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WEED CONTROL IN GRASSLAND

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INTRODUCTION

The annual Governmental surveys of land use in Britain give an indication of the extent to which grassland dominates the UK scene. Of a total of 46.5 million acres of land in Britain 36 million are devoted to grassland of one type or another:

Temporary grassland	:	12 million acres
Permanent grassland	:	6 million acres
Rough grazing	:	18 million acres. (H.M.S.O. 1971).

The overall acreage of grassland has remained remarkably constant over many years, showing a decrease only in time of war or of movement towards cereal growing, and an increase in times of economic recession. There is a continuing annual loss to arable cropping, forestry, amenity or urban development of some 60,000 acres, most important in the areas of temporary and permanent grassland; this is a factor which has become more apparent in the past twenty or so years, and which will continue, and perhaps for a time increase, for the foreseeable future. The voices demanding land for urban and amenity development have become more insistent and more organised in recent years - perhaps rightly so, but it does mean increasing demands on land, especially grassland, for multi-purpose use in amenity areas, or for sterility by urbanisation.

In the northern environment of Scotland, grassland plays a greater part in the sources of the agricultural industry's output. Here we have a total agricultural land area of 15.4 million acres with:

Temporary grassland	:	2.6 million acres
Permanent grassland	:	1.0 million acres
Rough grazing	:	11.2 million acres. (H.M.S.O. 1971).

Eighty two per cent of Scottish grassland is thus permanent or rough, and therefore, because this land forms the basis of the hill sheep industry, we not only have agricultural factors to consider, but social factors as well. This land could continue to lose its already sparse population, or could, with the impact of EEC, the requirements for meat and the potential for increasing meat sales within the EEC and, not least, the hard cash available within the EEC for land improvement, be improved in terms of output from an all-the-year-round industry.

The distribution of major grassland groups in Scotland is of interest, showing a distinctive east-west separation.

Table 1

Distribution of grassland groups in Scotland (after H.M.S.O. 1971)

	% Rough Grazings	% Grass Under 7 years old
Highland	58.9	8.9
South West	14.5	26.6
North East	8.7	36.2
East Central	11.8	15.6
South East	6.1	12.7

It will be seen that the western side of the country contains 73.4% of the rough grazings but only 26.6% of short rotation grassland compared with 35.5% and 64.5% respectively on the eastern half of the country.

The HFRO investigations have shown that the potential of the livestock on our hills has been by no means reached in practice. Much of the productivity gap must be filled by a combination of techniques - fertilisers, fencing, weed control and improvement of these natural swards by biotic factors inherent in good, even improved, husbandry and the correct type of stock in the correct proportions - whether they be sheep, cattle or deer - especially on the permanent grass and rough grazings.

A pilot survey of the weed problems in U.K. grassland (Holtham 1973) has shown that some 50% of the grassland surveyed contained a problem with a weed or weeds. Of particular importance were buttercups, thistles, docks, rushes, ragwort and bracken.

The question of what is a weed in rough grazings areas is dependent on the quality of the herbage overall, the utilisation of that herbage and the potentialities for improvement. In a *Festuca*/*Agrostis* pasture one would hesitate to call either a weed in the absence of any techniques designed to improve the herbage quality. But each does, in its turn, merit definition as a weed whenever improvements are undertaken; fertilising, or more efficient control of grazing, will result in an improvement in the yield of *Agrostis* and *Festuca* alike, to the detriment of the *Agrostis*, which is selectively grazed by the sheep (and to some extent by cattle) and at the same time has to withstand the increased pressure of growth, shading and water demand by the *Festuca* sp. At this stage and in these circumstances *Festuca* can be allotted one of the definitions of a weed - a plant which hinders the growth of another plant of higher economic value.

There are on the other hand many plants which, no matter the quality of herbage be it low or high, are regarded as weeds because they inhibit the growth of better species or because they are poisonous or for both reasons. They are by no means confined to Scotland nor, if one looks at the Atlas of the British Flora (Perring and Watters 1962), are they particularly affected by east-west considerations except that of altitude. We are equally afflicted by buttercups, horsetails, wild garlic, bracken, coltsfoot, thistles, docks and ragwort. Locally sparse, locally frequent and locally dominant examples can be found throughout the country. But, in common, they are rarely grazed and have become important weeds; on this account they are worth our attention.

They are subject to the same growth limitations imposed by climate and edaphic conditions as are the beneficial plants, and precise classification of these conditions is difficult if not impossible - consider the range of conditions in which bracken can grow successfully. Temperature appears to be the most significant, affecting length of growing season and winter viability, even for the bracken plant with its normally well-protected rhizome system.

In these circumstances it seems pertinent to consider two major Scottish grassland weeds in more detail.

1. Docks (R. crispus and R.conglomeratus)

These species are found in all areas of the British Isles, from sea level to 535 m altitude. Both tend to be less frequent in the north and centre of Scotland, a factor attributed to the lack of cultivated ground over much of that Central Highland and North-Western Highland area. Spread of the plants is locally by seeds or more widespread by carriage of seeds in hay and dung, and by root fragments broken and spread in ploughing.

Hunt (1970) from a survey in South West and Central Scotland, concluded that the dock problem was worsening in these areas and that the significant factors were (among others) the increased use of dung and slurry on grass, increased levels of fertiliser, increased stocking and prolonged grazing leading to poaching, taking two or more silage cuts and thus opening up the sward.

These survey results are substantiated in a W.R.C. survey reported by Haggar (1974) who showed a positive correlation between docks and higher applied nitrogen levels, the application of slurry and the presence of poaching. This survey further ranked Devon and Sussex as being "the" dock areas (rated 100) compared with Ulster at 74 and N. Scotland at 44. No comparable ratings are available for Central or South-West Scotland.

Whilst docks were generally regarded as waste and poor land invaders it is obvious from these survey results that they are benefiting as much as the grass from intensive grassland production methods, the opening up of grass swards and the quick return of slurry to land. It is also believed in certain quarters that modern fertilisers contain a secret additive which stimulates dock growth!

It could be that standards of grassland husbandry and weed control in the northern British environment are higher, despite the higher incidence of poaching and use of slurry, thus accounting for the lower dock ratings referred to above.

There is evidence to suggest that there is a germination polymorphism present in any community of docks, due to genetic variation (Palmblad 1969); this variation might also account for variation in response to herbicides at the seedling or adult stage. The hard seed coat in these species has been shown to restrict embryo growth and germination, some damage to the coat, either by mechanical or environmental means, allowing full germination rates to be expressed.

Seed production in docks can be suppressed by overspraying with 2,4-D up to 7 days before or after anthesis (Maun and Cavers 1969). R. crispus can propagate vegetatively from root sections 47 days after germination, R. obtusifolius 51 days after seed germination. This has an important bearing on the control of seedling docks by mechanical means. In older plants, regeneration is only possible from the upper 3-4 inches of tap root (Monaco and Cumbo 1972).

The Weed Control Handbook recommends asulam, dicamba, or a mixture of mecoprop with dicamba for the control of established plants; in the west of Scotland and in N. Ireland herbicides containing dicamba have been found to be most effective. Dicamba with mecoprop at 1.5 lb/acre gave the most consistent control in Northern Ireland trials and increased Lolium in the sward at the expense of Poa species (Courtney 1970, 1972). In west Scotland dicamba or dicamba with mecoprop gave the best results, 65% reduction one year after treatment (Frame and Harkess 1972). Asulam and MCPA or mecoprop have given good results in the eastern counties of Scotland, elsewhere asulam has generally given good results, 3 pts/acre giving reductions of 80-85%, although regeneration may occur (Ritchie 1969).

Time of treatment may be critical; for young plants the optimum spraying time is between the formation of a complete basal rosette and the appearance of the second stem node. Some workers suggest a worthwhile increase in effect if re-spraying is carried out after the lapse of a year (Lescar and Bouchet 1971).

Translocation in docks is acropetal at the rosette stage, basipetal with considerable accumulation in the roots at full flowering stage, and basipetal but with no accumulation due to the low rate of translocation at the seeding stage (Muller 1969). Reduction of leaf surface of up to 75% made no difference to the effect of an asulam treatment, defoliation taking place two days after spraying (Savory and Soper 1970). Other work with asulam has shown that there is no increased uptake due to the use of a wetter, and that the highest concentration of asulam occurs in the meristematic regions four days after treatment (Catchpole and Hibbitt 1972).

The use of glyphosate against docks is still in the preliminary stages, but 1 kg/ha has given excellent control (Davison 1972). Again, regeneration from the root tissues may occur.

There is a considerable scarcity of information regarding the control of docks by biological means. The rust fungus Uromyces rumicis will seriously affect dock growth and 60% suppression has been found in the second year after a severe attack. This rust has Ranunculus ficaria (lesser celandine) as its alternate host (Inman 1970).

2. Pteridium aquilinum L. (Bracken)

Bracken is a widespread weed in Scotland, now present on an estimated acreage of at least 400,000. It is found growing from conditions of extreme exposure on open, high hills to sheltered woodland; the "best" bracken is found on fertile soils where some shelter is afforded by topography. Here the fronds may be over six feet in height and the ground beneath is completely denuded of other vegetation in summer due to the depth of bracken litter and the low light intensity at ground level.

Until the advent of wide-scale sheep rearing bracken was no particular problem since it was used for cattle bedding and thatching, but in the past century the reduction in cattle numbers on the hills, the reduction in farming units, sophistication of stock housing and the more selective grazing pattern of sheep has led to the present situation. In the relatively recent past, control or eradication has been attempted by mechanical methods, chemicals and flooding.

Where the ground is suitable and safe, ploughing followed by discing is the method most likely to give permanent results, provided the area can be put into annual cropping thereafter, combined with fertiliser applications. The situation regarding methods of control has been well summarised by Braid (1959) and more recently by McKelvie and Scragg (1973).

The herbicides mostly used over the past twenty years are MCPA, aminotriazole, 4-CPA, picloram, dicamba and asulam. With the possible exception of the last of these, all have been erratic in performance, costly, lethal to other more useful vegetation or showed long-term residual effects which prevented pasture improvement programmes being initiated.

In 1969, workers at the Weed Research Organisation showed that asulam affected bracken growth (Holroyd et al. 1970), and since then country-wide trials have taken place with it. Generally speaking, asulam at the recommended rate of four pounds a.i. per acre will cause a reduction in frond number in the succeeding year by up to 100%, usually in the order of 95%. There are instances of this effect from all parts of the United Kingdom. Since trials on a wide scale only began in 1969 or 1970, it is too early yet to have fully explored and exploited all the possibilities of time of application, weather conditions, spraying equipment, regeneration rates etc., but this herbicide is certainly the most effective one to have been tested in the west of Scotland. The information we now have from field and laboratory trials indicates that it closely parallels in behaviour other bracken herbicides, but has advantages in cost, water carry, safety to other species and lack of residual toxicity.

McKelvie and Scragg (1973) and Martin et al. (1972) are in agreement that regeneration will run at 10% or more per annum. Observations by the North of Scotland College staff indicate that regeneration rate may well be inversely proportional to the original level of control.

Early reports on the use of asulam suggested that treatment between July and the time of senescence in September was suitable (Anon. 1972) but experience in Scotland has shown that only in the last two weeks of July and the first two of August can an application be assured of success.

The variation in response to spraying date in the west of Scotland is shown in Table 2; asulam was applied at 4.5 kg ha^{-1} in 400 1 ha^{-1} water towards the end of each month.

Table 2

Percentage reduction in frond numbers

Spraying date

Site	May	June	July	August
Oban	-	57.1	82.3	85.4
Callander	0	84.2	88.5	87.1
Glespin	0	0	91.6	89.1
Thornhill	0	41.7	98.2	52.4

Effective uptake and translocation of the herbicide are obvious prerequisites for success. Veerasekaran and Kirkwood (1972) have shown that these occur only at and shortly after maturation and complete unfurling of the fronds, early application being ineffective due to lack of basipetal translocation and later application becoming progressively less effective due to changes in the cuticle barrier as the fronds age.

Air and soil temperatures, wind velocity, rainfall and genetic variation may all play some part in this anomaly of differential response.

Elsewhere in this symposium a research report is presented on the effect of glyphosate on bracken (Williams 1974). The effect of 2.2 kg ha a.i. applied in August 1972 and assessed in 1973 showed frond reductions as good as those obtained with asulox. Regeneration can not yet be assessed. Damage to the underlying sward varied from slight to severe, depending on the bracken frond cover and time of treatment, but even severe damage could be taken advantage of to allow re-seeding and possibly quick seed establishment.

Poisoning by bracken fern has long been accepted as a hazard to stock but outbreaks tend to be sporadic in time and place and, while they may be related to availability of spring grazing or to exposure of rhizomes by ploughing or erosion, it is as yet impossible to relate them to weather conditions alone. Leach et al. (1971) have reported the isolation of an active principle which is mutagenic and carcinogenic in mice and affects young cattle stock. Further work (Evans 1972) has established the molecular weight and an empirical formula for this compound. There is evidence that the rhizomes are more toxic than the fronds so far as pigs are concerned (Evans et al. 1972) although the use of pigs as a biotic bracken eradicant is still occasionally encountered despite warnings to the contrary (Harding 1972).

Inherent in all bracken control or eradication programmes must be acceptance that this is but one step in a general improvement programme. Control based only on a single spray will almost inevitably fail due to regeneration. Even areas eradicated of the weed by a bracken-lethal herbicide will suffer re-infestation from peripheral untreated areas, or from the infrequent spore-borne re-growth. Only on enclosed ground subject either to cattle grazing after a suitable interval or with heavy sheep stocking will a spray alone be sufficient without the application of fertilisers and/or a suitable seeds mixture. On the open hills of west Scotland, with relatively few cattle as yet, and sheep stocking on occasion as low as one ewe to six acres the effect of stock is nil except where they congregate or make their walks.

Further treatment can vary from none to any combination of fertilisers, especially lime and phosphate, along with fencing or other methods of controlling grazing and re-seeding. It is likely that all bracken soils oversown by re-seeding, or with a natural flora, would benefit in the long run from the application of both calcium and phosphorus (in the short run this might first benefit the weeds such as foxglove, thistles and nettles which quickly appear but equally quickly have disappeared on our trial plots), but the economics of such treatment, and especially the application costs, do cause concern on the steep, rough bracken lands of west Scotland, where application by helicopter is the only feasible method for large areas. To this end we are investigating the beneficial effect of phosphate only, on unseeded areas and on areas seeded with selected grasses and legumes.

Some farmers are concerned at the prospect of bracken eradication on the grounds that a light infestation gives a degree of shelter to the other herbage, especially important in the autumn with the possibility of frost, but at the present time there is no herbicide which will reduce a heavy infestation to a light one and which will also prevent regeneration occurring.

A further possibly advantageous feature of the presence of bracken is the finding by Mitchell (1973) that bracken rhizomes could release inorganic phosphate in a plant-available form from both ground mineral phosphate and a mineral soil. The importance of this ability to mobilise nutrients in hill land, where the application of fertilisers tends towards the uneconomic in many cases, is of interest as also is the possible extrapolation that bracken may improve the soil in which it grows.

References

Anon (1972) Bracken control with Asulox. May and Baker Technical Bulletin.

Braid K.W. (1959) Bracken: A Review of the Literature. Comm. Agric. Bureaux Publ. No.3.

Catchpole A.H. and Hibbitt C.J. (1972) Studies on the retention, penetration and translocation of asulam in some perennial weed species. Proc. 11th Br. Weed Control Conf. 77-83.

Courtney A.D. (1970) Control of Rumex spp. in N. Ireland and the influence of herbicidal treatment on herbage yield and composition. Proc. 10th Br. Weed Control Conf., 488-494.

Courtney A.D. (1972) Docks in grassland, their influence on herbage productivity. Proc. 11th Br. Weed Control Conf., 315-322.

Davison J.G. (1972) The response of 21 perennial weed species to glyphosate. Proc. 11th Br. Weed Control Conf., 11-16.

Evans I.A. (1972) Naturally occurring chemical carcinogens - bracken fern toxin. In Oncology 1970; Proc. Tenth Int. Cancer Cong., 178-195.

Evans E.C., Widdop B. and Harding J.D.J. (1972) Experimental poisoning by bracken rhizomes in pigs. Vet. Rec. 90, 471-475.
Frame J. and Harkess R.D. (1972) Herbicides for control of docks (Rumex spp.) in grassland. Proc. 11th Br. Weed Control Conf., 323-330.
H.M.S.O. (1971) Agricultural Statistics (Scotland).
Haggar R. (1974) Pers. comm.
Harding J.D.J. (1972) Bracken poisoning in pigs. Agriculture 79, 313-314.
Holtham E.S. (1973) New herbicide for weed control in grassland. Fisons Agricultural Technical Information, Autumn, 32-34.
Holroyd J., Parker C. and Rowlands A. (1970) Asulam for the control of bracken. Proc. 10th Br. Weed Control Conf., 371-376.
Hunt I.V. (1970) Survey No. 4, docks and chickweed. J. South West and Central Scot. Grass. Socs., 13, 64-65.
Inman R.E. (1970) Host resistance and biological weed control. Proc. 1st Int. Sym. on Biol. Control of Weeds 41-45.
Leach H., Barker G.D., Evans I.A. and Evans W.C. (1971) Isolation of an active principle from the bracken fern that is mutagenic, carcinogenic and lethal to mice on intraperitoneal injection. Biochem. Journal 124, 13-14.
Lescar L. and Bouchet C. (1971) Three years' control of Rumex spp. in permanent pastures. Compte rendu 6e Conference du Comite. Francais de Lutte contre les Mauvaises Herbes, 566-76.
McKelvie A.D. and Scragg E.B. (1973) The control of bracken by asulam. Scot. Agric. 51, 474-480.
Martin D.J., Williams G.H. and Raymond J.C. (1972) The effect of asulam on bracken frond number, rhizome viability and frond carbohydrate ratios. Proc. 11th Br. Weed Control Conf., 331-334.
Maun, M.A. and Cavers P.B. (1969) Effects of 2,4-D on seed production and embryo development of curly dock. Weed Science 17, 533-6.
Mitchell J. (1973) Mobilisation of phosphorus by Pteridium aquilinum. Plant and Soil 38, 489-491.
Monaco T.J. and Cumbo E.L. (1972) Growth and development of curly dock and broadleaf dock. Weed Science 20, 64-67.
Muller F. (1969) Relationships between stage of development, carbohydrate content and transport of 14C-MCPA in the case of several perennial weeds. Z. PflKrankh. PflPath. PflSchutz., 76, 473-83.
Palmblad I.G. (1969) Populational variation in germination of weedy species. Ecology, 50, 746-8.
Perring F.H. and Walters S.M. (1962) (Ed.) Atlas of the British Flora. Nelson, London.
Ritchie A.C. (1969) Bracken control trials. Rep. Edinb. E. Scotl. Coll. Agric. (County Expts.) (1968), 102.
Savory B.M. and Soper D. (1970) Factors affecting the control of docks (Rumex spp.) with asulam. Proc. 10th Br. Weed Control Conf., 358-65.
Veerasekaran P. and Kirkwood R.C. (1972) The effect of stage of frond development in the absorption and translocation of asulam in bracken. Proc. 11th Br. Weed Control Conf., 17-23.
Williams G.H. (1974) The use of glyphosate in the control of bracken. Proc. B.C.P.C. Symposium (in press).

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WEED PROBLEMS AND CONTROL IN FORESTRY

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Summary For control purposes forest weeds are arranged into four groups, grass/broad-leaved, bracken, woody broad-leaved, and heather. In general forest weed populations have a similar composition whether in the south or north, but growth is more vigorous in the south due to more favourable climatic and edaphic conditions. This is reflected in the greater concentration of weeding effort and the different emphasis placed on the various groups of forest weeds in the two regions. Choice of chemicals and effectiveness of control in the north is more likely to be influenced by local site factors which affect the feasibility of herbicide application than any broad climatic or edaphic differences.

1. INTRODUCTION

The concept of control of weeds, or undesirable species, in forestry is different from that in agriculture. As a general rule weed control is necessary for two reasons:

a) prevention of smothering or mechanical damage by competing vegetation;

b) prevention of woody weeds interfering with normal development of the crop either by shading or by the space they occupy in the plantation.

Except for heather (*Calluna vulgaris*), control does not usually result in improved tree growth due to removal or reduction of competition for nutrients and moisture; yield therefore is not seriously reduced by weed competition, but initial survival can be. Weeding operations have to be carried out sometimes before planting and usually after planting for from 2-5 years. Costs cannot be recovered by timber sales for a considerable time, and early weeding costs therefore must be kept to a minimum. In contrast to agriculture or horticulture forest weed control is not a permanent requirement on a given piece of land.

In the north of Great Britain forest weed control in many upland areas is not required because the initial ploughing provides sufficient suppression of the existing vegetation for the trees to keep ahead of any re-invading weeds. Protection from grazing, coupled with initial ploughing and fertilising can cause substantial development of ground vegetation, but with good plants and planting practices initial growth is sufficiently vigorous to keep the tree crop out of any danger from smothering or mechanical damage.

2. FOREST WEED POPULATIONS

Forest weeds can be classified into 4 broad categories for the purposes of control. These are common to both the south and the north of Great Britain, but differences can occur in the local importance of each category, as shown in Table 2.

a) Grasses and broad-leaved weeds.

b) Bracken.

c) Woody broad-leaved species.

d) Heather

Mixtures of these groups often occur with proportions varying according to particular areas.

2.1 Grasses and broad-leaved weeds

Both in the north and south this type is involved as a major part of any weeding programme, not only because it occurs most commonly, but because with any treatment, hand or chemical, control lasts only one season. At best, treatment of the same area is required once a year for several years after planting, and at worst several times per season, particularly in the first 2 years. Five herbicides, paraquat, dalapon, atrazine, chlorthiamid, and dichlobenil currently are used for chemical control of weeds in this category. The choice of which herbicide to use depends initially on its ability to leave the tree crop undamaged, but thereafter the choice depends on the differences in weed species controlled.

2.1.1 Grasses

As forest weeds, grasses can be grouped conveniently into 3 types.

1. FINE grasses eg *Deschampsia flexuosa* (Wavy hair-grass)
   Agrostis spp. (Bent-grasses)
   Festuca spp. (Fescues)

2. SOFT grasses eg *Holcus lanatus* (Yorkshire Fog)
   Holcus mollis (Creeping soft-grass)
   Anthoxanthum odoratum (Sweet Vernel-grass)
   Poa spp. (Meadow-grasses)
   Agropyron repens (Couch-grass)

3. COARSE or TUSSOCKY grasses eg *Deschampsia caespitosa* (Tufted hair-grass)
   Dactylis glomerata (Cocksfoot)
   Molinia caerulea (Purple Moor-grass)

Fine grasses are more common in upland areas on heathland podzols and ironpan soils. In general, they do not present a problem during tree establishment, and can be dealt with adequately by forest ploughing practices. Even where growth of *D. flexuosa* becomes vigorous following standard ground preparation techniques, such as burning, ploughing, fertilising or heather removal, it seldom presents a hazard to normal transplant stock.

Soft grasses are common on the more fertile sites eg moist brown earths, flushed gleys and peats, and usually occur in combination with mixed herbaceous vegetation. Sometimes where bracken also occurs and is removed, the changed light conditions cause the soft grasses to become troublesome. This type of weed is locally important and requires control usually as a post-planting operation. Pre-planting weeding with herbicides could be carried out, but in northern upland sites there may be difficulty in distinguishing treated spots or strips at the normal planting time of March/April when the untreated areas are still naturally brown.

Coarse grasses occur commonly on heavy textured soils which are often gleyed. This group of tall species, many of which can be fairly resistant to chemical treatment, causes the greatest hazard to a tree crop. The sites on which they occur are however generally fairly fertile and reasonably rapid growth can be expected, if early tending is carried out. Such sites often occur in water receiving situations ie hollows, gulleys or low lying flats, which often are prone to cold air accumulation, leading to frost damage of the more sensitive tree species. Weeds in this group are common in the Borders on heavy soils derived from Carboniferous deposits and are recognised as a problem which is becoming more important as the forests move into the re-stocking regeneration phase, in many instances prematurely because of the windthrow problems.

2.1.2 Broad-leaved Weeds

Broad-leaved weeds seldom present large scale problems in forest conditions, but may be locally important. Rosebay willowherb (*Epilobium angustifolium*) is probably the most common. Although tall it can be fairly sturdy and is sometimes regarded by some foresters as a "friendly" weed, as it provides shelter and there is plenty of air circulation at ground level. It is indicative of conditions of ample nitrogen mineralisation and therefore good tree growth can be expected where it occurs. Application of phosphate fertiliser can markedly stimulate invasion of *E. angustifolium*, particularly on phosphate deficient soils. It can develop even on the poorest acid peats following ploughing and phosphate/potash fertiliser application.

Other broad-leaved weeds rarely reach proportions where they have to be considered separately, except perhaps locally on waste ground and reclamation sites. It is important however to recognise them as constituents in mixed grass and herbaceous ground vegetation, as their presence could effect the choice of a suitable herbicide. Where specific grass herbicides are applied resistant broad-leaved species may become troublesome following removal of grass competition.

2.2 Bracken (Pteridium aquilinum)

It is estimated that some 8,000 hectares are weeded annually for bracken control in the Forestry Commission with possibly a similar area in private forestry. This represents a substantial proportion (about 20%) of the current Forestry Commission programme, and is consequently of considerable importance. In the north of Great Britain the major areas of bracken infested forest land are in the west (Argyll) and in southern and central Scotland. They are usually found in areas where freely drained soils predominate on steeper slopes. The bracken problem in forestry is different from that in agriculture, as follow-up treatment after chemical application in the form of increased grazing pressure, cannot be carried out. Bracken is more troublesome where there is a deep litter layer with no grass understory. Here chemicals such as dicamba are least effective, but weeding is most important. Chemical treatment with dicamba and MCPA has been more successful on acid sandy soils in the drier areas of both the north and south.

The danger to the young planted tree crop is in smothering by the dead fronds in winter. This could be a disadvantage with a post-planting summer application of herbicide eg asulam to the fully developed fronds, as winter smothering may still occur. In forestry complete bracken control is not always necessary. Some reduction in frond numbers can be sufficient, as light cover can be advantageous in providing shade and shelter for young trees. Ideally the best compromise is partial reduction in summer canopy, enough to prevent winter smothering and give a sufficient degree of control to last for 3 or 4 seasons.

Chemical application with dicamba or asulam is currently recommended as a pre-planting treatment. But with dicamba the advantage of the first year control cannot always be taken because of soil residues presenting danger to the newly planted crop. In many areas, particularly on the more fertile sites chemical control may last only 2 or at best 3 seasons, which may not be long enough for the trees to grow sufficiently to obviate further weeding. Hand weeding after planting is most successful when done early, and can be done fairly cheaply by "whipping" the young uncurling fronds. However this is not always possible due to pressure of other work, such as planting, at this time of year. The latest successful herbicide treatments using asulam are now very competitive with hand cutting methods.

2.3 Woody Broad-leaved Species

These weeds are much more of a problem in the south, particularly on the heavy clay soils of East England. But in the north particularly in certain private forestry areas they can be locally important eg in central Scotland. Into this group fall many tree species which are regarded as weeds where conifers have been planted for greater economic return and are likely to be damaged by shading and over-topping by the initially faster growing hardwoods. Elsewhere these species are planted or are left untouched for amenity or recreation purposes. Such tree species include Birch, Willow, Alder, Sycamore, Ash, Elder, Hazel, Hawthorn and Blackthorn. Shrubby species such as Gorse, Broom, Bramble and Snowberry also can be important locally. There are different methods of herbicide application to control such weeds. Summer or autumn foliage application, or winter cut-stump application, or stem injection of 2, 4, 5 - T deals very adequately with most species whether in the north or the south. But more resistant species such as Ash and Hawthorn will succumb only to cut-stump application of ammonium sulphamate, used as pre-planting treatment.

Rhododendron ponticum is included in this group and can be singled out as a difficult problem weed species in certain areas, particularly on acid soils in the milder parts of the country. This is because of the rapidity with which it establishes itself after initial hand clearing. Although classed as a weed resistant to normal 2, 4, 5-T application, stump treatment or foliage application to the re-growth after cutting will give good control. Regional differences in control have not been reported.

2.4 Heather (*Calluna vulgaris*)

This merits a separate section because of its vital importance as a weed in forestry, being one of the few species to compete very successfully for nutrients, particularly nitrogen, with a tree species many times larger than itself. Other ericaceous species, such as *Erica sp*. and *Empetrum nigrum*, can compete, as can *Vaccinium myrtillus*, but only in a mild way, possibly because they are rarely found as the dominant constituent of upland flora. Heather is dominant in the ground vegetation of many forestry sites particularly in the drier eastern heathland areas of Scotland and North England. On the poorer hill peat sites it can quickly become dominant in most upland areas when burning is terminated, grazing animals are excluded and ploughing for planting and surface drainage is carried out. Cutting alone is not usually sufficient to eliminate competition and plants must be completely killed to promote successful tree growth. Damage from smothering is not important; neither is mechanical damage, except in areas of tall heather when no ploughing has been carried out.

Competition from heather takes place most commonly where Spruces, Silver firs, Hemlock, and Douglas fir are planted. Pines are not usually affected, but in the south Corsican pine does respond to removal of heather competition. Usually these former species which are fast growing and high yielders are not planted on sites where heather is dominant or likely to become rampant following planting. With Sitka spruce, which is currently the most widely planted commercial conifer in Britain, heather is a weed of major importance particularly in the north. Earlier plantings of spruce were carried out in mixture with other species, such as pine or larch, which slowly suppressed the competing heather, the initial slow growth of the spruce being accepted. But now as more pure spruce is being planted, the heather problem in the north is being highlighted.

It is estimated that there is a potential of 4,000 hectares per annum requiring treatment for control of heather within the Forestry Commission and possibly as much again in private forestry. It is fortunate that in 2,4-D properly applied there is an effective herbicide which can give lasting control, is relatively cheap, and above all is reasonably selective as far as Sitka spruce is concerned. Control does not take place usually until some years after planting, and a successful treatment ie giving over 80% control, is once only and should last until the tree canopy closes and the crop is beyond any effect of nutrient competition.

3. SCALE OF WEEDING OPERATIONS

Table 1 indicates the scale of weeding operations, both hand and chemical, in the Forestry Commission. The northern data is the total of the 4 Scottish and the 2 North of England Conservancies. The figures include areas that may have been weeded more than once during the year, and also areas of different crop ages. Despite this an idea of the different emphasis placed on weeding in the north and south can be gained by relating the area weeded to the aréa planted.

Table 1

A comparison of areas planted and weeded by the Forestry Commission in the north and south of Great Britain

Year		1966	1969	1972
Areas planted (hectares)				
New Planting	North	14,990	15,590	19,400
	South	4,080	2,700	2,360
Restocking	North	750	1,970	2,510
	South	1,760	1,970	1,970
Areas weeded (hectares)	North	30,940	23,390	22,570
	South	33,560	23,540	20,390
Proportion of area planted to area weeded	North	1 to 2.0	1 to 1.3	1 to 1.0
	South	1 to 5.7	1 to 5.1	1 to 4.7

A similar total area is planted in private forestry with similar trends and distribution, and it can be assumed that at least an area similar to the Forestry Commission figure will be weeded.

It can be seen that a far greater concentration of effort on weeding is required in the south. This is necessary not only because of edaphic and climatic factors favourable to weed growth, but also because of the type of land being planted. There has been a noticeable decline in the forest area weeded over the past few years. This is more significant in the north because of the substantial rise in planting programmes and is probably because foresters have become more discerning of the need to weed in the face of an expanding programme of other forest operations, coupled with a reduction in the available labour force. It is interesting to note the major rise in the re-stocking figure in the north, and it can be anticipated that weeding problems will take greater prominence in the future.

It is impossible to distinguish the areas of different types of weed populations treated, as records are not kept in this way. However an estimate can be made from the quantities of different selective herbicides ordered within the Forestry Commission and adjusted according to the likely method of application. The area of bracken treated cannot be ascertained as there has been little or no chemical control carried out in the past, although the introduction of asulam may change this in future.

Table 2

Estimate of areas (hectares) of treated weed types (Forestry Commission) as deduced by quantities of chemicals ordered

Year		1966	1969	1972
Grass/Broad-leaved Weeds	North	2,740	9,940	5,560
	South	5,410	13,500	9,490
Woody Broad-leaved	North	700	1,650	750
	South	2,680	10,920	2,600
Heather	North	30	170	690
	South	150	220	490

The following points are of interest:-

a) The greater use of chemicals for grass control in the south, reflecting in part the importance of weeding in this area.

b) The far greater emphasis on woody weed control in the south.

c) The recent decline in the use of most chemicals in both areas.

d) The increasing importance of heather control in both areas, but particularly in the north.

There is a history of more intensive management in the south than in the north, where out of necessity to cope with much larger work programmes, management practices are more extensive in their outlook. This may be responsible for different standards of weeding being practiced in the two regions, and this rather than a true need for weed control may be influencing the figures.

4. OTHER FACTORS RELATING TO WEED CONTROL

When discussing forest weeds in the northern environment other factors relating to their control must be mentioned. These may influence decisions on whether or not to use chemicals, the choice of chemical and hence efficiency of weed control compared with practices in the south. They are particularly relevant in upland conditions and will seriously limit the extended use of chemicals in such areas.

a) Poor access - road construction in the establishment phase is limited, as full access is not required until harvesting operations are due to commence.

b) Lack of suitable water supplies which are essential for application of many recommended herbicides.

c) Very difficult ground conditions for herbicide application eg steep and rocky terrain particularly in many bracken and heather areas.

d) Scattered nature of weedy sites, often occurring in a variable complex of site types.

e) Timing of herbicide application often coincides with the planting season, thus limiting the size of programme which can be achieved.

f) Shortage of suitably skilled labour - the effectiveness of herbicides depends on skilled techniques of application. Skilled labour is currently in short supply, and training is essential.

g) Water catchment areas - many upland forest areas are within catchment areas of local Water Authorities. There are often restrictions in the use of herbicides in such areas.

Although large areas are planted each year in the north, many will never require weeding because of pre-planting ploughing practices. Where chemical weeding is required application must be made as easy as possible. Hence the preference for granular residual soil acting herbicides to remove the need for water and to extend the application period outwith the planting season. The current development of ultra low volume (ULV) spraying of herbicides for heather and bracken control should make application possible under difficult ground conditions where access is poor and water supplies are limited. It may be argued that aerial application would be an obvious answer to overcome the above limitations. However, ignoring the conservation controversy, in many instances such application would mean blanket application over larger areas than necessary, which in upland areas with a scattered occurrence of problem sites would mean wasteful and hence inefficient use of chemical which is the major part of the cost of weeding. Again the low level flying required for efficient herbicide application is difficult and hazardous in broken country, even for helicopters.

In northern lowland areas conditions are likely to be similar to the south. It is fortunate that this is where the major weed problem areas are to be found, ie on the more fertile soils. Here access generally is much easier and water supplies are less of a problem, but again if water supply considerations can be avoided so much the better. Here too, granular herbicides and ULV techniques are attractive.

The time of year or stage of crop and weed growth is likely to influence the efficiency of most herbicides used in forestry. This is due to the varying period of activity within the plant which influences translocation of the herbicide. Although site for site in terms of vigour and composition of the vegetation, rates of applied herbicide are likely to be equally effective in the north and south; but successful results in the north can follow a later start to application in the spring and an earlier finish in the late summer. Differences in local performance must be appreciated by the user and adjustments made to rates and application timing if consistently reliable results are to be achieved. Otherwise herbicidal weed control techniques will never be fully accepted in field practice.

References

ALDHOUS, J. R. (1969). Chemical Control of Weeds in the Forest. Leaflet 51 (Second Edition). For Commn. Lond. (Third Edition in print).

FRYER, J. D. and EVANS, B. A. (1970). Weed Control Handbook. Volume I Principles. 5th edition (revised). Blackwell, Oxford & Edinburgh.

FRYER, J. D. and MAKEPEACE, R. J. (1972). Weed Control Handbook. Volume II. Recommendations. 7th edition. Blackwell, Oxford & Edinburgh.

Discussion Session II

Mr M.G. Allen (Shell Chemicals) - asked Mr MacKenzie to comment on methods of evaluating grass weed control. In his own trials 30% remaining grass was treated as acceptable; would this standard be regarded as satisfactory by Mr MacKenzie? Mr MacKenzie replied that the Forestry Commission does not work to a fixed scale as the degree of control required depends on the vigour of the original vegetation. They do a scoring assessment based on experience of the degree of control necessary in relation to the vigour of vegetation in particular circumstances. Thirty to fifty per cent of grass remaining would probably be perfectly satisfactory for general forestry purposes. With heather 80 per cent control is regarded as necessary.

Mr J.G. Elliott (Weed Research Organisation) - asked Mr. Scragg about evidence for the existence of ecotypes in the north versus the south which may affect weed control in the northern environment. Mr Scragg replied that there was ample evidence to show that ecotypes exist in many species such as *Polygonum aviculare* and other *Polygonums*, *Veronica*, *Fumaria* and *Galeopsis*, but no studies have been made of their distribution within the United Kingdom, nor is there anything other than personal observations about their response to herbicides. Salisbury says that *Raphanus* is more resistant to MCPA in the north than the south but this statement of doubtful validity. Similarly there are rumours that *Chrysanthemum segetum* in Devon can be controlled by mecoprop whereas in Morayshire it is resistant to this herbicide. There is a lack of information and ample scope for research on this subject.

Mr D. Robinson (Dublin) - raised the question of "friendly weeds" in forestry and said that in Ireland investigations into beneficial effects of *Ulex gallii* were in progress. There were indications that this weed might raise the level of soil nitrogen above the critical level for satisfactory growth of Sitka spruce. Mr MacKenzie replied that *Ulex gallii* does not occur in the north but it is regarded as an indicator of phosphate deficiency in the south west. Nitrogen status is usually good where *Ulex gallii* occurs. Professor Fletcher asked if the properties of *Ulex gallii* were related to nodulation rather than as an indicator of nitrogen in the soil. Mr Robinson replied that nodules had been observed on seedling plants but the work had not progressed sufficiently far yet to decide how the beneficial effect arose. It seemed possible that given phosphate the *Ulex* might fix sufficient nitrogen to meet the needs of Sitka spruce.

Mr A.N. Courtney (Northern Ireland) - asked Mr Scragg to expand his view that crop competition in cereals was greater in the northern environment and to consider how this would effect yield, bearing in mind the data from Evans which showed that there was little yield benefit from spraying in the south compared with information which suggested that there were positive yield responses in the north. Mr Scragg replied that many factors are involved; it was probably true that there was a greater yield response in the north. There is evidence to suggest that densities of weeds are higher in the north and that more competitive species are present. Given the same species and densities it is possible that the more competitive northern crops would overcome weed competition better than southern crops and this may explain why MCPA which only checks many species still gives satisfactory results in the north.

Mr J.W. Barbour (Chemical Spraying Co.) - asked Mr Waterson to expand on his remarks about residue problems in the use of TCA for couch control. Mr Waterson replied that the problem arose when TCA was used late in the autumn or winter followed by a spring cereal in experimental work not commercial application.

Mr M.G. Allen (Shell Chemicals) - asked Mr Scragg if in weed surveying he had encountered Fumaria capreolata which is quite common in the Borders and seems to be increasing. It is proving resistant to herbicides which control F. officinalis. Mr Scragg replied that as identification of sub-species was impossible at the seedling stage all fumitory had been classified as F. officinalis in the north of Scotland weed survey. However sub-species of fumitory differing in leaf form and habit of growth existed and if they varied in their sensitivity to herbicides this was a matter requiring further investigation.

Dr R.W. Gloyne (Meteorological Office) - commented that Mr Waterson doubted if there was a northern environment or that the meteorological data did not show differences proportionate to the observed agricultural differences. He considered it possible that environmental factors controlling germination and emergence were the key to successful crop production in a harsh climate, and if that is the case there are considerable differences in environmental conditions at a critical time of year when germination was occurring. He agreed that the recorded differences in climate were not large but small differences might have a strong influence at a critical stage of growth. Mr Waterson agreed in general and quoted the improvement in sugar beet crops in Scotland which can be achieved by pre-germinating the seed and transplanting emerged seedlings, but thought that in other cases, eg maize, germination difficulties might be only one factor in limiting its growth.