Forest Research

Stump Harvesting: Interim Guidance on Site Selection and Good Practice

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Background

The need to reduce carbon emissions has led to the development of alternative energy sources, including biomass for fossil fuel substitution. Forest harvesting residues are increasingly being used to supply biomass for heat and power generation in the UK and attention is now turning to the potential to utilise tree stumps.

Advice has been provided on harvesting forest residues in the form of a protocol for site selection for brash harvesting (Forestry Commission, 2007). This does not address the issue of stump harvesting and thus there is a requirement for additional guidance to assist the forest industry in identifying sites where stumps may be harvested without compromising long-term sustainability, and on any environmental safeguards that must be applied.

For the purpose of this guidance, the ‘stump’ is defined as the basal part of the tree, including most of its woody roots, that remains after felling of the stem/log. Various stump harvesting systems have been attempted, but the most widely used system in the UK involves a purpose built stump harvesting head mounted on a tracked excavator. The head is used to pull stumps out of the ground, and then split and shake them in an attempt to remove soil. The processed stumps are temporarily placed in adjacent ‘wind-rows’, and then extracted by forwarder to road side for storage and subsequent lorry haulage before chipping and burning.

This guidance does not apply to sites where there is an operational imperative to remove stumps for plant health reasons, such as in East Anglia for controlling *Heterobasidion annosum* infection. The guidance applies only to stump harvesting where stumps are pulled out of the ground, i.e. “uproot stump harvesting”, and not to other systems. Uproot stump harvesting should not be practised as part of thinning operations due to the serious risk of damaging and weakening adjacent trees.

Stump harvesting poses a number of risks to the forest environment that can threaten both sustainable forest management and the wider environment. Where these can be reduced to a low level on suitable sites, the benefits of increasing the use of biomass, as well as other potential advantages (such as easier site conditions for subsequent replanting), are expected to outweigh the potential disadvantages. There are four principal risks to soil sustainability and water quality that must be considered:

- Increased soil damage due to compaction, rutting and disturbance leading to erosion and increased turbidity and siltation of local watercourses.
- Increased carbon loss due to stump removal and soil disturbance leading to reduced soil carbon stock.

- Removal of essential major and micronutrients (e.g. nitrogen, phosphorus, potassium and boron), leading to lower soil fertility, and potential loss of tree growth in subsequent rotations.
- Removal of base cations (calcium, magnesium, sodium and potassium) reducing soil buffering capacity and leading to increased soil and stream water acidification.

Those considering site suitability for stump and brash harvesting should also refer to the UK Forestry Standard and associated guidelines (being revised in 2009), as well as the related protocol “Guidance for site selection for brash removal - Final protocol” (2007), which is available from the FR web site. Other useful sources of information are included at the end of the document, together with the References.

The guidance adopts a three-stage process to aid forest managers to select suitable sites for stump harvesting. The first stage is to consider each of the four factors listed above in turn, and, in respect of each, to categorise soils as **high, medium or low risk**. The next step is to combine the individual assessments to produce an overall risk rating by soil type. The third, and final stage is to provide a summary of recommended best practice measures to control risks in relation to each category. This process is described below.

Site Planning

Good site planning is fundamental to all forest operations. It is essential to consider the potential environmental impacts of stump harvesting and to liaise with appropriate bodies to assess the sensitivity of the area and the existence of any legal requirements. From a water aspect, the degree of sensitivity depends on the quality of freshwater habitats in relation to the need to achieve at least good ecological status and the requirements of water users. Examples of sites at high risk from disturbance include those draining to freshwater Special Areas of Conservation or water bodies of high ecological status. It is an offence to cause or knowingly permit the entry of poisonous, noxious or polluting material into any controlled waters, or to damage, destroy or disturb protected species such as the freshwater pearl mussel.

Although this guidance focuses on soil and water protection, there will be a need for a detailed site assessment and the production of a well annotated map (site plan) showing all site constraints. The soil disturbance and mixing caused by stump harvesting is potentially damaging to biodiversity and the historic environment. A particular constraint is the presence of priority and protected plant and animal species, whose needs must be given due protection. Close liaison and collaboration with local authority archaeologists is important to greatly reduce the risk to buried archaeology by identifying known sites and those with potential for unrecorded features. A standard requirement is to leave an undisturbed buffer area, within which stumps are left in place, around all sensitive areas (see Table 6).

Health and Safety

As with all operations, Health and Safety is imperative and safe working practices must be identified and implemented. Published guidance is available from Arboriculture and Forestry Advisory Group (AFAG) leaflets No. 501 (Tractor units in tree work), 503 (Extraction by forwarder), and 704 (Excavators in tree work). Consideration needs to be given to the risks posed to excavator operators from the repeated shaking of tree stumps to remove soil. Additionally, it is important that a site specific risk assessment is carried out before any operations commence. This should identify all hazards associated with the lifting, transport and storage of stumps. Roadside stacks must be built safely in line with published guidance (see AFAG leaflet No. 503).

Site Suitability

The environmental risks vary with site type and tend to be greater in the uplands due to steep topography and the preponderance of poorly drained, nutrient poor, carbon rich and acidic soils. Lowland soils may be less sensitive to stump harvesting but could present other problems such as an increased risk of soil loss by wind erosion on lighter soils, although this can be controlled by brash management. Recommendations on site suitability are described below and address each of the four principal risks: ground damage, soil carbon loss, reduced soil fertility, and acidification. These all relate to soil and water protection and are central to the over-arching issue of sustainable forest management as defined by the UK Forestry Standard.

This guidance assumes a knowledge of soil types across the harvesting coupe and uses the Forestry Commission's soil classification system (Kennedy, 2002 and Appendix 1). The assessment of site suitability should be based on the main soil types, which are defined as those occupying >20% of the coupe. However, harvesting practice needs to reflect smaller areas of more sensitive soils within the defined harvesting site, particularly those at high risk of ground damage and delivering sediment to watercourses. If high risk soils (see below) are present on part of a site, a 5 m wide protection buffer should be established around these and stump harvesting operations confined to the adjacent lower risk soils. It may be possible to harvest stumps on sites with larger areas of high risk soils providing it is practicable to access the remaining areas of lower risk soils and respect the buffer areas. Where it is difficult to distinguish between risk classes, a precautionary approach should be adopted and the higher class selected, or advice sought from an experienced soil surveyor.

Ground damage

The main factors affecting the risk of ground damage are **slope** and **soil type**. Slopes >20º are considered to be vulnerable to soil slumping/slippage and surface runoff delivering eroded sediment to watercourses, and therefore stump harvesting should be avoided on such sites. In general, the harvesting of stumps creates considerable, localised soil disturbance and increases the risk of ground damage due to the additional trafficking associated with stump lifting and windrowing by tracked excavator and removal to roadside by forwarder. The timing of the latter poses a particular challenge since supporting brash mats will dry out and become increasingly brittle with age. They will therefore be less able to bear loaded forwarders, although loads will be lighter due to reduced packing of stumps compared to logs. This risk can be addressed by minimising the time-gap between stem and stump harvesting and by planning the site layout for stem harvesting with the follow-up stump harvesting in mind. Where required, the brash mats used for timber extraction should be combined into a smaller number of strengthened mats for stump harvesting. Strengthening is particularly important on heavily used sections such as access points and stacking areas at roadside. There will be greater flexibility in timing of operations on lower risk sites.

Soil types are categorised by risk of ground damage using the system shown in Table 1. Soils in the low risk category are unlikely to be significantly damaged by stump harvesting, providing that normal good practice is employed. Those in the medium risk category require restrictions to the timing of stump lifting and extraction, which should be limited to periods when the soil is relatively dry and better able to support machinery; more likely from May to September, inclusive. Wherever possible, green brash mats should be used at standard harvesting spacing, but where material has aged and turned brown, the mats should be combined for strengthening (every two into one) as required to prevent ground damage. Care is required not to expose any damaged soil beneath the mats that could lead to increased erosion and sediment delivery to watercourses. Retaining stumps under brash mats on extraction routes is important to reduce the likelihood of ground damage. Any rutting may need intervention to prevent the flow of water causing erosion, such as by digging offlets at appropriate intervals to split and dissipate the flow. The peaty phases of podzols (3p), ironpans (4p) and groundwater gleys (5p) are included in the medium risk category but vary in sensitivity due to the variable depth of surface peat. Where the latter exceeds 25 cm in depth, these soil phases should be considered high risk and managed accordingly. This will necessitate a peat depth survey as part of the site assessment process. The high risk category comprises soils that are highly likely to be damaged by, and thus are unsuitable for, the extraction of tree stumps.

Table 1. Distribution of soil types by ground damage risk categories.

Risk Category	Forestry Commission Soil Types
Low	Brown earths, Podzols (except peaty type (3p), Rankers (except gley (13g) and peaty (13p) types), Skeletal soils, Calcareous soils and Littoral soils (except sands with shallow (15g) and very shallow (15w) water-table).
Medium	Peaty gley soils (except deep phase (6p)), Surface-water gleys, Ground-water gleys*, Peaty podzols (3p)*, Ironpan soils*, Gley and Peaty Rankers (13g, 13p).
High	Peatland/bog soils, deep phase peaty gleys (6p), and Littoral sandy soils with shallow (15g) or very shallow water-table (15w).

* Where the depth of the surface peat layer in the peaty soil phases (3p, 4p and 5p) exceeds 25 cm, these should be classed as high risk for ground damage.

Extracted stumps can retain large amounts of soil attached to roots, especially on clay soils. It is important to minimise the amount of soil removed from the site as this can represent a significant loss of carbon and nutrients, and diminish the soil resource. It can also cause problems for stump processing, generating high levels of dust and poor air quality. Site storage, especially over winter, can help to reduce soil contamination due to the action of rainfall and freeze-thaw. If soil is removed from the site and collected during off-site stump processing, particular care is required in its subsequent management to avoid the spread of soil fungal infections such as *Heterobasidion annosum*. Soil residues should not be transferred between sites where there is any evidence of soil borne pests or pathogens being present.

Soil Carbon Loss

More carbon is generally stored in soil than in the above-ground parts of forests. This is mainly in the form of litter, soil organic matter (SOM) and biomass. Stump extraction involves extensive soil disturbance in terms of relative area and depth, with the result that decomposition rates are likely to increase, thereby increasing CO_2 release from the soil.

Table 2. Distribution of soil types by risk of soil carbon loss.

Risk Category	Forestry Commission Soil Types
Low	Brown earths, Podzols (except peaty type (3p), Calcareous soils, Integrade and Podzolic Ironpan soils (4b and 4z), Ground-water gleys (except peaty phase (5p), Surface-water gleys, Littoral soils, Rankers (except peaty type (13p)) and Skeletal soils.
Medium	Peaty podzol (3p), Ironpan soils (except Integrade (4b) and Podzolic (4z) types), Peaty Groundwater gleys (5p), Peaty gley soils and Peaty rankers (13p)
High	*Juncus* bogs, Unflushed peatland/bog soils and *Molinia* bogs.

A lack of empirical data makes it difficult to predict the impact of stump removal on the exchange of CO_2 and other greenhouse gases for different soil types. Until such information becomes available, a simple soil classification is adopted based on the expectation that the scale of carbon lost will be directly related to the proportion of SOM. Soils are classified into three risk categories based on the depth of peat layer and thus the amount of soil carbon that could be potentially lost by increased decomposition (Table 2).

Soils with a peat depth of >45 cm are considered to be at high risk from disturbance, with the possibility of additional CO_2 released from the disturbed peat outweighing the CO_2 benefit from using stumps as a fuel. These soils should therefore be excluded from stump harvesting.

Soils with a peat layer of between 5-45 cm depth are classed as medium risk. Although there is less carbon in these soils, the carbon balance of stump harvesting remains uncertain and care should be taken to limit the extent of soil disturbance. Retaining stumps under brash mats and in buffer areas will result in around 30-40% of the ground being undisturbed.

The remaining soils with relatively low SOM content, such as brown earths, podzols, calcareous soils, mineral gleys and rankers are classed as low risk for carbon loss (except for the peaty phases of these groups, defined as having a surface peat layer >5 cm thick).

Re-vegetation is likely to be more rapid on sites cleared for stump removal, which will promote carbon sequestration and help to offset the effects of soil disturbance.

Soil infertility

Previous work on site nutrition and fertiliser practice has provided a reasonably good understanding of which soil types are at risk for soil infertility (Table 3). Soils in the high risk category are likely to be damaged by the additional removal of nutrients in stumps or brash, with consequent detrimental effects on site productivity in the medium to long term, while those in the low risk category are expected to be relatively unaffected. Rendzina soils are included in the high risk category for conifer stands due to the risk of soil mixing promoting iron-induced chlorosis.

Medium risk soils are those that could sustain an increased removal of nutrients through stump harvesting but with certain constraints. Firstly, stumps should not be removed from these soils where brash (either with or without needles) is also to be harvested, since this would result in an excessive drain on site nutrition. Secondly, where brash mats are to be combined to provide a reinforced route for the subsequent extraction of stumps, movement of brash should be delayed until the material is largely needle-free (<20% needles remaining). Delaying the movement of brash until needle drop will significantly reduce the localised drain on soil fertility since about half to two thirds of the nutrients in brash are present within the needles. The period required for sufficient needle drop will depend on the local climate/time of year and normally range between 3 and 9 months. The ratio of combining individual brash mats should be restricted to 2:1 to limit the risk of creating wide bands of reduced fertility and promoting leaching losses. At least three rows of stumps will be retained within individual brash extraction routes (covering approx 20-30% of the ground), further limiting the impact on fertility.

Table 3. Distribution of soil types by soil infertility risk categories. *Only applies to conifer stands on this soil type, otherwise Rendzinas are 'Low' risk.

Risk Category	Forestry Commission Soil Types
Low	Brown earths (except podzolic type (1z)), Surface-water gleys (except podzolic type (7z)), Ground-water gleys, Calcareous soils (except Rendzinas (12a))* and *Juncus* bogs.
Medium	Podzolic brown earths (1z), Podzolic surface-water gleys (7z), Ironpan soils (except podzolic (4z) and ericaceous (4e) types), Peaty gley soils (except podzolic type (6z)) and *Molinia* bogs (9a, b).
High	Unflushed peatland/bog soils, *Molinia* bogs (9c-e), Podzolic peaty gley (6z), Podzolic (4z) and Ericaceous (4e) ironpan soils, Podzols, Littoral soils, Rendzinas (12a)*, Rankers and Skeletal soils.

The removal of stumps may be acceptable on soil types at high risk of infertility provided it only occurs once, such as where there is a change in land use for habitat restoration. It may also be more generally acceptable, at least from a soil fertility point of view, provided that the nutrients are replaced through remedial treatments. This could involve the application of limestone or wood ash (see Pitman, 2006), depending on which nutrients are likely to become limiting. However, the use of some of these materials could be costly, affect the carbon balance and would be unsuitable on certain sites due to interactions with nitrogen availability and the impact on nutrient runoff and stream water acidification. For example, wood ash can induce nitrogen deficiency on nutrient poor soils, while on nitrogen saturated sites it can stimulate nitrate release and acidification. Their application could also run counter to the prevailing desire to reduce chemical usage associated with forest certification.

Acidification

The categorisation of soil types for risk of site infertility can also be generally applied to the issue of acidification since soil buffering tends to be directly related to soil nutrient availability (Table 4).

Table 4. Distribution of soil types by soil acidification risk categories.

Risk Category	Forestry Commission Soil Types
Low	Brown earths (except podzolic type (1z)), Ground-water gleys, Calcareous soils and *Juncus* bogs.
Medium	Podzolic brown earth (1z), Ironpan soils (except podzolic (4z) and ericaceous (4e) types), Surface-water gleys, Peaty gley soils (except podzolic type (6z)) and *Molinia* bogs (9a, b).
High	Unflushed peatland/bog soils, *Molinia* bogs (9c-e), Podzolic peaty gley (6z), Podzolic (4z) and Ericaceous (4e) ironpan soils, Podzols, Littoral soils, Rankers and Skeletal soils.

Soils in the low risk category are considered able to withstand the additional removal of base cations in stumps without detriment to the soil in terms of acidity and buffering capacity. Those in the medium risk category are vulnerable to such losses but this could be countered by only removing stumps or brash. Movement of brash mats should be restricted until after needle drop and the spacing of strengthened extraction routes limited to prevent the development of more acidic soil bands. Restricting the width of brash-free zones will make it more likely that variation in the placement of brash mats between consecutive forest rotations will prevent soil banding. Soils in the high risk category are unlikely to be able to sustain the extra drain on base cations from stump harvesting, and therefore this practice should be avoided unless the base cations are replaced by remedial treatments such as applications of limestone or wood ash, subject to the caveats listed under soil infertility.

Combined Hazard Assessment

The distribution of soil types by risk category (Low, Medium and High) for each hazard is compared in Table 5. The individual assessments are combined in the end column on the basis of assigning soil types by their most sensitive classification. Recommended good practice measures for each combined risk category are described in Table 6. Soil type codes (Pyatt, 1982) are defined in Appendix 1.

Other issues

Stump harvesting raises a number of other important issues that need to be addressed on a site by site basis:

Restocking practice

Consideration needs to be given to a number of potentially positive and negative effects, with the relative weighting of each varying from site to site. Advantages of stump harvesting could include the need for less intensive or no additional ground preparation on drier sites, and possible improvements in tree stability due to more even root architecture development. In some cases there may be an operational imperative to remove stumps for disease control, for example to reduce *Heterobasidion annosum* infection within severely affected areas. A potential disadvantage is stronger weed growth and thus the need for greater weed control. Stump stacks may also harbour pests such as rabbit.

Biodiversity and Historic Environment

Biodiversity issues include the need to retain sufficient deadwood on site (see Forestry Commission (2002)), including dead/rotting stumps, and the potential use of stump stacks by nesting birds, mammals or reptiles. Historic environment considerations focus on the need to protect archaeological sites, other above ground features of historical importance, including veteran trees, and any known or suspected below ground features.

Buffer areas

Sensitive features should be protected by establishing a buffer area of appropriate width, e.g. a minimum of 5 m around archaeological sites. Stumps should also be left within riparian buffer zones (minimum widths ranging between 5 and 20 m depending on width of watercourse, as defined by the Forests & Water Guidelines) and within 5 m of drain sides, including road drains, due to the risk of increasing sediment delivery to watercourses. Stumps should be retained within a 5 m buffer along breaks of slope such as the upper edge of steep valley sides, to reduce the risk of initiating slope failure.

Roadside stacking and handling

Another important consideration for site selection is the availability of space for the stacking and handling of stumps at roadside, including the capacity and condition of the forest road and track infrastructure to cope with the increased number of vehicle movements. Particular care will be required to ensure that the siting of stump stacks does not block or pollute roadside drains. The leachate from fresh stacks could contain relatively high concentrations of nutrients and exert a strong biological oxygen demand, soil dislodgement from stumps could block drains, while machine and lorry movements can damage road surfaces and promote erosion and sediment delivery to watercourses.

The Forests & Water Guidelines provide advice on some of these aspects. The relevant issues should be identified, considered and recorded as part of the long-term forest plan, which will assist in the identification of suitable areas for stump harvesting.

Increasing precision of guidance

This guidance is largely based on expert judgement of the scientific issues informed by practical experience of managing forest soils. Uncertainties remain about the long-term sustainability of stump harvesting on certain soil types, especially in terms of carbon loss, but also for soil fertility and acidification. These will be assessed by developing site critical load, carbon and nutrient budgets. This will require new field studies to quantify impacts, including long-term monitoring to demonstrate that the proposed categorisation system and guidance is fit for purpose. We will continue to engage with private sector companies and international partners to learn from their experience of stump harvesting.

This document will be regularly reviewed and updated as new research findings become available. Practitioners are recommended to check the Forest Research web site (www.forestresearch.gov.uk/stumpharvesting) for new developments and updates of this guidance.

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Further advice

For further explanation of the issues raised in this document or for advice on site selection or sustainability of stump harvesting, please contact Tom Nisbet (tom.nisbet@forestry.gsi.gov.uk), Bruce Nicoll (bruce.nicoll@forestry.gsi.gov.uk), or Mike Perks (mike.perks@forestry.gsi.gov.uk) at Forest Research. For advice on technical aspects of stump harvesting, contact Ian Murgatroyd (ian.murgatroyd@forestry.gsi.gov.uk) at Forest Research - Technical Development.

Table 5. Relative risks of ground damage, soil carbon loss, soil infertility and soil acidification from stump harvesting, together with combined risk for each Forestry Commission soil type.

Soil group	Soil type	Ground damage	Soil carbon loss	Soil infertility	Soil acidification	***Combined Risk***
Brown earths	1, 1d, 1u	L	L	L	L	L
	1z	L	L	M	M	M
Podzols	3, 3m	L	L	H	H	H
	3p	M**	M	H	H	H
Ironpan soils	4, 4p	M**	M	M	M	M**
	4b	M	L	M	M	M
	4z, 4e	M	L	H	H	H
Calcareous	12b, t	L	L	L	L	L
	12a	L	L	H*	L	H*
Ground-water	5	M	L	L	L	M
	5p	M**	M	L	L	M**
Peaty gleys	6	M	M	M	M	M
	6z	M	M	H	H	H
	6p	H***	M	M	M	H
Surface-water	7, 7b	M	L	L	M	M
	7z	M	L	M	M	M
Juncus bogs	8a-d	H	H	L	L	H
Molinia bogs	9a, b	H	H	M	M	H
	9c, d, e	H	H	H	H	H
Unflushed	11a-d	H	H	H	H	H
Rankers	13b,z,r	L	L	H	H	H
	13g	M	L	H	H	H
	13p	M	M	H	H	H
Skeletal soils	13s	L	L	H	H	H
Littoral soils	15s,d,e,i	L	L	H	H	H
	15g, w	H	L	H	H	H

L: low risk; M: medium risk; H: high risk. *Only for conifer stands, otherwise low risk.
**3p, 4p and 5p are high risk where the depth of the peaty surface layer is >25 cm.
***6p is classed high risk for ground damage because depth of peat is 25-45 cm.

Table 6. Summary of recommended good practice measures to control risks in relation to low, medium and high risk categories from Table 5.

Combined Risk	Recommended Good Practice Measures to Control Risk
Low	• No stump harvesting on slopes that are >20º. • Normal good practice, including the retention of brash mats to protect the soil from trafficking by loaded forwarders. • Stumps retained within riparian buffers (5-20 m) and along drains, breaks of slope, and around archaeological sites, veteran trees and adjacent crops (minimum 5 m buffer). • Stump stacks sited away from drains to reduce the risk of blockage and increased nutrient leaching and sediment delivery to watercourses. Avoid archaeological remains. • Minimise amount of soil attached to stumps. • Rotten stumps retained for wildlife value.
Medium	***In addition to the above:*** • No stump harvesting on sites where brash has been harvested, either with or without needles. • Where possible, extract stumps while brash remains green. • Brash mats combined to strengthen extraction routes, especially when there is a prolonged gap between timber harvesting and stump harvesting resulting in reduced bearing capacity. • Brash movement to strengthen mats delayed until material is needle free. Ratio of combining mats limited to 2:1 to reduce risk of creating wide bands of infertile and more acidic soil. • Stumps retained within brash mats and buffer areas. • Stump lifting and extraction confined to periods when the soil is relatively dry, which will most likely be between May and September, inclusive. Sites require careful monitoring during periods of high or prolonged precipitation. • Remedial treatments such as the application of limestone and/or wood ash could permit harvesting of both stumps and brash, but a site assessment must first confirm the suitability, cost effectiveness and sustainability of such treatments.
High	• Harvesting of stumps is not commensurate with sustainable forest management and should be generally avoided. One exception is where there is an operational imperative such as for disease control. • Stumps retained within 5 m buffers around areas of high risk soils. • Stump harvesting could be considered on some soil types (where high risk is confined to soil fertility and acidification factors) if nutrients and/or base cations are replaced via remedial treatments such as the application of limestone or wood ash, subject to an assessment of the suitability, cost effectiveness and sustainability of such treatments. Where stump harvesting is practiced on high risk soils, the good practice measures listed for low and medium risk soils also apply.

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Appendix 1. The Forestry Commission classification system for the main mineral and peaty soils (Pyatt 1982).

Soil group	**Soil type or phase**	**Code**
Brown earths	Typical	1
	Basic	1d
	Upland	1u
	Podzolic	1z
Podzols	Typical	3
	Peaty phase (5-45 cm peat)	3p
	Hardpan	3m
Ironpan soils	Typical	4
	Podzolic	4z
	Peaty phase (15-45 cm peat)	4p
	Integrade	4b
	Ericaceous	4e
Calcareous soils	Rendzina	12a
	Calcareous brown earth	12b
	Argillic brown earth	12t
Ground water gleys	Typical	5
	Peaty phase (5-45 cm peat)	5p
Peaty gley soils	Typical	6
	Podzolic	6z
	Deeper peaty phase (25-45 cm peat)	6p
Surface water gleys	Typical	7
	Podzolic	7z
	Brown	7b
Juncus bogs	*Phragmites* (or Fen) bog	8a
	Juncus articulatus or *acutiflorus* bog	8b
	Juncus effuses bog	8c
	Carex bog	8d
Molinia (flushed blanket) bogs	*Molinia, Myrica, Salix* bog	9a
	Tussocky *Molinia, Molinia, Calluna* bog	9b
	Tussocky *Molinia, E. vaginatum* bog	9c
	Non-tussocky *Molinia, E. vaginatum, Trichophorum* bog	9d
	Trichophorum, Calluna, Eriophorum,	9e

	Molinia bog (weakly flushed)	
Unflushed blanket bogs	*Calluna* blanket bog	11a
	Calluna, E. vaginatum blanket bog	11b
	Trichophorum, Calluna blanket bog	11c
	Eriophorum blanket bog	11d
Rankers	Brown	13b
	Gley	13g
	Peaty	13p
	Podzolic	13z
	Rock	13r
Skeletal soils	Scree	13s
Littoral soils	Shingle	15s
	Dunes	15d
	Sand with deep water-table	15e
	Sand with moderately deep water-table	15i
	Sand with shallow water-table	15g
	Sand with very shallow water-table	15w