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Rapid Evidence Assessment of the Alternatives to Horticultural Peat in Scotland

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Executive summary

The Scottish Government has a commitment to restore Scotland's peatlands. An element of this is to phase out the use of peat in horticulture. This Rapid Evidence Assessment looks at the current state of knowledge on the role of peat in UK growing media, and the potential for alternative growing media constituents.

There are significant gaps in Scotland specific data. Our review of published literature (both grey and academic) has therefore been supplemented by information from industry experts.

Further research would be required to refine and tie findings to the Scottish context. Further research into user preferences would also be helpful.

Key findings

- Peat extraction in Scotland occurs mainly on lowland raised bogs in the south and east of the country. Estimation of extraction volumes is hampered by information gaps, but is of the order of 0.5 million m^3 per year. This represents perhaps 60% of the estimated 0.8 million m^3 of UK production.
- Estimated carbon emissions arising from extraction in Scotland are of the order of 100k t CO_2e per year, which could be avoided if all extraction ceased. However, alternative media also emit carbon so the net saving would be lower, at around 50k t CO_2e per year, if they were used instead.
- Scotland-level estimates of peat consumption are not available, but UK-level estimates show that overall demand for horticultural growing media is approximately 3.8million m^3, of which 2.1million m^3 (55%) are peat-based. The shortfall relative to domestic production is met by imports, principally from the Republic of Ireland (which could risk displacing emissions abroad if domestic production fell but consumption did not: supply-chains cross internal and external borders).
- Within overall demand for horticultural growing media, professional users (e.g. landscape gardeners, commercial growers) account for about 1.1 million m^3, of which 65% is peat-based, whilst amateur users (i.e. households) account for about 2.7 million m^3, of which 51% is peat-based.
- A variety of alternatives to peat are available, including coir, pine bark, wood fibre and composted organic waste. Most need to be mixed with other ingredients and are more expensive and not as readily available as peat. For example, wood fibre is also in demand for renewable energy.
- Peat-free alternatives have gained market share since the 1990s, but peat-based media remain commonplace. This reflects advantages offered by peat in terms of availability, price and consistency which are hard to replicate with alternatives and hence have to be traded-off against other criteria, such as environmental impact. The weight attached to different criteria will vary across different users, but those not already switched to alternatives may be harder to convert.

Summary tables of analysis and evidence assessment

The following PESTLE analysis (Political, Economic, Socio-cultural, Technological, Legal and Environmental), captures some of the key issues we have identified.

Political	**Economic**
• Lack of up to date information on peat extraction in Scotland presents a challenge. • There may be merit in co-ordinated working across UK administrations and with EU agencies to build collaborative solutions.	• The higher financial cost and generally inferior performance of peat alternatives is one of the main barriers to increased uptake in the commercial sector • The rising cost of wood fibre driven by biomass demand is a major barrier to competitiveness in that sector • Low profit margins in the commercial sector
Socio-cultural	**Technological**
• Consumers are driven by green aspirations and widespread publicity from NGO's to seek peat-free growing media • However, a lack of consistency in the available peat-free alternatives can lead to poor experience and a return to peat-based media. • Providing consumers with greater confidence in quality standards through transparent certification and labelling are essential to encourage uptake	• The poor performance of many of the peat alternatives currently available is the other main barrier to increased commercial uptake • Improvements in technology are essential if peat-alternatives are to improve their technical and economic performance
Legal	**Environmental**
• The lack of legally enforceable targets or mechanisms to increase the use of peat alternatives is one reason for the limited uptake • However, exerting legal pressure on the Scottish and UK horticulture industries brings with it a high risk of exporting horticultural production to overseas producers	• Peat alternatives offer in most cases a lower environmental impact than peat extraction • Wide difference in assessment methodologies make direct comparisons between different materials problematic • Some environmental costs of growing media constituents are externalised. Life-cycle analyses should take ALL environmental costs into account.

The evidence assessment demonstrated some limitations in the available data and highlighted different levels of confidence in the findings, and these are summarised here.

Finding	Data limitations	Degree of confidence
Volume of peat extracted in Scotland	No site-specific data. (section 2.1)	Medium - broad-brush, order of magnitude estimates
Volume of peat consumed in Scotland	No sub-UK regional-level estimates available. (section 2.3)	Low - no evidence
Market segment sizes	No split available beyond Professional vs. Amateur split (section 2.3)	Medium - broad-brush, order of magnitude estimates
Extraction emissions	No site-specific data (section 3)	Medium - broad-brush, order of magnitude estimates
Net savings from switching to alternative media	Only two papers on emissions from substitute media (section 3.4)	Medium - peer-reviewed sources–but sensitive to assumptions
Alternative media	Considerable literature and industry information (section 4.2)	High - but ongoing research may reveal more
Market acceptance of alternative media	Largely based on industry sources, weaker on amateur demands (section 5)	Medium - descriptions, but no quantitative estimates of likely responsiveness of demand to further efforts to promote uptake of alternatives, further user research would be helpful.
Progressing change	Largely based on industry sources (section 6)	Medium - but no objective insights into impacts or effectiveness

Contents

1. Introduction

This Rapid Evidence Assessment looks at the current state of knowledge on the role of peat in UK growing media and the potential for alternative growing media constituents, in the context of the UK and Scottish Government targets to reduce and phase out the use of peat in horticulture.

Peat became the dominant ingredient in growing media used by both professional, commercial growers and amateur, household gardeners when it replaced loam-based media in the 1960s and 70s. This occurred because peat offered advantages in terms of availability and cost. However, there is now widespread acknowledgement that the environmental impacts of peat extraction are too high and that sustainable alternatives to peat must be sought.

The horticultural industries within the UK and Republic of Ireland are closely integrated, and trade with other EU countries also occurs. Hence peat extracted from one country may be transported for sale as bagged media or in pots of container-grown plants in other countries. This was acknowledged in the UK government's response to the Sustainable Growing Media Task Force (SGMTF) in 2013 in the following statement: "*Two thirds of the peat used within the UK is imported from across Europe and we are a net importer of plants. Our horticultural industry needs to operate on the European stage and we need to work with partners throughout Europe to achieve a level playing field*." (Defra, 2013). For this reason, this report examines UK data and looks at the issue of peat use in growing media as a UK challenge, rather than simply a Scottish one. This is appropriate also because the industry's efforts to reduce peat use are being made by UK and European organisations rather than Scottish, English and Irish organisations.

The main gap in the data used to compile this report is the complete lack of "Scotland-specific" figures on the amount of peat used in growing media, the types of growing media sold in the retail and professional sectors and the amount of peat used to produce container-grown plants for sale in Scotland.

1.1 Note on horticultural terminology

The term 'growing medium' is used in the UK to describe the material used in a container to grow a plant. The term 'substrate' is also used in the UK and means the same thing. In the UK some people use the term 'compost' in the same context. However, this is a misleading term, since compost is technically the product of a composting operation which involves mixing and self-generated heating (e.g. the compost heap at the bottom of the garden or a commercial garden waste composting system). A composted material may be a component of a growing medium but neither peat nor most other ingredients used in growing media are products of composting.

1.2 Project approach

Following the approach set out by NERC (2015), we reviewed academic and 'grey' literature to assess the current state of knowledge on the market for peat-free and reduced-peat growing media.

Around 200 scientific papers, government and other reports were sourced for use in this project. These were screened to select the most recent, relevant information, which amounted to around 85 publications. All of those used are listed in the References section. Supplementary insights were gleaned through contact with selected industry experts. Further details on the methodology can be found in Appendix I.

1.3 Report structure

The next two sections of this report present a brief summary on the supply and demand for peat, the associated carbon emissions and the scope for reducing these through using alternative growing media. Section 4 reviews available alternatives, with market acceptance of these considered in section 5. Section 7 considers recent and current initiatives to reduce peat usage. Section 8 summarises key findings in Tabular form, with Section 9 offering some conclusions.

2. Current horticultural peat supply and demand

2.1 Peat extraction in Scotland

Official figures (UK Government, 2016) suggest that peat extraction in Scotland in 2014 amounted to around 0.5million m^3, approximately 60% of the UK[1] total. The precise methodology for calculating these estimates is unclear, but draws on information provided voluntarily by trade bodies, commercial companies and industry experts. Scottish extraction activity is concentrated on lowland raised bogs, rather than on more common blanket bogs found elsewhere in Scotland. Unlike in the rest of the UK, the estimated volume extracted in Scotland includes some (0.03 m^3) for non-horticultural use. This is believed to be mainly for the whisky industry (various distilleries, pers. comm.), particularly in the Highlands. The current level of small-scale extraction for fuel use, historically important in the Crofting Counties, is unknown.

AHDB (2016) suggest a similar total for UK-sourced peat in 2014, but imply around 0.2million m^3 from Northern Irish and Scottish output being closer to 0.3million m^3 and slightly less than English output of 0.35million m^3. Discrepancies from the figures cited above may reflect differences in underlying survey sampling of firms but also differences in where peat is extracted from and subsequently supplied to end-users from. That is, firms with multiple sites may physically move material around or assign it to a single site for reporting purposes, which may mask the country of origin. AHDB (2016) also show year-on-year variation in volumes over the period between 2011 and 2015 in output levels, partly reflecting variation in rainfall patterns (wet years hinder extraction).

Identifying where in Scotland aggregate output occurs is hindered by the lack of a definitive, up-to-date database of active extraction sites.

More recent extraction estimates are not yet available, but will likely also suffer from similar uncertainties arising from data gaps and a lack of supply-chain transparency. As such, although available estimates give an indication of the order of magnitude of aggregate production, regional or site-specific production levels are not known with any degree of confidence.

2.2 Sources of peat used as growing media in the UK

In addition to peat extracted within the UK, AHDB (2016) show that the majority of peat used for growing media in the UK actually originates from the Republic of Ireland. For example, Irish exports to the UK in 2014 accounted for around 1.2million m^3 compared to estimated UK production of around 0.8million m^3. EU exports to the UK added about a further 0.1million m^3, with a very small volume of UK exports reducing the balance to an overall total supply for growing media purposes in the UK of around 2.1million m^3. As with extraction estimates for Scotland, there is a degree of uncertainty around these figures but they have been produced in a consistent manner over a number of years and the orders of magnitude can be used with some confidence.

Further qualitative insights were offered by industry experts who emphasised that the Scottish horticultural and growing media industries are closely integrated with those in England, Ireland and several other European countries, including in the Baltics (N Bragg, P. Alexander and S. Holmes, pers. comm.). In particular, the following key points were made, although (reflecting the commercial sensitivities of supply-chains) none is supported by independent, published evidence.

- Much of the growing media used in both professional and retail sectors in Scotland is imported from the Republic of Ireland and England (and further afield). Phasing out peat extraction in Scotland or the production of peat-based growing media in Scotland may simply mean that existing growing media buyers will import it from elsewhere. However, no work done to evaluate the likelihood of this or possible mitigation measures (e.g. import controls) has been published.
- Some of the peat harvested in Scotland is sent to England (and Northern Ireland) in order to manufacture growing media for sales throughout the UK. Phasing out the use of peat-based

[1] Although figures cited for Great Britain relate to 2014, the most recent Official figures for Northern Ireland are 40,000 m^3 date from 1993 (Environment and Heritage Service, Department of Environment, Northern Ireland, 1993).

growing media in Scotland may not therefore help Scottish peat bogs unless the export of Scottish peat for growing media production elsewhere was also phased out.

- Scottish commercial producers of nursery stock, pot plant and vegetable transplants have to compete in tough European markets where profit margins are tight. Almost all currently rely mainly on peat-based growing media because it is cheaper and performs better than easily available alternatives. Should Scottish growers be prevented from using peat-based growing media, there may be some competitive disadvantage compared with their English and European competitors unless restrictions on peat-based media were imposed across at least the whole of the UK.
- Most of the container-grown plants sold in Scottish nurseries, DIY stores, supermarkets and garden centres are imported from other countries (mainly England, France, Belgium, Germany, Netherlands and Italy). Some are brought in as young plants and grown on in Scotland and others are brought in for immediate sale. Stopping the use of peat-based media in imported plants will be difficult unless the issue is tackled on at least a UK-wide basis.

2.3 Current horticultural uses for peat in Scotland

The overall market for growing media splits into distinct segments, most notably amateur, household users and professional users. The latter tend to buy in bulk and in loose rather than packaged form, whereas household users tend to buy modest volumes in bagged form from retail outlets. Professional users can be further sub-divided into wholesale and retail horticultural nurseries but also landscape gardeners. The latter include firms providing services to individual households, but also to corporate and (especially) public-sector customers.

At the UK-level (Table 1), overall demand for growing media is approximately 3.8million m^3, of which peat-based media accounted for 55% at 2.1million m^3 and peat-free media 45% at 1.3million m^3 in 2014 (AHDB, 2016). Within this, the professional market accounted for around 29% (1.1million m^3) of overall demand and the amateur, retail market for around 70% (2.7million m^3), but with different peat and non-peat shares. Specifically, in the 2014, the professional market was split 65% (0.7million m^3) peat-based and 35% (0.4million m^3) non-peat, but retail buyers split 51% (1.4million m^3) peat-based and 49% (1.3million m^3) non-peat. These differences in the composition of market shares for different segments reflect different buying preferences, in particular professional users' apparent greater sensitivity to cost and performance (see later section). No demand figures are available at a regional level within the UK, including for Scotland.

Table 1: Estimated UK-level use of growing media in 2014, by market segment (million m^3)

	Peat-based	Non-peat	Total
Amateur	1.4	1.3	2.7
Professional	0.7	0.4	1.1
Total	2.1	1.7	3.8

Between 2011 and 2015, the volume of growing media sold by UK manufacturers for use in the UK fluctuated between 3.6 million and 4.5 million m^3, but the percentage split between sales into the retail and professional sectors has changed very little in the past 5 years. The overall share of peat has dropped slightly from 62% in 2011, and from 72% for professional users and from 58% for amateur users.

Reasons behind the reductions in peat use in growing media, and the differences in composition between media were not discussed in the final report of Project CP100 (AHDB, 2016). However, industry sources have said that the reductions are due to an understanding by growing media manufactures, growing media users, professional growers and plant retailers that they must seek alternatives to peat (HDC, 2012; Sustainable Growing Media Task Force, 2012).

As with estimated peat supply figures, demand estimates are subject to a degree of uncertainty over their derivation. However, they have been produced on a consistent basis over a number of years by

relevant experts working with the industry and hence support a degree of confidence over their order of magnitude and composition.

3. Climate change impacts of peat extraction in Scotland

3.1 Changes in stored carbon resulting from peat extraction

Peatlands are an important store of sequestered carbon, which is released when they are damaged, including through peat extraction. During the extraction process, carbon is lost directly from the removal of surface vegetation and subsequently over time from within the extracted peat itself as it decomposes. Secondary losses from the local area affected by drainage and lowering of the water table may also occur (IUCN, 2016).

An estimate of the carbon lost can be calculated by using the 'carbon calculator'. This was devised in order to quantify carbon losses and savings associated with wind farm developments on peatland in Scotland (Scottish Executive, 2006; Nayak et al., 2008), but it may also be used to provide an estimate of carbon losses associated with other forms of development such as extraction of peat for horticultural purposes. The calculations are set out in Appendix II and indicate that Scottish Government (2016) estimates of peat extraction volumes in Scotland imply annual emissions of approximately 100kt CO_2e.

The evidence for carbon losses from damaged peatlands is robust, and has prompted ambitious restoration targets (IUCN, 2016; SNH, 2015; SNH, 2019b; Scotland's Soils, 2018). The precise intensity (t CO_2e/ha) of emission losses is subject to some uncertainty due to variation in site-specific conditions and external factors, but the intensity of losses from bare peat (as associated with extraction) is higher than for less extreme damage (Smyth et al., 2015). Estimates of total carbon losses from extraction in Scotland will vary with the assumed emission intensity but also the area assumed to be being extracted. Nevertheless, the order of magnitude of estimates presented in Appendix II may be used with reasonable confidence.

3.2 Responsible peat extraction

In principle, the impacts of peat extraction might be mitigated through adherence to best practice, as formalised in voluntary industry codes. For example, the "Strategy for Responsible Peatland Management" adopted by The International Peat Society (IPS) in October 2010 aims to:

- Undertake peatland management according to the principles and within the framework of 'Wise Use of Mires and Peatlands' by safeguarding their environmental, social and economic functions and respecting their local, regional and global values.
- Ensure that high conservation value peatlands are identified and conserved, 'utilised' peatlands are managed responsibly, and drained, degraded or otherwise irreversibly changed peatlands are rehabilitated to restore as many ecological and landscape functions as possible.
- Provide those involved in or responsible for peatland management with strategic objectives and actions for implementation.

Similarly, the Europe-wide industry-led Responsibly Produced Peat (RPP, see Appendix III for further details) scheme aims to:

- Leave natural peatlands with high conservation value untouched
- Assure long-term availability of peat as a valuable growing media constituent
- Maximise peat production from degraded peatlands and encourage restoration

However, we found no assessments of impacts for either of these codes. Nor did we identify any other responsible peat extraction codes or strategies and there is no extraction code or certification scheme specific to the UK or the Republic of Ireland (pers. comm. N. Bragg, S. Holmes, P. Alexander). Moreover, the RPP has no members in the UK or the Republic of Ireland.

Nevertheless, UK discussions between growing media manufacturers, Defra, environmental NGOs and other stakeholders have led to the recent formation of the Responsible Sourcing Scheme (RSS), which evaluates the sustainability of all potential growing media constituents in a wider sense than

just extraction of peat (pers. comm. N. Bragg, S. Holmes, P. Alexander). The RSS is described and discussed in Section 7, in the context of promoting peat-free growing media more generally.

3.3 Climate change benefits of reducing extraction

Given that estimated emissions arising from peat extraction in Scotland are of the order of 100kt CO_2e per year, complete cessation would save this volume of domestic annual emissions. Moreover, unless emission intensities vary significantly across individual sites, overall emissions would fall in proportion to any less-than-complete reduction in extraction activities. For example, a 10% cessation would reduce overall emissions by 10%, a 90% cessation by 90% etc.[2]

It should be noted, however, that cessation of extraction will not by itself be sufficient to stop emissions from an extraction site since remaining bare peat will still emit carbon. Rather, some restoration action will be required to protect the remaining carbon stock. This may take the form of simply raising the water table or, more ambitiously, of revegetating the site (Smyth et al., 2015).

Consideration also needs to be given to the availability and volume of imported peat. In the absence of import controls, unless demand is reduced, restrictions on domestic peat extraction may simply result in increased imports and displacement of environmental impacts to other countries. Demand reductions could perhaps be achieved through taxes on peat-based products and/or increased availability and awareness of substitute products. Market acceptability of the latter is considered in Section 6, but attention also has to be paid to the emissions associated with substitutes.

3.4 Climate change benefits of switching to peat-free substitutes

Although cessation of extraction reduces peat-related emissions, if alternative products generate emissions themselves then the net change will be less than the gross reduction. However, specific comparisons of the global warming potential of peat and alternative materials as constituents of growing media are limited. A detailed search of the literature found only two key relevant papers. Both are somewhat complex, and use different modelling techniques and hence are not directly comparable.

Boldrin et al. (2010) looked at replacement of peat with two types of compost, using Life Cycle Analysis (LCA)[3] techniques to compare the global warming potential of growing media containing either peat or compost made from kitchen waste or garden waste. For the compost option, the composting process, growing media use, and offsetting of mineral fertilizers were taken into account. For the peat option, peatland preparation, excavation, transport, and growing media use were considered. The research concluded that the effect of substituting compost for peat as a constituent of growing media was a net reduction in global warming potential of 70-150 kg CO_2e per tonne of growing media.

Within this, the direct carbon losses from the compost life cycle are 48% of those lost from the utilisation of peat for the same purpose (Table 2). The most significant loss for peat is during peat extraction, closely followed by the magnitude of losses during application to land. Carbon losses during application to land are similar irrespective of compost type, however these are around 40% of those released during the application of peat. The results show a greater emission of methane from compost than from peat, and this is in agreement with the findings of Bong et al. (2017). This is of note as the global warming potential of methane is significantly greater than that of carbon dioxide. However, there are a number of mitigation methods being introduced into composting processes to reduce the methane emissions, such as the use of locally available bulking agents (enhancing oxygen availability) e.g. wood chips (Maulini-Duran et al, 2014) or sawdust (Yang et al. 2013). As technology further improves, it is likely that these emissions will decline further.

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[2] A phased reduction in extraction activities may be unavoidable given the long time horizons attached to many existing and active planning consents, particularly those granted before the year 2000 (UK Government, 1995). For example, Auchencorth Moss in Midlothian was originally granted permission in 1986 but had this extended to 2042 in 2017 (BBC, 2017). Forcing early cessation may lead to requirements for significant financial compensation to operators.

[3] Life Cycle Analysis is defined by the Cambridge on-line Dictionary as; “the detailed study of the series of changes that a product, process, activity, etc. goes through during its existence”. It should be noted that LCA is limited by the scope of the study itself and of the set system boundaries (Bong et al., 2017).

Importantly, biogenic CO_2e (from biological sources, not fossil fuels) released from compost is considered to be neutral in relation to global warming potential under the 100-year time frame as applied to greenhouse gas emissions by the IPCC, while peat is not (Christensen, 2009). A 48% reduction in carbon losses implies a saving of up to perhaps 50kt CO_2e per year by replacing peat extracted from Scotland with composted growing media.

Table 2: Summary Life Cycle Analysis (LCA) for 1 tonne of kitchen waste compost (KWC) and garden waste compost (GWC) vs. 1 tonne of peat. (Adapted from Boldrin et al., 2010)

PEAT	Unit	Preparation and use	Production	Transport	Use on Land	Total	
Carbon Loss	kg	1108	39	12	815	1974	
COMPOST		Composting		Use		Total	
		KWC	GWC	KWC	GWC	KWC	GWC
Carbon loss	kg	353	612	339	336	692	948
Carbon losses in compost as % of losses in peat	%						48%

Quantis (2012) also used LCA techniques, in a study undertaken for the European Peat and Growing Media Association. This looked at the environmental impacts of peat-based growing media compared to growing media comprising peat in combination with other constituents, but also one peat-free medium. Performance was compared across five different applications: “fruity vegetables” (e.g. eggplant, tomato, pepper, cucumber); pot plants; young plant production using loose-filled trays; tree nursery stock; and the hobby (amateur) market.

The LCA considered: production (raw material extraction or growing), transport, processing and mixing; distribution to customers; degradation of the growing media during use; and, end of life degradation. Importantly, impacts on climate change were considered alongside three other environmental impact indicators: resources (mineral extraction and primary non-renewable energy consumption); ecosystem quality (e.g. ecotoxicity, acidification, eutrophication) and, human health (e.g. toxicity and respiratory effects).

The analysis indicated that it was not possible to identify one particular growing medium option that had the least (or worst) impact across all four indicators. However, some general conclusions could be made, notably that mixes containing a relatively large peat component had a higher impact on climate change; those having a large coir pith component had the highest impact on ecosystem quality; and those with a large share of green compost or mineral wool had the highest impacts on human health. It is worth noting that the climate change indicator for mixtures containing a preponderance of peat, across all areas of application, calculated average carbon emission intensity of 160 to 240 kg CO_2e/m^3 (average of 198), which is consistent with the figure derived from the carbon calculator (213 kg CO_2e $/m^3$) for peat extracted in Scotland.

Quantis (2012) therefore provides further evidence that growing media containing peat as a major constituent are responsible for higher CO_2e emissions than those in which peat is replaced by other components. Across all the areas of application, there was an average maximum reduction of 40% (range 59-32%) when comparing mixes that were largely peat with the mixes that gave the lowest emissions. In addition, there are other benefits of leaving peat bogs undisturbed, including: the maintenance of an internationally important habitat and its associated biodiversity; the absorption of

atmospheric pollutants; improving water quality; and reducing flooding (IUCN, 2016). Carbon savings of 40% imply replacing all peat extracted from Scotland with compost-based growing media could reduce emissions by around 40kt CO_2e per year.

The evidence for the net effect on emissions of replacing peat-based growing media with alternative products is limited, but appears to be scientifically robust. Further research might refine estimates and sensitivity to key assumptions (including limits to substitutability), but those currently available confirm that substitute products can reduce emissions. The next section considers peat-free alternatives in greater detail.

4. Peat-based and peat-free growing media

4.1 The development and current importance of peat in growing media

Sphagnum peat has been the most important bulk constituent of growing media for several decades. This followed considerable research by both private and public bodies to develop a variety of peat-based growing media for different horticultural applications, and contributed particularly to growth in the retail market for growing media from the 1970s onwards (Alexander et al., 2008); Bragg, 1995; Bragg, 1990, 1991; Bunt, 1988; Barrett et al., 2016; Robertson, 1993; Schmileswski, 2008).

The popularity of peat reflects its physical, chemical and biological suitability for use in growing media, plus its relative cheapness (ignoring its external environmental costs). However, environmental concerns about the sustainability of peat use began in the 1980s and were being widely reported in the popular media in the 1990s, most notably by the TV gardener Geoff Hamilton.

Pressure to limit or stop peat extraction and conserve and restore remaining peatlands has increased since then and there is widespread acknowledgement within government, environmental organisations, the horticultural industry and amongst the general public that we must find viable alternatives to peat in growing media. However, the challenge is to find readily available alternatives which perform as well as peat across a variety of applications at an acceptable price to users (Alexander et al., 2008; Barrett et al., 2016; BBC, 2016; Carlile,1999; HDC, 2012; Hickman, 2010; HM Government, 2018; IUCN, 2011; Sams, 2012; SNH, 2008).

The great majority of commercial growers now rely on specialist growing media producers to supply them with ready-made media which fit their requirements (Barrett et al., 2016; Bragg, N. pers. comm.). In some cases, these mixes are part of the manufacturers' standard ranges, and in others, special mixes are produced for particular purposes at the grower's request. Modern commercial horticultural systems have been designed around the use of peat as a growing medium, because peat has many advantages over other bulk materials. Similarly, amateur users predominantly rely upon retail suppliers of ready-made growing media.

4.2 Bulk growing media constituents other than peat

Soil-free growing media can be manufactured from both inorganic (e.g. rockwool, perlite, vermiculite) and organic constituents. However, due to their ease of availability and relatively low cost, organic constituents such as peat, composted garden wastes, composted bark and wood fibre have been the main focus of research and development for most applications (Barrett et al., 2016). Organic materials are also easier to dispose of after use, given that they can usually be beneficially applied to land or treated in a composting system.

Relatively few organic materials have the potential to partly or wholly replace peat in growing media. There is robust scientific evidence to support statements made about the four main commercially viable ones. These are described below, and their advantages and disadvantages are summarised briefly. The descriptions are based on the work of horticultural scientists who have published key refereed papers and reviews. These include: Barrett et al., 2016; Bragg, 1990, 1995; Schmilewski, 2008.

- **Coir –** Coir is probably the most widely used alternative to peat in growing media and its use has been widely studied and reviewed (Schmilewski, 2008). It is widely used as the main constituent in grow bags in the UK for soft fruit production. Coir is similar to peat in that it provides a favourable balance of air and water to plant roots. It is easily re-wetted after drying (which is an

advantage over peat). However, given that it is a waste product (from the coconut industry) and is not produced specifically for the horticultural industry, its physical, chemical and biological properties are not always favourable and can be very inconsistent (Nichols, 2013). It has to be transported for long distances when used in Europe and often requires a considerable amount of secondary processing to render it suitable for use, which can make it expensive. Coir is widely available, but most growing media specialists doubt it could replace peat entirely for financial, logistical and technical reasons (and many believe that it *should* not for environmental and human health reasons).

- **Softwood pine bark –** Softwood pine bark dominates container plant production in southern Europe and several countries elsewhere, including Australia, New Zealand and the USA, which have limited indigenous peat resources. Its use has been widely studied and reviewed (Barrett et al., 2016; Bragg, 1990). Pine barks usually have a high air capacity and they often have to be mixed with finer materials in order to give them sufficient water holding capacity. As with coir, pine bark is not produced specifically for use in growing media and it tends to have variable, and often unfavourable, physical, chemical and biological properties. Manufacturers usually have to undertake secondary processing to render it suitable for inclusion in growing media and this makes it expensive compared with other constituents, particularly since there is increased competition for the raw product in biomass boilers for renewable energy generation. Quality pine bark is expensive and in very short supply in the UK now (N. Bragg, pers. comm.).
- **Wood fibre –** The term “wood fibre” is poorly defined in the literature and is commonly applied to a range of materials produced from both primary and waste wood (Barrett et al., 2016). Those used most widely in growing media production are those produced using extensive, secondary processing methods including high pressure and high temperatures. The wood fibres produced in this way tend to have a sterile, more stable and more consistent nature. Wood fibre is widely used in commercial and retail growing media mixes but it is rarely used alone because it tends to retain insufficient plant-available water and tends to become compressed over time. Instead, it is used to optimise the properties of growing media by balancing the less favourable aspects of other constituents in mixtures. In economic terms, wood fibre processing is expensive initially due to the need for specialist machinery, but for the larger growing media manufacturers, the cost of wood fibre is similar to peat. Competition for forestry by-products for renewable energy generation means that wood fibre is becoming increasingly expensive compared to peat, coir and composted green wastes.
- **Composted organic wastes –** there has been considerable political pressure for UK growing media producers to consider using composted organic wastes as a component of growing media and significant government funding has been provided to help develop sufficiently high-quality composts (Certified through the UK Compost Quality Certification Scheme to BSI PAS 100:2018 (British Standards Institution Publicly Available Specification)) for this purpose (WRAP, 2003, 2014a and b). The in-depth “Peatering Out” project concluded that composted garden wastes were likely to form a significant part of bulk growing media in future (RSPB and English Nature, 2013). However, even quality certified composts can be very variable in terms of their chemical properties and there are problems with the quality of even some of the best composts of this type, due to contamination with herbicides, glass and plastic. Despite initial interest from several UK growing media manufacturers, only one now includes PAS 100-certified compost in its professional growing media and only then when growers specifically request it (N. Bragg and P. Alexander, pers. comm.).

A range of more novel potential growing media constituents including several wastes and raw materials have been recently reviewed (Barrett et al., 2016). These include materials such as horse manure, switchgrass and willow. The majority of these alternatives are from industrial, agricultural and municipal waste streams. The potential to re-use such wastes is an attractive prospect for the industries that produce them. Moreover, they are generally of low economic value and in abundant supply. They can be divided broadly into three types:

- **Untransformed waste materials with low secondary processing requirements** (including hazelnut husks and poultry feather fibre) **–** The main disadvantage of these is that they are not produced specifically for horticultural requirements, can be highly inconsistent and often have a number of undesirable properties.

- **Transformed waste materials with high secondary processing requirements** (including municipal solid waste, sewage sludge and horse manure) **–** Again, these materials are not produced specifically for horticultural requirements, they often have a number of undesirable properties and their use is likely to incur significant costs in research, development and ongoing product testing.
- **Renewable primary materials** (including processed switchgrass and willow) **–** Some of these have been shown to support plant growth but their economic potential has not been investigated and is thought to be poor.

In the case of specialist garden habitats for peatland and acid-loving plants, there may be no alternative to peat-based media, but in most other applications there is at least some potential for using alternatives, subject to user demands (P. Alexander and S. Holmes, pers. comm.). Robust evidence from scientific reviews shows that only four constituents (coir, softwood pine bark, wood fibre and composted organic wastes) have the potential to partially or wholly replace peat in growing media at present. Of these, only coir can perform well as the sole bulk constituent of a growing medium; all the others must be blended with other materials in order to produce media of acceptable quality.

AHDB (2016) estimate that the most frequent alternative constituents in 2015 were wood-based products, coir and green compost at 18%, 10% and 8% by volume respectively. The breakdown by market segment is, however, slightly different: for amateur users, wood, compost, bark and coir accounted for 21%, 12%, 5% and 5% by volume respectively; for professional users, coir, wood-based and bark accounted for 21%, 8% and 4% by volume respectively i.e. wood is more popular with amateurs and coir more popular with professionals.

4.3 Sustainability of alternative growing media constituents

Growing media manufacturers are increasingly aware of sustainability issues when sourcing constituents. Whilst peat is known to be a finite resource, and growing media manufacturers are under pressure to reduce its use, the use of coir also has environmental, social and sustainability issues. In particular, coir is a waste product which would not be available in sufficient volumes to replace peat, even if the entire world supply was used in growing media. The growing media sector is working together to improve the sustainability of their products and working practices.

5. Market acceptance of peat-free alternatives

5.1 Important properties of growing media

The chemical and physical properties of an effective growing medium differ to some extent, depending on context. For example, the relatively coarse, open medium required to produce large container-grown shrubs is very different to the fine, close-textured, almost sticky medium required to form small, free-standing blocks for growing vegetable transplants. Nevertheless, some general considerations in relation to cost, technical performance and environmental sustainability apply to all growing media. There is robust scientific evidence in the form of scientific papers, project reports, review papers and text books which describe the ideal characteristics of bulk growing media constituents in detail. Key references are: Barrett et al., 2016; Bragg, 1990, 1991, 1995; Bunt, 1998; Schmilewski, 2008; Youbin et al., 2009.

The important properties of growing media are described briefly below, with reference to peat, which is still the main constituent in many growing media. A fuller description of the ideal characteristics of bulk growing media constituents is provided in Appendix IV.

- **Cost -** Commercial users operating in competitive markets with low margins and households with limited budgets are likely to be price-sensitive. Peat compares well to all other bulk growing media constituents in the UK in terms of financial cost, remaining cheap in comparison to other bulk constituents of growing media when the costs of purchase, transport and secondary processing are taken into account.

- **Availability –** The constituent must be easily available in sufficiently large quantities. Peat is at present easily available, and will be available for the foreseeable future from sources outside the UK should UK supplies dwindle due to extraction ceasing.
- **Consistency (lack of variability) –** It is vitally important that the constituent is consistent in terms of its physical, chemical and biological properties. Peat extracted from the same areas of the same bog is exceptionally consistent, although its properties do change with depth.
- **Physical properties –** Effective soil-less growing media must have a physical structure that allows for an appropriate balance of air and water to facilitate healthy root growth. This physical structure must be stable over time. Peats can be extracted and processed to provide products with a useful range of pore space sizes or different applications, and peat generally has excellent stability over the length of time required for container-grown horticulture.
- **Chemical properties –** Growing media must provide a suitable environment for provision of appropriate amounts of essential plant nutrients. A range of chemical properties are important in a bulk growing medium constituent. Sphagnum peat tends to have ideal values for all important chemical properties.
- **Biological properties –** Media must be free from plant pathogens and weeds, biologically stable and must not "lock up" plant nutrients. Peat performs favourably in comparison to almost all other bulk growing media constituents in terms of its biological properties, not least because it is to a large extent devoid of microbial life.
- **Environmental impact –** The environmental impact of plant cultivation was not widely considered when commercial, peat-based growing media were first being produced in the 1970s. However, there is now solid evidence that the use of peat in growing media has clear negative implications for the environment.

The relative weight applied to each of these criteria by an individual user will vary. For example, some users may be more price-sensitive and demand greater levels of consistency than others prepared to tolerate higher prices and inconsistency if it delivers lower environmental impacts. Hence overall market demand (see Table 1) already includes both peat-based and peat-free growing media.

5.2 Market segments

The overall market for growing media can be divided between amateur and professional users. The latter includes landscape gardeners as well as commercial growers supplying retailers or households, all of whom who tend to buy in bulk and in loose rather than bagged form direct from producers. There is plenty of robust evidence in relation to the broad requirements for professional growing media in terms of supporting plant germination and growth in a consistent and predictable manner at a reasonable cost (Barrett et al., 2016; Bragg, 1990, 1991, 1995; Bunt, 1998; Schmilewski, 2008). By contrast, amateur users tend to buy smaller volumes in bagged form from retail outlets. Amateur requirements are presumed to be similar to professional demand, although there is less published evidence for this (Dawson, 2005; Schmilewski, 2008).

As shown in Table 1, some professional users are already using peat-free growing media. This reflects heterogeneity of specific requirements and tolerance of compromises. For example, although there are some issues around visual appearance, peat-free media have been widely adopted as soil conditioners by landscape gardeners. Similarly, some other professional users have switched in response to specific demands from individual end-clients and/or organisational policies. In such cases, end-clients may be willing to pay a premium to cover higher costs and/or organisations may be covering additional media costs plus possible additional staff training and time required to manage reduced media consistency. However, other professional users are deterred by higher costs which cannot be passed onto end-clients and concerns about the poorer performance and by inconsistency SGMTF and industry reps, pers. comm.)

In particular, today's commercial horticultural crops are produced in high-technology systems based on years of research and development. Production systems involve computer-controlled irrigation and plant nutrition systems, potting machines and robots to plant seedlings and young plants, climate-controlled glasshouses and accurate crop scheduling. They require growing media which perform in a consistent and predictable manner. Unless a market premium is available for adhering to a

particular production technique/standard, the input media must be available at an affordable cost given constraints on output prices obtainable in competitive markets.

Similarly, growing media are almost always used in containers of some sort, including pots (of all sizes), trays, bags and hanging baskets. Containerised plants require a growing medium which can provide a stable physical environment which allows both sufficient aeration and sufficient moisture holding capacity (Bunt, 1988; Barrett et al., 2016). The inability of true soil to provide this balance in such small volumes has been the key driver in development of soil-less (including peat-based) growing media. (Soil-based growing media are those such as the John Innes types, which contain heavy, natural topsoil). Indeed, the development of relatively lightweight, low-cost soil-less growing media has been a key innovation in the horticultural industry. It has allowed growers the ability to carefully control water, air and nutrient supply, whilst greatly limiting the potential for plant pathogens to cause damage. In short, soil-less growing media are vital in modern horticulture.

Table 1 shows that the split of amateur demand between peat-based and peat-free growing media is more even than in the professional market segment. This indicates that a high proportion of amateur users are content with the cost and performance of peat-free alternatives, and this may reflect marketing efforts by retailers (most notably B&Q) over the past two decades. However, either not all consumers are aware of peat-free alternatives and/or some choose to continue with peat-based media for reasons of cost, convenience or performance (SGMTF & industry experts, pers. comm.). Further research into user preferences would be helpful.

6. Progressing change

6.1 Government targets

UK Government targets for reducing horticultural uses of peat have been in place since the 1990's UK Biodiversity Action Plan (JNCC, 1994) and have been renewed and revised subsequently, for example in the "Natural Choice: securing the value of nature" White Paper (UK Government, 2011) and most recently in the "A Green Future: our 25-year plan to improve the environment" White Paper (HM Government, 2018). The latter emphasised reliance on voluntary change[4], but noted that lack of progress might necessitate further measures (HM Government, 2018, p45). There are no Scotland-specific targets, but the Scottish Government has signed-up to the UK-level ones.

A 2005 target to achieve 40% peat-free usage was met through combined efforts across the industry, but a 2010 target of 90% was not met. Currently, UK-level targets are to phase-out peat-based media by 2020 for the amateur market and by 2030 for the professional market, both of which appear challenging given current market usage. Lack of progress against targets is a discussion topic for the industry (The Commercial Greenhouse Grower, 2018; Horticulture Week, 2018a, b).

In 2011, the UK government established the Sustainable Growing Media Task Force (SGMTF), led by Dr Alan Knight (a consultant specialising in sustainable development) and made use of stakeholders from across the supply chain to determine how best to identify and overcome the technical and commercial barriers to achieving the targets. Findings from this group, available in published form and via contact with selected members, together with evidence from other literature suggest that the key reasons for failure to achieve the targets are as outlined below.

6.2 Price of growing media constituents

Whilst there are no published figures on UK wholesale prices for peat or growing media, or retail prices for growing media, several scientists working for growing media manufacturing companies have commented on prices in broad terms in refereed science papers (Alexander et al., 2008; Barrett et al., 2016; Schmilewski, 2008). One reason for the slow move towards peat alternatives in growing media is price: competition from other industries for woodchip and other materials and high processing costs for some materials means that peat is still cheap in comparison. This problem has been discussed on several occasions in the horticultural trade press (e.g. Horticulture Week, 2018c).

[4] A supposed mandatory ban by 2015 on public-sector usage of peat-based media in England and Wales was apparently not enforced (Horticulture Week, 2018c).

Peat, as with many fossil carbon materials, requires minimum processing and extraction costs can never reflect the time that the material took to accumulate and develop its unique properties. A history of competitive pricing for amateur peat-based products, combined with consumer tendency to buy growing media on price and failing to recognise either the environmental or the quality attributes of the products, has exacerbated the costs of producing alternatives (Alexander et al., 2008 and P. Alexander, pers. comm.). Garden centre chains often see bagged growing media products as loss leaders and some appear to believe that consumers will not pay more than they currently do for growing media (N. Bragg, pers. comm.).

6.3 Variable and often extremely poor quality of reduced-peat and peat-free products (in retail media)

A key reason for the failure to move more quickly towards achieving the target for reduction of peat content in retail media may be the variable and often extremely poor quality of reduced-peat and peat-free products (Alexander et al., 2008; Alexander and Williams, 2013; N. Bragg, pers. comm.). There is very little published evidence for this, but it is widely discussed in consumer gardening programmes, magazines and websites. For example, Gardening Which? (which publishes annual ratings in the form of replicated test scores for retail growing media) has often placed named peat-free growing brands at the bottom of its league tables (which include all types of media, including peat-based).

The performance of some of these products in terms of their ability to support plant growth is very poor. There is also a marked lack of consistency in product performance scores between years, with a named reduced peat or peat-based product achieving a good test score one year, and an exceptionally poor score the next (Gardening Which?, 2015, 2016, 2017, 2018). Richard Gianfrancesco, Head of Research at Gardening Which? said "Our trials of garden composts show that some manufacturers have made decent peat-free products for many years but others, especially those at the cheaper end of the market, have been churning out pretty poor ones and consumers have been burned by using these" (BBC, 2016).

Further evidence of the poor quality in retail peat-free and reduced-peat media and the impact these had on the drive to limit peat extraction is contained in the SGMTF's initial report (SGMTF, 2012). The chairman stated that in 1991 "the quality and performance of alternatives was just not good enough and the campaign resulted in peat-free products on the market that at best were not as good as peat and at worst did not work. Therefore, whilst intellectually the ask of the anti-peat campaign was well intentioned, in hindsight the rapid drive to 100% peat-free products was a tactical error whose legacy impedes consumer confidence to this day. If the campaign groups had been more sensitive to the economic and quality challenges of creating an alternative to peat at the launch of their campaign I believe more would have been achieved."

Given the lack of published scientific evidence concerning the performance of (and consumer satisfaction with) retail reduced peat and peat-free growing media (which members of SGMTF acknowledge [N Bragg, pers. comm.]), industry research funding is currently being targeted at improving evidence on both (AHDB, 2018); results are not yet available.

6.4 Confusion over labelling (in retail media)

Some industry representatives suspected that amateur gardeners are inadvertently buying peat-based growing media due to confusion over the meaning of the word "compost" (Alexander et al., 2008). These representatives believed that a high proportion of gardeners assumed that growing media labelled as "compost" (which most retail growing media are) was either a product of a composting process and/or contained no peat. This belief was borne out by a number of consumer surveys (Alexander et al., 2008). This may still be an issue (e.g. BBC, 2016). However, clearer labelling of retail media is now making it easier for gardeners to understand what they are buying in terms of peat content.

6.5 Poor uptake of peat-free and reduced peat media in commercial horticulture

Alexander et al. (2008) felt that the reluctance of professional growers to use constituents other than peat in growing media was due partly to the poor quality of these constituents, partly to the fear of poor traceability and risk to operators of using the new materials and partly due to the cost of developing new mixes, particularly alongside changing nursery practices.

When government targets for peat reduction were published, with an aspiration for zero peat use by 2030, many industry figures expressed concern that the targets were not based on evidence, that the trajectory of change proposed was arbitrary and that the prospect of a ban was out of proportion to the problem to be solved (Alexander et al., 2008; Sustainable Growing Media Task Force, 2012; P. Alexander, pers. comm.). The prospect of peat replacement was seen as unrealistic by some in the horticultural industry, especially given the scarcity of quality peat-free alternatives at that time (Alexander et al., 2008).

It is only since the late 1990s that some growing media suppliers have been able to raise the performance of professional reduced-peat mixes to match that of peat-based mixes (Alexander et al., 2008; HDC, 2012). Even by 2012, a great deal of work still needed to be done to improve understanding of water and fertiliser management in these new mixes.

Despite increasing pressure from the UK government, from some buyers of container-grown plants and considerable ongoing efforts by industry-led organisations, government and levy funded teams and environmental organisations, many growers continue to use peat-based media where they still can. This is because peat remains cheaper than alternative bulk constituents, because many reduced-peat and peat-free products simply do not perform as well as peat-based media in existing production systems and because there is insufficient pressure from buyers of ornamental plants to sell plants produced in peat-free and reduced peat media (P. Alexander, N. Bragg and S. Holmes, pers. comm.)

It may also be partly because media attention on peat reduction has decreased over recent years, as has the demand for peat-free products from some sectors (The Commercial Greenhouse Grower, 2018). For example, Hermann Konnemann of German-based Klasmann-Deilmann growing media manufacturers said in that publication, “For us, UK requests for peat free and peat reduced substrates have reduced over the past five years or so, despite our continuous investment in machinery to manufacture wood fibre and other constituents, whilst also financing ongoing R&D work into more alternative materials”. Mr Konnemann felt that the UK Government’s 25 Year Environment Plan would be likely to result in interest in peat-free and reduced-peat media rising again.

7 Recent initiatives to reduce peat use in the UK

7.1 Sustainable Growing Media Task Force (SGMTF)

The UK horticultural industry, in some cases funded by government and levy-boards, has made efforts towards reducing the use of peat in growing media over the past three decades. Although peat usage remains common, there is clear and robust evidence of continuing industry progress in the form of reports published by Defra, the UK levy boards and the Sustainable Growing Media Task Force (SGMTF) (AHDB, 2018, Defra, 2013; HDC, 2012; SGMTF, 2012, 2016, 2017).

Importantly, the SGMTF was set up by Defra following its consultation on reducing the horticultural use of peat in England in 2010. The SGMTF is made up of growing media manufacturers, professional growers from several horticultural sectors, retailers, researchers and environmental and horticultural NGOs. At least one representative from Defra usually attended meetings. The objective of the group was to examine the various barriers preventing a more rapid uptake of alternative materials by the horticultural industry.

The task force was intended not only to represent the whole supply chain but to give voice to sometimes competing concerns, such as those of growing media manufacturers and environmental groups. But what really drew them all together was the clear consensus that the UK horticultural industry should not be basing its whole production on a single material (peat), expecting it will always be readily available (AHDB, 2018).

The SGMTF initially produced a “Chairman’s Report and Roadmap” which aimed to make UK growing media and its production more sustainable. They identified several goals which they felt the industry needed to attain (SGMTF, 2012). Perhaps most importantly, they stated that there should be performance standards for growing media and all growing media should be fit for purpose. They also stated that all growing media should be made from raw materials that are environmentally and socially responsibly sourced and manufactured. Defra gave the SGMTF the go-ahead for projects to address

the issues it had identified (Defra, 2013) and many of these are now well underway. The most recent update for this work was published by AHDB in 2018.

Technical work includes Project CP138, which is being funded by Defra and AHDB (AHDB, 2018). This 5-year research, development and knowledge transfer programme aims to address the costs and technical issues being faced by professional growers in terms of sustainable growing media. The first three years of the project have concentrated on analysing the characteristics of growing media materials that govern performance for growers and on using those data to create new blends that can help the industry reduce its reliance on peat. The research team are now investigating the cost implications of adopting such mixes. Some other aspects of their use – such as whether handling, mixing or potting and tray-filling machinery may need to be adapted to deal with them – is already being investigated as the new blends are developed. An additional horticultural fellowship project (CP95) aims to help growers gain a better understanding of how to manage growing media containing a significant proportion of non-peat ingredients. The final report and expected scientific publications from this work are not yet available, so there is not yet evidence on outcomes to date. A more complete overview of the progress of initiatives, working groups and project work following the UK Government Response to the SGMTF (Defra, 2013) is presented in Appendix V.

7.2 Potential for labelling and/or certification schemes

An assessment of the evidence in the trade press and refereed science papers has shown that there have been several calls over the years, from environmental campaigners, amateur gardening groups and from the SGMTF, for improved labelling or a labelling scheme to differentiate between the sustainability of different types/brands of peat-based, reduced-peat and peat-free growing media and to provide more comprehensive information on the bag about the product within (Alexander et al., 2008; Horticulture Week, 2018a; SGMTF, 2012).

There is no detailed published evidence concerning the way in which UK/Irish growing media manufacturers label their bags, and no evidence of their opinions about labelling. In his first report, in 2012, The Chairman of the SGMTF, Dr Alan Knight said: “At present, when a consumer visits a retailer to buy growing media, they are confronted by a plethora of complex messages relating to the products on the shelf. There is a huge diversity in the words that are used to describe very similar products, whilst there is also an inconsistency in the presentation of a product’s key characteristics.” (SGMTF, 2012). There is currently no legal requirement to publish details of the contents on bags of growing media for sale in the UK (as there is with pesticides and fertilisers).

We found evidence (from consumer surveys) that amateur gardeners have little awareness of what ingredients make up a bag of growing media, and this confusion could be leading to inadvertent buying of peat-based media (Alexander et al., 2008; BBC, 2016; Section 6.1).

In an effort to minimise possible confusion over the contents of bags of growing media, the Waste and Resources Action Programme (WRAP), in their “Retailers guide to reducing peat in growing media” recommend that growing media manufacturers clearly label their products as being peat-based, reduced-peat or peat free, so that customers are clear about the product choice they are making (WRAP, 2014d).

Three existing certification and labelling schemes are described in the following sections, along with a summary of the potential for other schemes. The first two are Europe-wide schemes. The third (the UK Responsible Sourcing Scheme) is in the early stages of development. There is clear, robust evidence surrounding these schemes and how they operate. The evidence is supplied as references along with the text.

7.2.1 The EU Ecolabel

The voluntary EU Ecolabel was introduced in 1992 (http://ec.europa.eu/environment/ecolabel/the-ecolabel-scheme.html). It applies to a wide range of products including textiles, household equipment, cleaning materials and electronic items (not just growing media, mulches and soil improvers). It aims to enable growing media buyers to make informed choices (WRAP, 2014c). It is currently only awarded to peat-free growing media, but the possibility of including up to 20% peat in future is under review. The Ecolabel uses a range of sustainability criteria. Importantly, it only allows constituents that are recycled or recyclable and that present a demonstrable reduction in hazard to

the environment. Products must fulfil a limited number of performance criteria and are evaluated by independent experts, which makes the label useful to the consumer. It does not require manufacturers to state exactly what proportions of constituents are present in the bag.

The EU Ecolabel is not widely used in the UK for growing media (P. Alexander, pers. comm.). There is no published evidence as to why this might be the case, although leading industry professionals believe that it is probably because there has been no demand for it from the retailers that sell growing media in the UK (P Alexander and N Bragg., pers. comm.). We could find no evidence of independent assessment of the performance of this scheme in terms of its impact on the extraction and use of peat in growing media production.

7.2.2 The European RHP scheme

The voluntary RHP scheme is based in the Netherlands but is open to growing media manufacturers throughout Europe (https://www.rhp.nl/en/about-rhp). RHP certification guarantees the quality of growing media (e.g. water uptake, air content, pH, electrical conductivity, nutrients and freedom from harmful organisms). The scheme requires manufacturers to monitor the quality of growing media in the chain, starting from the production of raw materials and a large part of that is peat. RHP certification does not include a requirement to extract or source raw materials responsibly, but an additional scheme run by the same management team (The RPP Scheme) does. Seventy-one companies are currently certified with the RHP scheme, all of them in mainland Europe. We could find no evidence of independent assessment of the performance of this scheme in terms of its impact on the extraction and use of peat in growing media production.

7.2.3 The Growing Media Initiative

The Growing Media Association and the Horticultural Trades Association, in conjunction with DIY and Garden Centre retailers, Defra, the RSPB and the Royal Horticultural Society, set up the Growing Media Initiative in 2008 (Alexander et al., 2008). It was set up to help the horticultural industry in the UK meet government targets for reduction in peat use. Participants agreed to set themselves targets to reduce their use of peat year-on-year and to have policies in place that illustrated how they would do that. Companies' peat use figures and policies were independently audited and those that met mutually agreed targets were allowed to promote themselves as GMI members and display a logo on products that met set criteria. The scheme has now been closed and has been replaced by a broader and more ambitious scheme: the Responsible Sourcing Scheme (see below). Given commercial sensitivities, it is perhaps unsurprising that we found no published figures to compare the reductions achieved by GMI members with those of non-members.

7.3 The Responsible Sourcing Scheme

The Growing Media Association has led the development of a voluntary scheme which growing media manufacturers can use to differentiate products by how responsibly they (and their constituents, including all raw materials, not just peat) are sourced. The scheme, now called the Responsible Sourcing Scheme (RSS) has been designed to be practical, simple, robust, meaningful and cost-effective (AHDB, 2018). Defra officials sit on the RSS Steering Group and chair the scheme's technical committee.

Performance criteria to ensure that all products perform to a minimum standard are also part of the scheme. The scheme is also concerned with the social as well as environmental impacts of each raw material across its supply chain. (The social impact of harvesting some materials, in particular coir, can be extremely negative in some countries.) In the UK, each raw material will be scored against a set of environmental and ethical criteria that will include (at least) water consumption, pollution of soil, water and air and working conditions throughout the supply chains.

The RSS is different to the Responsibly Produced Peat Scheme (Appendix III) and the RHP Scheme (Section 3.2) in that it is more comprehensive. It deals with sustainable sourcing and manufacture of growing media from all potential constituents, rather than just peat, and also includes performance standards.

The criteria taken into account in the scheme include:

- Energy and water used in extraction, transport and production

- Social compliance
- The impacts on habitat and biodiversity of obtaining the materials
- Renewability
- Resource use efficiency in terms of the source of the material and the waste generated in processing it

Companies are now being audited on their products and processes and their performances are being scored. A pilot version of the RSS was launched in 2016 and the first trial audits took place in early 2019. Full rollout of the scheme is currently underway. Growing Media Association chair Steve Harper believes that the RSS will go a long way towards helping to achieve the necessary reductions in peat use in growing media (Horticulture Week, 2018a) though there is currently no published evidence of the success of the scheme in terms of its impact on peat use.

7.4 Other possibilities

Another possibility would be to design and implement a scheme of a similar type to the UK Compost Certification Scheme (UK CCS), which currently accredits compost producers to the British Standards Institute Publicly Available Standard 100:2018 (compost as defined in Section 1.1). This scheme is owned by Renewable Energy Assurance and is independently audited by United Kingdom Accreditation Service (UKAS) - accredited specialist auditors. Independently audited schemes such as the UK CCS, the UK Biofertiliser Certification Scheme and food assurance schemes such as Red Tractor Assurance and Scottish Quality Crops have increased confidence in the safety and quality of manufactured products and ensure traceability from the start to the end of the manufacturing process.

Compost producers design a set of quality management system documents including a “Quality Policy”, Hazard Analysis and Critical Control Point plan and a “Standard Operating Procedure”. They test and validate their system to ensure that it works to consistently produce a product of suitable quality and they maintain records demonstrating that their process works effectively and safely. They regularly test their products and are independently audited annually.

A scheme such as the UK CCS could work well in the UK growing media sector. However, in the “Responsible Sourcing Scheme” (RSS), the industry has now developed a scheme which will be independently audited and looks likely to achieve much of what a scheme like the UK CCS would do. There seems little point in attempting to develop an additional certification scheme until the success of the new RSS can be evaluated following the first full year of its use.

7.5 Examples of retailer incentives and other industry schemes

It has been very difficult to obtain robust evidence surrounding the role of retailers (other than B&Q) in reducing the peat content in the growing media that they sell or in the media of plants that they sell. There is almost no evidence from after 2011 and much of the evidence we have used in this section is from personal communications from growing media industry experts, from government-funded Waste and Resources Action Programme (WRAP) projects and from a single refereed scientific review (Alexander et al., 2008).

The part played by major retailers in reducing peat use in growing media became highly significant once they had understood and accepted the environmental arguments against peat use (Alexander et al., 2008). B&Q (the largest home improvement and DIY retailer in the UK and Europe) has played a particularly strong role since the early 1990s. In 1991, it made a commitment to stop peat extraction from SSSIs (or the non-UK equivalent) and to encourage research and development into alternatives. In 1992, it introduced, alongside its peat-based products, a comparably priced range of peat-free media packaged with information about their environmental benefits. However, by 1998, the persistence of demand for peat-based products highlighted that peat reduction could not be achieved purely by provision of a peat-free product.

In 1999, B&Q again led the way by committing to incremental dilution of its peat-based products, thereby signalling peat dilution, as opposed to offering only completely peat-free alternative products, as the most promising route for achieving eventual peat replacement. They produced a policy on peat use and have updated it regularly. Today, they state clearly on their website their aim to move

away from using peat and the reasons for the move (https://www.diy.com/one-planet-home/greener-gardens/moving-to-zero-peat).

Other large retailers including Sainsbury's, Focus, Homebase and several large garden centre chains, followed suit and produced publicly available policies on peat use in growing media that aimed towards achievement of government targets. These policies are summarised in Annex 1, Section 7 in Defra (2010a). We found no more recent information on retailers' policies on peat for companies other than B&Q.

Key elements of retailers' peat policies are:

- clear product labelling; requiring peat extraction sites to have in place at the onset of peat extraction effective plans for restoring the habitat lost
- a commitment to use peat from existing commercial sites (effectively capping peat production) and
- targets for ongoing peat reduction and its ultimate replacement

Although some of the smaller retailers have also produced publicly available peat policies, Alexander et al. (2008) felt that not all were responding actively or positively to the drive for peat replacement.

It is very difficult to find evidence of current policies specifically on peat use by retailers other than B&Q, partly due to the increasing drive for sustainable sourcing, transport and manufacture across all types of products. In other words, their policies on ethics and sustainability cover many raw materials and products, of which peat is only one and in many cases it is not mentioned at all.

Many NGOs and local authorities also have policies in place to ensure that the plants which they buy in for use or for sale are produced in reduced-peat or peat-free growing media. Examples of these include the Royal Horticultural Society, the RSPB, the National Trust and various local authorities (The Commercial Greenhouse Grower, 2018 and websites of the named organisations listed above).

WRAP has funded several projects which aim to help achieve government targets for a reduction in peat use. They funded a successful project in 2010/11 to support eight major retailers (Sainsbury's, B&Q, Homebase, Garden Centre Group, Marks and Spencer, Dobbies, Wilkinson and Travis Perkins) through the process of introducing or strengthening peat reduction policies in their businesses and supply chains (WRAP, 2012). The volume of peat sold by these accounted for 37% of the peat sold in bagged growing media per annum in the UK at the time, or a volume of 762, 507 m^3 of peat.

The programme initiated and built momentum for retailer peat reduction programmes in the absence of existing activity and strengthened the implementation of the peat reduction programmes where action was already underway. Retailers then embedded sustainable actions into retailer management processes such as the initiation and stronger implementation of peat reduction policies, embedding peat reduction into corporate training programmes, establishing peat usage information and providing an easy way for retailers to continue to track peat reduction in the business. Each retailer prepared an action plan place to sustain the momentum created by the project.

WRAP also produced the Retailers Guide to Reducing Peat in Growing Media in (WRAP, 2014d) which outlined the practical steps retailers can take to understand the issues surrounding the use of peat in growing media and ultimately minimise their impact on peat. It explained some of the drivers for change within the horticultural industry, such as the issues caused by the extraction of peat, the UK Government's targets in peat reduction, through to identifying what best practice looks like for the responsible retailing of growing media.

8 Tabular summaries

For convenience, findings presented in previous sections are also summarised here in Tabular form as a PESTLE (Political, Economic, Socio-cultural, Technological, Legal and Environmental) analysis. In addition, a summary of data limitations is also provided.

Table 3: PESTLE analysis of factors influencing reductions in peat-based growing media

Political	**Economic**
• Lack of up to date information on peat extraction in Scotland presents a challenge. • There may be merit in co-ordinated working across UK administrations and with EU agencies to build collaborative solutions.	• The higher financial cost and generally inferior performance of peat alternatives is one of the main barriers to increased uptake in the commercial sector • The rising cost of wood fibre driven by biomass demand is a major barrier to competitiveness in that sector • Low margins in the commercial sector
Socio-cultural	**Technological**
• Consumers are driven by green aspirations and widespread publicity from NGO's to seek peat-free growing media • However, a lack of consistency in the available peat-free alternatives can lead to poor experience and a return to peat-based media. • Providing consumers with greater confidence in quality standards through transparent certification and labelling are essential to encourage uptake	• The poor performance of many of the peat alternatives currently available is the other main barrier to increased commercial uptake • Improvements in technology are essential if peat-alternatives are to improve their technical and economic performance
Legal	**Environmental**
• The lack of legally enforceable targets or mechanisms to increase the use of peat alternatives is one reason for the limited uptake • However, exerting legal pressure on the Scottish and UK horticulture industries brings with it a high risk of exporting horticultural production to overseas producers	• Peat alternatives offer in most cases a lower environmental impact than peat extraction • Wide difference in methodologies make direct comparisons between different materials problematic • Some environmental costs of growing media constituents are externalised. Life-cycle analyses should take ALL environmental costs into account.

Table 4: Summary of data limitations and confidence in findings

The evidence assessment demonstrated some limitations in the available data and highlighted different levels of confidence in the findings, and these are summarised here.

Finding	Data limitations	Degree of confidence
Volume of peat extracted in Scotland	No site-specific data. (section 2.1)	Medium - broad-brush, order of magnitude estimates
Volume of peat consumed in Scotland	No sub-UK regional-level estimates available. (section 2.3)	Low - no evidence
Market segment sizes	No split available beyond Professional vs. Amateur split (section 2.3)	Medium - broad-brush, order of magnitude estimates
Extraction emissions	No site-specific data (section 3)	Medium - broad-brush, order of magnitude estimates
Net savings from switching to alternative media	Only two papers on emissions from substitute media (section 3.4)	Medium - peer-reviewed sources–but sensitive to assumptions
Alternative media	Considerable literature and industry information (section 4.2)	High - but ongoing research may reveal more
Market acceptance of alternative media	Largely based on industry sources, weaker on amateur demands (section 5)	Medium - descriptions, but no quantitative estimates of likely responsiveness of demand to further efforts to promote uptake of alternatives, further user research would be helpful.
Progressing change	Largely based on industry sources (section 6)	Medium - but no objective insights into impacts or effectiveness

9 Conclusions

Peat became the dominant ingredient in horticultural growing media in the 1960s and 70s, replacing loam-based mixes. More recently, increased awareness of environmental impacts has prompted attempts to reduce its usage in growing media. Following a Rapid Evidence Assessment method, this report has presented various findings relating to the production and use of peat-based growing media in Scotland and the scope for using alternatives. Scottish-specific findings are limited by data gaps,

but information in published literature (both grey and academic) plus contact with industry experts was sufficient to draw a number of conclusions.

- Peat extraction in Scotland occurs mainly on lowland raised bogs in the south and east of the country. Estimation of extraction volumes is hampered by information gaps, but official figures suggest that it is of the order of 0.5million m^3 per year. This represents perhaps 60% of the estimated 0.8million m^3 of UK production.
- Estimated carbon emissions arising from extraction in Scotland are of the order of 100k t CO_2e per year, which could be avoided if all extraction ceased – provided that sites were subject to some form of restoration to protect remaining bare peat. However, alternative media also emit carbon so the net saving would be lower, at around 50k t CO_2e per year, if they were used instead.
- Scotland-level estimates of peat consumption are not available, but UK-level estimates show that overall demand for horticultural growing media is approximately 3.8million m^3, of which 2.1million m^3 (55%) are peat-based. The shortfall relative to domestic production is met by imports, principally from the Republic of Ireland (which could risk displacing emissions abroad if domestic production fell but consumption did not: supply-chains cross internal and external borders).
- Within overall demand for horticultural growing media, professional users (e.g. landscape gardeners, commercial growers) account for about 1.1million m^3, of which 65% is peat-based, whilst amateur users (i.e. households) account for about 2.7million m^3, of which 51% is peat-based.
- A variety of alternatives to peat are available, including coir, pine bark, wood fibre and composted organic waste. Most need to be used in combination with other ingredients and are not as readily available or as financially cheap as peat. For example, wood fibre is also in demand from the renewable energy sector.
- Peat-free alternatives have gained market share since the 1990s, but peat-based media remain commonplace. This reflects advantages offered by peat in terms of availability, price and consistency which are hard to replicate with alternatives and hence have to be traded-off against other criteria, such as environmental impact. The weight attached to different criteria will vary across different users, but those not already switched to alternatives may be harder to convert.

  For example, commercial growers operating in competitive markets for their outputs are particularly sensitive to the price and consistency of their growing media inputs. Similarly, a proportion of household users will prioritise germination and growth performance. A lack of awareness of or confusion about alternatives may also be limiting higher uptake, as may unsatisfactory experiences with poorer quality substitute products promoted in the early 2000s.
- Continued R&D into alternatives together with efforts to raise awareness (possibly through certification) may help to further reduce the use of peat-based growing media. However, the likely responsiveness in terms of changing preferences/attitudes and behaviours is unknown. The UK Government has already signalled that reliance on voluntary uptake may not be sufficient to achieve stated targets (some of which have already been missed). Further research into user preferences would be helpful.

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Sincere thanks are due to Dr Neil Bragg (Bulrush Horticulture) and Dr Paul Alexander (formerly Royal Horticultural Society, Wisley and now Bulrush Horticulture Ltd) for their considerable help with this project, which was cheerfully given. Both are acknowledged horticultural scientists and growing media experts with significant publication records in the field. They are firmly committed to reducing peat in growing media and to a sustainable future for production of high-quality growing media. Both are members of the Growing Media Association and both were active participants in the Growing Media Initiative. Both have been key members of the Sustainable Growing Media Task Force since its inception and are involved with several projects to develop sustainable growing media, including

development and implementation of the Responsible Sourcing Scheme. Thanks are also due to Susie Holmes, another horticultural scientist and growing media expert (formerly ADAS and now Susie Holmes Consulting) who has worked hard over the years to develop quality growing media for the amateur and professional markets. Thanks too to Mr Hein Boon, Chief Executive of the RPP and RHP schemes, who helped with matters relating to the European growing media sector.

Abbreviations and acronyms

AHDB - The UK Agriculture and Horticulture Development Board. The UK levy board which funds agricultural and horticultural research

BBC - British Broadcasting Corporation

BSI – British Standards Institution

Defra – Department for the Environment, Food and Rural Affairs

EPAGMA - European Peat and Growing Media Association

GHG – Greenhouse Gas

GMA - Growing Media Association

GMI - Growing Media Initiative

HDC - Horticultural Development Council

HTA - Horticultural Trades Association

IPPC – Intergovernmental Panel on Climate Change

IPS – International Peat Society (IPS)

IUCN - International Union for Conservation of Nature

JNCC - Joint Nature Conservation Committee

NGO – Non-government organisation

PAS – Publicly available specification

PCC – The Peatlands Campaign Consortium

PPA – Peat Producers Association (changed in 2002 to the Growing Media Association)

RHP – The label of the European quality certification scheme for growing media

RPP – Responsibly Produced Peat

RSS - Responsible Sourcing Scheme

RSPB – Royal Society for the Protection of Birds

SGMTF - Sustainable Growing Media Task Force

SNH - Scottish Natural Heritage

SNIFFER – Scotland and Northern Ireland Forum for Environmental Research

SSSI – Site of Special Scientific Interest

UK CCS – United Kingdom Compost Certification Scheme

WRAP - The Waste and Resources Action Programme

Glossary

Air-filled porosity (AFP) - a measure of the degree of aeration in a growing medium. Defined as the portion (or percentage) of the compost volume which contains air after saturation and drainage.

Blanket bogs - bogs developed over large areas of ground hollows or undulating ground, where rainfall is high and evapotranspiration is low.

BSI PAS 100: 2018 - A publicly available specification which covers the entire production process for composts and ensures that composts are quality assured, traceable, safe and reliable.

Bog (Ombrotrophic) - A peatland that receives water from just precipitation.

Bulk density - The mass per unit volume of materials.

Cation Exchange capacity – a measure of how well a growing medium (or soil) can hold onto positively charged nutrient ions (or cations).

Compost – a stable, sanitised, soil-like material, which has been made through mixing, self-generated heating and aeration.

Composted green waste - a term often used by growing media manufacturers for green PAS 100 compost.

Composting – The natural breakdown of biodegradable materials through mixing, self-generated heating and aeration to form a stable, soil-like material.

Electrical conductivity – a measure of the concentration of soluble salts**.**

Fen - a peatland that receives water and nutrients from soil/rock/groundwater in addition to precipitation.

Green waste - Grass cuttings, leaves and prunings, from parks or gardens.

Growing medium - a material, usually used for potting plants or sowing seeds, which can be made from single constituents or more usually a mix of constituents such as peat, perlite, compost or loam.

Irrigation - Water applied to plants to sustain healthy growth and development.

Loam – Soil containing a desirable mixture of sand, silt and clay, suitable for crop production.

Life Cycle Analysis – the detailed study of the series of changes that a product, process, activity goes through during its existence.

Microorganism - An organism too small to see with the naked eye that is capable of living on its own.

Mire - a peatland where peat is currently formed and accumulating.

Nitrogen - An essential element (one of three major nutrients) required for plant nutrition.

Plant nutrient - essential element required for healthy plant growth.

Nutrient immobilisation - The degree to which nutrients in a growing medium (mainly nitrogen, but to a lesser extent phosphorus) are taken up by microorganisms as the medium decomposes and thus rendered unavailable to plants.

Organic – A confusing term, because there are multiple definitions for different contexts. When applied to growing media or waste products, it means that the substance is biodegradable. When applied to chemicals, it means that the chemical compounds contain the element carbon. When applied to farming, it refers to a legally defined system of sustainable food production.

Pathogen – Any organism capable of producing disease through infection.

Peat – a soil made of dead organic material that has been formed in situ and under waterlogged conditions.

Peatlands – Land with a carbon rich peat soil which may or may not be covered in peat forming vegetation.

pH – A measure of the concentration of hydrogen ions in solution. pH below 7 = acidic, pH above 7 = alkaline.

Raised bog – Bog habitat characterised by an accumulation of peat that rises above the surrounding landscape often in lowland wet floodplains and/or often over the surface of existing fen peat.

Sewage sludge – A semi-liquid waste with a solid concentration in excess of 2,500 parts per million, obtained from the purification of municipal sewage. Also known as “sludge” or “biosolids”.

Substrate – a term often used in place of “growing medium”.

Appendix I: Project Methodology

Project aims

- Determine the current state of knowledge for Scotland on the source, site condition and carbon release from peat extraction, the demand for horticultural peat and the relative scale of the horticultural industry in Scotland and wider UK and EU integration.
- Assess the comparative climate change benefits (in terms of feasibility) of a zero target for peat, compared to a 90% reduction in horticultural peat use.
- Identify peat-free alternatives, their commercial suitability in horticulture in Scotland and their environmental impact.
- Determine how well peat-free alternatives meet different needs and their costs.
- Assess the practical potential for the development of a certification scheme for alternative growing media.
- Assess the potential for labelling schemes highlighting peat content and whether there are existing schemes elsewhere.

Methodology

With the project title and aims in mind, the project team agreed a list of search terms on which to base all searches for non-academic (published in paper form and online) and scientific/academic publications. Most search terms were agreed with the staff team at ClimateXChange before literature searching began. Additional terms were added during the project. Search terms were:

Agreed project search terms	
• Coir	• Peat free growing media
• Coir growing media	• Peat-free growing media quality
• Coir growing media quality	• Peat-free growing media poor quality
• Food green compost growing media	• Peat targets
• Food green compost growing media quality	• Peat reduction targets
• Green compost growing media	• Peat reduction targets Scotland
• Green compost growing media quality	• Peatland protection Scotland
• Growing media attributes	• Phase out peat horticulture
• Growing Media Association	• Reduced peat
• Growing Media Association peat	• Reduced peat growing media
• Growing media quality	• Reduced peat growing media quality
• Horticultural peat	• Reduced peat growing media poor quality
• Horticultural peat Scotland	• Responsibly sourced growing media
• Horticultural Trades Association peat	• Sustainable growing media
• Horticultural Trades Association growing media	• Sustainable growing media quality
• Peat alternatives	• Wood fibre
• Peat alternatives growing media	• Wood fibre growing media
• Peat free	• Wood fibre growing media quality

Additional search terms added during project (usually used in combination)

- Anaerobic digestate
- Biochar
- Carbon dioxide
- CO_2
- Carbon release
- Climate change
- Compost
- Growing Media Initiative
- Horticulture
- Life Cycle Assessment
- LCA
- Peat
- Responsible sourcing scheme
- Sewage sludge
- Soil conditioner
- Sustainable Growing Media Task force

SAC Consulting (Julian Bell, Anna Sellars and Jennifer Carfrae) undertook searching and writing on Sections 3.1 to 3.7. Earthcare Technical (Audrey Litterick) undertook searching and writing on Sections 3.8 to 7.2. Julian and Audrey prepared the conclusions and executive summary and read, revised and commented on the final version of the report prior to submission.

Evidence from the most recent work on each subject was always used in preference to older evidence and refereed scientific papers, reviews and reports were always used in preference to non-refereed publications. For the sections on peat bogs, peat use and carbon dynamics SRUC undertook a review of literature using Web of Science® and Google Scholar®. All subscribed resources available to the search engine (considered the most comprehensive available) were used in all searches. The SRUC team also conducted a search of planning portals for information on peat extraction sites and spoke to industry contacts.

For the sections relating to peat use in growing media, growing media constituents, the requirements of good growing media, alternative growing media constituents and industry progress towards peat-reduction targets, there was definitive, published evidence and/or relevant information for most of the subjects of concern. This evidence was drawn from scientific publications in refereed journals and from published reports from government and levy-board-funded work (e.g. from the AHDB) to reduce peat use in growing media and to improve the sustainability of growing media production. Web of Science® and Google Scholar® were used to search for relevant scientific literature.

Industry reports, trade press articles and websites were used where no refereed scientific papers and government or levy board-funded reports were available. Professional contacts in the horticultural science and growing media sectors, including members of the SGMTF, helped to ensure that relevant websites and meeting reports were not missed. Anecdotal evidence and opinion from industry leaders was sometimes quoted where no published evidence was available. Where such evidence and opinions were stated (particularly in relation to events which have happened during the progress of work to develop peat alternatives and to reduce peat use in growing media) these were obtained from acknowledged industry experts and were referenced as such in the report. The authors remain impartial and have not given ANY opinions in this report. All sources were fully referenced.

Factual conclusions based solely on the evidence obtained were provided.

Appendix II: Calculating CO_2 emissions resulting from the extraction of peat for horticulture

An estimate of the carbon lost can be calculated using the 'carbon calculator', which was devised to quantify carbon losses and savings associated with wind farm developments on peatland in Scotland (Scottish Executive 2006, Nayak et al., 2008).

The relevant equation from the carbon calculator is:

$$L_{removed} = (3.667/100)*pC_{drypeat}*BD_{drysoil}*V_{direct}$$

Equation 1

where $L_{removed}$, t CO_2, is the loss of carbon dioxide resulting from peat extraction
$pC_{drypeat}$, %, is the carbon content of dry peat
$BD_{drysoil}$, g/cm^3, is the bulk density of dry soil
V_{direct}, m^3, is the volume of peat extracted

For this purpose, Equation 1 uses estimates of soil bulk density (Chapman et al., 2009), an average figure of 52.9 % C in dry peat (Ratcliffe et al., 2019), and the total volume extracted in Scotland. Whilst the values for BD would be best collected on a site by site basis and linked directly to peat depth and condition, an average value based on collected data can be used, with recognition of the larger site by site variability, to complete the calculations. Thus, carbon losses resulting from peat extraction have been calculated by the authors of this report using Equation 1 from the carbon calculator for raised bog, which is the predominant source of extracted peat for horticulture (Table A3).

Table A3: Loss of CO_2 resulting from extraction of peat from a basin raised bog, calculated using Equation 1. The calculations have made for differences in bulk density at different depths

Depth (m)	Bulk density (g/cm3)	% carbon content of dry peat	Volume of peat extracted (m3)	L removed (t CO_2 lost during peat extraction)
0-0.3	0.136	52.9	469,000	123,731
0.3-1.0	0.114	52.9	469,000	103,716
>1.0	0.092	52.9	469,000	83,700

These calculations give a broad indication of the annual amounts of CO_2 that might be lost as a result of extracting peat for horticulture, based on the total volume extracted in 2014: an average figure of 103,716 t CO_2.

A more robust analysis would be needed to calculate losses on a site by site basis. For example, potential losses at the periphery of extraction activity can be attributed to changes in the hydrological system in the surrounding peat, and the impacts of this on carbon losses as a consequence. Desiccation impact on the surrounding peatland will be more pronounced near the boundary but is likely to extend into the surrounding peatland area and dependent on the site hydrology could have a larger impact area (i.e. where the water table height is more greatly affected due to the degree and angle of slope). This requires site by site assessment to allow inclusion of these losses in estimates and to allow recovery of these areas following remediation.

Site-based estimates could be refined further by using emissions factors already available which tend to be higher for extracted peats, with the exception of methane (Artz et al., 2014). Indeed, Smyth et al., (2014) suggested greenhouse gas (GHG) emissions of 23.84 t CO_2e/ha/yr for peatland left bare, and Artz et al. (2014) suggest 12.3 t CO_2e/ha/yr for peatland undergoing extraction in the UK, the difference emphasising perhaps the need for the development of regionally specific emissions factors for Scottish conditions. (Note that CO_2e, or carbon dioxide equivalent, is a standard unit for measuring carbon footprints. It expresses the impact of each different greenhouse gas in terms of the amount of CO_2 that would create the same amount of warming.)

Appendix III: The Responsibly Produced Peat (RPP) Scheme

This industry-led certification scheme is open to European (including UK) growers, although there are currently no UK or Irish members. It is designed for the responsible and transparent production of peat resources and is based around the Strategy for Responsible Peatland Management. The scheme (https://www.responsiblyproducedpeat.org/) aims to:

- Leave natural peatlands with high conservation value untouched
- Assure long-term availability of peat as a valuable growing media constituent
- Maximise peat production from degraded peatlands and encourage restoration.

There are five chapters on peat extraction (which they call peat production) and one on the chain of custody. These chapters cover:

- Legal issues (compliance with all applicable regulations of the country of production, as well as international laws and agreements)
- Good governance (peat producing companies must be transparent about their operations and must organise stakeholder dialogue)
- Site selection (peatland of high conservation value must not be used or drained, and degraded peatlands must be prioritised for extraction)
- Site preparation and peat extraction (environmental impact assessments must be conducted prior to extraction and a mitigation and monitoring plan must be submitted and accepted, which covers extraction and restoration)
- After use and rehabilitation to as near natural condition as possible (a clear after-use plan must be prepared and followed, in conjunction with relevant public authorities and relevant stakeholders including NGOs.)
- Chain of custody and RPP labelling (this will provide certainty that the peat or peat component in the product has come from certificated locations.

Foundation RPP was formally established on 19 August 2013 and the board was installed on 6 September 2013 in Vilnius (Lithuania). It currently has around 50 members in several countries including Germany, Sweden, Estonia, Latvia and Poland.

Appendix IV: The ideal characteristics of bulk growing medium constituents

- **Cost –** The cost must be as low as possible, since the margins for producing and selling plants in the UK are extremely low. Peat compares well to all other bulk growing media constituents in this regard. It remains cheap in comparison to other bulk constituents of growing media when the costs of purchase, transport and secondary processing are taken into account.
- **Availability –** The constituent must be easily available in sufficiently large quantities. Peat is at present easily available, and will be available for the foreseeable future from sources outside the UK should UK supplies dwindle due to extraction ceasing. Peat is much less available in some countries (e.g. the USA) and for this reason, it is used much less there in horticultural media than it is in Europe. Research, development and horticultural production there are based on composted bark, wood fibre and other non-peat constituents (AHDB, 2018).
- **Consistency (lack of variability) –** It is vitally important that the constituent is consistent in terms of its physical, chemical and biological properties. It is very expensive to repeatedly test, adjust and quality assure growing media to ensure consistency between batches (even those made using relatively non-variable bulk constituents). Peat extracted from the same areas of the same bog is exceptionally consistent, although its properties do change with depth.
- **Physical properties –** Effective soilless growing media must have a physical structure that allows for an appropriate balance of air and water to facilitate healthy root growth. The most commonly measured physical property in this regard is known as “air-filled porosity” (AFP). This balance must be maintained over the whole growing cycle, which might last for a few weeks or more than a year, depending on the crop, so the stability of the measured AFP is also important. Peats can be extracted and processed to provide products with a useful range of AFP values (low values are required for small containers, much higher values for larger containers) and peat generally has excellent stability over the length of time required for container-grown horticulture.
- **Chemical properties -** Growing media must provide a suitable environment for provision of appropriate amounts of essential plant nutrients. A range of chemical properties including nutrient content, pH (a measure of acidity/alkalinity), electrical conductivity (a measure of the salt content) and cation exchange capacity (a measure of the medium’s ability to retain nutrients) are important in a bulk growing media constituent. Sphagnum peat tends to have ideal values for all important chemical properties. In particular, the pH tends to be low and nutrients tend to be absent (or nearly so). This means that ensuring a bespoke pH value and nutrient profile in peat-based growing media is easy because all the lime and nutrients required must be added. (The requirement for complex characterisation of bulk materials prior to adding lime and nutrients is not required).
- **Biological properties –** Biological properties fall into three broad areas, namely: freedom from plant pathogens and weeds, biological stability and nutrient immobilisation (or drawdown) Barrett *et al*., (2016). Biological stability is the tendency of organic materials to break down due to microbial decomposition. Such breakdown can lead to undesirable physical changes in the medium. Nutrient immobilisation can take place when naturally present microorganisms take up plant nutrients as they break down the carbon compounds which form the main part of bulk constituents. Microbial uptake of nutrients (mainly nitrogen and phosphorus) can reduce plant performance unless compensated for. Peat performs favourably in comparison to almost all other bulk growing media constituents in terms of its biological properties, not least because it is to a large extent devoid of microbial life.
- **Environmental impact –** The environmental impact of plant cultivation was not widely considered when commercial, peat-based growing media were first being produced in the 1970s. However, it is now attracting significant interest (Youbin, et al., 2009; Barrett et al., 2016, Section 6). Environmental organisations and some consumers of both growing media and container-grown plants have become increasingly aware that peat is a finite resource, that destruction of peat-bogs is bad for biodiversity and that restoration of peat bogs is a step towards climate change mitigation. The use of peat in growing media has clear negative implications for the environment.

Appendix V: Recent and current working groups and R & D which aim to reduce peat use in UK horticulture

The Horticultural Development Council (part of The Agricultural and Horticultural Development board [AHDB]) commissioned a review to look at the horticultural use of "peats" by the various crop sectors (Project CP01). This led to a considerable amount of research and development work, funded by growers through the levy board panels and a series of independent projects and reports (e.g. Waller, 2006; Defra, 2010a; RSPB and English Nature, 2013). Work done during this time is summarised in the HDC Growing Media Review (HDC, 2012).

The Growing Media Initiative (GMI) was set up in 2008 by the Horticultural Trades Association (HTA) in conjunction with the Growing Media Association, DIY and Garden Centre retailers, Defra, the RSPB and the Royal Horticultural Society. It was set up to help UK growing media manufacturers meet government targets for reduction in peat use. It has now been closed and has been replaced by the Responsible Sourcing Scheme (see below).

The Sustainable Growing Media Task Force (SGMTF) was set up by Defra following its consultation on reducing the horticultural use of peat in England in 2010. The SGMTF was made up of growing media manufacturers, growers from several horticultural sectors, retailers, researchers, and representatives of horticultural and environmental NGOs. The objective of the group was to examine the various barriers preventing a more rapid uptake of alternative materials by the horticultural industry. One specific area examined by the Task Force was the role of research and development and knowledge transfer in overcoming the technical challenges to facilitate a more rapid move towards using higher rates of peat alternatives. The Task Force called for the establishment of a two to five-year programme of work supported by both Defra and the industry. This programme would define, develop and test responsibly sourced growing media suitable for the various horticultural sectors. The aim was to enable the industry to make informed choices about the growing media it uses and facilitate a move towards those that are deemed to be responsibly sourced, available in sufficient quantities, of consistent quality and are commercially viable to use. The need for this was acknowledged and supported by Defra (Defra, 2013), which gave the SGMTF the go-ahead for projects to address the twelve issues it had identified. These twelve issues were:

- Defining and agreeing the environmental problem we are trying to solve
- What are the non-market methods for protecting peat bogs
- Clarifying the greenhouse gas emissions associated with different growing media
- What do responsibly-sourced growing media look like?
- Sustainable growing media stewardship principles and certification
- What is the role of public policy in achieving the solutions to the 'non-bog' problems
- Performance standard for amateur products
- What are the price issues for growers – and other sector-specific issues
- Consumer messages and green claims
- How to measure success and progress
- Engagement and commitment – establishing a charter
- What will the horticultural sector look like in 2030?

The latest report summarising progress was published in 2018 (AHDB, 2018). To date, more progress has been made on some themes than others. Key achievements have been summarised below.

Project 4 has had the most attention from the Task Force so far (AHDB, 2018). The project is being conducted by a team of consultants and industry representatives under the auspices of the Growing Media Association. The aim was to design a voluntary scheme which growing media manufacturers could use to differentiate products by how responsibly they (and their constituents) were sourced,

including being able to compare the credentials of the same material from different sources. This voluntary scheme, now called the Responsible Sourcing Scheme (RSS) has been designed to be practical, simple, robust, meaningful and cost-effective. The criteria taken into account in the scheme include:

- Energy and water used in extraction, transport and production
- Social compliance
- The impacts on habitat and biodiversity of obtaining the materials
- Renewability
- Resource use efficiency in terms of the source of the material and the waste generated in processing it

Companies will be audited on their products and processes and their performance will be scored. A pilot version of the RSS was launched in 2016 and trial audits have taken place. Full rollout of the scheme is currently underway. Growing Media Association chair, Steve Harper believes that the RSS will go a long way towards helping to achieve the necessary reductions in peat use in growing media (Horticulture Week, 2018a).

Project 7 involved the development of performance standards for retail (amateur) growing media, which account for around 70% of the total volume of UK growing media sales. The SGMTF understood that all growing media should perform adequately but acknowledged that the performance of retail growing media was often poor. Work was first conducted to develop and standardise test methods. The results of this work are currently being assessed and will be used to develop a simple and robust testing protocol which can be applied to all constituents and growing media blends.

Project 8 addressed the costs and technical issues being faced by professional growers in a 5-year research, development and knowledge transfer programme supported by Defra and the AHDB (CP138)(AHDB, 2018). The first three years of the project have concentrated on analysing the characteristics of growing media materials that govern performance for growers and on using that data to create new blends that can help the industry reduce its reliance on peat. The research team are now investigating the cost implications of adopting such mixes. Some other aspects of their use – such as whether handling, mixing or potting and tray-filling machinery may need to be adapted to deal with them – is already being investigated as the new blends are developed.

An additional horticultural fellowship project (CP95) is also being conducted under the auspices of Project 8 (AHDB, 2018). It aims to help growers gain a better understanding of how to manage growing media containing a significant proportion of non-peat ingredients.

Appendix VI: Goals for the horticultural sector published within the SGMTF Chairman's Report and Roadmap (2012).

The SGMTF produced a "Chairman's Report and Roadmap" which aimed to make UK growing media and its production more sustainable. They identified several goals which they felt the industry needed to attain (SGMTF, 2012). These are summarised here:

- There should be performance standards for growing media and all growing media should be fit for purpose
- All growing media should be made from raw materials that are environmentally and socially responsibly sourced and manufactured
- Commercial horticulture should use only responsibly sourced and manufactured growing media
- Retailers should only stock products which meet the performance and responsible sourcing and manufacturing standards
- All public sector procurement should include a requirement to source plants and products that have been grown in sustainable growing media
- (Effective) consumer education should allow consumers to make informed choices in their purchase of growing media and are confident in how to get the best performance from them
- Confidence in green compost should be improved so that it can fulfil its maximum potential in the growing media market (estimated to be around 20% of the market)
- The waste regime should no longer be a barrier to the sourcing of high-quality waste-derived materials for use in growing media
- A voluntary approach should be sufficient to successfully deliver a transition to sustainable growing media within the horticultural sector

Appendix VII: Industry organisations in the horticulture and growing media sectors

European Peat and Growing Media Association (EPAGMA) – This ceased to exist in 2016, when it was split into Growing Media Europe (see below) and Energy Peat Europe.

Growing Media Europe AISBL - an international non-profit organisation representing the producers of growing media and soil improvers at European level. Their main objective is to promote optimum legislation for the manufacturing as well as the free and fair trade of growing media within Europe. Coordinating their work with the member companies and associate members all over Europe, the organisation aims to ensure a single voice for the industry. It provides scientific information as well as technical expertise on the use of growing media products and act as focal point for political decision makers and stakeholders inside and outside the European Institutions. It is committed to the highest environmental standards, to the sustainable use of natural resources and to contributing to the competitiveness of the European horticultural sector by providing high quality growing media products.

International Peat Society (IPS) - The IPS is an international, non-governmental and non-profit organisation, with approximately 1,400 members from 30 countries. It is dedicated to fostering the advancement, exchange and communication of scientific, technical and social knowledge and understanding for the wise use of peatlands and peat. To achieve its goals, the IPS via its Commissions and National Committees regularly organises conferences, symposia and workshops, publishes research results from science and industry and serves in general as a forum to bring together experts from different fields of business, science, culture and regulatory bodies dealing with peat and peatlands.

The Growing Media Association (GMA, formerly the Peat Producers Association) - a UK membership organisation formed from peat producers and growing media manufacturers. It represents the interests of its members as they move towards increased sustainability of sourcing and product manufacture. The GMA have been active in the Growing Media Initiative, the Sustainable Growing Media Task Force, various Defra-sponsored projects and the Responsible Sourcing Scheme (see Appendix III).

The Horticultural Trades Association (HTA) – a membership organising representing the UK gardening industry. HTA provides a forum for identifying and dealing with key garden industry issues and opportunities, represents industry views to Government and is its voice in the media.

The Peatlands Campaign Consortium (PCC) – a coalition of twelve of the UK's leading wildlife and archaeological conservation organisations, which was launched in 1990 to raise awareness of the peat issue amongst gardeners, growers and retailers.

Peat Producers Association (PPA) – This was re-named as the Growing Media Association in 2002, to reflect the fact that most growing media manufacturers were using other constituents in their mixes in addition to peat, and their focus was starting to move away from peat.

The Royal Horticultural Society (RHS) – a UK charity established to share the best in gardening. It aims to enrich everyone's life through plants, and make the UK a greener and more beautiful place.

The Sustainable Growing Media Task Force (SGMTF) - was set up by Defra following its consultation on reducing the horticultural use of peat in England in 2010. The task force, which remains active today, is made up of growing media manufacturers, growers from several sectors, retailers, researchers, and conservation groups. The objective of the group was to examine the various barriers preventing a more rapid uptake of alternative materials by the horticultural industry.

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