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INSTITUTE OF TERRESTRIAL ECOLOGY
(NATURAL ENVIRONMENT RESEARCH COUNCIL)

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Report to the Countryside Commission for Scotland

PROGRESS REPORT: CHARACTERISTICS OF LIVE MULCH AND EFFECTS OF EXTRACTION ON THE SOURCE AREA

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SUMMARY

1. This study described the characteristics of live mulch from different sites, and investigated the effects of extraction on source areas.

2. Extraction was undertaken at six sites; birch woodland, tussock bog, *Calluna* heath, *Vaccinium* grassland, acid grassland and *Racomitrium* heath. There were four rates of extraction, and half of each plot was treated with fertiliser to see if this would improve the rate of recovery.

3. "High" rates of extraction caused 20-87% damage to source plots, and provided 28-94 l/m^2 of mulch material.

4. Calculations showed that for equivalent levels of damage, *Calluna* heath and *Vaccinium* grassland produced the least mulch material, and acid grassland the most.

5. The composition of live mulch material varied greatly. In some cases, the major component was grass or heath litter, in others, moss. The highest proportion of viable plant fragments (mosses and rooted vascular plants) was in material from *Racomitrium* heath.

6. The plant growth from mulch established under near ideal conditions in a glass house did not relate closely to the amounts of viable material present. Mulches from acid grass land and tussock bog grew best, and those from *Calluna* heath and *Vaccinium* grassland were poor.

7. Most sites recovered well within the first growing season. The slowest was at the birch woodland, where recovery was about 50% on unfertilised plots and 70% on fertilised plots.

8. Fertiliser application increased recovery at some sites, but was ineffective at others.

9. Mulch extraction at "medium" rates (<25% bare ground) would appear to allow the vegetation to recover and avoid any lasting damage. Such levels of extraction would provide enough material to plant an area 6-15 times larger than that extracted.

10. Further field analysis 12 months after extraction should indicate whether there have been any substantial changes to species composition resulting from either extraction or fertiliser applications.

1. INTRODUCTION

The live mulch technique is a way of obtaining plant propagules from intact ground for revegetation of bare or damaged sites. The mulch is cut with a sharp rake, or similar tool, to provide a debris of topsoil, plant litter and moss, and vascular plant material, part of which may be rooted. This material can provide seeds (from the soil seed bank), moss fragments and rooted vascular plants. Live mulch is applied to the bare surface and lightly compressed into the soil, (to ensure good soil contact), but with most of the material still at the surface. As well as providing plant propagules, the debris has a slight mulching effect on the surface.

The technique was first tested in studies for the Yorkshire Dales National Park (Bayfield & Miller 1987). Initial results on wet peat soils were very encouraging, with live mulch introducing species not available commercially, substantially increasing colonization by mosses and improving cover when sown in conjunction with grass seed. Subsequently, trials undertaken for the Countryside Commission for Scotland have aimed to develop the technique further. Studies completed so far have examined the effects of different rates of application, methods of burial, and degrees of comminution (Bayfield, McGowan & Paterson 1991).

This is a further development study. The aims were to investigate:

- the composition and yield of live mulch from different upland habitats;
- the impacts of extraction on the source area;
- the effects of fertiliser in mitigating the impacts of extraction.

The study involved extracting and analyzing live mulch from six contrasting sites in spring and early summer 1991. Recovery of extracted ground was recorded in autumn 1991, and this interim report outlines the results. The study will be completed by a further analysis 12 months after extraction.

2. METHODS

2.1. Experimental design

Live mulch was extracted from areas of homogeneous vegetation at six contrasting sites. At each site there were four rates of extraction; control (none), light, medium and heavy. These rates were intended to correspond roughly with 0, 25%, 50% and 75% disturbance of the areas in question, judged by eye during extraction. In practise, it was difficult to ensure the same intensity of extraction in the different habitats because of variations in the types and textures of surface vegetation present. At one site (the Lecht) much lower rates of disturbance were achieved because of the nature of the sward (closely grazed, dense grassland). These problems are discussed further in section 4.1.

A slow release fertiliser (Vitax Q4, NPK 5.3:7.5:10) was applied to half the area of the plots at 50 gm/m^2. The overall design can be summarized as follows:

Treatments:	control/light/medium/heavy
Replication:	x 4
Fertiliser:	present/absent
Total plots:	32

Each treatment was applied to a plot 110 by 50 cm, consisting of two subplots 50 cm square with a 10 cm buffer zone between them. One of the subplots was dressed with fertiliser after extraction had taken place, and the other was left unfertilised.

2.1.1 Recording

Over the growing season four recordings were taken in the field -

(1) **Before** live mulch extraction the species composition of each plot was recorded by visual estimates of cover.

(2) **After** each pair of plots had been treated, 100 random points (using a five point quadrat with points 1mm diameter and 50mm apart) were observed to estimate the amount of bare ground resulting from mulch extraction.

(3) **At the end of the growing season** the species composition was re-recorded; as was-

(4) Point quadrat data to determine the extent of recovery.

To provide a detailed analysis of the composition of the mulches, the extracted material from each site was subsampled. Aliquots were combined to give a representative sample of 4 litres which was then sub-divided into -

- rooted and unrooted monocotyledons
- dicotyledons
- mosses
- plant litter
- soil

and analysed quantitatively and volumetrically.

A bioassay of mulch growth was also undertaken. 500 ml subsamples of mulch were placed on capillary matting in seed trays and allowed to grow on in an unheated, watered glasshouse for three months. The percentage species composition of surviving and new growth was then analysed to indicate the productivity of the mulch from each vegetation type.

3. SITE DESCRIPTIONS

Six sites with differing types of vegetation were investigated-

(1) Birch woodland at Hill of Brathens , Banchory.
(2) Tussock bog at Rhindbuckie Hill, Pilmuir.
(3) *Calluna* heath at Rhindbuckie Hill, Pilmuir.
(4) *Vaccinium* grassland at Rhindbuckie Hill, Pilmuir.
(5) Acid grassland at the Lecht, and-
(6) *Racomitrium* heath at Aonach Mor.

Site details are given in Table 1, and their locations are shown in Figure 1.

Table 1 Site descriptions

	Birch Woodland	**Tussock bog**	***Calluna* Heath**	***Vaccinium* grassland**	**Acid Grassland**	***Racomitrium* heath**
Altitude (m)	120	150	165	160	600	1000
Aspect	All	All	South	South	South	North
Soil type	Loam	Silty clay/loam	Loamy peat	Loamy peat	Loamy peat	Peaty loam
Drainage	Moderate	Poor	Good	Good	Good	Good
Canopy cover	Moderate	Poor	Absent	Absent	Absent	Absent
Principal species:						
Vascular	*Holcus lanatus*	*Deschampsia cespitosa*	*Calluna vulgaris*	*Vaccinium myrtillus*	*Agrostis capillaris*	
	Agrostis capillaris	*Juncus effusus*	*Vaccinium myrtillus*	*Deschampsia flexuosa*	*Festuca ovina*	*Festuca ovina*
			Deschampsia flexuosa			
Mosses	*Pleurozium schreberi*	-	*Pleurozium schreberi*	*Pleurozium schreberi*	*Rhytidiadelphus squarrosus*	*Racomitrium lanuginosum*
pH	4.5	5.5	4.5	4.5	4.5	4.5
N	moderate	low	low	moderate	low	v low
P	low	low	v low	moderate	moderate	v low
K	v low	v low	v low	v low	v low	v low
Mg	moderate	moderate	low	v low	v low	moderate

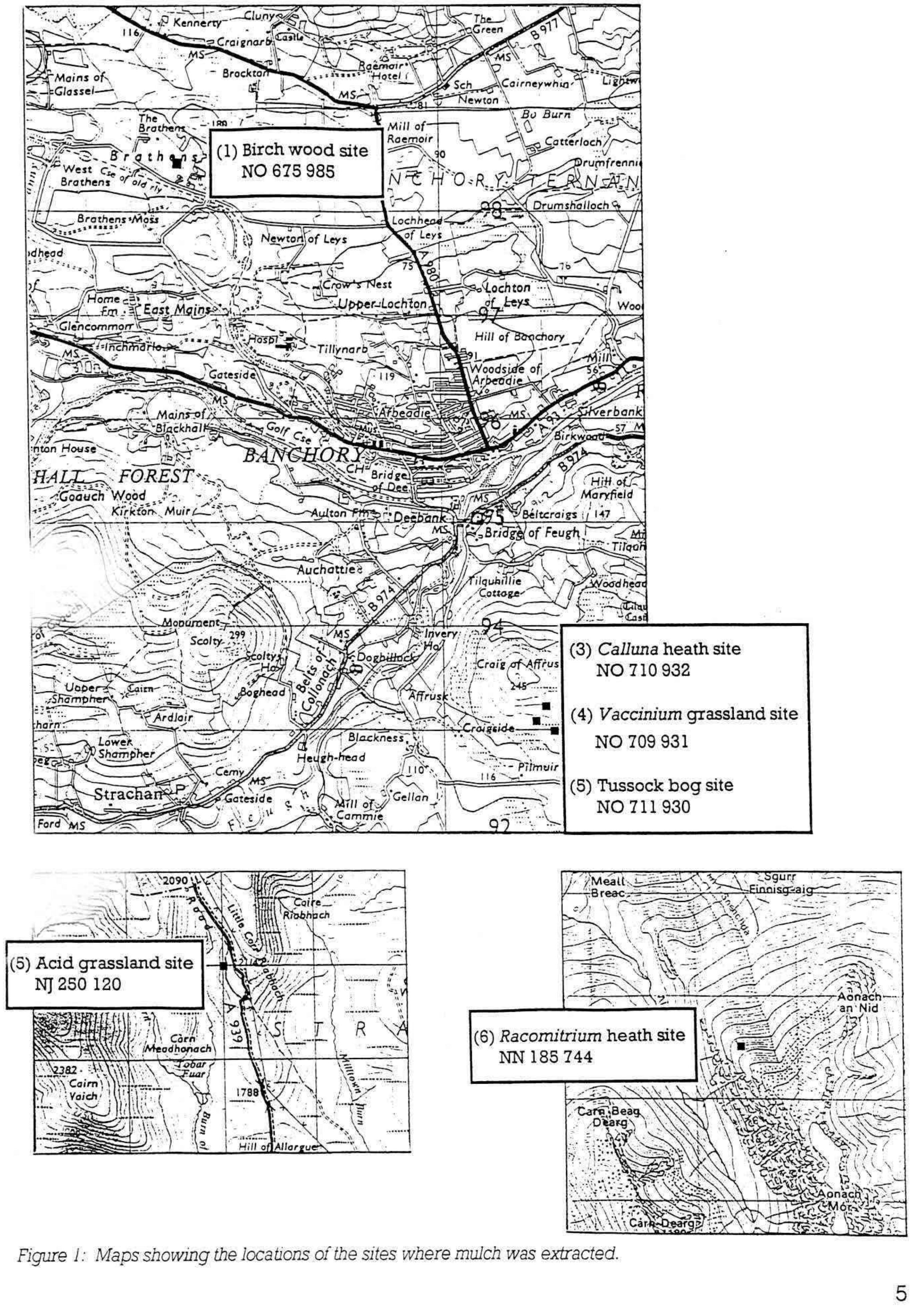

Figure 1: Maps showing the locations of the sites where mulch was extracted.

4. CHARACTERISTICS OF LIVE MULCH FROM THE SIX SITES

This section describes differences in the amounts of mulch extracted from the six sites, the principal components (living and dead) and the potential colonising material present.

4.1. Ease of extraction

At most sites mulch was easily extracted, but at the *Deschampsia flexuosa/Juncus effusus* tussock bog, the tall vegetation was difficult to cut. However, at two other sites there were further difficulties which reduced the planned rates of extraction. At the acid grassland site, it proved difficult to cause 75% disturbance of the surface because of the very short and dense vegetation. Here a maximum rate of extraction resulting in 20% bare ground was adopted (Table 2). This still produced a substantial volume of mulch. At the *Racomitrium* site the problem was almost the reverse. Even slight disturbance seemed to cause a great deal of damage to the moss surface. Extraction was stopped when surface destruction reached 75%, although after the site was tidied up and the plots lightly consolidated, the damage appeared substantially less severe. This final value was recorded (31% maximum).

Table 2. Percentage damage (bare ground) to vegetation surfaces at the six sites resulting from low, medium and high extraction rates.

	Extraction rate (% damage):		
	"low"	"medium"	"high"
Birch woodland	22	35	83
Tussock bog	18	51	74
Calluna heath	11	43	67
Vaccinium grassland	21	46	87
Acid grassland	0	5	20
Racomitrium heath	14	19	31

4.2. Volumes of mulch extracted

The "high" rates of extraction resulted in large, but variable, volumes of mulch material from each site (28 l/m^2 on *Racomitrium* heath to 94 l/m^2 in birch woodland) (Table 3). Calculation of the volumes of mulch that could be produced by extracting 50% of the vegetation, shows that *Calluna* heath and *Vaccinium* grassland were the least productive (25-26 l/m^2) and acid grassland the most (180 l/m^2).

The density of the mulches also varied from community to community. Those from the *Calluna* heath, *Vaccinium* grassland and acid grassland were relatively light (0.03-0.04 g/ml) whereas those from the tussock bog and *Racomitrium* heath were much denser (0.09-0.10 g/ml). These figures refer to freshly extracted mulch, and are affected by the proportion of moisture and mineral soil in the samples. Since the moisture content clearly depends on soil conditions and recent rainfall, the figures are only of limited value for comparative purposes (although none of the mulches was cut immediately after rain).

The next section provides a more detailed breakdown of mulch composition in terms of the components present.

Table 3. Volumes of mulch extracted at "high" rates from vegetated surfaces at the six different sites.

	Volume Extracted at "high" rate (l/m²)	Damage caused by "high" extraction (%)	Equivalent volume of mulch to cause 50% damage (l/m²)	Mulch density (g/ml)
Birch woodland	94	83	57	0.05
Tussock bog	80	74	54	0.10
Calluna heath	35	67	26	0.03
Vaccinium grassland	44	87	25	0.03
Acid grassland	72	20	18	0.04
Racomitrium heath	28	31	45	0.09

4.3. Mulch composition

The main components of live mulch are vascular plant material (rooted and unrooted), mosses, plant litter (including dead plant material) and soil (including organic layers). Volumetric analysis of subsamples of mulch from each of the six sites showed that there were major differences in mulch composition (Table 4).

Table 4. Composition of live mulch from different sites (% by volume). Means of four subsamples.

	Birch woodland	Tussock bog	*Calluna* heath	*Vaccinium* grassland	Acid grassland	*Racomitrium* heath
Forbes and dwarf shrubs						
(rooted)	0.2	0.2	5.1	0.9	1.3	1.7
(unrooted)	0.1	-	7.8	5.1	2.2	
Graminoids						
(rooted)	5.5	4.3	1.3	7.0	25.9	0.2
(unrooted)	0.7	5.9	1.6	6.3	6.9	0.4
Moss	50.7	2.2	64.6	22.5	6.3	96.2
Litter and dead	38.5	81.8	13.8	49.2	42.3	0.7
Soil	4.6	5.4	5.9	8.8	15.0	-

Each site was distinct in the proportion of soil, litter and plant components. The major component in mulch from birch woodland, *Calluna* heath and *Racomitrium* heath was moss, whereas in acid grassland, tussock bog and *Vaccinium* grassland, it was litter. Mulch from acid grassland contained the most soil and rooted plant material. The highest proportion of viable plant material (rooted vascular plants or moss) came from *Racomitrium* heath (98%) and the lowest that from tussock bog (7%) (Figure 2).

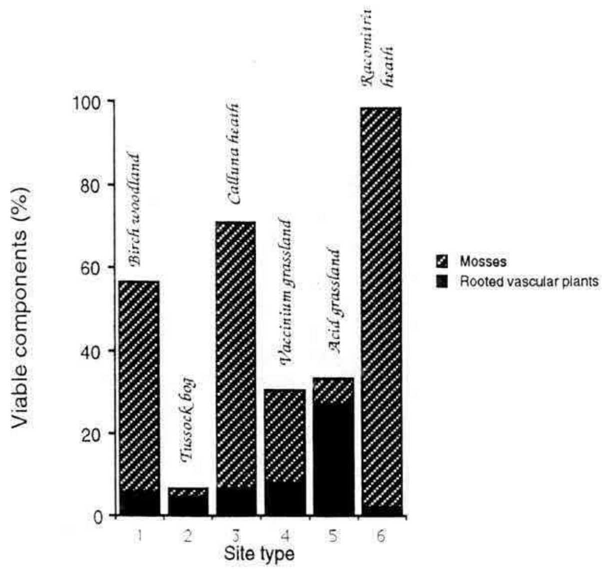

Figure 2 : Proportions of viable plant material (mosses and vascular plants) in live mulch from different sites.

4.4. Mulch bioassay

Although the mulch composition data give some indication of the colonizing ability of the live mulch, they do not take into account the actual growth capability of the plant propagules, or any soil seed bank availability. However, an estimate of growth potential was obtained from the glasshouse bioassay of mulch material. In this exercise the cover of surviving vegetation (living green material; surviving or new growth) was scored. Analysis showed that the mulch producing the largest change in cover was from the birch woodland. Cover of forbs, graminoids and mosses all increased substantially relative to their proportions at the beginning of the assay. Tussock bog mulch also increased the ratio of living material, but *Calluna* heath and *Vaccinium* grassland showed declines in dwarf shrub and graminoid cover. Both had increased moss cover and there was a substantial number of small *Calluna* seedlings present in the *Calluna* heath samples (Table 5).

Table 5. Percentage cover of living plant material after 3 months (means of visual estimates; 6 replicates). The proportion of apparently viable material in the mulch prior to biossay is shown in brackets.

	Birch woodland	Tussock bog	*Calluna* heath	*Vaccinium* grassland	Acid grassland	*Racomitrium* heath
Forbs/dwarf shrubs	15 (<1)	3 (<1)	<1 (5)	<1 (1)	2 (1)	4 (2)
Graminoids	39 (6)	17 (4)	<1 (1)	1 (7)	28 (26)	3 (<1)
Mosses	40 (51)	7 (2)	80 (65)	49 (23)	22 (6)	4 (96)
Percentage change	+36	+20	+10	+19	+19	+3

Racomitrium heath showed little change in cover, although the dominance of *Racomitrium* moss made detecting change difficult. Perhaps the most surprising result was the comparatively small change in cover of the acid grassland vascular plant material, which was only slightly more abundant after three months. The mosses did, however, increase by a factor of about three.

On the evidence of these bioassays the most successful mulches would seem to be those from birch woodland and tussock bog, and those from the *Calluna* and *Vaccinium* communities the least likely to succeed . It must be borne in mind, however, that the favourable conditions in the glasshouse are seldom encountered in the field, so survival and growth under field conditions are likely to be substantially different from those recorded here. In addition, in the field it may not be desirable to transfer mulches between differing communities, so introducing alien species, but even if this were acceptable, the mulch may perform in a totally different way in its new habitat.

5. RECOVERY OF EXTRACTED SITES

5.1. Recovery of bare ground

Generally, sites appeared to recover fairly quickly after mulch extraction and on most plots there were only small areas of bare or damaged ground remaining in the autumn (Table 6). The highest proportion of residual damage was at the birch woodland site (heavy extraction plots) where bare ground accounted for 28% of the area on fertilised plots and 40% on unfertilised plots.

Smaller areas of damage remained at the *Racomitrium* heath and acid grassland sites. It should be noted, however, that the porportion of bare ground remaining at these sites is greater when compared with the initial damage produced by the extraction process.

Table 6. Bare ground (%) remaining on extracted and control plots at the end of the first season. Also shown is the initial damage (bare ground) on heavily extracted plots.

Extraction rate:	Control	Light	Medium	Heavy	(initial damage:heavy)
Birch woodland:					
fertilised	0	1	3	28	(83)
unfertilised	0	<1	9	40	(81)
Tussock bog:					
fertilised	1	0	3	2	(74)
unfertilised	2	0	1	<1	(80)
Calluna heath:					
fertilised	0	0	0	0	(67)
unfertilised	0	0	0	0	(72)
Vaccinium grassland:					
fertilised	0	<1	0	3	(87)
unfertilised	0	0	0	3	(88)
Acid grassland:					
fertilised	2	0	<1	2	(20)
unfertilised	2	1	1	7	(21)
Racomitrium heath:					
fertilised	3	5	6	9	(29)
unfertilised	3	5	8	9	(33)

Figure 3 shows the extent of recovery at heavy extraction sites as a proportion of initial damage. This shows that there was almost complete recovery at tussock bog (2), *Calluna* heath (4) and *Vaccinium* grassland (5), and 50-90% recovery at birch woodland (1), *Racomitrium* heath (6) and acid grassland sites (3). In the last three, fertiliser appeared to improve recovery; the effect was statistically significant at the acid grassland and birch woodland sites.

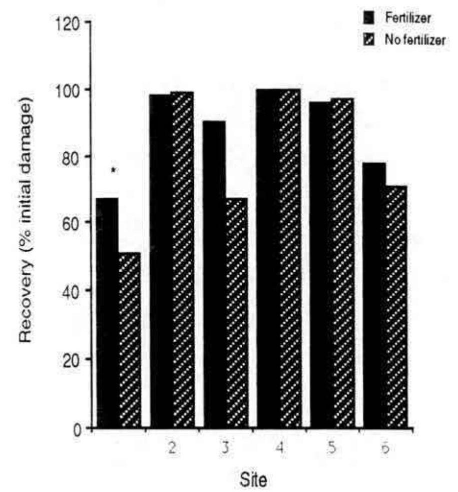

*Figure 3: Recovery of bare ground (%) during the first season after "heavy" mulch extraction at six sites. The difference between fertilised and unfertilised plots was statistically significant at sites marked *. *, P=0.05 (t test)*

The relatively poor recovery at the birch woodland site might be attributable to shade from the trees, or more likely, to the generally dry surface conditions during much of the summer. A layer of fibrous litter at the surface may also have inhibited colonization. At the acid grassland and *Racomitrium* sites there were no obvious reasons for slow recovery other than the severe climate at higher altitudes and low soil fertility.

5.2. Changes in species composition

There were substantial changes in species composition at many of the sites during the course of the season. In particular there were decreases in moss cover and increases in vascular plants. These variations in the proportions of species present were generally larger on untreated plots, but there were no consistent changes in composition that could be attributed with confidence to the extraction process. A more comparable analysis will be possible when the plots are re-analysed after 12 months, and the confounding problem of seasonal growth is minimised.

6. DISCUSSION

This study has shown that there are major differences in the quantities of live mulch that can be produced from different plant communities. There does not appear to be a straightforward relationship between vegetation biomass and potential mulch yield. In communities containing large species, such as rushes and heather, much of the material is not able to be collected as mulch because of its tussocky or woody nature. On the other hand, in the case of *Racomitrium* heath, although there may be a considerable depth of potential material, removal of even the surface layer gives the appearance of extensive damage.

A site cut at the medium rates (25-50 % bare ground) could provide enough mulch for 6-15 times its area, assuming a planting rate of 2 litres of live mulch/m^2,

There are also large differences in the composition of mulch from different sites. The proportion of apparently viable material ranged from less than 10% in the case of tussock bog mulch, to more than 90% in the case of material from the *Racomitrium* heath site. However, growth from the mulches in the glasshouse did not appear to relate very closely, if at all, to the proportions of viable and non-viable materials present. Therefore, the potential usefulness of the mulch cannot readily be determined from physical analysis. The glasshouse bioassay should be more instructive, but even here results may not reflect performance under field conditions. Further field trials are needed to demonstrate the value of live mulch in different types of habitat.

The substantial recovery of the six sites within a season is encouraging. It certainly appears feasible to extract at least the "medium" rate without causing lasting damage to the sites investigated This is equivalent to about 50% disturbance of the surface in the case of birch woodland, tussock bog, *Calluna* heath and *Vaccinium* grassland, about 20% in the case of *Racomitrium* heath and 5% in high altitude acid grassland. Fertiliser seems to help recovery at some sites, but it is not always needed.

Further analysis 12 months after extraction should indicate whether extraction or fertiliser have changed the species composition at the six sites.

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