Guidance on Site Selection for Brash Removal

Background

Interest is growing in harvesting brash material following timber harvesting to supply the biofuel market. A number of systems are available but those based on brash bailing or secondary extraction of brash mats are currently favoured. Brash bailing involves feeding the loose brash into a bailer unit to form 1m^3 cylindrical tied bales, which are subsequently removed from the site using a forwarder. Secondary extraction involves a range of possible methods, including the harvesting of compact brash from timber extraction routes by a forwarder working backwards along individual brash mats.

The removal of brash residues poses a number of hazards to the forest environment that can threaten sustainable forest management. There are three principal threats:

1. Machine trafficking causing soil physical damage such as compaction, rutting and erosion, leading to increased turbidity and siltation of local watercourses.

2. Removal of essential nutrients (nitrogen, phosphorus and potassium) and carbon in brash residues, leading to lower soil fertility, potential loss of tree growth in subsequent rotations, and reduced soil carbon storage.

3. Removal of base cations (calcium, magnesium, sodium and potassium) reducing soil buffering capacity and leading to increased soil and stream water acidification.

The propensity for damage depends on site sensitivity and on many sites can be effectively controlled by good forest planning and management. Guidance on best practice is provided by the Forestry Practice Guide ‘Whole-Tree Harvesting: A Guide to Good Practice’ (Forestry Commission, 1997), Forests and Soil Conservation Guidelines (Forestry Commission, 1998), Forests & Water Guidelines (Forestry Commission, 2003), Forestry Commission Technical Note ‘Protecting the Environment during Mechanised Harvesting Operations’ (Forestry Commission 2005) and Forestry Commission Practice Note ‘Managing brash on conifer clearfell sites’ (Forestry Commission, 2006). The guidance adopts a relatively broad-brush, precautionary approach and recommends avoiding the removal of brash residues in potential acid sensitive areas (as defined by freshwater critical loads exceedance and adjacent squares) and on all nutrient poor soils (where fertility is considered to be a possible limiting factor on tree growth).

Increasing concern about climate change and the need to reduce carbon emissions has led to new policies and support mechanisms for developing alternative energy sources, including the development of biofuels for fossil fuel substitution. It may now be cost effective to consider harvesting brash from forest areas for this purpose. However, the existing guidance classifies a large part of the forest estate as being potentially sensitive to the removal of brash, leading to a shortage of suitable sites. This has prompted a re-examination of the original criteria for defining sensitive soils and waters.

FINAL PROTOCOL

The following assessment considers site selection for brash removal in upland conifer forests, with a focus on Sitka spruce stands. Additional considerations would apply to the harvesting of brash from other conifer species and broadleaves in terms of brash quality and quantity, and timing of needle/leaf fall, which are not considered here. Ground damage represents the main threat in the lowlands since soil fertility and acid-buffering capacity are generally good. Although the smaller volume of brash removed from thinning operations poses less of a threat, the cumulative loss over several thinning cycles can represent a significant drain on soil nutrient and base cation reserves. Consequently, the guidance also applies to site selection for brash removal from thinning operations.

Health and Safety is imperative and all operational practice should be in accordance with the manufacturer's recommendations and follow published guidance, particularly Aboricultural and Forestry Advisory Group (AFAG) leaflets No. 501 (Tractor units in tree work) and 503 (Extraction by forwarder). 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 production, transport and roadside stacking of brash bales, including the stability of stacks and fire risk. It should be noted that there is a greater risk of fire when the bales comprise brown brash, i.e. material where the green needles have turned brown or fallen off and moisture content has reduced as a result of drying.

Site Suitability

Recommendations on site suitability are described below and address each of the three principal threats: ground damage, soil fertility and acidification. They assume that soils have been surveyed at a scale of 1:10,000 according to the Forestry Commission's soil classification system (see Pyatt (1982)). Where this is not the case, an indication of the soil type can be obtained from the published 1:250,000 scale soil maps and descriptive memoirs by the Soil Survey of England and Wales and the Soil Survey of Scotland. These use different soil classification systems but it is possible to match up the Soil Series and Soil Associations with the Soil Types used by the FC. More detailed Soil Survey soil maps at a scale of 1:63,360 are also available for many parts of the country.

In the absence of a FC soil map or I: 63,360 Soil Survey map it will be necessary to check or identify the soil types present at a given site. Guidance is provided by Forestry Commission Field Guide 'The identification of soils for forest management' (Forestry Commission, 2002)). The Field Guide relies on finding a soil exposure within a coupe or digging a soil pit. Ideally, the site should be surveyed using a soil auger prior to digging to ensure that the pit is located in a representative or dominant soil type. The pit should be dug to at least 60 cm depth (unless bedrock is shallower) and one face cleaned to permit identification. Additional pits are likely to be required within large felling coupes, especially where there are significant changes in slope and site wetness. The assessment of site suitability should be based on the most sensitive, main soil type (main soil types defined as those occupying >20% of the area/coupe), although harvesting practice needs to reflect smaller areas of more sensitive soils, particularly those at risk of ground damage and delivering sediment to watercourses. Where it is difficult to distinguish between risk classes, a precautionary approach should be adopted and the higher class selected. Alternatively, advice can be sought from an experienced soil surveyor.

Ground damage

The existing guidance on reducing ground damage focuses on the risk posed by timber, rather than brash, extraction. In general, the harvesting of brash residues presents less of a threat due to the lower density of material and thus lighter forwarder loads (assuming no increased stacking of brash). This is especially the case with secondary extraction involving machinery working backwards on the protective brash mat or forwarders restricted to brash mats but being loaded by tracked excavators working off mat. The main risk with secondary working is where harvesting is delayed by 3 to 9 months to facilitate drying and needle drop to reduce nutrient and base cation removal (see below). Drying reduces the bearing capacity of the brash mat and thus increases the risk of soil damage. However, this is unlikely to be a problem where brash mats are well constructed (see Forestry Commission Technical Note 11 (Forestry Commission, 2005)). The market requirement for relatively large volumes of good quality brash with a low level of contamination by soil essentially restricts brash harvesting operations to sites that can support adequate brash mats.

Brash baling presents a greater hazard due to the trafficking of the baler itself and the extraction of the bales by forwarder. The risk of ground damage will be greatest where insufficient brash has been retained to form protective brash mats or the bearing capacity of the mats has been significantly weakened by delaying bale extraction to permit needle drop. However, these factors should be controlled by good site selection and management practice.

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

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

The good practice guide for whole-tree harvesting categorises main soil types according to risk of ground damage (Table 1). Soils in the low risk category are considered unlikely to be damaged by the harvesting of fresh or dry (defined as largely needle-free (<20%)) brash residues either by bailing or secondary extraction, providing normal good harvesting practice is employed. Those in the medium risk category require restrictions to the timing of extracting dry brash bales, which should be limited to dry periods; mainly from May to September, inclusive. The harvesting of fresh brash bales or the secondary extraction of fresh or dry brash mats should not damage these soils. The high risk category comprises soils that are likely to be damaged or unsuitable for the extraction of dry brash bales and possibly the secondary extraction of dry brash mats, depending on their condition/bearing capacity.

Soil fertility

Previous work on site nutrition and fertiliser practice has provided a reasonably good understanding of which soil types classify as low or high risk for soil infertility (Table 2). Soils in the high risk category can be damaged by the removal of nutrients in brash residues while those in the low risk category are expected to be unaffected. Delaying the removal of brash until needle drop will significantly reduce the drain on soil fertility since about half to two thirds of the nutrients in brash are present within the needles. However, this will have less of an impact where the brash has been concentrated within specific zones, which tends to promote nutrient leaching to drainage waters and leave localised areas of infertility in-between. It will also have little or no effect where the fresh brash is baled and then left to dry on site, since the fallen needles will be largely retained within the bales.

The high risk category includes a wide range of soil types that vary in the relative degree of infertility. It is considered that those at the lower end of the spectrum could probably sustain the removal of brash provided largely needle-free material is removed (<20% needles remaining). Consequently, a third, medium category has been added to the classification to reflect such conditions. The period required for sufficient needle drop will depend on the local climate/time of year and normally range between 3 and 9 months.

It is important to note that the removal of brash could be acceptable on all of the high risk soil types provided that the nutrients are replaced through remedial fertilisation, involving the application of inorganic fertilisers, limestone or wood ash (see Pitman (2006), depending on which nutrients become limiting. However, the use of some of these materials 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 would also run counter to the prevailing desire to reduce chemical usage associated with forest certification.

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

Table 2: Distribution of soil types by soil fertility risk categories

<u>Acidification</u>

The current guidance on acidification focuses on stream water and uses the critical loads approach to identify the potential area at risk. Originally, the harvesting of residues was not recommended within critical load exceedance squares but this was extended to include all adjacent 10 km squares when the Forests & Water Guidelines were revised in 2003. However, it is recognised that the critical load exceedance squares are indicative only since the 10 km square values are based on the assessment of a single water body within each square. Specific guidance is not provided for refining the area at risk from brash removal but the approach for dealing with the forest scavenging effect associated with new planting and restocking uses information on local geology, followed by a more detailed catchment-based critical load assessment to check on the sensitivity of individual streams.

A catchment-based critical load assessment is less appropriate for assessing the impact of brash removal since it is the soil rather than drainage water that is most sensitive to this activity. Consequently, the focus should be on the acid-base status of the underlying soil when determining the sensitivity of local areas. One approach would be to use published data on soil critical loads and critical load exceedance values but a number of issues remain concerning the robustness of these estimates. Until these issues are resolved, it is thought preferable to adopt a more simplistic system based on our understanding of the base status of the main soil types and their vulnerability to base cation removal in harvested products. Soils are allocated to low, medium and high risk categories in Table 3.

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

Table 3: Distribution of soil types by soil acidification risk categories

Soils in the low risk category are considered able to withstand the additional removal of base cations in brash residues 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 can be effectively countered by only removing dry brash and leaving most of the needles to return 30-50% of base cations to the soil. Soils in the high risk category are unlikely to sustain the extra drain on base cations, even resulting from the removal of needle-free brash, and therefore brash harvesting should be avoided unless the base cations are replaced by fertiliser, limestone or wood ash applications (see Pitman (2006)).

Combined Hazard Assessment

The distribution of soil types by risk category for each hazard is compared in Table 4. The individual assessments are combined in the end column on the basis of assigning soil types by their most sensitive classification. Best practice measures underpinning the risk assessment are described in the key. Soil type codes are defined in Table 5.

Other issues

A range of other options is available to reduce the impact of brash removal. One way would be to remove only the tree tops/stemwood <7 cm diameter, leaving the branchwood and needles from the larger diameter stemwood on site for soil protection. Alternatively, the volume of brash and therefore the potential drain on site fertility and base status could be reduced by limiting removal to every second or third row of brash. However, this could lead to localised zones or bands of site infertility and soil acidification unless care was taken to vary the pattern of brash removal over consecutive rotations.

Brash removal also has implications for restocking, including ground preparation. Consideration needs to be given to a number of positive and negative effects, the relative weighting of each varying from site to site. Advantages of brash removal include potentially easier and cheaper ground preparation, planting and maintenance (e.g. reduced plant loss from rabbits and voles), while the main disadvantages are an increased risk of ground damage by site trafficking of ground preparation and other machinery, stronger weed growth and thus the need for greater weed control, potentially slower growth of the planted crop due to reduced shelter, and increased loss of plants due to greater browsing by *Hylobius*.

Retention of sufficient deadwood for wildlife is another important issue. This should be covered by the normal site planning process, which should identify a definite area on site where deadwood is either left standing or lying on the ground. If retained on the ground, it needs to be clearly separated from brash residues.

Finally, site selection will depend on the availability of space for the stacking and handling of harvested brash or brash bales, 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 and handling of roadside brash stores do not block or pollute roadside drains. The leachate from fresh brash stores can contain high concentrations of nutrients and exert a strong biological oxygen demand, while machine and lorry movements can damage road surfaces and promote erosion and sediment delivery to watercourses. The FC's Forests & Water Guidelines (Fourth Edition) address these issues.

Increasing precision of guidance

The 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 brash removal on certain soil types, both in terms of soil fertility and acidification. Work is required to improve the critical load and nutrient budget assessments to clarify the susceptibility of these soils. There is also a need to establish long-term monitoring studies to demonstrate that the proposed categorisation system is fit for purpose.

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Table 4: Distribution of soil types by ground damage, soil fertility, soil acidity and combined pressure risk categories.

Soil group	Soil type	Ground damage	Soil fertility	Soil Acidity		Combined Factors
Brown earths	1, 1d, u					
	1z					
Podzols	3, 3m					
Iron pan soils	4, 4z					
	4b					
Limestone soils	12a, b, t					
Ground water gleys	5					
Peaty gleys	6, 6z					
Surface water gleys	7, 7b					
	7z					
Juncus bogs	8a, b, c, d					
Molinia bogs	9a, b					
	9c, d, e					
Unflushed blanket bogs	11a, b, c, d					
Rankers	13b, z					
	13g, p					
Skeletal soils	13s					
Littoral soils	15s, d, e, i					
	15g, w					

Key

	Risk category	Best Practice Measures to Control Risk
	Low	Normal good practice
	Medium	Brash baling and brash removal should be limited to largely needle-free brash (<20% needles remaining), except on groundwater gley soils, where fresh brash can be removed. Brash removal should be restricted to dry periods unless it involves secondary extraction, which can be done in wet periods. Sufficient quantities of brash need to be retained on site and on extraction routes to protect soils from machine trafficking.
	High	Removal of brash unlikely to be sustainable and should generally be avoided. Could be considered if nutrients and/or base cations are replaced via application of fertiliser, limestone or wood ash (none needed on *Juncus* peats), and sufficient brash of adequate strength is retained to protect soils from machine trafficking.

Table 5: The FC classification system for the main mineral and peaty soils

Soil group	Soil type	Code
Brown earths	Typical	1
	Basic	1d
	Upland	1u
	Podzolic	1z
Podzols	Typical	3
	Hardpan	3m
Ironpan soils	Typical	4
	Podzolic	4z
	Integrade	4b
Limestone soils	Rendzina	12a
	Calcareous brown earth	12b
	Argillic brown earth	12t
Ground water gleys	Typical	5
Peaty gley soils	Typical	6
	Podzolic	6z
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, Molinia bog (weakly flushed)	9e
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