Portlethen Moss

Concise habitat, topography, hydrology & peat baseline

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1 Introduction

1.1 This concise, habitat, topography, hydrology & peat depth baseline for Portlethen Moss is based on field-based observations & measurement; open (publically-available) data; and modelling within a Geographic Information System to derive secondary information.

2 Baseline

Habitats & vegetation

2.1 Habitats have been mapped in Figure 1 using the standard Phase 1 habitat method and additional detail has been provided, on the National Vegetation Classification. The habitat and vegetation community correspondence; and relative and absolute areas are provided in Table 1.

2.2 Gorse and willow scrub are the most extensive habitats, collectively covering 56% of the Moss. 'Wet modified bog' is the next most extensive habitat, covering 15% that together with 'raised *Sphagnum* bog' (8.4%) and 'dry modified bog' (7%) results in a peatland habitat cover of 30% (4.7 ha). Neutral grassland (7%) and dry heath/acid grassland mosaic (5%) are moderately extensive. Small stands of mature trees (2%); a stand of Japanese knotweed ('other tall herb and fern - non ruderal' habitat; <0.1%) and the non-Phase 1 habitat, 'gravel surfacing' (<0.1%) account for the remaining minor areas of habitat or ground cover.

Table 1: Habitats and vegetation, and their relative and absolute areas.

Phase 1 habitat	Vegetation (NVC community)	Area	
		Hectares	Percent
A1.1.1 Broadleaved woodland - semi-natural	W11 *Quercus petraea-Betula pubescens-Oxalis acetosella* woodland	0.25	1.60
A2.1.1 Gorse scrub - dense/continuous	W23 *Ulex europaeus-Rubus fruticosus* scrub	4.21	27.50
A2.1.2 Willow scrub - dense/continuous	W1 *Salix cinerea-Galium palustre* woodland	3.48	22.70
	W3 *Salix pentandra-Carex rostrata* woodland	0.87	5.68
B2.1 Neutral grassland - unimproved	MG9 *Holcus lanatus-Deschampsia cespitosa* grassland	1.06	6.94
C3.2 Other tall herb and fern - non ruderal	n.a	0.01	0.05
D5 Dry heath/acid grassland	Non-NVC heath -U4 Mosaic	0.79	5.16
E1.6.2 Raised *Sphagnum* bog	M19 *Calluna vulgaris-Eriophorum vaginatum* mire	1.28	8.35
E1.7 Wet modified bog	M6-M19 mosaic: *Carex echinata-Sphagnum fallax/denticulatum* mire - *Calluna vulgaris-Eriophorum vaginatum* mire mosaic	2.30	14.98
E1.8 Dry modified bog	Non-NVC heath	1.07	6.97
Gravel surface		0.01	0.07
	Totals:	**15.33**	**100.00**

A1.1.1 Broadleaved woodland - semi-natural

2.3 Small stands of mature birch trees overlying a grassy field layer dominated by Yorkshire fog are included within this habitat. They are located in the south, on mineral soils and shallow peat (<0.5 m). The secondary ('colonist') nature of the woodland is evident in the even-age of the trees and the species-poor and uneven[1] composition of the field layer.

[1] Biodiversity includes the number of species and the number of inter-relations between species. 'Species richness' measures the former and 'evenness' the number of inter-relations. Uneven communities are dominated by one or a small number of species that are responsible for most of

2.4 The association of birch and grasses identifies the W11 *Quercus petraea-Betula pubescens-Oxalis acetosella* woodland NVC community. No sub-community is assigned because of the lack of defining or distinctive species or other features.

A2.1.1 Gorse scrub - dense/continuous

2.5 Gorse scrub is extensive across the Moss and concentrated in the north and west where it overlies upstanding, dewatered, deep peat. Towards the south, it is also present on mineral soils. The dense growth of this shrub limits the field layer beneath to nothing more than a prickly mat of its litter. Only bramble manages to persist as a frequent associate, as loose coils in the canopy that can be up to 2.5 m high.

2.6 NVC community, 'W23 *Ulex europaeus-Rubus fruticosus* scrub' is identified by the dominance of gorse and its association with bramble.

A2.1.2 Willow scrub - dense/continuous

2.7 Grey willow is the dominant canopy species within the willow scrub. Two types of are identified and defined by the NVC communities:

- W1 *Salix cinerea-Galium palustre* woodland
- W3 *Salix pentandra-Carex rostrata* woodland

2.8 'W1' is located on areas of dewatered, deep peat on the periphery of the Moss and is most extensive along the western edge where it extends onto mineral soil. The grey willow canopy may be supplemented with occasional birches and beneath, the field layer is composed of a moderately species-rich and even assemblage of mosses, herbs and grasses. This distinguishes it from the more productive, species-poor and uneven W11 field layer that is subject to less shade.

2.9 Areas of very wet peat in the centre of the Moss are occupied by 'W3' scrub. In these, grey willow is almost exclusively dominant. It has evidently established over 'wet modified bog' habitat because this and the scrub field layer have a similar, moderately species-rich and even, flora and composition. However, distinctive species and features are present within the scrub, such as common and widespread lichens on the willow boughs; or *Sphagnum fimbriatum* and *Sphagnum squarrosum* that were not recorded elsewhere. This indicates that a distinctive 'wet woodland' habitat is developing.

B2.1 Neutral grassland – unimproved

2.10 'Neutral grassland' is present on mineral soil in the south and in smaller areas on dewatered, deep peat amongst gorse scrub in the north. Yorkshire fog is dominant and there are few additional associates. As such, the neutral grassland is similar to the W11 woodland field layer and likely to have been the habitat colonised by the birches.

2.11 The dominance of Yorkshire fog is suggestive of the MG9 community although its typical associate, tufted hair-grass, is very scarce.

C3.2 Other tall herb and fern - non ruderal

2.12 A single area of 'other tall herb and fern - non ruderal' habitat, in the northwest, is used to delimit an area of Japanese knotweed.

D5 Dry heath/acid grassland mosaic

2.13 A single but moderately extensive area of dry heath/acid grassland mosaic is located in the centre of the Moss. It occupies the transition between peat soil and peatland habitat; and marginal areas of acid grassland and gorse on mineral soil.

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the inter-relationships (transfer of matter and/or energy). Even communities have a more equable mix of species and a more complex network of inter-relations that is presumed to offer greater resilience to a habitat.

2.14 Both habitat elements (heath and grassland) are species-poor and uneven. The 'heath' is little more than heather bushes within the acid grassland that is moderately even but species-poor. Yorkshire fog is abundant, but not as dominant as it is in the neutral grassland; and other species are frequent. These include other grasses and a low number and cover of forbs[2] in a composition that has affinities with the U4 *Festuca ovina-Agrostis capillaris-Galium saxatile* grassland NVC community.

E1.6.2 Raised *Sphagnum* bog

2.15 In the north of the Moss there is an area where the peatland vegetation is moderately species-rich and even, with a high cover of *Sphagnum* amongst the co-dominant hare's-tail bog-cotton and heather. This is identified as 'raised *Sphagnum* bog' habitat because of this composition, the depth of peat, and the rarity of atypical species. The latter feature distinguishes the 'raised *Sphagnum* bog' habitat from the 'wet modified bog habitat'.

2.16 The co-dominance of hare's-tail bog-cotton and heather, and relatively low cover of *Sphagnum* (in comparison to other bog types), indicates the M19 *Calluna vulgaris-Eriophorum vaginatum* mire NVC community.

E1.7 Wet modified bog

2.17 Located on wet, deep peat, on lower-lying parts of the moss, the 'wet modified bog' habitat typically retains a high cover of *Sphagnum* but this genus and its associates include atypical species. Most noticeable is the tall sward of abundant soft rush. This plant has spread in recent years to now over-top abundant tussocks of hare's-tail bog-cotton rooted in wet lawns of *Sphagnum*. In the shade of the rushes, heather is now rare. The *Sphagnum* lawn is dominated by *Sphagnum fallax*, a species that relates the influence of nutrient enrichment upon bog vegetation in such circumstances. More typical bog species persist, especially: cross-leafed heath, crowberry, heather, *Sphagnum capillifolium* and *Sphagnum cuspidatum*.

2.18 Identification of the NVC vegetation community associated with the wet modified bog is complicated by its transitional nature. The abundance of hare's-tail bog-cotton and localised persistence of heather, and historical observations (over the past decade) relate the habitat's origins as M19 ('raised *Sphagnum* bog' habitat). This is being replaced by M6-like vegetation, usually associated with 'acid/neutral flush habitat', that is indicated by the association of soft rush and *Sphagnum fallax*.

E1.8 Dry modified bog

2.19 Dry modified bog is located on upstanding, dewatered peat through the northern part of the Moss. It is dominated almost exclusively by heather, except for one grass-dominated area in the centre, and *Sphagnum* is absent in the dry to at most, damp conditions. This is classified as non-NVC heath because no analogue for it exists in the NVC, in the absence of any distinctive species.

Gravel surface

2.20 Gravel-surfacing is present at the interpretation board at the southern entrance to the moss from Bruntland Road.

Peatland Condition Assessment

2.21 SNH's Peatland Condition Assessment was applied to the dry, modified and *Sphagnum* bog habitats (E1.6.2, E1.7 & E1.8). The results of this are mapped in Figure 2 and summarised in Table 2 that includes the Phase 1 habitat correspondence and absolute (ha) and relative (%) areas.

2.22 Class 1 (near-natural) is assigned to the 'raised *Sphagnum* bog' habitat because although it has been modified (by cutting and drainage), it retains distinctive and typical peatland species. These have evidently established on a cut-over surface, according to the lowered surface (Figures 3, 4 & 8) and bordering drain (Figure 5). Greater

[2] 'Forbs' are herbs other than grasses.

modification of the Class 2 ('modified'), 'wet modified bog' habitat is apparent in its transitional vegetation that is now dominated by mire species not typical of bogs (i.e. soft-rush and *Sphagnum fallax*).

Table 2: Peatland Condition Assessment, habitat correspondence and areas.

Peatland Condition Assessment class		Area	
		Hectares	Percent
1. Near-natural	E1.6.2 Raised *Sphagnum* bog	1.28	27.55
2. Modified	E1.7 Wet modified bog	2.30	49.43
3. Drained	E1.8 Dry modified bog	1.07	23.02
	Totals:	**4.65 ha**	**100%**

2.23 Although it influences the entire Moss, drainage is especially evident in the dewatered condition of the Class 3 'dry modified bog' habitat. This reflects the upstanding situation of the associated peat that renders it especially vulnerable to drainage/dewatering, even in the absence of drains.

Topography

2.24 Topographic maps have been produced (in Figures 3 & 4) from publically available LiDAR data accessed as a Digital Terrain Model. This data has the benefit of producing a high-resolution, continuous surface (in contrast to the spacing of contour lines) that maps the ground surface and not vegetation or houses, for example.

2.25 The topography of the Moss is subdued, with an amplitude of <6 m, ranging from 76.5 m in the northwest to 71.0 m in the south. Cutting has produced a series of level surfaces in the north. The 'hillshade' (Figure 4) makes this especially clear by revealing:

- steep, cut faces;
- smooth surfaces of regenerating, *Sphagnum*-rich vegetation; and
- bordering, broad lines of spoil arising from cutting.

2.26 To the south, the topography is relatively level but more undulating because of the removal of blanketing peat and exposure of the underlying substrate (now under grass, scrub or woodland). An upstanding hillock of peat has been exposed by cutting in the northwest that is over 3 m higher than the surrounding peat surfaces. The summit of this may be uncut but this is unlikely as the crown of a raised bog is a favoured area for cutting. As a result, the current topography cannot be used to reconstruct the likely shape of the Moss before it was cut. However, planned modelling will provide an estimate of the Moss's maximum extent and likely points of origin.

Drainage

Drains

2.27 Drains conduct water along the western boundary of the Moss and through its centre, from the northeast. They are mapped in Figure 5. The western drain catchment starts north of the Moss and collects water from a drain alongside the A90. Its major source appears to be this drain with relatively small quantities likely to derive from the Moss itself. The eastern drain's catchment encompasses most of the Moss. This is inferred from its central location, the surrounding topography, and is evident too in its increasing activity as it flows southwards.

Flow accumulation

2.28 'Flow accumulation' is mapped in Figure 6. This modelling approach uses the topographic data presented in Figures 3 & 4 to predict the direction of flow at each point and to sum the number of points flowing to each point. It is useful to undertsnad the behavious of surface water and identify major pathways of surface water flow, for example.

2.29 No such pathways are identified. Instead, the topographically-controlled pathways are short and dispersed in numerous directions. This suggests that surface water has a relatively high residence time on the Moss that increases its potential for percolation into the peat beneath.

Perched water table

2.30 Comparison of habitat/vegetation condition and the high-resolution topography mapped in Figure 3 indicates that the perched water table is currently at around 73.5 m in altitude. This encompasses the 'wet modified bog' and 'raised *Sphagnum* bog' habitat. Dry modified bog and non-peatland habitats are generally located above this altitude when based on peat.

Peat depth

2.31 Peat depth has been measured across the Moss using a peat-probe at the intersects of a 25 m grid. This is illustrated in Figure 7 where the depth of peat at each point is also indicated. 'Interpolation' (estimation) of the peat depths between the sample points is illustrated in the same figure.

2.32 Peat is concentrated in the north of the Moss with only small pockets remaining in the south. These pockets have been left unharvested while the peat has otherwise been cut back to its current limits. The peat ranges from 1 m to almost 4 m in depth. Depths >3 m in the northeast relate the presence of a basin, as well as a small area of upstanding peat (mapped as 'dry modified bog' in Figure 1). Along the western edge, the greater depths (>1.5 m) are associated with upstanding, uncut peat.

Peat cutting

2.33 Peat cutting is the primary factor determining the current shape of the Moss. It appears to have been undertaken in several phases. The steep, cut faces at the terminus of each are mapped in Figure 8. Phase 1 maps three 'peat quarries' at the termination of a phase (or phases) of cutting that progressed westward to here. Phase 2 cut westward and eastward to the current summit of the remaining peat. Other phases may have cut eastward to here but their trace is now lost beneath the line of the A90.

2.34 Four additional phases of cutting are evident in the east. These have cut westward, and in the case of Phases 3 & 6, northward, to terminate along the indicated lines. There is an evident pattern of cutting westward and down for shortening distances from the east.

2.35 Lowering of the cut surfaces is evident in the altitudinal data reproduced in Figure 8 as is the pattern of a smooth, regenerating, cut-over surface edged by low mounds west of the lines of Phases 3 to 6. These mounds are likely to be residual, harvested peat that will have been placed here to dry.

Carbon content

2.36 Botanæco has used a number of methods to determine the carbon content of peatlands. The most effective is to calculate the peat volume (average depth x area) and to then apply the published, 'NSIS_2' figures for carbon content[3]. In calculating the carbon content of the specified areas, the following NSIS_2 values (converted to kg.m^3) are used to estimate the carbon content values (in tonnes) provided in Table 4 from the volumes in Table 3:

- mean: 97 kg.m^3
- minimum: 59 kg.m^3
- maximum: 138 kg.m^3

Table 3: Peat volume of the study area.

Average depth (m)	Area (m^2)	Volume (m^3)
1.546	153,300	237,001.8

[3] Chapman SJ, Artz RRE & Poggio L 2015. Determination of organic carbon stocks in blanket peat soils in different condition - assessment of peat condition. Available for download from https://www.sepa.org.uk/media/163207/sepa_carbonstocks_in_blanket-bog_final_report_a.pdf. Accessed 19/03/2018.

Table 4: Mean, maximum & minimum, estimated carbon content of the study area.

Estimated carbon content (tonnes)			Mean CO_2 equivalents		
Mean	Min.	Max.	Tonnes	% of 2015 Scottish annual emissions	Car miles (85 g km^{-1})
22,989	13,983	32,706	119,922	0.3	881,779,411

Carbon capture

2.37 A number of estimated and directly measured carbon sequestration rates have been published[4] for *Sphagnum*-dominated peatlands in the range of 14 to 72 g m^{-2} $annum^{-1}$. A maximum figure of 70 g m^{-2} $annum^{-1}$ is applied in Table 5 to calculate the potential carbon capture rate by the *Sphagnum*-rich 'wet modified bog' and 'raised *Sphagnum* bog' habitats (totalling 3.58 ha) at Portlethen Moss.

Table 5: Peat volume of the study area.

Area (m^2)	C capture rate (g m^{-2} $annum^{-1}$)	Total C capture (tonnes/annum)	Mean CO_2 equivalents		
			Tonnes	% of 2015 Scottish annual emissions	Car miles (85 g km^{-1})
358,000	70	25.6	93.9	<<0.1	690,441

3 Key observations

3.1 Areas of 'wet modified bog' and 'raised *Sphagnum* bog' habitat retain *Sphagnum*-rich vegetation and typical peatland ecosystem services.

3.2 The wet modified bog has been influenced by nutrient enrichment that has led to the spread of atypical bog species. Nutrients are likely to derive from decomposition ('mineralisation') of the dewatered peat perched above the perched water table.

3.3 A large mound of peat has been left perched above the perched water table in the northwest of the site as a result of peat cutting. As well as being a source of nutrient enrichment, it is likely to be a source of carbon pollution. It lacks typical peatland features and is covered by scrub.

3.4 Cutting has lowered the peat surface so that it locally remains in contact with the perched water table so it supports 'wet modified bog' and 'raised *Sphagnum* bog' habitat.

3.5 Drainage via the eastern/central drain poses an ongoing threat to the persistence of the 'wet modified bog' and 'raised *Sphagnum* bog' habitat because it has the potential to lower the perched water table (so it no longer supports these habitats). This will also increase the rate of peat decomposition and related, polluting effects.

3.6 There is a store of 119,922 tonnes of carbon within the peat, equivalent to 119,922 tonnes, 0.3% of Scotland's annual CO_2 emissions, or 881,779,411 car miles.

3.7 The peatland vegetation in near-natural/modified condition has the potential to capture up to 25.6 tonnes of carbon annually, equivalent to 93.9 tonnes of CO_2 or 690,441 car miles.

[4] The following sources and their stated sequestration states have been used in this report:
• Belyea, L.R. and Malmer, N. 2004. Carbon sequestration in peatland: patterns and mechanisms of response to climate change. Global Change Biology 10: 1043–1052. (Stated sequestration rate: 14 to 72 g m^{-2} $annum^{-1}$).
• Cannell, M.G.R., Dewar, R.C. and Pyatt, D. G. 1993. Conifer plantations on drained peatlands in Britain: a net gain or loss of carbon? Forestry 66, 353-369. (Stated sequestration rate: 14 to 72 g m^{-2} $annum^{-1}$).
• Clymo, R.S., Turunen, J., Tolonen, K. 1998. Carbon accumulation in peatlands. Oikos 81, 368-388. (Sequestration rate: 20 to 37 g m^{-2} $annum^{-1}$).