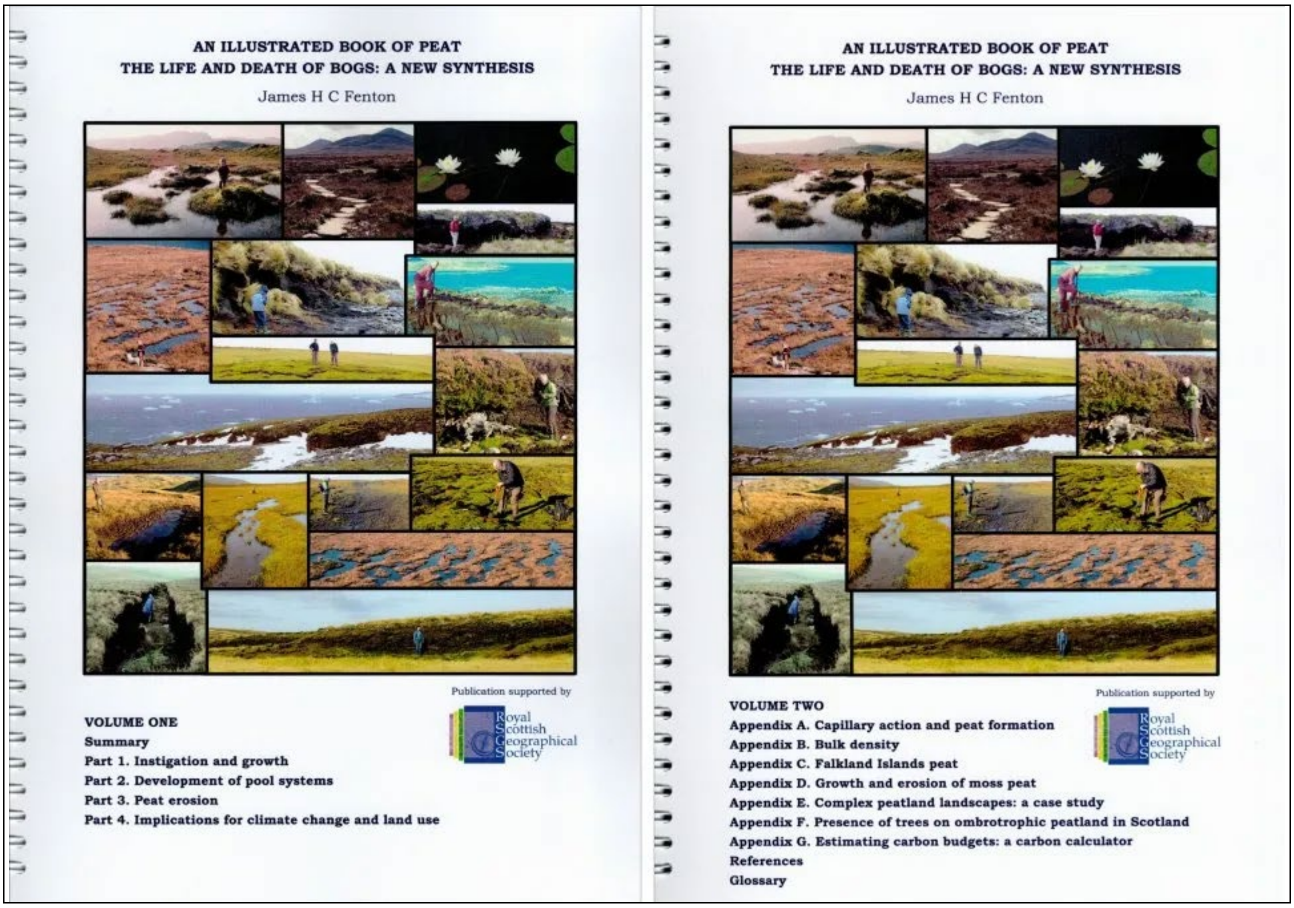
An Illustrated Book of Peat — The Life and Death of Bogs: a new synthesis

James H.C. Fenton (March 2021)



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Two spiral bound A4 volumes

Volume ONE: Text, Tables, and numerous Photographs (many Figures contain multiple photographs); pp.≃ 143.

Contents, Summaries, and Four Parts: 1) Instigation and Growth; 2) Development of Pool Systems; 3) Peat Erosion; 4) Implications for Climate Change & Land Use.

Volume TWO: Seven Appendices A to G, References, Glossary, Text, Tables, and numerous Photographs (many Figures contain multiple photographs); pp. ≃ 69.

A) Capillary Action and Peat Formation; B) Bulk Density; C) Falkland Islands Peat; D) Growth and Erosion of Moss Peat; E) Complex Peatlands Landscapes - a Case Study; F) Prescence of Trees on Ombrotrophic Peatlands in Scotland; G) Estimating Carbon Budgets: A Carbon Calculator.

A remarkable book in both format and content. It is Fenton's *magnum opus*, reporting a lifetime of observation, measurement, study, and independent thought about the processes of peat and peatland formation and destruction, first in the Antarctic 'moss banks' and subsequently mainly in Scotland.

A digital camera was the only complex equipment involved. Evidence is presented in numerous (hundreds?) of un-numbered annotated photographs, most assembled into numbered Figures. (Figure and Table numbers are linked to page numbers: Figure 2.12 will be on page 12 of Part 2. A thoughtful touch.) The high-definition photographs, glossy paper, and skilled printing combine to make even small details visible. Even the smallest photographs, with dimensions 5–19 cm, are clear. There are also numerous diagrams that summarise the relevant observations, and others that show Fenton's inferences.

The captions are specific about location of course, but a further nice touch is that the colour of the boundary of photographs indicates the location: red Scotland, green Falkland Islands, blue Maritime Antarctic, black other locations.

What follows is *a selective review (Dicky Clymo)*, followed by *a more detailed review (Jack Rieley).*

Selective Review by Dicky Clymo

1. The practical consequences of capillarity for peatland vertical growth are considered in Vol. 2, using a sponge (large pores) and a toilet paper roll (smaller pores). You may wish to be able to discuss this further. Fenton's argument seems to me to depend on a continued, if intermittent, supply of water at the surface, though he does not say so explicitly. In an ideal world one might enclose a 2 m diameter column of peat in an impermeable container with a few small holes in the wall at the base, cover the cylinder to prevent ingress or evaporation of water, and wait for years to see what happened to the watertable. We know that peat hydraulic conductivity in the catotelm - a measure of the permeability to mass flow of water - is finite, though usually (very) small. So what would happen to the surface peat? Would it remain wet enough to support plant growth, or have drained out? Very roughly $h = 0.1 / r$ where h is the height (cm) to which water will rise in a wettable tube of radius r. A 5 m tall tube would require contiguous pores of radius no more than 1 μm. (the hyaline cells in *Sphagnum papillosum*, for example, are 20 μm across). Peat is not a continuous tube, though; but more akin to an irregular network in which the rate of movement of water, again for simple shapes, is inversely proportional to r^4. Fenton often stimulates thought and the need for constructive discussion.

   Fenton's reliance on his own observations and experience is admirable in many ways. But that means he makes no mention of tropical peatlands, the largest parts of which are very different from Antarctic and Boreal (*sensu lato*) peatlands. The tropical peats form mainly from tree roots and branch fragments. They are highly porous, and it seems probable that their maintenance depends critically on renewed water supply to the surface.

2. Fenton gives a detailed description of how he suggests that the acrotelm works. Again this stimulates readers' thoughts in a constructive way. A single example may illustrate. Figure 1.22 presents a generalised dry bulk density (DBD) profile, showing (i) an initial small increase from the surface, below which is (ii) a longer and bigger decrease to (iii) a relatively abrupt and even bigger increase. The axes have ticks, but these are without numerical values. The vertical divisions may well each be about 1 cm. The three phases would then span 2.5, 7.5, and 0.5 cm. Surface plant growth, decomposition, mechanical compaction, and loss of mechanical strength are invoked in differing places and proportions to account for the DBD profile. I would add that stem internode expansion of the distance between branches in a *Sphagnum* capitulum from 0.1 to 1.0 cm may have a part in the top 2 cm of the profile as well; and that in some places the weight of a seasonal covering of wet snow may be a major cause of acrotelm compaction.

   All below the phase (iii) collapse becomes the catotelm, and in Fenton's treatment is not further compacted. We do know that the profile of CH_4 concentration is largest near the base of the peat and decreases upwards through the catotelm, probably as a result of continued very slow decay. The assessment of the importance of these processes is a further, welcome, stimulus to discussion.

3. Next, Fenton stresses the important rôle of pool formation in the life of a peatland.

   The acrotelm as a flexible but coherent fibrous layer protects the catotelm from erosion. On slopes the surface acrotelm may slide very slowly downhill over the stationary catotelm, buckling into waves against a fixed point where the slope flattens out. These shallow parallel troughs are the sites where elongate pools may form, with their length at right angles to the slope. This parallel orientation must be so because any other orientation and the pool would drain down to its lowest point and cease to be a pool. Fenton describes in detail scenarios with differing combinations of acrotelm thickness, wavelength of wrinkles, amplitude of waves, and slope steepness. He cites W.H. Pearsall as an originator of this idea - the primary reference is Pearsall (1956). Fenton uses ‘creep’ in the general sense. The engineer’s creep involves steady increase in a length that is dependent on log (time), continuing indefinitely but at a steadily slower rate. One should recall that catotelm peat may also flow in some circumstances such as those at Muckle Moss (Pearson 1960) and at Coom Rigg (Chapman 1964) where a deep peat flows slowly over a downward step in the underlying rock, creating a 5-m deep pool behind it. That pool is itself obliterated as the next wedge of peat flows during half a human lifetime over the step, creating a replacement deep pool behind it. Bog slides (‘bursts’) are other spectacular examples of whole-peat movements, commonest in areas with high rainfall. But these examples all form over steep, or very steep, rocky substrata. Shallow slopes and moderate rainfall are much commoner.

Fenton then shows how narrow pools on a slope may amalgamate, or on level surface such as at the highest point of a bog may come to form a large pool such as the dubh lochans in Scotland. Fenton’s main postulate is that pools are points of weakness (with no fibrous acrotelm) that eventually drain, and thus become the focus for erosion.

4. Erosion and the peatland life cycle. Fenton presents a modified and comprehensive set of erosion types (E1–E12). Most lead to almost complete loss of the peat. But the important idea is that a new peatland which is initially stable can form amid the wreckage of what has eroded away. Which leads to the concept that a peatland may (often?) be cyclic, with a timescale of millennia, that may be compared with other cyclic systems.

   A short-lived one is an annual crop, say barley. The seed is sown, germinates, and grows until it produces grain that is harvested. During this C is removed from the atmosphere. The grain is put to use as food, or perhaps fermented to whisky. The cycle length is perhaps 1–3 years (or 1–50 yr for whisky). By the end of that part of the cycle the carbon removed from the atmosphere during growth has (almost) all *been returned to the atmosphere*. The net change in atmospheric C is almost zero.

   A longer cycle is that of a tree in a planted woodland/forest. Again the trees grow, removing C from the atmosphere at an increasing rate at first but later slowing. Eventually the trees die, fall and decay, or are felled and burned, or are felled and used in construction of some kind that delays the return of C to the atmosphere. But r*eturn to the atmosphere it eventually does* (excepting on the first few cycles some C that is incorporated in the soil). The cycle time is measured in hundreds of years. After the first cycle or two, the net change in atmospheric C is almost zero.

   For a peatland there are similar phases of growth removing C from the atmosphere, *followed by erosion (or peat cutting) and decay that return most of the C to the atmosphere*. The cycle time may be 10–50 millennia.

   In summary, the details in these three cases are different in detail and highly variable but it follows that, although planting trees may have many benefits, the widespread public belief that one of them is *long term* sequestering of C from the atmosphere is fallacious. It is Fenton’s recognition of peatland cycles that concentrates our attention on times much longer than a single human lifespan.

5. There are many other sections. For example, the lessons to be learned from Antarctic moss banks: permafrost freezes (in both senses) mechanical dimensions and decay. Section G3 is a spreadsheet calculator of carbon budgets, both peatland and woodland. Of these Fenton says: “Just because the calculator comes up with exact figures does not mean they are accurate.” A sentiment that applies to almost all peatland calculations.

6. These are but a few of the thoughts that this wonderful book provokes. I believe that any serious student of peatland processes would benefit greatly from acquiring, reading, and discussing it.

REFERENCES

Chapman, S.B. (1964) The ecology of Coom Rigg Moss, Northumberland. 1. Stratigraphy and present vegetation. *Journal of Ecology*, 52, 299–313.

Pearsall, W.H. (1956) Two blanket bogs in Sutherland. *Journal of Ecology*, 44, 493–516.

Pearson, M.C. (1960) Muckle Moss, Northumberland. 1. Historical. *Journal of Ecology*,48, 647–666.

Detailed review of contents by Jack Rieley

What follows appeared in *Peatlands International*: the House Magazine of the International Peatland Society, available to members only. It seems useful for a wider audience and is reproduced here with permission.

This heavily illustrated book provides a new assessment of the long-term dynamics of temperate ombrotrophic bogs. It adopts a holistic approach to their life cycle that should be considered in timescales of millennia.

The background to the information provided and discussed is based on the author's own experiences in the United Kingdom, especially Scotland, and the Falkland Islands where he worked for two years. It contains 212 A4 pages with many colour photographs and colour illustrations in two volumes (text and appendices) to aid in the understanding of the complex processes the author describes. The pages are not numbered consecutively from beginning to end of the volumes but separately in each of the four Parts and Appendices. It is only available as hard copy because a digital version would be too large a file (to ensure the detail of the photographs is maintained), and the reader needs to make cross-references within and between volumes.

Both volumes are printed on high quality glossy paper to support the many high-definition photographs. These are complemented by diagrams to supplement the explanations given rather than large amounts of text. As a result, the book is an unusual visual approach that should be read using both volumes together. The spiral binding enables the pages of both volumes to be fully opened side by side, something that is unusual, but essential to enable immediate cross-referencing and obtain full benefit of this book.

The author provides some definitions of peatland and peat that do not always coincide with those of other experts. For example, in the early stages of ombrotrophic peat development the organic matter generated by peat-forming plants will be too thin and uncompacted to form a catotelm. This can take place only when the accumulated organic surface layer exceeds 20–25 cm. Dr Fenton suggests that while the terms 'peatland' and 'peat bog' refer to the entire system, the term 'peat' should be restricted to the catotelm only. Consequently, an ombrotrophic peat bog is a soil type containing both an acrotelm and a catotelm.

Volume 1 is divided into four parts:

1. Instigation and growth
2. Development of pool systems
3. Peat erosion
4. Implications for climate change and management

In the First Part the author explains why peat forms, how it grows above the surrounding landscape, taking its own water table with it, and subsequent lateral spread. The Second Part is devoted to analysing the development of parallel pool systems on peatlands (patterned bogs) and suggests they are sinusoidal waves of the acrotelm caused by downhill creep. The Third Part examines the different types of peat erosion and proposes a new classification system, together with a listing of the causes of erosion, both natural and human induced.

The first three parts take a detailed look at the different factors influencing the long-term dynamics of ombrotrophic bogs, while the fourth applies this understanding to the conservation and management of peatlands, and implications for climate change.

A summary of Parts 1, 2 and 3 is presented, not as may be expected, at the beginning or end of Volume 1, but at the start of Part 4 on Climate Change and Land Use to aid their understanding. Conclusions concerning Implications for Climate Change and Land Use are provided at the end of Part 4. A summary of how to assess the carbon balance of a peatland is provided in Table 4.9, and peat erosion types in Figure 3.8.

Part 1: Instigation and growth

This Part considers peat initiation, growth, compression, and decomposition; uncompacted peat, different types of temperate peat; lateral expansion of blanket peat; succession to ombrotrophic peat on nutrient-richer sites; role of *Sphagnum* and other peat-forming vegetation.

Three conditions are said to be necessary for ombrotrophic peat formation:

a) Presence of plants that can provide a tightly bound water-retaining turf, capable of drying out at times (*Sphagnum* is helpful but not essential).
b) A fibrous surface layer, the acrotelm, capable of holding the structure together, preventing slumping and erosion.
c) Enough compaction to produce an amorphous mass with small pore spaces to facilitate capillary action and overcome gravitational drainage.

Part 2: Development of pool systems

Peat bogs in many geographical regions have pool systems of different sizes and orientation. These are referred to as 'patterned bogs'. This Part deals with origin of parallel pools, expansion of pools over time, and discussion of various scenarios of pool development and decline. It is important to note that:

a) Some bogs do not have pools even in areas where patterned bogs occur.
b) On level ground pools tend to be randomly orientated, while

c) on sloping ground pools are parallel to each other at right angles to the slope.
d) Some bog pools are of similar size, but
e) others can differ greatly in extent.
f) Pools can develop on large and small bogs.
g) If a bog surface is intact, without pools, subsequent pool development must be a secondary feature.

Part 3: Peat erosion

Many authors have written about this subject, and there is a consensus that peatlands in boreal and temperate regions are inherently unstable. They have initiation, life cycle and eventual degradation phases, and possible disappearance. Some authorities, however, believe that erosion may not lead to the complete demise of a bog because it is possible for peat formation to restart even in eroded areas, or elsewhere when eroded peat is redistributed downslope.

The causes of peat erosion are numerous, with older bogs and thicker peat being most susceptible. James Fenton re-examines the types and origins of peat erosion, explains its development, and proposes a modified classification and revised terminology.

One process may dominate but several or all may be present with one type merging into another. In Type 1 the acrotelm is lost, resulting in exposed catotelm, for which there are numerous possible causes, natural and artificial. Types 2 and 3 occur where the catotelm peat erodes and oxidises either underwater or owing to changes in surface vegetation. Type 4 is catastrophic because the entire peat mass moves downhill suddenly.

Proposed Classification of Erosion Types

1. Loss of acrotelm
- 1.a. **Surface erosion** - sheet erosion
  - 1.a.i Cessation of peat growth
  - 1.a.ii Fire damage
  - 1.a.iii Mechanical damage
- 1.b. **Gully erosion** - Water erosion/dissection
  - 1.b.i Watercourses: natural
  - 1.b.ii Watercourses: artificial
- ***1.b./1.c. Gully erosion - Vertical edge cut-back***
- 1.c. **Vertical edge cut-back** - Marginal erosion
  - 1.c.i Peat growth, creep, and instability
  - 1.c.ii Mechanical damage
  - 1.c.iii Water erosion
  - 1.c.iv Animal rubbing
  - 1.c.v Fire damage
  - 1.c.vi Peat cutting

2. Underwater
- ***2./1b./1c. Underwater - Peat hags***

3. Internal

4. Catastrophic - mass movement

Peat growth can restart in eroded areas, and peat accumulation can be rapid, suggesting that ombrotrophic peat can experience long-term cycles of growth and erosion. Peat regrowth may not commence in all parts of an already eroded bog.

Peat cutting for domestic fuel is like erosion, but is deeper and widespread over larger areas, initially. Peat growth can restart on cutover bogs if the surface turf (acrotelm) has been preserved below the cutting face. Where bogs have had their peat cut down to expose the mineral substrate peat regrowth may take a very long time or never occur.

The author concludes that erosion is the fate of most temperate ombrotrophic bogs, similar to boreal ones. He postulates that since temperate peat-forming plants are tolerant of a wide range of climatic conditions, and if they are still available, able to colonise and grow, peat formation and accumulation are independent of climate.

Part 4: Implications for climate change and land use

There are four sections in the final part of this book - conservation, climate change mitigation, future of peatlands in a changing climate, and trees in and on peat.

Conservation

The author quite correctly states that ombrotrophic peatlands are an internationally rare habitat worthy of protection. This is true for all stages of their life cycle from early initiation, through pool formation, to the final erosion stage. Any one peatland is likely to exhibit several stages in their development and degradation, and this adds to their biodiversity of habitats and species.

Although human intervention such as removing trees and blocking ditches to rewet peat to promote growth of peat-forming plants and return peatlands to more natural states are laudable activities, there are potential conflicts between climate change mitigation and nature conservation. For example, gulley blocking to reduce release of stored carbon interferes with a peat bog's natural processes. If this intervention is carried out to mitigate the impact of human activity it might be justified, but if not then it can reduce the naturalness of the landscape.

Strategic landscape planning is therefore necessary to identify and prioritise the most important interventive actions to prevent unforeseen consequences damaging nationally or internationally important habitats.

Climate change mitigation

Peatlands, globally, are the largest terrestrial carbon store on the planet, and steps must be taken to ensure as much of it as possible is kept in the ground. Climate change mitigation of ombrotrophic peatland is advocated when their degradation and excessive emission of greenhouse gases has been initiated and/ or maintained by human actions such as farming, forestry, industrial pollution, leisure activities, peat cutting and water regulation.

Early stage and shallow peatlands where the catotelms are thin or still developing have the best long-term carbon sequestration and storage potential and should be prioritised for strongest protection and mitigation. Older bogs with thicker peat are likely to be experiencing some form of erosion somewhere, making them less effective net carbon sequestrators, although they will remain significant carbon stores.

Owing to the large range of peat erosion causes and features, it is virtually impossible to provide a single all-embracing meaningful definition. Peat erosion can be a natural or a man-induced feature, but the presence of erosion does not necessary imply overall loss of peat from a bog, although this could be the case. It is the overall carbon balance of a bog that is important. As mentioned, in Part 1, the absence of *Sphagnum* does not necessarily mean that there is no peat accumulation.

Peatland carbon balance is determined by three rates, all of which are difficult to measure making carbon balance assessment an inexact science:

- Active peat growth of the first cycle peat
- Erosion
- Growth of the second and subsequent peat cycles.

A peat bog can be in any one of three carbon balance states:

1. Positive - sequestering carbon that increases the store over time.
2. Neutral - maintaining a carbon store of constant size.
3. Negative - releasing carbon, decreasing the store over time.

At a landscape scale a peatland could experience all three states in different locations, making it difficult to assess the overall carbon balance. This book contains a simple table (4.9) to assist with estimating the overall carbon balance, while a carbon budget calculator using an Excel spreadsheet is provided in Appendix G.

Over millennial timescales, it is likely there is a maximum carbon storage potential for ombrotrophic peatlands, after which the amount of carbon stored fluctuates about a lower mean, with growth matching erosion over the long-term.

Pools on bogs are erosion features because of the way they expand, coalesce, and eventually drain, making it difficult to determine the surface area of pools that will change a bog from carbon positive to negative. In terms of climate mitigation, the question arises 'should the rate of carbon sequestration be increased through rewetting and artificially revegetating drained and eroded areas'? Rewetting alone only serves to reduce greenhouse gas emissions of CO_2 but does not stop them. Reintroduction of peat forming plants and their proven sequestration of carbon is essential to increase the carbon store.

The author contends that from a climate mitigation perspective, most impact will be achieved if revegetation of eroded areas is targeted at locations where the entire peatland is in negative carbon balance, or there is evidence that erosion was caused by human activity.

The future of peatlands in a changing climate

The rate of growth of temperate ombrotrophic peat is probably insensitive to climate and is influenced more by the ecological characteristics of the peat-forming plants. Most of these species have a distribution range extending from the British Isles south to warmer climates, and east and north to colder ones. A greater impact is likely to be from intense rainfall and drought events causing greater peat erosion, catastrophic collapse, and increased peatland and peat fires.

According to the author, if climate mitigation is to be taken seriously, all activities that result in removal of or damage to peat and its oxidation should stop. However, although he includes peat harvesting and construction, he excludes grazing animals and the use of peat in the malting of barley for Scotch whisky production. He states that the impact of grazing on peat erosion has been overstated and should be regarded as a natural feature, although it has accelerated because of over-grazing at high density. He adds further that in Scotland peat erosion was extensive before sheep farming was introduced.

This logic is difficult to follow or agree to because the largest greenhouse gas emissions from drained, degraded peatland at the present time are from upland blanket bogs subject to past gripping and grazing, lowland peatlands used for arable crops, and forestry on peatland. GHG emissions from domestic peat cuttings are a historical feature but at the present day are still considerable, while those from commercial peat extraction for horticulture are the smallest of all at around 2 % of emissions from all UK drained peatland, and 0.1–0.2 % of total UK emissions. Peat extraction for production of Scotch malt whisky appears to be sacrosanct, although it is a product introduced in the Victorian era as a fashion drink for the wealthy.

The ongoing use of peatlands and peat to ensure optimal climate change mitigation should be based on their responsible management, and wise use supported by verifiable science and justifiable needs.

Trees in and on peat

In this final section of his book the author introduces the dilemma of multiple land uses, multiple activities, and the impact of reducing some to further the cause of climate change mitigation on ombrotrophic peatland.

Historically, in the British Isles, colonisation of ombrotrophic peatland by trees (mostly conifers) was relatively rare owing to the climate, acidity, and nutrient deficiency of this habitat. After the last glacial period, few conifer species recolonised these islands and only Scots Pine and Juniper colonised acid soils. As climate ameliorated and became milder, pine was pushed to the margins in northern Scotland and a few locations in Ireland. This tree does not tolerate waterlogging and on upland acid soils it was unable to survive on the rapidly developing blanket peatland in the Atlantic Period, proof of which can be found underneath the peat.

From the mid-18th century coniferous trees, including pine were planted in estates from which they spread to the margins of peat bogs, colonising drier peat. In some cases, Scots Pine was planted on drained peat bogs in the lowlands as part of attempts to convert them to other uses. Conifer planting increased greatly following World War 1 that highlighted the danger to Britain's war effort of a lack of timber, most of which was imported. Many of these new plantations were established on marginal land with poorer soil including ombrotrophic bog. This expanded post 1960s when tax incentives were provided for planting conifers, including in the Flow Country peatland of northern Scotland from which Sitka Spruce is now being removed.

The dilemma is that peatland can be invaded and colonised by non-native conifers that only grazing by sheep and cattle can control. If grazing were to be stopped bogs are likely to be taken over by conifers and other trees such as birch that would dry the peat and liberate some of their carbon store, hence contributing to climate change processes.

Volume 2 contains seven appendices that present additional information on:

A. Capillary action and peat formation

Peat forms when partially decomposed dead plant material becomes compacted, forming a perched water table, enabling the peat to remain permanently waterlogged, and preventing complete decomposition under anaerobic conditions. Water is held by capillary action and can move upwards against gravity. The extent of this water height increase is a function of the balance between capillary and gravitational forces. This equilibrium means that water will not drain downwards. The smaller the peat pore size, the greater the capillary force, and the higher water can rise.

B. Bulk density

Bulk density of peat is the dry mass of a standard volume of field material (solids plus pore space and water), usually expressed in grams per cubic centimetre. It is probably the most important physical characteristic of peat because many other properties, for example, particle density, porosity and water holding capacity, are linked to it. Bulk density depends on the degree of peat compaction, the plants from which the peat has formed and their stage of decomposition, and the mineral content of the peat. Bulk density determinations are essential in interpreting a range of peat analytical measurements, especially those relating to drainage, subsidence, cultivation, and carbon content.

C. Falkland Islands peat

Sphagnum moss is not a major contributor to peat formation in the Falkland Islands where its role is taken by the grass *Cortaderia pilosa*, the flowering member of the Liliaceae *Astelia pumila*, and occasionally the tall tussock grass *Poa flabellata*, or the moss *Polytrichum strictum*. Peat in the Falklands can date back to the pre-Holocene up to 16,000 years BP.

D. Growth and erosion of moss peat

Extensive banks of *Polytrichum strictum* moss peat are common in the Maritime Antarctic, especially South Orkney Islands, South Shetland Islands, and the western side of the Antarctic Peninsula. The author mentions one bank in the Falkland Islands near Johnson's Harbour.

E. Complex peatland landscapes: a case study

This is a Case Study of a complex peatland landscape at Coire Ceirsle Hill, Inverness-shire, Scotland at an altitude of 380–650 metres. Many of the instigation, development and erosion features described in this book are from this location. These are presented, described, and explained in many high-quality photographs.

F. Presence of trees on ombrotrophic peatland in Scotland

On ombrotrophic peatlands that receive their water only from rainfall, trees dry out the surface peat owing to their transpiration. If the upper layer of the catotelm dries and oxidises, aerobic respiration can cause peat to oxidise and release carbon to the atmosphere as carbon dioxide.

Commercial plantations on peatland require creation of a network of drainage ditches to increase and maintain drainage, leading to a constant release of stored carbon. The author concludes that any tree planting on peatland landscapes is detrimental to climate change mitigation, and where trees have been planted on peat, they should be removed.

G. Estimating carbon budgets: a carbon calculator

A simple carbon calculator is presented to determine which of the three states the peatland is experiencing:

1. Positive, and absorbing more carbon than it is releasing.
2. Neutral, with a carbon store that is neither increasing nor decreasing.
3. Negative, and releasing more carbon than it is storing.

Several problems associated with determination of peat growth and erosion rates are discussed including carbon-dating, measuring plant growth and decomposition, measurement of gas fluxes, and direct measurement of erosion. Accurate knowledge of peat bulk density is essential to estimate the total amount of carbon stored.

Selected references and a glossary are also provided.

R.S. Clymo and J.O. Rieley, January 2022