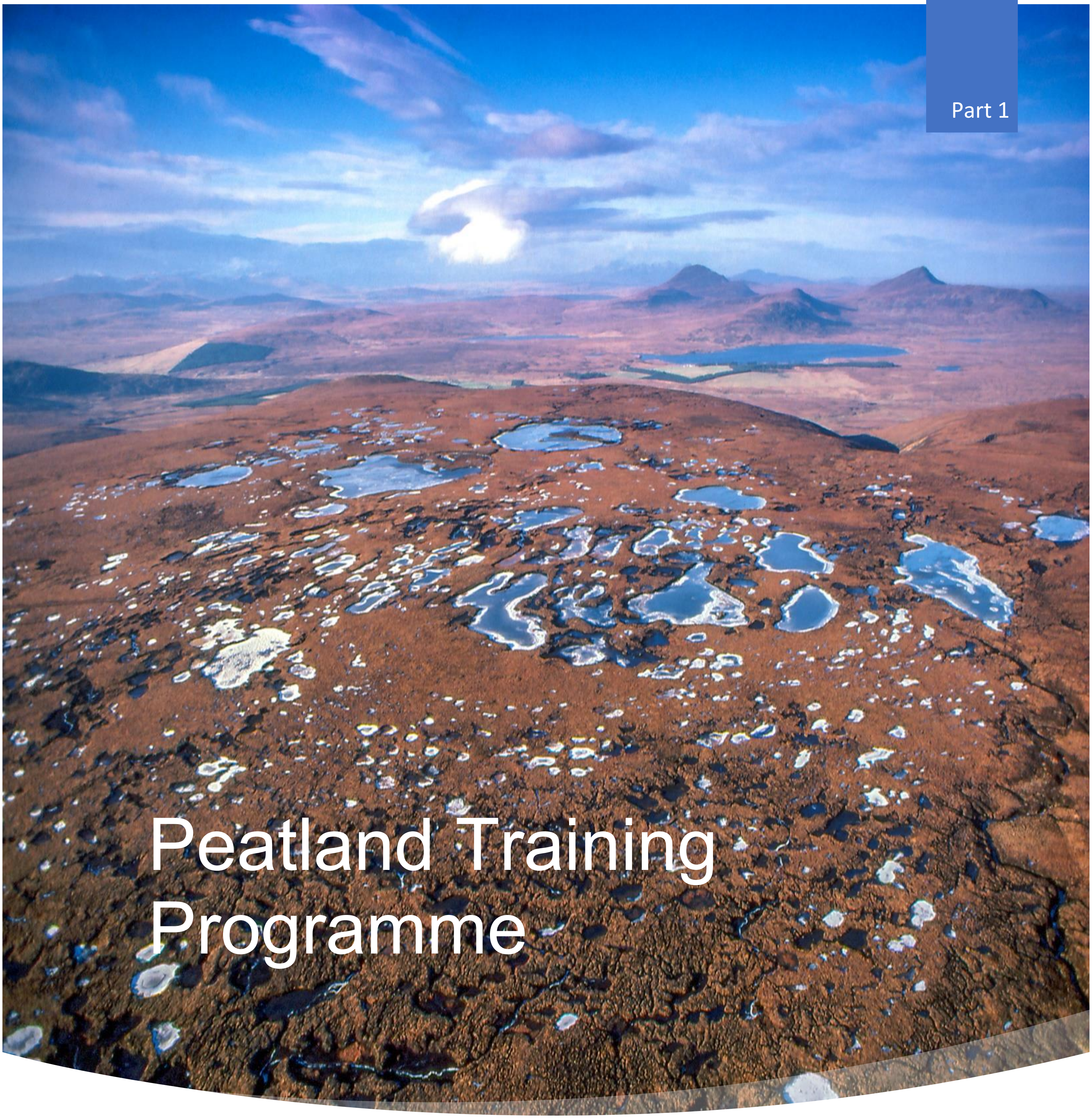

Part 1

Peatland Training Programme

PART 1

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Peatland Programme

Peatland Training Programme – Part 1

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Introduction

This peatland training programme consists of published documents, Powerpoints and 3D animations that are almost all accessible through the University of East London Open Access Repository, specifically within my section of that repository, or via the IUCN UK Peatland Programme website, so all material is freely available and can be accessed at any time, individually or in any order. There is one link right at the end to a commercially-operated website, though the link provided is an open-access link. We are exploring, however, the potential for bringing this link in-house, so this link may change in time and we will update this if and when this happens.

The programme set out here is suggested as a means of establishing a logical learning curve, introducing key peatland concepts, then moving on to the implications of these for peatland policy, and finally offering more in-depth information about certain topics. The programme does not seek to be comprehensive in terms of addressing all aspects of peatland science, policy and practice, but does aim to focus on key issues relevant to the UK while also offering insights into the wider European or global perspective.

Further topic areas, or topics in more depth, will be addressed in due course as more training materials are created. Their availability will be flagged on the IUCN UK Peatland Programme website as well as appearing in my UEL Repository.

Important note: Peatlands have risen rather abruptly up the science and policy agendas during the last decade or so, but instead of bringing greater understanding and clarity to the topic, this rapid rise in interest has in many cases given rise to increasing levels of confusion across both science and policy sectors. Much of this confusion can be attributed to a very simple fact – not enough attention has been paid to determining the nature of the peatland being considered, nor to its true condition. As a result, certain research conclusions about a 'peatland' may seem at complete odds with other research conclusions about a 'peatland' when in fact the differences arise because the peatland types, or conditions-states of those peatlands, are very different. The sequence of information provided in the programme set out below seeks to help the reader to recognise such differences and thus be able to draw their own conclusions about the significance of any given set of information.

There's lots of reading in this part, but each recommended document is designed to be short, well illustrated, and to the point, so hopefully they won't feel too daunting or too much of a drudge to plod through. Being relatively short, they also give you the chance to take regular breaks. And towards the end there are a few more entertaining things to explore.

Key peatland concepts

The following sections address important key concepts, a knowledge of which is essential for an unambiguous understanding of peatland ecosystems. These concepts underpin many of the policy aspects relevant to peatlands likely to be encountered, at least within the UK.

What is peat?

Read: https://doi.org/10.1007/978-94-007-6173-5_274-1

From this, and other sources, the key points to know are that:

- Peat is formed *only* under waterlogged conditions;
- Waterlogging prevent oxygen from decomposing this organic material rapidly, leaving only *very* slow anaerobic decomposition as the dominant decomposition process;
- Peat consist of dead plant matter rich in organic carbon and is often several metres deep with no gaps (unlike forests), so it is by far our largest terrestrial carbon store;
- There is variation in the threshold used to separate 'peat' from other organic-rich soils such as podzols; in the UK, Scotland has traditionally used a threshold of 50 cm whereas England and Wales have traditionally used a threshold of 40 cm, but it is worth noting that in the recent comprehensive review of peatlands in all 49 nations within the continent of Europe (Joosten et al., 2017) of the 30 nations that used a threshold (some had no minimum threshold), 25 of the 30 used a minimum threshold of 30 cm;
- Peat is formed *in-situ* rather than being deposited from somewhere else;
- Peat is formed as successive *in-situ* layers, preserving an important *chronology* often dating back several thousand years, so strictly speaking once these layers are physically disturbed they become organic sediment or organic waste rather than true peat. [This is admittedly a tricky issue because we talk about 'bags of peat', but the fact remains that 'true peat' contains an *irreplaceable* chronology that no amount of restoration can restore – it is one of the virtually-unique features of a peatland only partially matched by certain lake or marine sediments, or ice cores];
- Peat formation is possible using a range of plant species – the common feature is waterlogging.

What is this term 'mire' that I keep encountering?

Read: https://doi.org/10.1007/978-94-007-6173-5_273-1

From this, and other sources, the key points to know are that:

- There is still some debate amongst peatland specialists about the term 'mire' (see, for example, Joosten et al., 2017), with some requiring that *current* peat accumulation is demonstrated whereas others argue that this is not possible to demonstrate definitively for practical reasons of timescale – given that long-term peat storage only becomes clear once material passes into the long-term store, which may take a century or more; consequently presence of a '*normally peat-forming vegetation*' is instead used as a proxy for peat formation;

- The concept of '*active bog*', as used in the EU Habitats Directive and now more widely, is broadly equivalent to 'mire' because it requires presence of a vegetation that is normally peat-forming but does not require proof of actual peat accumulation;
- This definition of 'active bog' can therefore include damaged bogs that are showing evidence of recovery in the form of 'significant' presence of a vegetation that is normally peat-forming (for example, eroding bogs where the gullies are infilling with peat-forming vegetation);
- That said, the concept of 'active bog' was created specifically by the UK Government in response to the Habitats Directive proposal that *all* bog should be a Priority Habitat (I was present at, though not responsible for, the birth of this term); the invented and undefined term 'active bog' was being used to reduce the extent of habitat in the UK that would fall under the Priority category; lack of a definition at its birth meant that there has been ongoing 'catch-up' debate about what exactly it means, although it has become a widely used term and the JNCC has provided some stability and clarity to the definition;
- The definition of '*favourable conservation status*' and '*favourable condition*' within the EU Habitats Directive, on the other hand, are much more clearly defined and relate *only* to those sites and habitats which are now in a sufficiently good condition that their identified features of interest are stable or increasing and will be so for the foreseeable future – in other words, all relevant negative pressures that might prevent long-term stability or improvement have been removed or reduced to a no-impact level; this is a condition that no lowland raised bog in Britain can currently achieve, nor can the majority of UK blanket bog, because of the ongoing effects of long-term human impact;
- Debate about the term 'mire' also surrounds those areas that very evidently support a 'normally peat-forming vegetation' but which are demonstrably *not* forming peat for purely natural reasons, as illustrated in the article above; the 'Hans Joosten School' at the University of Greifswald would not class these areas as 'mire' but many other peatland specialists (including myself) disagree, and would use an inclusive definition that embraces such areas – mainly because if they are not classed as 'mire' they will tend to fall between the cracks of policy-making as they don't fit very well into any other habitat type, and, most important of all, their needs are the same as systems that do produce peat.

- A word or two about other confusing use of terms at this level of habitat description:
  - "marsh" in both North America and Japan is a treeless wetland that may or may not have peat, whereas "marsh" in Europe refers explicitly to a vegetated wetland on *mineral* soil and which explicitly does not create peat and does *not* support a vegetation 'that is normally peat forming';
  - "swamp" in North America is used specifically for *wooded* wetlands which may or may not have peat, whereas in Europe "swamp" is generally used for an open vegetated wetland *lacking* trees, and may or may not be peat-forming; meanwhile in the tropics, 'peat-swamp forest' is evidently wooded *and* peat-forming – but is not generally used outside the tropics to describe naturally-wooded peatlands;
  - The terms 'marsh', 'swamp' and 'peat-swamp forest' say nothing about the *type* of peatland, if peat is present; for that, see the Section about 'Types of Peatland'.

Broad classification of peatland systems

Read this document <u>down to (but not including) Ecosystem Classification Approaches</u>:
https://doi.org/10.1007/978-94-007-6172-8_341-1
(You can read the rest of this document later, if you wish, but you will also encounter parts of it in later Sections)

From this, and other sources, the key points to know are that:

- There are just *two* basic types of peatland – those fed predominantly by surface water/groundwater (*fens*), and those fed only by direct precipitation which has not been in contact with the groundwater table (*bogs*);
- Transitions between these two fundamental states exist, but it remains important to recognise the relative contribution of these two states to the overall character and functioning of such '*transition mire*' sites;
- Fens are highly *dependent on what goes on in their catchment* and effects may include (amongst a great many other things) changes in deep aquifers, alterations in headwater streams, blockage of surface seepage, or increased nutrient loading on catchment slopes;
- Bogs are much less dependent on their surrounding catchment, but lowland sites in particular are highly dependent upon the *immediately adjacent groundwater table* which acts as a foundation level for the perched bog water table;
- 'Blanket bogs' in upland areas are actually complex mosaics of bog and fen, with the fen elements representing *very important features* in terms of hydrology and biodiversity. Unfortunately these fen components are often overlooked because of the focus created by the commonly-used term 'blanket bog' for the whole landscape (see Sections 'Blanket Mire' and 'Blanket Bog'.

Types of Peatland

Read: https://doi.org/10.1007/978-94-007-6173-5_279-1

From this, and other sources, the key points to know are that:

- Complexes of these differing peatland types exist, particularly in blanket mire landscapes and in large floodplain systems;
- Terms such as 'peat-swamp forest', or 'fen carr', or 'reedswamp' are not based on peatland *type*, merely the predominant vegetation; thus, a peat-swamp forest may be (and often is) a raised bog, while a reedswamp may be an open-water transition mire or a floodplain mire;
- It is important to identify *peatland type* because this provides a fundamental understanding of the hydrological processes that determine the character and functioning of the peatland.

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Peat Bogs: Key concepts and recap of several key points

Download: 'Publisher's version' Working paper 1: https://repository.uel.ac.uk/item/85870

From this, and other sources, the additional key points to know are that:

- The defined extent of peat in the UK varies enormously depending on what definition is used – but even the shallowest peats, if not in good condition, have the capacity to be emitting large volumes of CO_2 whether or not this land is included within national carbon accounting data;
- Peat bogs consist of several self-organising functional levels; these levels are extremely useful when dealing with systems which, particularly in the case of blanket mires, can occur as very large peat-dominated landscapes; by breaking the system down into these self-organising levels it becomes possible to understand the contribution of each component to the landscape as a whole.

Peat Bog Ecosystems: Structure and Function

Download: 'Publisher's version' 2 Biodiversity Final: https://repository.uel.ac.uk/item/85872

From this, and other sources, the key points to know are that:

- True bogs in a natural state consist of two distinct layers – a very thin surface layer (typically no more than 20-30 cm), within which the water table fluctuates and fresh growth occurs – the *acrotelm*; and the remainder of the peat body, which may be many metres deep, consisting of dead plant material (true peat) which remains permanently waterlogged and is thus preserved for, typically, thousands of years – the *catotelm* - which in terms of peat bog dynamics cannot *add* fresh material but if exposed to air can *lose* this long-term store of material;
- This two-layered structure is an elegant example of a self-organising system that provides hydrological stability in the face of variable precipitation inputs and variable levels of sunshine-induced evapotranspiration;
- Water movement through the catotelm is *extremely* slow – the slowest recorded rates are 1 million times slower than the fastest recorded snail, and speeds of less than 1 cm per day are not unusual, so the catotelm effectively exists as a very large droplet of water (anything from 500 m to 6 km across) sitting within the landscape;
- Movement of excess rainwater through a bog is therefore almost entirely sideways through the thin acrotelm, which is typically very much more conductive than the catotelm;
- The acrotelm is structured like a valve, so that when water levels are high in the acrotelm, the uppermost water can flow rapidly, whereas when water levels fall during dry weather, the lower parts of the acrotelm are less conductive, slowing water loss;
- The acrotelm of *all* bogs throughout the world adopts a growth form consisting of undulations, typically but not quite accurately referred to as a 'hummock-hollow' pattern, and these undulations lie *across* (exactly at right angles to) the line of water movement through the acrotelm, this pattern being termed 'microtopography', or 'micro-relief';

- Where the local climate generates more rain than the bog can shed before the next rain event, water is stored on the bog surface as either hollows or pools within the microtopography and therefore these hollows or pools also tend to be aligned across the line of water movement;
- The extremely narrow vertical zonations created by the microtopography provide a range of niches for different species groups – much as is seen on the better-known zonations found on a rocky shore;
- The range of features creating these undulations is greater than just 'hummocks and hollows' (a further Section will explore this), so it is important to recognise that evident undulations in a relatively dry climate region may consist entirely of 'hummock and high ridge';
- The microtopography is a key self-organising component of bog (and some fen) systems, providing feedback mechanisms that ensure stability over millennial timescales, so if the climate becomes drier, a bog that supported hummocks, ridges, hollows and pools is capable of transforming to a bog with just hummock and high ridge as its microtopography, thereby maintaining peat formation despite the change in climate conditions;
- Drainage empties the acrotelm more rapidly and therefore mirrors the effects of a shift to a drier climate, but the full range of drainage effects will be explored in another Section.

Raised Bog Ecosystems: Formation and structure

OK, you've been working hard through a whole range of documents so here's something a bit different, giving you the chance to just sit back and watch, taking in some key aspects of raised bog development.

Watch: https://www.youtube.com/watch?v=_CCMngoQdos

From this, and other sources, the key points to know are:

- Raised bogs form as individual units of peatland bounded by the dimension of the dome;
- Raised bogs are the commonest form of ombrotrophic bog, occurring from northern boreal regions down to the tropics and then again also to southern boreal regions, so they are found as far north as the White Sea, they occur throughout the circum-boreal regions of Russia and Canada, as far south in Europe as Spain, they occur as some tropical peatswamp forests in the tropics, and then are found as far south as Tierra del Fuego in the Southern Hemisphere;
- A single raised bog is actually a complex system because it consists of the ombrotrophic raised bog dome and its minerotrophic lagg fen;
- Raised bogs can occur as multi-domed complexes, as seen at Cors Caron NNR in Wales, the Lochar Mosses just east of Dumfries, and the huge peat-dominated landscape of the West Siberian Basin which consists entirely of multiple peat domes and intervening fens;
- There is a maximum size for any single dome before the surface-water flow leads to formation of streams ('endotelmic stream') that arise within the bog and which, ultimately separate an expanding dome into two domes and thus create a multi-domed complex;
- The dynamics controlling the shape of a raised bog dome, a critical understanding of which is crucial to an understanding of anthropogenic impact, will be covered in a separate Section.

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Blanket bog – Blanket mire: what's the difference, which should I use…?

The simple answer to the question is that blanket bog is a sub-set of blanket mire, and that blanket mire is more accurately termed a *blanket mire landscape*.

Read: https://repository.uel.ac.uk/item/85329
https://repository.uel.ac.uk/item/8532v

From this, and other sources, the key points to know are:

- Blanket mire landscapes are common in the UK. Indeed, they represent our most extensive terrestrial semi-natural habitat (see map at the start of https://hub.jncc.gov.uk/assets/f944af76-ec1b-4c7f-9f62-e47f68cb1050);
- In a global context, however, they are really quite rare (see Figure 10 of https://repository.uel.ac.uk/item/86qqv);
- The first published descriptions of this mire type, and the origin of many terms used today, concerned the blanket mires of Britain and Ireland. As a result, the UK and Ireland are regarded as the 'type' locations for global blanket mire – even though they are arguably some of the most anthropogenically disturbed examples of the type in the world and therefore present a character which is markedly different from many of the other examples scattered around the world (see https://repository.uel.ac.uk/item/87q24 - another opportunity to sit back and watch, though you need to click slides forward);
- Blanket mire landscapes are complexes of bog and fen, but the fen components are often overlooked by conservation bodies and developers alike, yet the fen systems are *hugely* important in terms of biodiversity, as well as for the hydrology of the blanket mire landscape;
- The Flow Country in northern Scotland is the largest continuous expanse of blanket mire in the UK, and almost certainly one of the most extensive examples of such a landscape in the world, on the basis of which it is now to be put forward by the UK Government for World Heritage Status: https://repository.uel.ac.uk/item/85331;
- To visit the Flow Country, you can either use the following link on your PC, or you can access it on your smartphone and, using a simple VR viewer with your phone, or by loading the link into a VR headset such as an Oculus, you can actually visit it immersively:

https://livetour.istaging.com/7dc88d34-5621-4ca7-b04c-7617d1a42e7a?index=1

- Or scan this QR code:

We will explore the whole use of VR immersion in bog systems in a later Section of these training materials. For the moment, just explore and enjoy.

You can also visit the blanket bog of the Pennines, specifically the various experimental plots located on Hard Hill in Moor House National Nature Reserve, to contrast the strongly-patterned peatlands of the far north with the character of peatlands found further south:

https://repository.uel.ac.uk/item/87v0w

The *vital* thing to understand is that describing these very different systems effectively requires a knowledge of how to describe the *microtopography*. Consequently, the final sections in this part will look at how to describe peatlands, and particularly peat bogs.

…so finally, having visited the Flow Country and perhaps the Pennines and therefore obtained a feel for the landscape and the surface features that characterise our peatlands, it's time to start learning what those features are.

Peat bog systems and their 'functional hierarchy'

It has already been noted that peat bog systems display a range of self-organising levels of functionality which enable them, for example, to control water movement and cope with shifts in climate. These self-organising components exist and function at different scales, from the landscape-scale down to individual small-scale stands of vegetation or even individual species.

These differing levels interlink with each other largely through processes of hydrology and peat growth, forming a hierarchy of scales ('hydromorphological hierarchy') which were first recognised for almost a century in the former USSR but which have since been widely adopted by many other nations. The original USSR system was translated into English in 1981 (Ivanov, K.E. 1981. Water Movement in Mirelands) and established Anglicised versions of the Russian terms (the 'tope' system). Other nations have sometimes used other terms within their national inventories but all are referring to, and utilising, essentially the same self-organising levels.

All, that is, except the UK and Ireland, where the focus has been almost entirely limited to recognition of mire type, which is equivalent to just one level within the hierarchy, or to vegetation based on the National Vegetation Classification (NVC), which actually spans two or more levels. Unfortunately, the 'Mires' volume of the NVC starts by stating that it will *only* consider vegetation and explicitly *excludes* any consideration of these self-organising features. Adoption of the NVC as the official method of describing peatland habitats undoubtedly provides descriptive tools suitable for regional comparisons but is a blunt tool for assessing the character and condition of peat bog systems. Some UK windfarm EIAs are now starting to incorporate the 'tope' system but otherwise the system has seen only limited use, which is a shame because it provides a multi-layered tool for describing peat bogs at a variety of functional levels, thus conferring the ability to tailor consideration of the system in terms of the appropriate information-level for the task in hand, as well as facilitating decisions about matching information-gathering to available resources.

Read: Section 24, up to and including Section 24.2.3 in: https://repository.uel.ac.uk/item/862y6

From this, and other sources, the key points to know are:

- A macrotope represents a continuous peatland complex bounded by mineral ground, so may contain several differing and interlinked mire components (the simplest being an isolated raised bog with its lagg fen, whereas a more complex macrotope might be raised bog sitting within a flood-plain mire within which there are also several spring mires, or alternatively an extensive tract of continuous blanket mire containing a mosaic of bog and fen units);
- A mesotope represents an individual mire unit, so it may have a name, such as 'White Moss';
- A microtope (or micro-landscape, or micro-relief) represents a repeated pattern of *natural* undulations formed by plant/peat growth (people sometimes think artificially-generated structures represent a microtope but this is not the case because natural microtopes are the key to self-sustaining regulation of the system because they can change if faced with altered conditions – artificial features cannot do this;
- A nanotope represents the individual building block that creates a microtope, and is formed by differential plant growth and peat formation – again, capable of changing if conditions change and thus not the same as an artificially-created structure;
- The vegetation sits across and within these various tope levels, with the NVC often most appropriate at the macrotope and mesotope (or even regional) scale although it is also capable of making broad distinctions between certain types of nanotope;
- No standardised international system currently exists for describing the *nature* of microtope patterns, although they can be some of the most informative components of all. They are often used in the national inventories of other nations to provide broad distinctions between different mesotope and microtope types and thus to identify different functional elements within a peatland.

Peat bog nanotopes – builders of microtope micro-relief

Nanotope structures and their arrangement into a surface micro-relief (microtope) together give some of the clearest available signs of peat bog condition. The presence, and the relative proportion, of different nanotopes and their orientation when creating micro-relief, are all strongly influenced by a wide range of factors influencing both character and condition.

Read: Section 24.2.4 in: https://repository.uel.ac.uk/item/862y6
Chapter 12 in: https://repository.uel.ac.uk/item/86qqv

From this, and other sources, the key points to know are:

- Natural micro-relief/microtope patterns *always* lie *across* the direction of water movement;

- Micro-relief/microtope patterns that lie *along/down* the line of water movement almost always indicate damage;
- Similarly, continuously interconnected drainage networks also generally indicate damage;
- Determination of nanotope type is generally linked to the general position of the bog water table, which can often be determined by the highest position of a *Sphagnum cuspidatum* or *S. fallax* mat (not individual occurrences of these species);
- Where these indicator species are not present, it is generally possible to dig a small hole and feel the depth at which the peat becomes saturated (don't wait for the hole to fill with water – this can take a long time);
- Where published papers describe research data in relation to the water table, it is important to know the datum against which the water levels are measured (is this measuring device in a T3 hummock, or a T1 low ridge, or an Em micro-erosion gully?) because the height differences between these nanotopes can exceed the water table fluctuations;
- Nanotopes can harvest 'occult precipitation' (i.e. fog, low cloud, mist, dew) which is capable of contributing significant quantities of moisture to the daily, monthly and annual hydrological budget and thus significantly shorten apparent drought periods, based on rainfall data, for moss species and particularly for *Sphagnum*, because mosses can absorb moisture directly into their leaves; see: https://repository.uel.ac.uk/item/85871