Extended abstract No. 8

USE OF BRASH MATS FOR CLEARFELLING OF FORESTRY ON PEAT: IRISH EXPERIENCE

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SUMMARY

In Irish clearfelling practice, a brash mat, consisting of small branches and logs, is laid ahead of the harvester and forwarder traffic to minimise soil disturbance. The aim of this study was twofold: (i) to evaluate the effectiveness of brash mats in preventing peat consolidation and (ii) to quantify nutrient release to the subsurface water. Moisture content profiles were compared to assess soil consolidation and subsurface water samples were analysed for their nutrient concentrations. There was no significant change in moisture content, indicating that the brash mat was successful in preventing peat volume changes. There was an increase in nutrient concentration under the brash mats, which indicates that they may be a long-term nutrient source if not removed.

KEYWORDS: peat, forestry, nutrients, consolidation, brash

INTRODUCTION

It is estimated that 59.6% of forestry in Ireland is on peat (National Forest Inventory, 2007) and approximately 300,000 hectares of afforestation is on upland peat areas (EEA, 2004; Rodgers et al., 2010). These soils are characterised by high moisture contents (gravimetric moisture contents usually exceed 500%) and typical ground bearing capacities of between 10 and 60 kPa (Owende et al., 2002). In Irish forestry clearfelling (harvesting) practice, soil disturbance is minimised by laying a brash mat, consisting of small branches and logs, ahead of the machinery used for the harvesting and timber removal processes. The scale of disturbance to a clearfell site is based on a combination of number of passes by the machinery, moisture content and the use of brash mats (Gerasimov and Katarov, 2010).

Previous research has highlighted the negative impacts of soil compaction (i.e. the expulsion of air from the void space) on the use of the soil for future afforestation. The reduced pore space for water movement reduces the growth rate of future tree and plant crops (Labelle and Jaeger, 2011), the value of the harvested timber is reduced (Eliasson and Wästerlund, 2007), and instances of windthrow and erosion are increased (Nugent et al., 2003). Consolidation (i.e. the expulsion of water when the soil is loaded), caused by clearfelling machinery, also occurs when saturated peats are loaded. The typically high moisture contents render peat densities to fall only marginally above that of water (usually in the region 1000-1200 kg m^{-3}), so density is not a sufficiently sensitive parameter to assess volume changes induced by consolidation. In addition, sampling peat for density determination is very difficult. Moisture content may be a more sensitive gauge of volume changes.

Installed brash mats generally remain *in situ*, following best practice guidelines (Forest Service, 2000), after felling and can, if timed correctly, re-fertilise the soil for future crops (Stevens et al., 1995). Peat is considered highly vulnerable to a loss in fertility and the removal of brash material from site following clearfelling can deplete the amount of base cations and reduce available nutrients for future growth of trees (Forest Research, 2009). Brash can be removed from site once the needle drop period is complete (approximately 6 to 9 months), as up to two-thirds of the total nutrients found in brash material are in the fresh needles (Forest Research, 2009). However, nutrient release from decaying brash mats may give rise to excessive nutrient release, which may enter sensitive receiving waters.

The aim of this study was to evaluate the success of brash mats in preventing soil consolidation, and to quantify nutrient release to the subsurface water. The study was conducted in two zones: (1) a naturally revegetated peatland with a brash mat left in place, which was clearfelled five years prior to the present study (Zone 1) and (2) a recently clearfelled mature forest (Zone 2). This study also compared the effects of degrading brash mats of varying ages (7 months to 5 years old) on the pore water nutrient content of underlying peat.

MATERIALS AND METHODS

The study site was located in the Altaconey forest in the Burrishoole catchment in Co. Mayo, Ireland (ITM reference 495380, 809170). The site has blanket peat to a maximum of 2 m depth and is subjected to approximately 2000 mm of rainfall annually. In 1966, the site was planted with Sitka Spruce (*Picea sitchensis*) and Lodgepole Pine (*Pinus contorta*). In May 2006, a 300 m long strip was clearfelled and allowed to naturally regenerate (Zone 1). The process of bole-only, cut-to-length clearfelling was carried out using a Valmet 921 harvester (wheel width: 650 mm front and 700 mm rear). The brash mats were constructed using up to 8 trees and, in line with best management practice (BMP), these brash mats were left *in situ* on completion of clearfelling. Logs were stacked in piles for collection by a Valmet 860 forwarder (wheel width 600 mm front and rear) before being taken off site. In February 2011, the forest upslope of the naturally revegetated peatland was clearfelled in the same manner. A total of 1230 m^3 of timber was removed from Zone 2 of which 58 m^3 pertained to the extraction rack under study.

Post-clearfelling data were collected in Zone 1 between April 2010 and October 2011; the brash had undergone 5 years of degradation at the end of this monitoring period. These data included nutrient concentrations of the surface and subsurface water. Similar measurements for nutrient concentration were conducted in Zone 2 over the same time period. Standpipes were installed in transects on site for subsurface water quality measurement and each sampling location comprised a cluster of 3 sampling tubes positioned at 20 cm, 50 cm, and 100 cm depths below the soil surface. Water samples were filtered on site immediately after collection using 0.45 µm filters, returned to the laboratory and tested in accordance with standard methods (APHA, 1998) using a nutrient analyser (Konelab 20; Thermo Clinical Labsystems, Finland). The water quality parameters measured were: (1) dissolved reactive phosphorus (DRP) (2) ammonium-N (NH_4-N) (3) nitrate N (NO_3-N) and (4) total oxidised nitrogen (TON).

In Zone 2, peat samples were collected from one extraction rack immediately before and after felling for moisture content determinations, which were subsequently used to assess soil consolidation. This extraction rack was subject to 12 to 20 forwarder passes. Samples to determine soil moisture content were taken along one extraction rack, 60 m in length, in Zone 2. Samples (n=3) were removed every 15 m along the line at 10 cm increments to a depth of approximately 1 m directly before and immediately after clearfelling of the rack. Controls were sampled in an adjacent standing forest to the same depth to show changes in moisture content in the forest soil due to external factors, unrelated to the clearfelling, such as weather or flooding. The soil moisture content data was analysed both spatially (along the rack and in the controls) and at all depths to identify significant differences using 2 sample t-tests.

RESULTS AND DISCUSSION

Water quality tests

At all depths and zones there was an increase in nutrient concentration of DRP, NH_4-N and TON under the brash mats. Results for DRP concentration for both zones at the 50 cm depth are shown in **Fig. 1** illustrating phosphorus (P) leaching to the soil following brash breakdown for two time periods, 5 years (Zone 1) and 7 months (Zone 2) following clearfelling. Median values of NH_4-N and TON in Zone 1 at the 50 cm depth for under the brash mat were 940 µg L^{-1} and 30 µg L^{-1}, respectively. The direction of flow at Zone 1 was perpendicular to the brash mats. Therefore, any vegetated areas adjacent to the brash mats, which had no brash directly on them, were still influenced by the decaying brash material. This is evident in the median values of NH_4-N (710 µg L^{-1}) and TON (110 µg L^{-1}) at the 50 cm depth for under the vegetated areas. In Zone 2, results from up to 7 months post clearfell showed a gradual increase in concentrations under the newly created brash mats. Statistically, the post-clearfell results were significantly different from the pre-clearfell results ($p<0.031$). The highest average concentration of DRP under the new brash mats after 7 months of decay at the 50 cm-depth was 336 µg/l - just over half the value of 574 µg L^{-1} found under the 5-year old brash mats at the same depth. Yearly data from Stevens et al., (1995) from a Sitka Spruce (*Picea sitchensis*) forest in Wales found that in the first 3 years following bole-only harvesting, approximately one third of the P had leached out of the brash material left on site, leaving a large resource of P in the decaying brash to slowly re-fertilise the soil. Stevens at al., (1995) also noted that this P remained on site rather than leaching to an adjacent stream and was therefore available to the next rotation of plantation.

Consolidation tests

Initial moisture contents lay in the range 750-1000% across the site, reflecting the inherent variability of peat. There was no significant change in moisture content in Zone 2 pre- and post-clearfelling along the entire length of the extraction rack, at all depths down to 1 m. This indicated that the brash mat thickness used was sufficient in preventing sufficient load transfer and associated volume changes to the peat (**Fig. 2**). Controls taken at the same time in an adjacent standing forest showed no change in moisture content in the forest soil due to external factors, unrelated to the clearfelling, such as weather or flooding ($p<0.809$). A slight increase in moisture content in Zone 2 in the top 0 – 30 cm was noted at the 60 m mark ($p<0.014$), the location which received the least number of forwarder passes of twelve. The protection by the brash mat for the underlying soil has been recorded in other studies with various soil types: moist, fine grained soils in northern Sweden (Eliasson and Wästerlund, 2007), sandy soil in the Netherlands (Ampoorter et al., 2007) and a surface water gley soil in the UK (Hutchings et al., 2002).

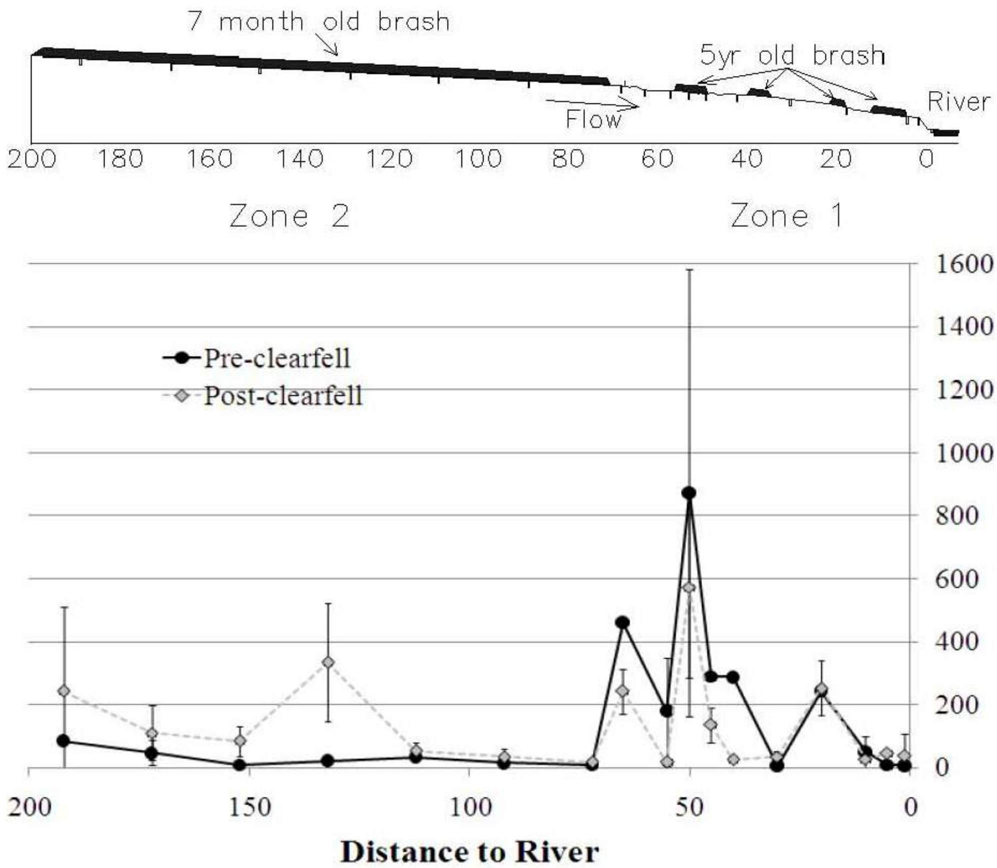

Fig. 1. DRP (µg/l) at 50 cm below ground level from transects across site pre and post clearfell in Zones 1 and 2.

In Ireland, Nugent et al. (2003) quantified typical levels and ascertained threshold levels for induced cone penetration resistance (CPR) and rutting depths for heavy machinery traffic associated with forest operations on a peat soil by studying the pre- and post- thinning processes along 4 extraction racks with brash thicknesses ranging from 8 – 13.8 cm post harvester travel and 3 – 6.4 cm post forwarder traffic. Results showed that the CPR increased following passage of machinery in the top 40 cm of the soil, signifying that the top 40 cm of the soil had become compacted. However, there was no significant rutting caused by the harvester and forwarder traffic, considered to be rutting depth that exceeds 15% of the overall wheel diameter of the machinery, which would impede machine manoeuvrability. Statistical analysis showed that threshold CPR levels ranged from 594 – 640 kPa for a peat soil with a initial CPR reading of between 524 – 581 kPa (Nugent, Kanali et al., 2003).

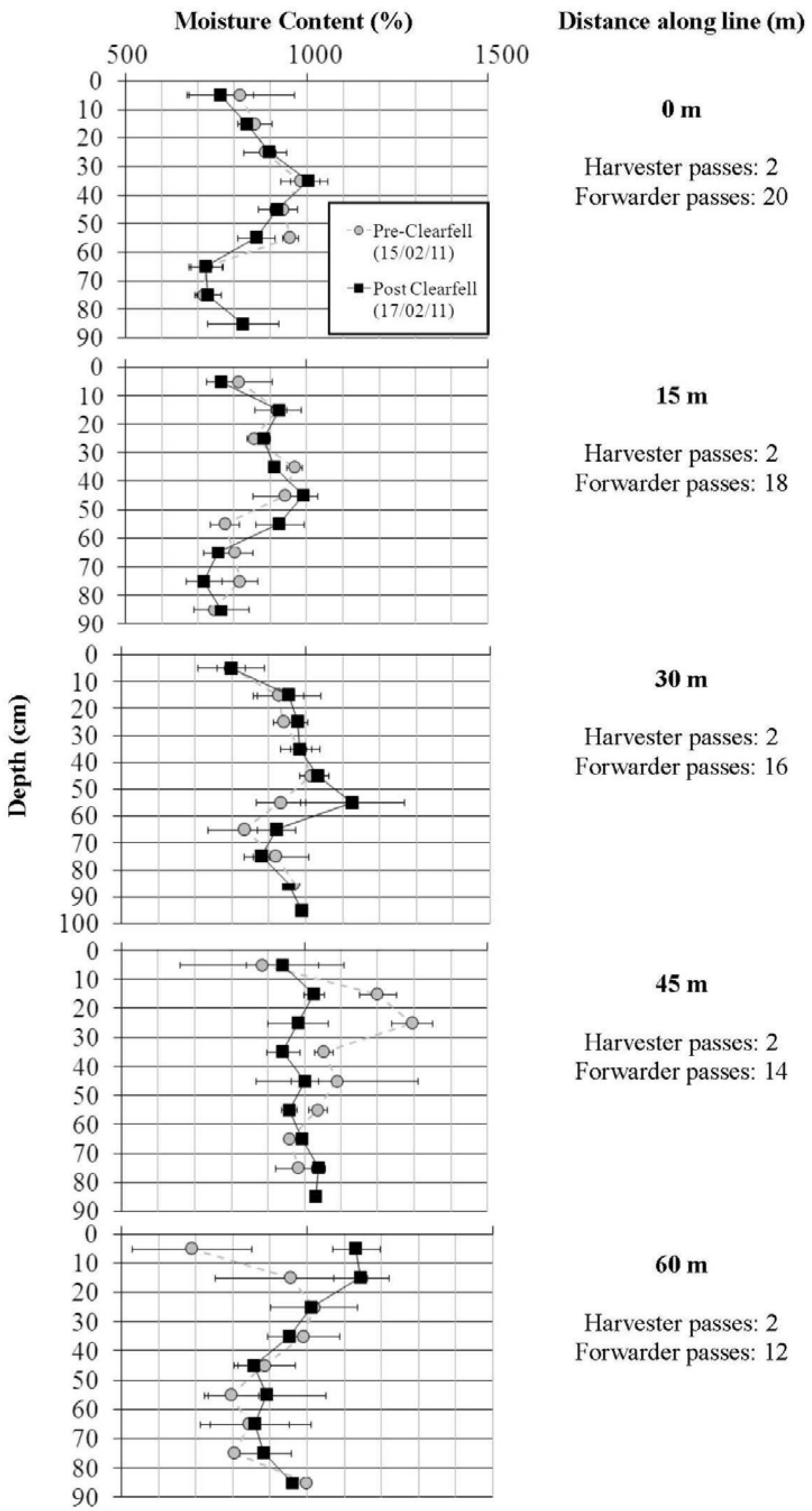

Fig. 2. Moisture content (%) versus depth below ground level (cm) pre and post clearfell at 15 m intervals along a line including number of harvester of harveter and forwarder passes.

CONCLUSION

The use of brash mats of sufficient thickness and quality during clearfelling protects the peat from consolidation, minimizes soil disturbance and re-fertilises the soil with dissolved nutrients. However, best management practices must be implemented to ensure that the brash mats are maintained and nutrients from degradation do not reach watercourses.

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