NON–CHEMICAL WEED CONTROL STRATEGIES AND EXPERIMENTATION ON BRACKEN SUPPRESSION USING A BIO–DYNAMIC APPROACH

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Introduction: the need for non-chemical methods

Many more methods of weed control are available to farmers, growers and gardeners than is often realised and people directly concerned with crop husbandry rarely depend on one method alone. But during the boom period of agriculture covering much of the Post-war period until the mid 1980s, the convenience and cost-effectiveness of herbicides as a method of weed control undoubtedly led to other methods being downgraded, rejected or simply overlooked. This drive towards agricultural efficiency with its clean, weed and pest-free fields was not only made possible by the chemical industry but was energetically marketed by it. The results of this phase of our agricultural history are now well known in terms of widespread damage to wildlife and water quality. However, concern over the environmental effects of herbicides together with the many other 'plant protection' and fertilizer chemicals is now joined by the serious need for lower input costs owing to the changed economic position of agriculture in the Developed world. This new economic climate has been brought about by substantial reductions in grant aid and price support in order to reduce the agricultural budget of the CAP. Current acrimonious debates within GATT are certain to reinforce this trend. Many farmers have unfortunately already gone out of business while the remainder search for ways of cutting costs and finding more profitable livelihoods including diversification into non-farm activities. It is in relation to this new and uncertain economic future that alternatives to the chemical control of weeds should be examined with urgency.

This paper outlines a number of alternative approaches before concentrating on the biodynamic-homoeopathic method and some recent experimentation on bracken control.

Approaches to the non-chemical control of weeds.

1 Mechanical

The physical action of inverting the soil in the process of ploughing is probably the most obvious method of coping with weeds in arable fields at the same time as benefitting the soil from the decaying residues of their growth. Discing prior to seeding or drilling acts as a further control on weed establishment as does hoeing on a garden scale. A variety of mechanical cultivation forms exist including those which can be carried out between rows of arable crops. One of the more sophisticated forms of weeding possible for row crops is brush weeding where adjustable rotating brushes cut the weed tops leaving them as a mulch on the soil surface.

Weed management on grassland and moorland takes other forms. Scrub encroachment is customarily dealt with by cutting and can involve use of a flail mower. The latter device is also used on moorlands for pasture improvement where over-age heather may also be cut rather than burnt. Bracken was traditionally cut when it had a variety of rural uses which kept it in check, and regular cutting is today one of the most effective methods for its control. Bracken has also been checked by rolling on fairly flat land and also by use of cattle to trample its young stems, a method particularly used in New Zealand.

2 Cultural practices over time

The husbandry of arable and pastureland over time plays a major part in the incidence of particular weed and pest problems. For instance, monocropping can lead to the build up of a massive seed bank of particular weeds. Traditional rotation and fallowing systems in various parts of the world designed with the explicit aim of maintaining soil fertility represent also long-term ecological approaches to the management of weeds and pests.

In the course of a single year, weed and pest problems may also be tackled by considering timing. Some winter-sown crops such as wheat may thus not only achieve

a good cover before weed germination in spring but develop strong plants before major build-up of pests such as aphids.

Aside from the question of planting season there are many examples of traditional agricultural systems where the timing of agricultural operations was considered of great importance and was often governed by lunar cycles. In particular, crops planted at certain times were considered more likely to be stronger and less prone to disease (Brush, 1977).

Grazing regimes can lead to the spread of coarse and unpalatable herbage and in this respect each grazing system is associated with its own weed problems. For instance, nitrogen-rich areas and patches, eg, those arising from cow pats, become associated with nitrophilous vegetation while the tearing of steeply sloping terrain by the hooves of heavy animals may provide opportunities for the seeds of certain scrub species such as gorse and hawthorn. Many upland swards in Britain deteriorate in time under a sheep grazing monopoly. The solution to ecological deterioration of pastureland inevitably involves regulation of the intensity or duration of grazing, or both. This is particularly a tragedy of lands where inhabitants or commoners are entitled freely to use unenclosed lands, with consequences ranging from deterioration of herbage quality to desertification (Hardin, 1968).

3 Crop management in space

Arable weeds normally produce copious seed, shed earlier than the main field crop with a high level of viability and often with a capacity for long-term dormancy, eg, *Papaver rhoeas* (the red poppy). The weeds themselves (ruderals) are normally well adapted to the local conditions they invade and more tolerant of soil and drainage than the crops with which they compete (Rudert, 1984). For these reasons it has been necessary to develop a variety of strategies to try to lessen the overall impact of weeds on crop yield. These may generally be described as forms of ecological management.

In the first place it is possible to use crop types and varieties which provide natural weed suppression such as rape, kale, lucerne, potatoes and the longer strawed grains

(Rudert, 1984). Seed selection is now regarded as an important factor, for seed size and weight have been correlated with emergence rates and eventual leaf area. It can readily be appreciated that poor crop performance, which can also arise from other factors, will lead to a high weed population.

The relationship between ground cover and weed growth is also recognised in various forms of mixed and intercrop systems where weed containment is only one aspect of a complex set of beneficial interactions among the various components of the mix. Thus the full utilisation of photosynthetic space by the various crop plants represents an efficient use of resources as well as a counter to weeds and pests. As a result, particularly in the case of soils of low fertility, certain mixtures can achieve far higher productivity (as measured by the land equivalent ratio) than under single crops (Papendick, 1976).

A further means of weed suppression, usually on the smaller scale, is the use of surface mulches which when correctly applied can also have benefits to the soil. On a larger scale, green manuring, the use of a green crop often grown over the winter period to improve soil organic activity, will counteract weed problems in fields which would otherwise be left fallow. Nevertheless, it has to be remembered that each field crop will tend to create its own weed problem for the succeeding crop unless cultivation is adequate.

Forest plantations can sometimes experience severe competition from indigenous weeds. For example, young conifers in the British uplands are retarded in growth through competition with heather which is a further justification for the ubiquitous ploughing prior to planting. Rapidly growing species of trees are sometimes used to gain control of terrain and act as nurse for slower growing and more weed sensitive trees. In the tropics a recent method which is favoured over hand weeding in young forests is the use of a leguminous cover crop which has the advantage of contributing nitrogen to soils of low inherent fertility.

4 Thermal

A small number of farmers have used flame-throwers as a method of weeding. Flame weeding as it is known is not without its hazards but its intent is simply to cause the weeds to wither and for this there is no need to actually ignite the plant tops. Depending on how it is carried out, this method may also have some value in suppressing the incidence of fungus or other pest problems where the latter depend on weeds as host.

Recently, research has been carried out on a method known as solarisation, involving heating soil under a cover of clear polyethylene sheet with natural sunlight. Here temperatures up to 55°C have been developed in soil at 5 cm depth but the method requires strong sunlight over a period of up to three weeks. Even after this time some weed seeds, eg, legumes, will germinate (Sauerborn, *et al* 1981, 1986).

5 Biodynamic

This approach will be explained in more detail in the sections which follow. Its main exponent is the German investigator Maria Thun (eg, Thun, 1981).

Biodynamic agriculture

Biodynamics is an agricultural movement which arose out of a series of lectures given by Rudolf Steiner in 1924 (Steiner, edition of 1974) and in important respects it can be regarded as a founder movement among various approaches to biological husbandry (Bezdicek, 1984; Scofield; 1986, Conford, 1988). On one level it advocates an ecological and sustainable approach to farming. This involves mixed, rotational farming with arable land, pasture and livestock, including cows. It embodies the idea of the farm operating as a kind of 'organism', a concept enthusiastically adopted by Schumacher in his 'small is beautiful' (Schumacher, 1974). But the holistic approach of biodynamics transcends organic farming for it considers life processes as depending on more than the simple provision of chemical substances (Koepf, 1989; Koepf *et al* 1976; Thun, 1979; Castelliz, 1980; Soper, 1983; Sattler and von Wistinghausen, 1992). Biodynamics involves the wider cosmos and makes use of its own unique preparations

for soil fertility and compost making. The whole approach of biodynamics is towards the promotion of plant vitality rather than productivity. Lack of such vitality is viewed as a major cause of the world's current pest and disease problems rather than a consequence of them. The view has been expressed by Podolinsky (1985, 1989) that biodynamics comes near to being the ultimate form of sustainable agriculture.

Through its holistic concerns biodynamic farming also aims towards new social models and, in particular, the regeneration of rural communities. It is also noted that many examples of traditional, indigenous agriculture are holistic in character (Richards, 1985; Smith, 1985). Further remarks on biodynamics will be found in Appendix 8.

The biodynamic approach to weed control

As mentioned already, weeds, particularly those of arable areas, have a high regenerative capacity and vitality. They are wonderful examples of pioneers or opportunists (r-strategists) which comprise the first stage in any succession (Putnam and Wratten, 1984, p 272). They have also been regarded as having intrinsic value in an indicative as well as ecological sense (Pfeiffer n.d; Soil Association, n.d.). Whilst weeds clearly constitute competition with crop plants they do provide ecological variety and in many cases are the food plants for the predators of the common pests of field crops. The bio-dynamic approach to weeds is not so much aimed at eradicating them as regulating (or suppressing) their activity and restoring balance to the agricultural areas affected.

In his 1924 lectures, Steiner asserted that the moon plays a part in the life of plants complementary to that of the sun (lecture 6, Koberwitz 1924, in edition 1974, p 111). Its activity is seen as fundamental to plant regeneration through acting as a 'condenser' for influences acting on Earth from cosmic space. This role is illustrated by indigenous agricultural societies where farming operations have been, and in some cases still are, geared to the moon's phases (see for example Kolisko, E and L, 1978; Bray, 1984; Brush, 1977; Smith, 1985, 1987). It follows from this that if we could somehow control the moon's influence we would have a method of regulating plant growth. According to Steiner, the seeds of plants encapsulate this lunar influence and if the latter are burnt and the ash collected, a negative, suppressive influence is

brought about. If this is then applied to the soil it should have the effect of counteracting the influence of the moon, thereby inhibiting the growth of genetically similar seeds and plants already there. This is the basis of the weed peppers which have been applied for many years on biodynamic farms. It is logical to assume in the case of vegetatively propagating plants like couch grass and bracken that burning the underground rhizomes will have a similar effect. This assumption has been carried into practice in the experiments on bracken which follow.

With many weeds there are difficulties of collecting sufficient seed before it is released or of collecting a sufficient bulk for practical purposes. Also, many seeds burn only with difficulty. The seeds have most often been burnt in a wood fire and all the ashes collected up and mixed before either scattering or burial in the fields. To help make the material easier to spread it is sometimes diluted by mixing with a carrier such as sand. Various refinements have taken place based on experimentation. These include dynamisation, a special rotary activation of the ash, and carrying out the various operations at particular lunar-zodiacal times in accordance with the particular activities of the plant. In two examples recently reported to the writer (K Castelliz and H G Kern, pers comm) common docks were effectively eliminated from a field after three to four years repeated treatment while ragwort disappeared the year following treatment. This latter was a field grazed by sheep and cattle; adjacent grazed pasture land still showed the original infestation.

There have been many attempts at private weed experimentation in bio-dynamic farming and gardening; not all have been totally successful - some have clearly failed. Indeed, as in all experimentation there are opportunities for error; much arises from a shortage of documented experience on the technique and resulting uncertainties about it. For example, how frequently should one repeat treatments and when in relation to each season? The fertility of the soil, the amount of weed seed in the soil and its characteristics of dormancy will also create a pattern of variation which is likely to affect the outcome of particular attempts at control. However, in biodynamics, as Corrin (1960), explains, the weight of substance is of less importance than its presence as a medium for the working (or in this case for the blocking) of particular processes. This suggests that a qualitative approach might be adopted rather than strict adherence to quantitative principles.

Some workers have recommended spraying homoeopathically potentised solutions of the original ash preparations and this has been done in the experiment on bracken. These are simpler to apply over wide areas but present similar uncertainty as to the dosage required, the optimal timing of operations and the need for repeated applications. Maria Thun, who has done much experimentation in this field, has reported on the merits of different techniques (Thun, 1981; Holbek, 1984). Her experiments used a variety of seed-based ashes and jauches or fermented preparations of the crushed seed. Several points emerged; first the various preparations had the capacity to act specifically so that single species could be targeted. Second, they had no effect on a range of crop plants. Third, the mixed ashes of several weeds were still effective at reducing growth of individual weeds grown in pots. Fourth, most trials showed that dynamised ash and the D8 homoeopathic potency were generally the most effective preparations. Notes on homoeopathy are offered at the end of Appendix 8.

Finally, the astronomical timing of cultivations is recognised in biodynamics as an appropriate method for the control of weeds. For the horticultural grower or gardener, Thun recommends that the soil is first ploughed or worked over when the moon is in the constellation of Leo, which should encourage maximum weed germination; final cultivation or discing is done later as required, Further, it is claimed that hoeing when the moon is in Capricorn results in lessened weed seed germination (Thun, 1979, 1986). Various agricultural calendars are available to farmers, growers and gardeners who wish to observe such detailed relationships, for example 'Working with the stars', an annual biodynamic sowing and planting calendar by Maria Thun (Thun, 1976, *et seq.*) and 'Kimberton Hills Agricultural Calendar' (Kimberton Hills, 1992).

Experiment in bracken suppression

1 Method

An area of dense bracken on Barden Moor, North Yorkshire was selected in 1987 (Appendix 1) and assessed generally for its density and productivity. This area was subsequently laid out to replicated plots, as shown in Appendix 2, early in 1988 and various treatments applied just before the emergence of the main mass of bracken

croziers in both 1988 and 1989. Repeat treatments were carried out three weeks after the first. Outlines of the technique and treatments are displayed in Appendices 3, 4 and 5.

The aim of the experiment was to explore a conservationally sound and inexpensive alternative to the chemical control of bracken. The latter, mostly as glyphosate (Monsanto) or asulam (Rhône Poulenc) has been used over wide areas of Britain and other countries for much of the past 20 years. The research objective was to explore the effects of a method involving bracken ashes and homoeopathic extracts of this material. Much controversy has surrounded the use of homoeopathy in science and medicine and it continues to be a field attracting not only scepticism but open hostility as witnessed recently by a rather discreditable episode in Nature (Nature, 1988). Nevertheless, prejudice does not appear to be universal. Scofield (1984), for instance, while very penetrating in his analysis of homoeopathy in agriculture was clearly able to see it contributing in the future while recent articles supporting new initiatives point uncompromisingly both to academic and to commercial interests as providing inertia to change (Stoff, 1983; Richards, 1988).

As already indicated, little or no published data is available on which to confidently set up a research design based on these materials so at the start of the work a wide variety of possible influences were taken into consideration. As will be seen from Appendix 5 the different treatments used rhizome ash alone or rhizome together with young bracken tops (croziers), both of which were collected and burnt in 1987. Different homoeopathic potencies were tried, and peppers (ash) as well as liquid sprays. In some cases repeated treatment was carried out. Different dates were used for preparation and application following the established biodynamic agricultural calendar of Thun. This great variety of treatment types and the need to keep the work manageable for the writer alone, limited the research by reducing the replication attached to any one treatment.

Field measurements were carried out during the third week of August in 1987 and 1988 and the fourth week of August in 1989. August field measurements involved systematic counts of all bracken stems in each plot (1.5m^2 except 7A and B). Height of bracken was measured, which was an average of 10 random stems from litter

surface to canopy top while stem diameter was determined by measuring the nearest 10 stems to a single random point in each plot.

2 Results and discussion

Various bracken growth parameters were measured in August 1988 and 1989 and these are listed in Appendix 6. For purposes of identifying the principle effects the results have been aggregated under headings; these are identified by the treatment code in the left column. Individual codes are detailed in Appendix 5. Essentially, the raw data gathered from treatments 1, 2 and 4 were so similar in spread and average that it was clear no significant differences occurred. In the case of the ash treatments 5, 6 and 7 there were effectively no replicates for each treatment. The data from these plots could not therefore be subject to further analysis. Subsequent investigation also showed that soil moisture availability at the neighbouring sites 7A and B was greater than elsewhere. This would account for the generally higher productivity in the two measurement years when all plots were stressed for moisture. So attention centres on (i) differences between groups of treatments, (ii) any progressive change from the first to the second year, and (iii) the role, if any, of the weather in the pattern of results.

The initial problem of the research was how to compare the performance of different parts of a bracken stand. No single parameter can be used, such as stems per m^2, because of spatial variations in the bracken canopy. Replication obviously provides a framework for addressing this but problems of sampling suggested the desirability of a more generalised productivity index. It was assumed that this would help minimise the effects of field variability of stand structure. Variations in the productivity index are presented in Appendix 6 and Figure 1 for each treatment year while this index is compared to that of the no-treatment control plots. It is estimated that field measurement error accounts for a variation of around 5%. Together with field variability itself this reinforces the importance of adequate plot replication.

In 1988 the only treatment showing consistent departure from control values was No 3 (see Fig 1) and these plots continued to show further reduction in productivity in 1989. On the face of it, some effective suppression of the bracken on these plots did

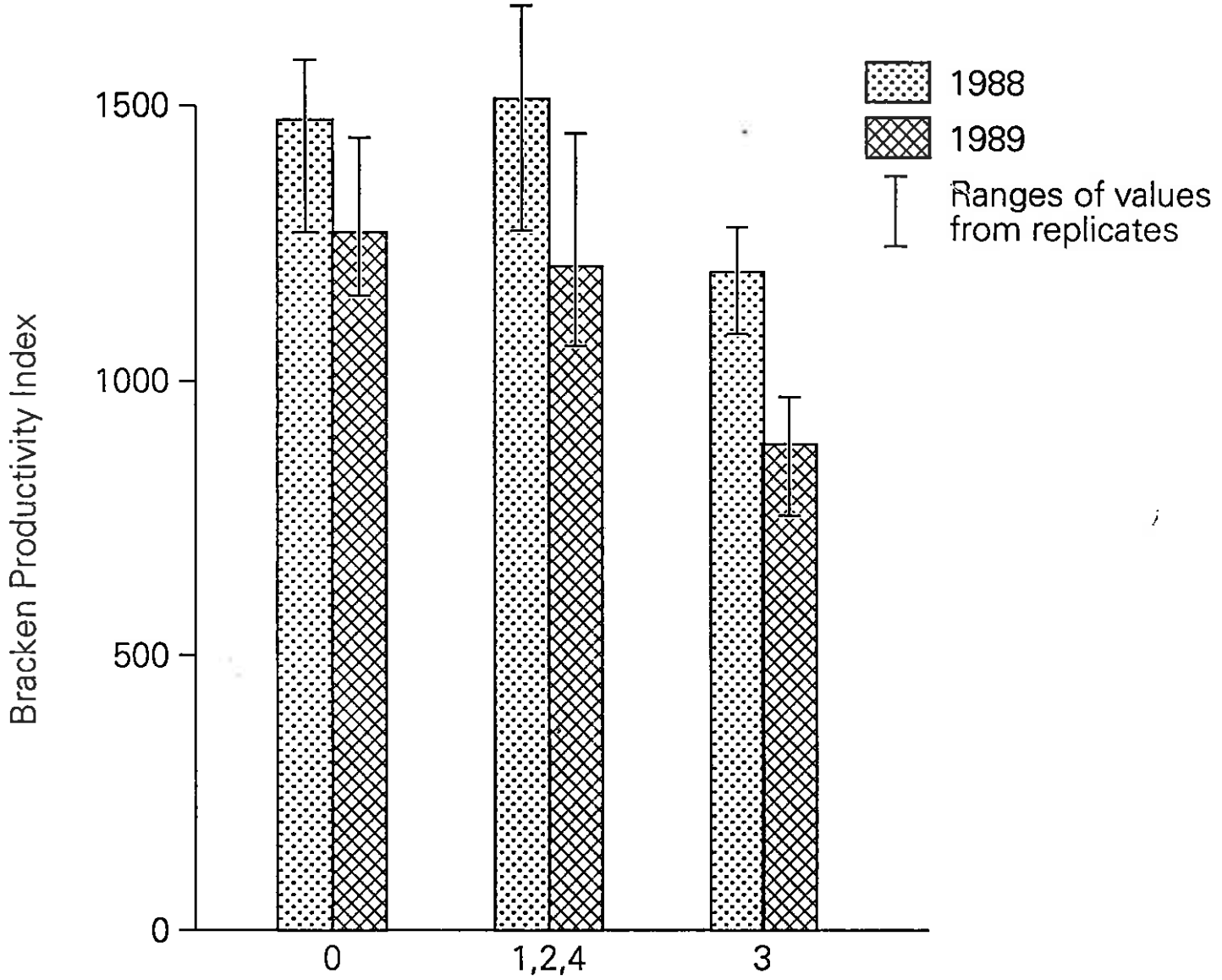

FIGURE 1: Comparisons of the bracken productivity index 1988-1989

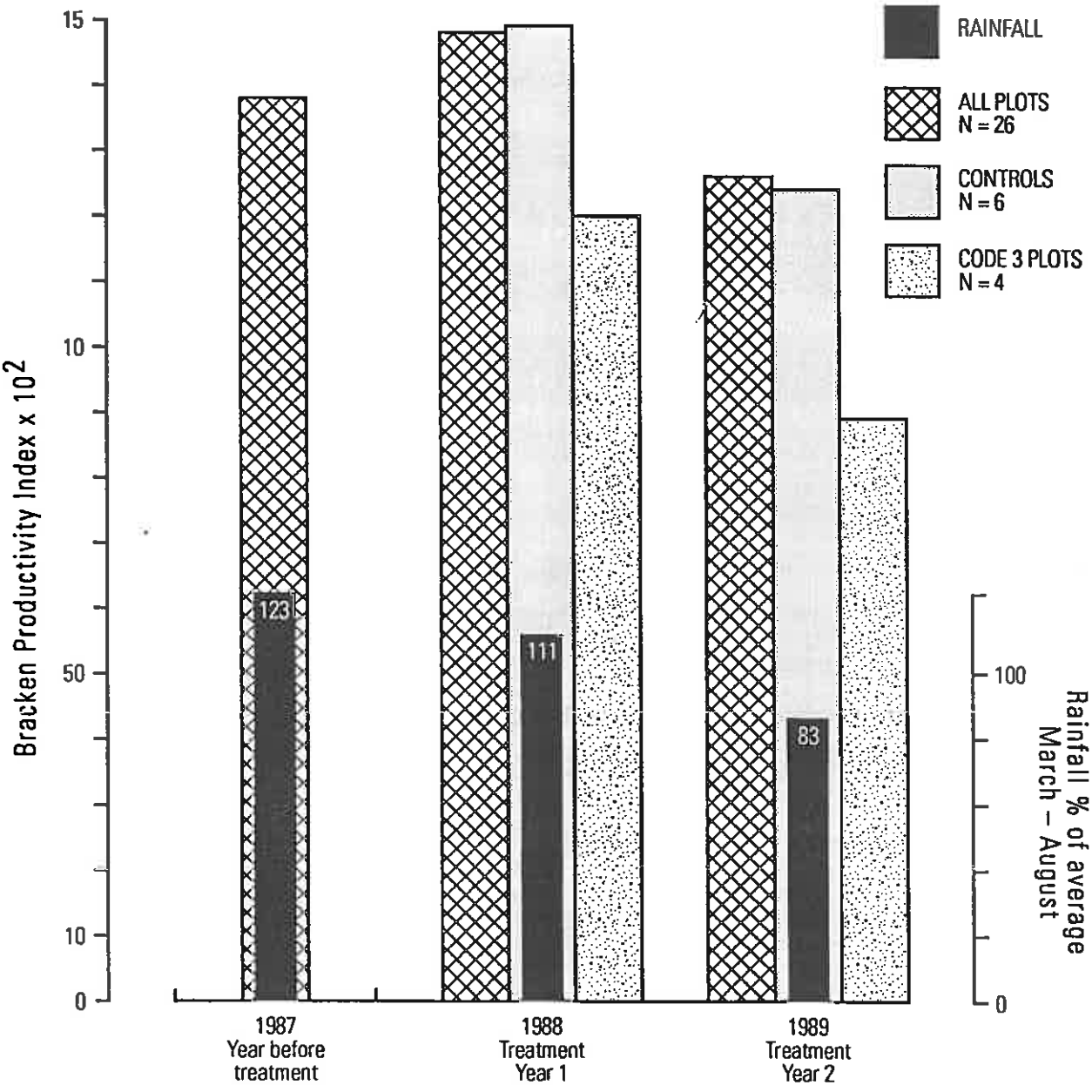

FIGURE 2: Selected bracken productivity and rainfall data 1987-1989

occur but it has already been stated that bracken stands are variable in productivity and conceivably four replicates could by chance have been sited on areas of weaker growth. But this argument must be applied to the other plots and the object of the initial examination of the bracken area in 1987 (see Fig 2) was to avoid just such a risk of poor spots occurring in the experimental area. A further factor to consider when conducting experimental work on bracken is that each treatment plot is surrounded by non-treated bracken which may therefore act to boulster the growth of small, treated areas. One may argue from this that very minor effects arising from treatments would be difficult to detect while only a treatment with real efficacy would stand a chance of being observed and moreover, of being sustained the following year. This I feel to be the case with treatment No 3.

The further matter to consider is the contribution to the results of the pattern of weather in the two treatment years. From Fig 2 and Appendix 7 it will be seen that both 1988 and 1989 were drier than 1987; in 1988 the drought was marked during the main period of stand development (April-June) while 1989, though overall a drier half year, was characterised by a later onset of moisture scarcity. Figure 2 shows that bracken productivity actually achieved a higher level in 1988 than 1987 while this fell in the second relatively dry year. It would be surprising if a further 25% reduction in growing season rainfall, as occurred in 1989, had not led to growth reduction in the stand for the bracken would react not simply to 1989 rainfall but to the fact that rhizomes had been stressed the previous year. However, while weather conditions may have been a cumulative factor over the experimental period these would not appear to explain the progressive reduction in productivity of treatment No 3 plots which in 1989 were an average 30% lower than the controls.

Conclusion

This research shows that the biodynamic approach to weed control has still to substantially demonstrate its effectiveness in statistical terms. One subset of the experiment on bracken did appear to achieve marked suppression over the two year period relative to all other plots and to an extent which would be unlikely to reflect soil moisture deficit alone. But with the relatively small number of replicates involved it would be unsafe at this stage to draw firm conclusions. What we may tentatively say

is that bracken material processed and applied on particular dates did exhibit a cumulative effect on bracken vigour over two years[1].

In running counter to conventional wisdom the biodynamic - homoeopathic method firstly needs to be subject to repeated demonstration that it works. It is therefore important that research in this field is pursued in order to establish whether the painstaking labours of pioneers and the more anecdotal reports of followers can be scientifically reproduced. If they can, then the method will justify being taken seriously by all those interested in environmentally responsible weed management.

The potential advantage of biodynamic methods appears to lie in their ability to target particular species, to leave no trace of environmentally damaging materials, to affect only the areas where treatments are applied and in the minimal cost of materials. On the other hand, like other alternatives to chemical weed control, the results are likely to be of a progressive rather than immediate nature. Further treatment with its attendant labour input will therefore be necessary as part of routine management until a required level of weed (or pest) suppression is achieved.

Non-chemical methods: a concluding note

From the earlier review of alternative methods it will be appreciated that there are non-chemical approaches to suit many different situations. There are also methods which can be used in combination and at different times of the year. Some of these methods are also beneficial in combatting pest and disease problems. Although realistically the methods to be used will depend on the system of agriculture or horticulture being practised it is certainly possible to visualise integrated systems of weed control being practised which bypass the automatic use of chemical herbicides.

[1]As this report is completed, further bracken suppression experiments have been started on Ashdown Forest in Sussex, based on the Leeds experience and supported by the Conservators of Ashdown Forest. Currently, work is being carried out at Leeds on *Senecio vulgaris* (groundsel).

Acknowledgements

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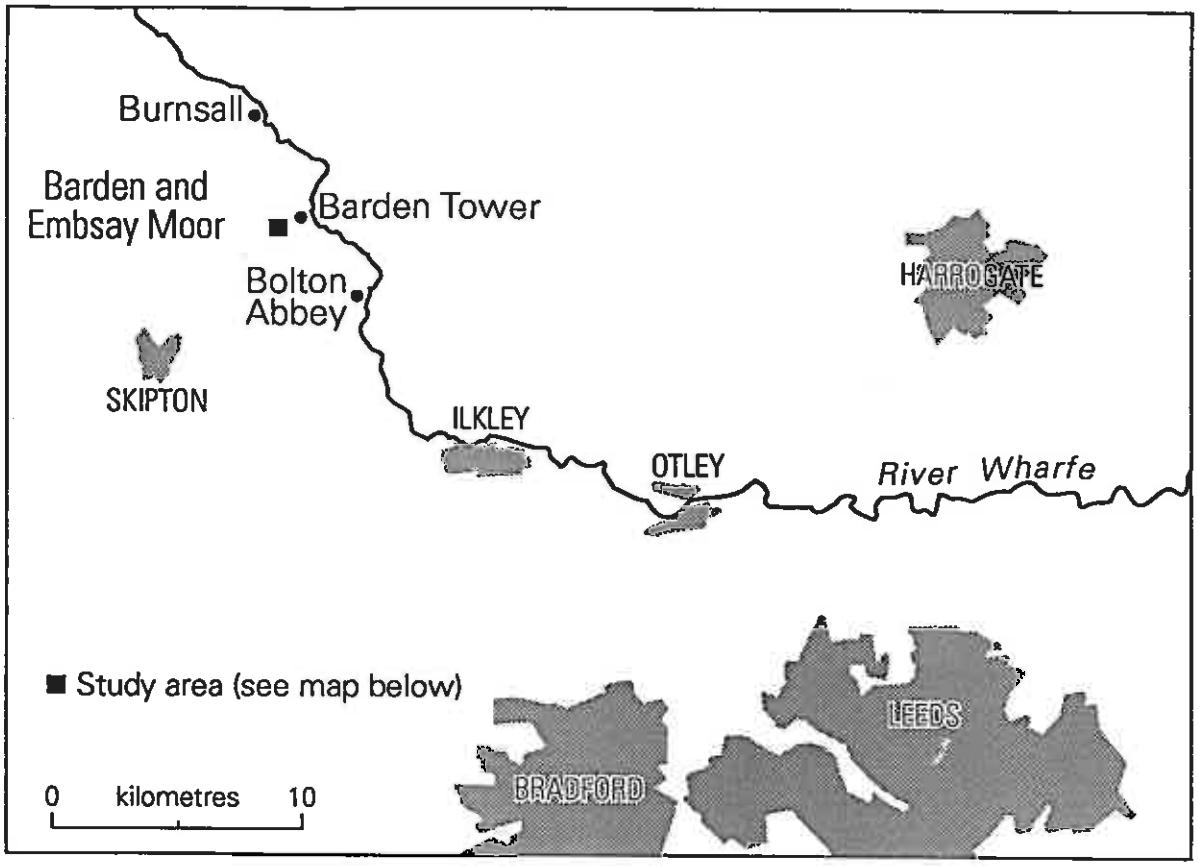
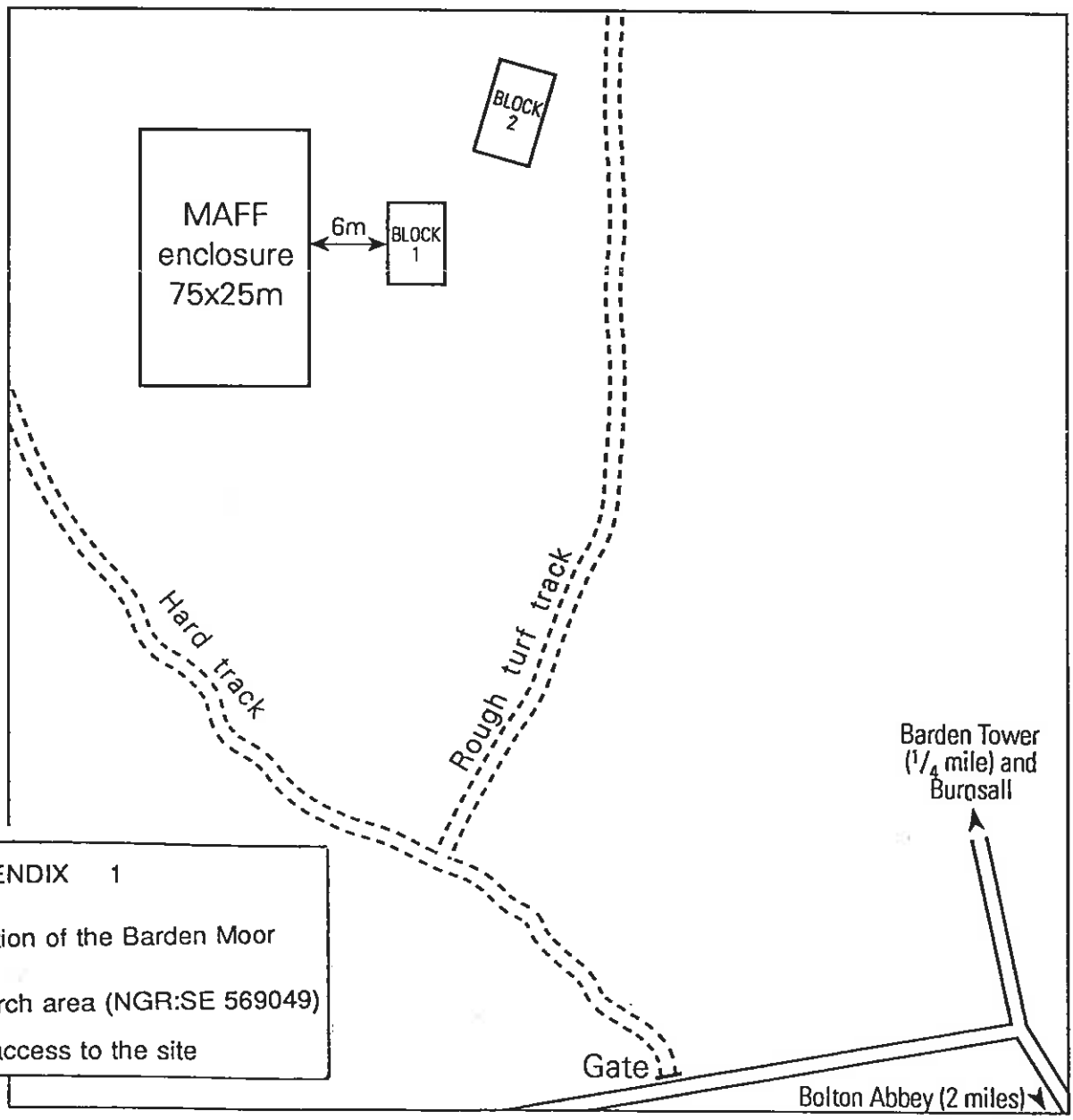
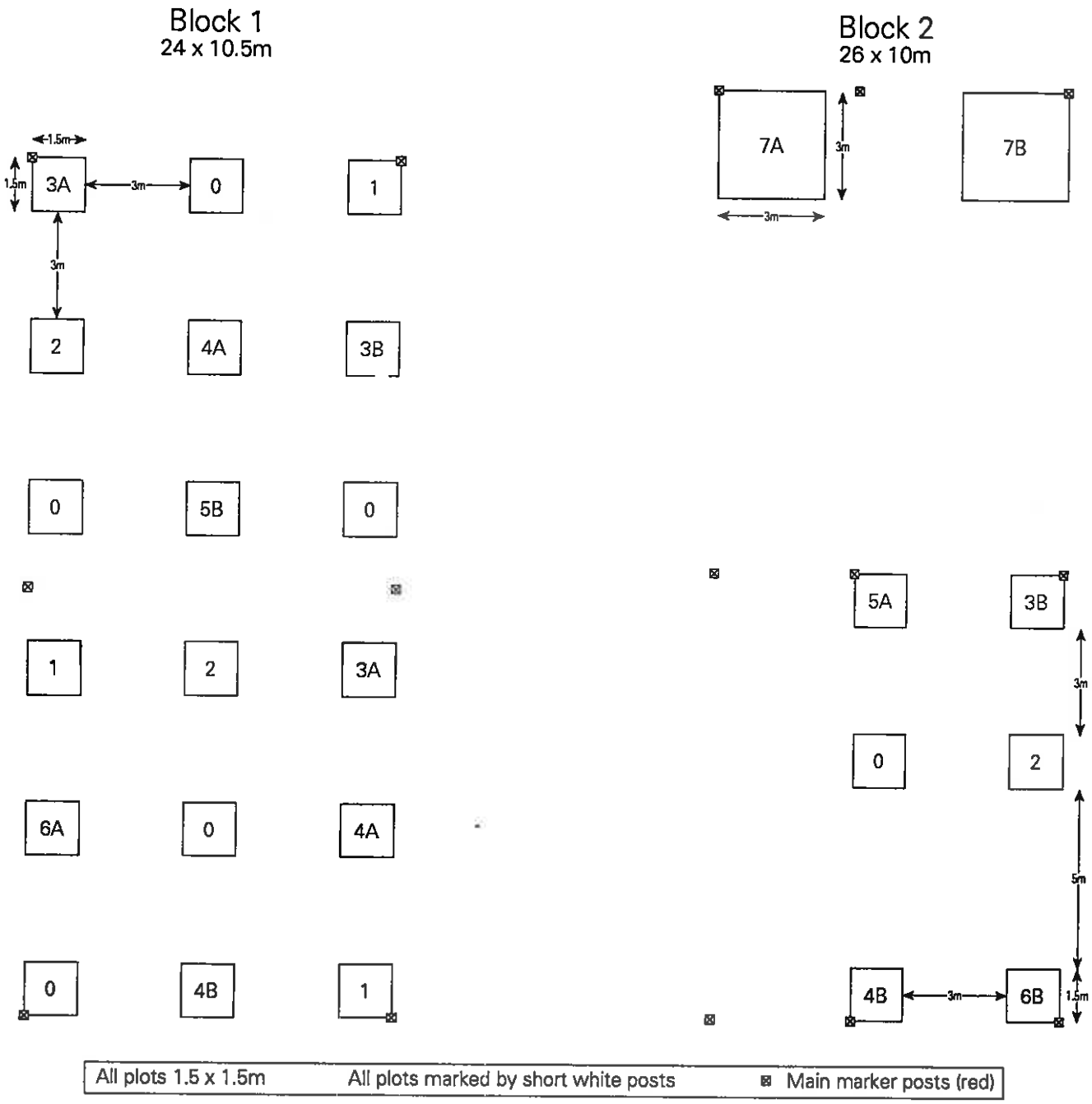




APPENDIX 1

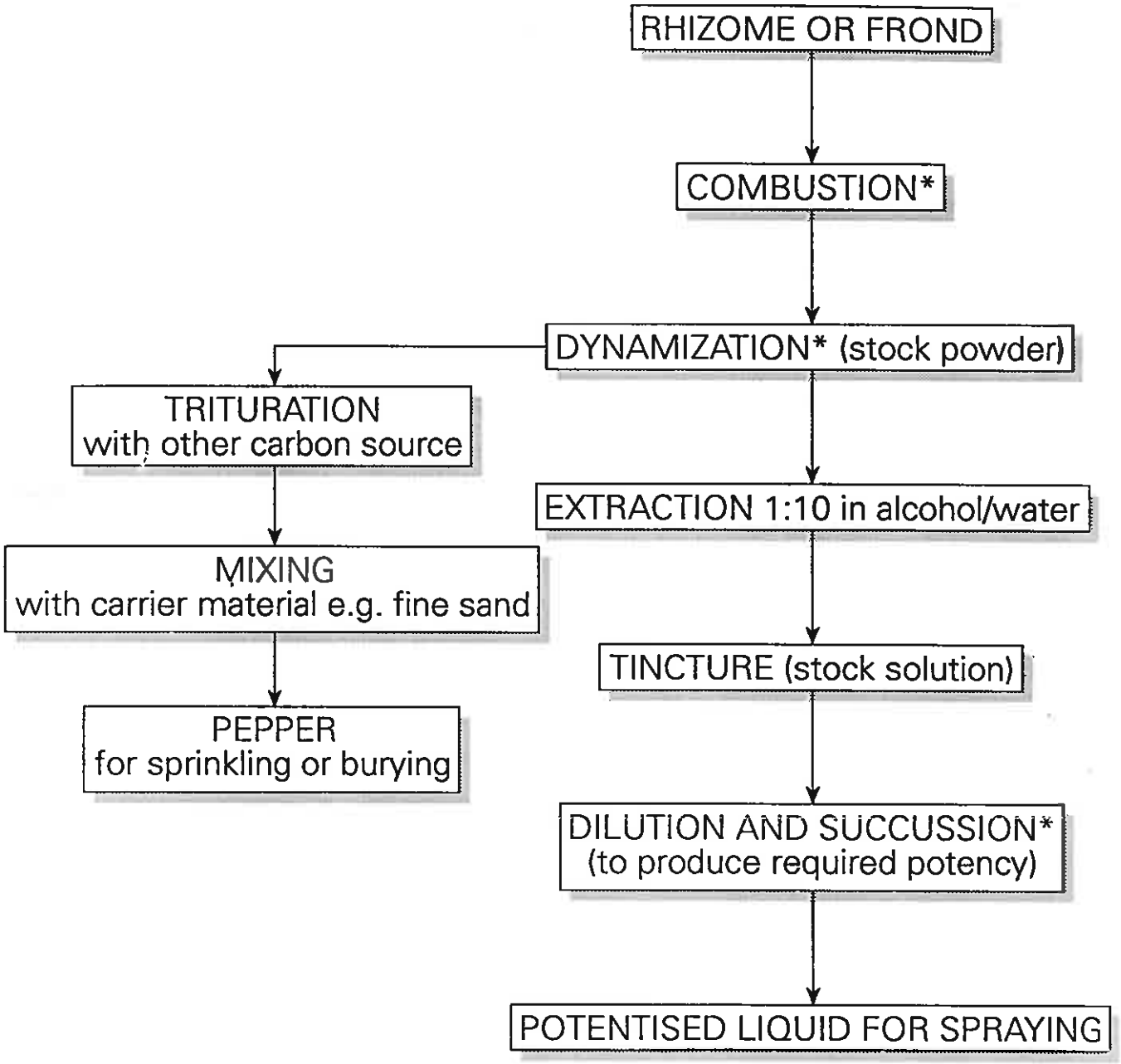
Location of the Barden Moor research area (NGR:SE 569049) and access to the site

APPENDIX 2 Layout of plots in the experimental area on Barden Moor



All plots 1.5 x 1.5m All plots marked by short white posts ⊠ Main marker posts (red)

Appendix 3 Flow diagram for bracken treatments



* These procedures carried out on separate dates (see text)

Appendix 4

Details of extraction, potentisation and spray volume production for bracken treatments

Initial Extract (Tincture): 10 g carbonized, ground, bracken extracted in 100 ml 60:40 alcohol/water at room temperature, allowed to stand with stirring for 60 minutes and filtered through Whatman No. 1 paper.

Homoeopathic potentisation	Decimal potency
1 ml tincture diluted in 9 ml 10% alcohol with succussion*	D1
1 ml D1 "	D2
1 ml D2 "	D3
1 ml D3 "	D4
1 ml D4 "	D5
10 ml D5 diluted in 90 ml water with succussion	D6
100 ml D6 diluted in 900 ml water "	D7
500 ml D7 diluted in 4500 ml water "	D8

* shaking with impact for 2½ minutes

Appendix 5 Types of replicated bracken treatment

CODE	TREATMENT	NUMBER OF REPLICATE PLOTS
0	Controls - zero application	6
1	Rhizome - early date non-specific (D12)	3
2	Weleda Pteridium - leaf date (D12)	3
3	Rhizome/crozier - root date (D8) A Single B Repeated	4
4	Rhizome/crozier - leaf date (D8) A Single B Repeated	4
5	Rhizome/crozier pepper - root A Single B Repeated	2
6	Rhizome/crozier pepper - leaf A Single B Repeated	2
7	Rhizome/crozier pepper - buried A Root B Leaf	2

Leaf and root dates were chosen with reference to the biodynamic agricultural calendar of Thun (1988, 1989). On these dates the specified laboratory and field operations were carried out. D signifies decimal homoeopathic potencies.

Appendix 6 Summary of data from bracken experiments

August 1988

Treatment Code (see Appendix 5)	No of plots	Bracken characteristics (averages)				
		stems/m^2	height (cm)	stem diameter (cm)	product-ivity index	index as % of controls
0	6	43.5	117	0.61	1488	100
1,2,4	10	47.5	116	0.59	1507	101
3	4	42.0	112	0.57	1201	81
5-7	6	42.2	124	0.63	1631	110

August 1989

0	6	41.0	112	0.59	1256	100
1,2,4	10	42.7	111	0.57	1210	96
3	4	37.4	104	0.54	891	71
5-7	6	41.3	122	0.62	1521	121

$$\textit{Bracken productivity index} = \textit{stems}/m^2 \times \textit{height} \times \pi \times \left(\frac{\textit{diam}}{2}\right)^2$$

Appendix 7

Averaged rainfall data for North East England extracted from Monthly Weather Report Vols 104, 105, 106, Met Office, London. Figures are percentages of 1951 - 1980 mean monthly rainfalls. March to August is chosen to cover the bracken growing season.

	1987	1988	1989
March	153	137	115
April	119	64	133
May	73	97	31
June	168	56	104
July	119	218	50
August	103	92	67
Average	123	111	83

Appendix 8

Further notes on biodynamics and homoeopathy

(1) Biodynamics

Some fifty years ago Sir Albert Howard as an agricultural adviser in India, recognised that the main cause of crop failure from pests and disease was unhealthy or ill-husbanded plants resulting from inadequate care of the soil (Conford, 1988). He adopted the indigenous Bengali composting technique and was able to grow crops which sustained their yields without recourse to chemical fertilizers or pesticides. Today this is often the experience of organic and biodynamic farms compared with conventional management and in almost all cases the higher yields under conventionally fertilized agriculture are only achieved as a result of regular use of pesticides. Even then this seems more likely to happen if rainfall has been adequate for the crop to take advantage of the soluble fertilizer (Lockeretz, 1981).

Biodynamic agriculture, as with standard 'Soil Association Certified' organic farming, does allow a permitted range of naturally occurring rock mineral fertilizers including basalt dust, rock phosphate and lime (Demeter 1991; Soil Association 1989). It uses a range of pesticide substances prepared from natural materials of plant origin such as nicotine and derris and also uses water extracts and ferments of plants for similar purposes; for example the stinging nettle, Urtica dioica, is used for the control of aphids.

In biodynamics there is also great interest in companion planting - the choice of plants which grow well together (Philbrick and Gregg 1967; Philbrick 1974; Hills n.d; Savigear 1980). This is a subject which encompasses many of the beneficial interactions between plants on both a small scale and larger scale, as with field inter-cropping.

Thus companions may directly assist in pest control or nutrient and water availability. In some cases interspecific competition for nutrients may be a factor which renders one crop component less susceptible to pest attack while a companion providing good ground cover will check weed growth, lower soil temperature and reduce direct soil moisture losses.

Biodynamics uniquely employs a number of special preparations suggested in Steiner's lectures; these are known as preparations 500 - 508 (Corrin, 1960). Preparation 500 is employed as a field spray to enhance soil life and plant root development. It is based on cow manure and contains enzymes and microorganisms. In the latter respect it superficially resembles the Japanese Nature farming where the introduction of soil organisms plays a role in stimulating nutrient release and humus formation. However, the material is applied in very dilute form and although some direct action within the soil may occur Steiner's lectures indicate that altogether finer processes are involved than simply a material effect on the soil. The widespread application of this material in Australia and New Zealand and its evident success in improving land quality suggests the material to be worthy of serious investigation (Podolinsky, 1985, 1989). Other preparations include 501, for enhancing the ripening of crops, 502 - 507 which are herbally based preparations for activation of compost and 508, a spray based on Equisetum which has a prophylactic effect to help plants resist fungal diseases. A further preparation has recently received attention in Germany based on cow manure, the preparations 502 - 507 plus mineral additions and is known variously as cowpat or barrel manure (Thun, 1979 p.40; Tompkins and Bird, 1989). The general view concerning the biodynamic preparations is that they stimulate plants to overcome factors in their immediate environment which otherwise inhibit metabolism and therefore generate imbalance.

It was largely the effects on agriculture arising from use of chemicals after the First World War which led a group of farmers to seek Steiner's advice and hence the 'Agriculture Course' of 1924. A serious problem then, and now even more so, is the resistance of crops to disease and the relatively short-term viability of each new variety introduced. Biodynamic agriculture thus arose in an attempt to tackle an underlying problem of plant vitality which Steiner saw as likely to be an increasingly serious problem in the future.

A further aspect of biodynamics is the effect on plant growth and morphology of planting and cultivating at chosen astronomical timings. The work of Thun (1976 *et seq.*, 1979) and Schultz (1985) in particular has shown that the key attributes of each crop; leaf, root, flower or fruit can be enhanced by planting under appropriate groups of constellations. Under this system, leaf crops are associated with the 'water element' which in turn is connected with Pisces, Cancer and Scorpio. Sowing, planting, transplanting and cultivating when the moon is passing these particular constellations has been shown to have beneficial effects compared with similar plants grown under identical soil and weather but planted at times dictated by convenience or the weather alone. It is also claimed by Thun that stronger plants with better yield are obtained when planting takes place during a period when the moon's arc is descending towards the horizon rather than ascending towards the zenith. Better root establishment is claimed for these circumstances where the moon's influence on growth is being reduced. Others claim that a lunar effect is observable but only when planting a few days before full moon or new moon (Kolisko E and L, 1978; Fyfe, 1967). The question of the moon's influence thus connects biodynamics with traditions in indigenous agriculture.

(2) Homoeopathy

Homoeopathy as originally conceived by Hahnemann (see 1983 edition) involves the treatment of like with like. For example in the treatment of a medical condition a substance of mineral or plant origin is used, which in concentrated form would produce the same symptoms. Instead, when greatly diluted, the substance is often observed to counteract those same symptoms. In parallel with the principle of dilution is the practice of potentisation whereby standard portions of solution are diluted by a constant factor with percussive shaking, this normally being in the ratio 1:10 or 1:100 (Homoeopathic Handbook, 1984; Koehler, 1986). After many dilution cycles it can be argued that none of the original substance is actually present in solution (Avogadros number = 10^{-23}). At very high potencies, therefore, it is clear that no straightforward physical effect can be possible, merely some 'memory' or 'essence' of the original material conveyed by the fluid or solid matter. This places homoeopathy on something of a collision course with conventional science yet there seems very little doubt that therapy of this kind works in the medical sphere. Furthermore, the different potencies are regarded as having different effects, higher potencies usually being considered the stronger but also acting on the organism in different ways.

In the case of biodynamic weed control based on ashed weed seeds, dilution of material in water on the one hand permits its ready application over wide areas. Potentisation has the capability of enhancing the effectiveness of the diluted solution yet it is interesting to note that different potencies appear to vary in this respect. The whole question of potentisation is clearly not one to become involved in without full and thorough study.

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