



Improved knowledge transfer for better soil management

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Executive summary

- Cross compliance within the Single Farm Payment Scheme for agriculture requires the maintenance of agricultural land in Good Agricultural and Environmental Condition (GAEC) in addition to Statutory Management Requirements. GAEC includes control of soil management practices which lead to loss of productive potential and on / off site environmental degradation.
- Because agriculture is a regionally devolved policy area in the UK, England, Scotland, Wales and Northern Ireland have independently developed their definitions of GAEC and requirements for cross compliance, partly reflecting regional differences in farming practice. The actual requirements for farmers are relatively similar. In general it appears the Scottish and Northern Irish schemes make fewer demands on farmers to identify problems and select solutions than the Welsh and English schemes. All devolved governments have provided training for farmers in meeting cross compliance requirements, including soil management.
- The implications of the Single Farm Payment Scheme are likely to be a major driver for requirements of knowledge transfer with regard to soil management for the foreseeable future. However, merely meeting the standards required for cross compliance is unlikely to result in the maximum productivity benefits that improved soil management has the potential to deliver on-farm. Conversely there may be negative consequences in terms of production in meeting these requirements. These are areas where the levy bodies may be well placed to meet farmer needs for knowledge to support decision-making.
- Priorities for knowledge transfer for soil management were identified by representatives of the levy bodies. Highest priority was given to meeting cross compliance; identifying and mitigating risks of water erosion and runoff; maintaining optimum soil structure and identifying options for enrichment of soil organic matter. A higher priority was placed on mitigation of poaching by animals and soil fertility within the livestock sector.
- A review of current levy body knowledge transfer activities identified the following areas as gaps in provision:
 - i. Organic matter - increasing through amendments, tillage and rotation (direct and indirect benefits).
 - ii. Soil structure - methods of assessment and influence of rotation and cultivation (direct and indirect benefits).
 - iii. Water erosion / runoff risks and management.
 - iv. Soil biology - the effect of soil management on incidence of pests and diseases.
- An electronic survey was carried out of potential service providers for soil management knowledge transfer. A total of 44 survey responses were received from organisations and independent consultants.
- Options for increasing organic matter are rarely presented as a stand alone issue by service providers. There is a large amount of historical research information available. The development of practical advice on organic matter management has suffered relative neglect in recent decades due to a reduced focus on soil management. Action by levy bodies is recommended to address this gap. There are no farmer-targeted tools to help assess options for increasing organic matter within the context of whole farm management. A programme which provides farmers with the skills to identify problems which are caused by or could be ameliorated by changing organic matter levels could be of particular value within the context of GAEC.

- The impact of cultivation practices on soil structure particularly in arable cropping has been the focus of knowledge transfer activity. A large amount of research has been translated and there is lots of very good practical information available (particularly through the Soil Management Initiative) on reducing cultivation related costs while optimising soil condition. Significantly less information is available on the relationship between structure and organic matter.
- There is a role for levy bodies in improving access to information on soil structural management. The ability of arable farmers to identify when a crop or other rotational practice has resulted in structural deterioration, and for livestock farmers to distinguish between suitable and unsuitable out-wintering areas, are both linked to knowledge about and ability to assess soil structure in the field. There is a need for a training programme in the field assessment of soil structure, identification of causes of degradation and management options.
- Because of the focus of the Soil Protection Review to meet GAEC in England, there is a lot of documentation available from Defra which outlines how the risks of water erosion / runoff risks and management should be identified and the steps that can be taken to mitigate risk. No immediate action by levy bodies recommended, although evaluation of training provided through cross compliance is desirable. Levy bodies have a role to play in ensuring farmer access to the information / training resources available through other organisations.
- Training on soil biology is only mentioned explicitly for the organic sector. Some general information is available relating to the role of soil biology in soil function. However, there is a lack of transfer of existing knowledge into robust guidelines that inform and/or improve agricultural practice. Ongoing applied research and development in sector specific areas is needed. There is potential to provide more general information to farmers on the role of soil biology to provide a hook as part of wider training programmes relating to soil condition/health.
- Service providers provide information in a range of formats including publication of information, interactive web resources, courses and workshops, and one-to-one advice on farm. The most appropriate form of knowledge transfer will vary depending on the intended learning outcome; and except where the task is simply that of making information available, facilitation providing support in using the information is important. The key constraint identified to the delivery of knowledge transfer activity was funding.
- Farmers most often identify other farmers as their most frequent and reliable source of information. There is a need to engage more fully with farmers to discover what processes actually have the largest effect in informing and/or changing practice. Approaches taken should engage farmers in processes of identifying and prioritizing problems and opportunities, testing and evaluating innovations and then being partners in sharing the information gained. The Levy Bodies have an important gatekeeper role with regard to meeting farmer needs for research, it would seem appropriate that they should take the lead in encouraging structures that better support facilitated learning by researchers and farmers alike.
- There is a need and an opportunity for the levy bodies to fill gaps in soil management knowledge transfer currently available to producers, with great potential to improve cross-sector productivity. Furthermore, it is important that timely action be taken while there is industry focus on the issue arising particularly from the new requirements of legislation. In suggesting a plan of action for the ARF, the emphasis has been placed on areas where it is felt there is scope for cross-sector collaboration. A number of different options are developed to address the gaps identified suggested; none of the suggested options are exclusive of others.

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1. Drivers for change and identification of priorities

1.1 Changing policy framework and soil management

The Council of Europe's European Soil Charter (1972) recognised the importance of the soil resource. Since then European countries have taken various steps to improve soil protection. In response to concerns about the degradation of soils in the EU, the European Commission adopted a Communication "Towards a Thematic Strategy for Soil Protection" in April 2002. This identified a number of threats to soil across the EU states:

- erosion,
- decline in organic matter,
- local and diffuse contamination,
- sealing,
- compaction,
- decline in biodiversity,
- salinisation and
- landslides.

There are currently moves in Europe that are likely to include measurement and monitoring of soil quality alongside air and water quality as a major component of assessments of environmental quality and the sustainability of land use. Soil has been included as one of the themes of the EC 6th Environment Programme and there is also a planned European Directive on Soil Monitoring.

In response to high levels of nitrate in ground and surface waters subject to abstraction for drinking, the Nitrates Directive (1991/676) required European Member States to identify vulnerable zones (known in the UK as Nitrate Vulnerable Zones, NVZs) and to implement action plans to ensure that farming in those zones was practiced to minimise nitrate pollution. Consequently in NVZs there are requirements for application timings of fertiliser and manure, storage capacity for manures, maximum applications of manure and records showing that land application of N takes account of slope, soil type, climate, irrigation and crop requirements as appropriate. The Water Framework Directive (2000/60) will integrate the various existing approaches to the protection and improvement of water quality in the EU. Its aim is to maintain and improve the aquatic environment in the Community and it will require that specific targeted measures will be developed in the context of each river basin to protect and enable the sustainable use of water. The current expectation is that compliance with this Directive in the UK will require measures affecting nutrient management decisions on a larger number of farms than those currently lying within NVZs and that further measures will be needed in relation to other sources of diffuse pollution such as sediments.

The introduction of the Single Payment Scheme for agriculture from 1st January 2005 means that for the first time CAP agricultural subsidies are linked to good practice and not to production levels. Cross compliance (1782/2003) requires the maintenance of agricultural land in Good Agricultural and Environmental Condition (GAEC) in addition to Statutory Management Requirements.

Due to the increasing awareness of soil-related issues outlined above, a major consideration of GAEC is the recognition of and actions against soil management practices which lead to loss of productive potential and on or off site environmental degradation. The link between cross compliance payments and soil management

means that aside from direct productivity gains available to farmers through better soil management, maintenance or increase of income through subsidies could be directly affected by their awareness of soil management issues.

1.2 Single Farm Payments Scheme: policy framework in the regions

The European Council has provided a framework defining Good Environmental and Agricultural Condition, under the headings soil erosion, soil organic matter, soil structure and minimum level of maintenance (1782/2003). Of these, the first 3 are of direct relevance to soil management. The definition of GAEC however, is the responsibility of the member states of the EU and may differ, reflecting national or regional differences in soil, climate, land use, farming practices and existing farming systems. Because agriculture is a regionally devolved policy area in the UK, England, Scotland, Wales and Northern Ireland have independently developed their definitions of GAEC and have different requirements to meet cross compliance, partly reflecting regional differences in farming practice.

England

There are 17 points relating to GAEC listed in the Cross Compliance Handbook (PB 11304). Of these 4 relate directly to soil management:

- GAEC 1 completion (by Sept 2006) and retention of the Soil Protection Review (PB 11160) detailing observed farm soil management issues and management actions against these issues. The resulting management plan is to be put into action from 1st Jan 2007.
- GAEC 2 Post harvest management of land after harvest of combinable crops
- GAEC 3 Waterlogged soil
- GAEC 4 Burning of crop residues

The Soil Protection Review (GAEC 1) is divided into the following (visible) problems:

- Low organic matter as indicated by soils that cap or slump
- Compaction due to mechanical cultivation
- Compaction due to other mechanical operations
- Runoff or water erosion from arable land
- Wind erosion
- Poaching of soil by livestock

These issues are considered on a whole farm basis, and where visible problems are observed, appropriate actions are to be taken and recorded. Cross Compliance Guidance for Soil Management (PB 11162) provides advice on identifying and preventing problems.

Wales

There are 3 GAEC categories relating to soils:

GAEC A1 Soil erosion

GAEC A2 Soil organic matter

GAEC A3 Soil structure

A 2 page fact sheet is provided by the Welsh Assembly relating to each, giving management advice and GAEC compliance requirements.

As in England, farmers are also obliged to complete and retain a document relating to soil management issues and plans and actions against them (in Wales called the Soils Record Book). This is to be completed in 2006 and reviewed and updated every January in subsequent years. The Soils Record Book differs from the Soil Protection Review issued by DEFRA, requiring information to be provided on a field by field not a whole farm basis. Farmers are required to take appropriate action against problems observed on their land as evidenced by the following:

- Heavy poaching and rutting
- Erosion of watercourse banks by overstocking
- Brown sediment laden runoff associated with late winter grazing of root crops or bare soil caused by overgrazing.
- Gullies and channels on fields left bare over winter
- Soil deposition on roads due to late harvesting of crops
- Damage to soil structure by compaction due to cultivation or use of heavy machinery/vehicles on wet ground.
- Reduced organic matter due to continuous cropping or mixing of topsoil/subsoil by deep ploughing (although it is unclear how the visible effects would be assessed).

Scotland

In Scotland there are a greater number of GAEC's (9) relating to soils under the 3 GAEC categories provided by the EU council framework (erosion, structure and organic matter), with specific management advice about each. Although farmers are required to "keep good records", there is not a similar requirement as in England and Wales to complete an official soil management document.

Soil erosion

- GAEC 1 – Post harvest management of land
- GAEC 2 – Wind erosion
- GAEC 3 – Soil capping
- GAEC 4 – Erosion by livestock
- GAEC 5 – Maintain functional drainage systems
- GAEC 6 – Muirburn code

Soil organic matter

- GAEC 7 – Arable crop rotational standards
- GAEC 8 – Arable stubble management

Soil structure

- GAEC 9 – Appropriate machinery use

Where problems are observed, farmers are required to take at least one of a list of options for remediation provided in the Cross Compliance Notes for Guidance 2005/2006. Notably there are specific requirements relating to the maintenance of organic matter levels through crop residue and rotational management on arable land,

unlike in the English and Welsh systems where remedial action to increase organic matter levels is required only where organic matter depletion is visibly evident.

Northern Ireland

Set out in the Cross Compliance Verifiable Standards there are 6 GAEC categories. GAEC 1 relates to soil management.

The 3 requirements of GAEC 1 are:

- Protect soil from erosion and maintain soil structure by preventing land from being severely trampled and poached
- All cultivated land must have crop cover, stubble cover, grass cover or be ploughed or disced over the following winter
- Do not carry out cultivations if water is standing at the surface, or if the soil is waterlogged.

Within each category there are guidelines as to the evidence for these problems, for example 'animals wading in muck' as evidence of poaching damage. The Cross Compliance Verifiable Standards document offers advice to avoid or manage these problems.

1.3 Cross compliance training for farmers

The new requirements have been accompanied by a drive by the respective governments to provide training for farmers in meeting cross compliance. In England 200 workshops have been offered to farmers by DEFRA/Momenta from February 2006 onwards to provide training towards meeting legislative requirements. In Scotland 23 cross compliance workshops were held in the winter of 2005-2006 throughout the country by SAC with the support of the European social fund, attracting an audience of 1424. In Wales the Assembly and farming unions have run more than 40 presentations from mid March to mid May on completing the Single Application Form. In Northern Ireland Cross Compliance workshops were organised by The College of Agriculture, Food and Rural Enterprise (CAFRE) at their campuses at Enniskillen, Greenmount and Loughry.

1.4 Entry level schemes

England

The Entry Level Stewardship scheme provides an option for completion of a Soil Management Plan (EM1) which contributes 3 points towards the 30 required per hectare. The requirements of the SMP are similar to those of the Soil Protection Review completed as part of cross compliance, but on a more detailed field by field basis. Other soil management related options include EM2 Nutrient Management Plan (2 points per hectare) and EM3 Manure Management Plan (2 points), which require field chemical and organic nutrient budgets to be recorded respectively. In circumstances where high risk crops are grown on inappropriate land (EJ1) in relation to soil erosion and runoff, a change in cropping can contribute 18 points per hectare. Measures to reduce soil erosion under maize (EJ2) also provide 18 points per hectare.

Wales

Tir Cynnal, the Welsh entry-level agri-environment scheme requires farmers (depending on farm type) to complete a Soil Nutrient Plan, budgeting bagged fertiliser applications, plus a similar Manure Management Plan. They are also required to complete a Farm Management Plan which includes consideration of soil organic matter, structure and erosion management, but there are no compulsory requirements relating to these issues.

Scotland

In Scotland payment for Land Management Contracts are made individually for specific actions selected from a range of 17 options up to a maximum annual allowance. There is less emphasis on soil issues than in England or Wales, the only directly related payment scheme being £2 per hectare for managing nutrient budgets.

Northern Ireland

The Entry Level Countryside Management Scheme does not require specific soil management actions, although there may be implications from the 'conservation cereals' option for conservation management.

1.5 Implications of regional differences

Despite differences in approach to cross compliance, the actual requirements of farmers appear relatively similar. However there are some noteworthy differences which may have implications for demand for information. The GAEC system for Scotland differs from the other 3 regional schemes having compulsory requirements for organic matter management (through crop rotation and arable residue management). The requirement to take actions to increase organic matter levels is only explicit in the English and Welsh schemes when there are visible signs of organic matter depletion. In the English scheme action is only required where soil capping or slumping are observed, which will not be problematic on all soils, while the Welsh system makes no mention of what the 'visible indicators' of organic matter depletion are. The scheme in Northern Ireland notably has no actual requirements regarding organic matter management. This possibly relates to a greater emphasis on grassland based systems which predominate in Northern Ireland.

The Scottish and Northern Irish schemes do not require the completion of an official record of soil management, although in the Northern Irish scheme, there is emphasis on farmer identification of visible soil management issues as in the Welsh and English schemes. The Scottish GAEC code does not offer guidance relating to the identification of soil problems. The Welsh scheme is similar to the English, although farmers are required to take consideration of soil management issues on a field by field basis not generalised for the whole farm, possibly meaning more rigour is required in assessments and actions taken against management issues for cross compliance. In general it appears the Scottish and Northern Irish schemes make fewer demands on farmers to identify problems and than the Welsh and English.

A key implication of regional differences in approaches to GAEC/cross compliance for knowledge transfer is the major disparity in the accompanying government advice. The information provided to farmers through official publications is much less detailed in all the devolved regions than the cross compliance soil guidance document provided by Defra (which is required reading for farmers in England as part of cross compliance). Although this is unlikely to affect farmer achievement of cross

compliance (as the lack of advice will probably be considered in the rigour with which inspections are implemented), it may have some effect on demand for further information by farmers, in particular the lack of practical advice in the identification of soil management problems.

Entry level schemes differ much more widely between the regions, varying between compulsory nutrient budgeting in the Welsh system, to no requirements in the Northern Irish system. Generally the technical requirements of nutrient budgeting are low, and are unlikely to require specialist soils advice. Only the English system has major soil management requirements, for managing erosion risks, although this is only one option from those available to farmers to meet the Entry Level Stewardship requirements.

1.6 Concluding comments

The changes in CAP are highly likely to have consequences for farmer requirements and demand for soil management advice. However, at this stage it remains unclear how rigorously the legislation will be applied and consequently the level of farmer focus on improving soil management.

An additional complicating factor is the scheduled introduction of Farm Advisory Schemes, which will become a state obligation from 1st January 2007. In 2010 a vote is planned in the EU on whether to make the system compulsory for farmers. Initially this system is intended to assist farmers in meeting cross compliance. At a minimum it is expected to provide farmers with the necessary advice to meet the conditions of GAEC, but there is still a lack of clarity as to the scale and detail of provision which will be available in January 2007. Any knowledge transfer actions to be taken by the ARF will therefore need to consider the information farmers may require to take actions for soil management to meet compliance, in the context of the proposed service provided by Defra and the devolved administrations. Whether this service will provide farmers with necessary advice for higher level schemes is also currently unclear.

While the implications of the Single Farm Payment Scheme are likely to be a major driver of soil management knowledge transfer requirements for the foreseeable future, merely meeting the standards required for cross compliance is unlikely to result in the maximum productivity benefits that improved soil management has the potential to deliver. Conversely there may be consequences for production in meeting these requirements, such as making more efficient use of fertilisers through limitations to use, or increased land management costs associated with limiting erosion and runoff. These are areas where the levy bodies are well placed to meet farmer needs as they develop. Farmers must also wherever possible take advantage of entry and higher level schemes to improve soil health (through less intensive cultivation or set aside for example) to offset losses in productivity. The ability of farmers to consider soil management as part of a whole farm system while maximising their income from the Single Payment Scheme will be an important factor in maintaining and increasing productivity in all sectors.

2. Study Methods

2.1 Identification of levy body priorities

Priorities for knowledge transfer were detailed by representatives of the levy bodies identified by the ARF knowledge transfer steering group, via an electronic survey. Responses were either provided by individuals (BPC, MLC, MDC, BBRO) or collectively for the organisation (HDC, HGCA). Summarised survey responses from each levy body are appended (Appendix A). This survey built upon information provided by the levy bodies themselves which is also appended (Appendix B). This information was collated and the responses are reported in section 3 grouped into the following categories:

1. Meeting cross compliance
2. Organic matter
3. Structure
4. Water erosion/runoff
5. Wind erosion
6. Soil fertility
7. Soil biology
8. Other

2.2 Gap analysis of current levy body service provision

Under the same headings as above, the survey also identified current levy body service provision. This information was used to perform a simple analysis of the gaps in current service provision.

2.3 Gap analysis of service provision of non levy body organisations

A similar electronic survey was sent to individuals at targeted organisations via project team contacts and to further individuals/organisations identified by levy bodies and other sources. At least 150 copies of the questionnaire were circulated. A total of 44 survey responses were received from organisations and independent consultants. The information provided was evaluated to assess how well these services filled the gaps identified in the levy body services. A summary of information provided, organised according to the categories detailed in section 2.1 is appended (Appendix C)

2.4 Review of knowledge transfer methods

A short review of past studies was conducted to evaluate the previous success and recent research conclusions on the appropriateness and likely success of different forms of knowledge transfer.

3. Review and gap analysis of knowledge transfer availability by theme

3.1 Levy body priorities for knowledge transfer

1. Meeting Cross compliance

Meeting the requirements of cross compliance was identified as a top priority across all production sectors, (with the exception of the HDC, who regarded this as an issue for Defra and beyond their remit). Feedback from levy body knowledge transfer and research and development staff indicated that much of the impetus for improved soil management knowledge transfer is being driven by the soil management requirements of the new legislation. Although in all the UK administrative regions, farmer training on the completion of cross compliance documentation has been offered by the government or appointed institutions, *actions* towards compliance to commence from 1st January 2007 are currently only addressed in the guidance documents (which vary considerably in detail of advice) and by the new Farm Advisory Systems, which are intended to offer individual advice to farmers, although there are currently few details on operation and scale of service. Although further knowledge transfer is seen to be necessary to enable producers to meet cross compliance, it is unlikely that state provision of services will provide farmers with sufficient information on the options available for management, and in particular the implications for sector productivity. Therefore it is recommended that in the short-term knowledge transfer programmes be targeted to (but not limited to) management implications of meeting the new legislation, under the headings described below.

2. Organic matter

Overall organic matter was not seen as a high priority issue. However information on options for increasing organic matter levels was highlighted as a high priority within a previous survey conducted by the levy bodies (Appendix B). The emphasis placed on this specific issue appears mainly due to the requirements within cross compliance to take action to increase organic matter levels. Organic matter levels are probably not a sector specific issue; no levy body placed strong emphasis on this aspect. Maintenance of organic matter levels was seen as less of an issue for livestock farmers. However, livestock-related issues are important on mixed farms and issues relating to the application of organic waste to arable crops were also noted.

3. Soil structure

Soil structure was identified as a high priority for knowledge transfer by levy bodies in the arable and horticultural production sectors. In particular, information on the link with quality and yield, influence of cultivation methods and means of assessment are seen as priorities. Rotation and sub soiling are also issues in arable sectors. A particular area of interest for BBRO and HGCA is the relationship between soil structural condition and crop establishment. Soil structure information was regarded as less of a priority in the livestock sectors. The emphasis on this issue within livestock sectors was connected with poaching problems. However, there is some commonality across all sectors in the need to identify structural problems in the field and determine the most appropriate options for ameliorative action.

4. Water erosion/runoff

Knowledge transfer information in this area was seen as the highest priority across all sectors; the drivers for this prioritisation are GAEC and the expected impact of the Water Framework Directive. Stand-out issues are how to identify and mitigate risks

on-farm. MLC see this area as less of a priority, probably due to their focus on indoor production.

5. Wind erosion

Wind erosion was regarded as inapplicable or a low priority. There appears to be limited perceived demand for information in this issue.

6. Poaching by animals

Poaching was identified as high priority area for livestock sectors, particularly in the dairy industry. The main priority identified was how to limit poaching damage, particularly while maximising outdoor time for animals to reduce feed costs. MLC also separately highlighted the maintenance of vegetation cover as a priority area. This is strongly linked to poaching of swards. Poaching is clearly less of an issue for arable producers, other than on mixed farms or rented land where structural damage through poaching under rotational pasture can have a detrimental effect on soil structure which may have consequences for succeeding crops.

7. Soil fertility

The need to provide soil fertility information was highlighted as more of a priority for livestock (managing grassland fertility) than for the arable sectors. The main issues identified in all sectors were reducing needs for chemical fertilisers (through both precision farming, and improved use of organic amendments), and the need to comply with the requirements under the Nitrates Directive in Nitrate Vulnerable Zones (NVZs and the expected requirements of catchment plans under the Water Framework Directive). BPC highlight a sector-specific interest (which may also apply to horticultural producers) of the effects of crop rotation on rented land on management of fertility for potato production.

8. Soil biology

The main area of interest identified was in the control of soil borne diseases (in both arable and livestock sectors). There was some interest in making information available to farmers to increase the understanding of the function and relevance of soil biology for maintaining soil function. While previous discussion at the ARF meeting in November 2005 appears to have highlighted soil biology and soil function as an important knowledge transfer area among levy body R&D staff (Rob Clayton, pers. comm.) the results of our consultations generally highlighted a much higher emphasis placed on pest and disease control in this subject area. This may be a subject for further discussion.

9. Other issues

BPC highlighted information on rotational effects on rented land as a high priority, although these are largely connected with issues of soil structure and fertility discussed above. Perhaps awareness of this issue would best be translated by joint knowledge transfer with other sectors which would make potato producers on rented land aware of the issues connected with fertility and structure connected with other crops.

Information on best practice management within NVZs and the interaction between soil nitrogen management requirements and other soil management issues (particularly structure, organic matter, runoff) were also highlighted by a number of sectors as of relevance.

3.2 Priorities of soil knowledge transfer providers

In a similar survey, knowledge transfer providers were asked to prioritise soil management information priorities for farmers and their advisors. Results were analysed statistically and are summarised in Table 1. Meeting cross compliance and controlling water erosion and runoff were regarded as the highest priorities, with soil fertility, biology and poaching being seen as of significantly lower in priority. These results are very similar to those of the levy body survey described above. This suggests a general agreement that the current key areas for farmer knowledge transfer are water erosion and runoff, meeting cross compliance and soil structure. However it should be noted that this conclusion is reached in the absence of feedback from the farmers themselves which would provide much more valuable insight into the sorts of information needed most urgently. This issue will be discussed in further detail in section 4 and in the recommendations for further actions (section 7.2).

Order of priority(ave)		Soil characteristic	Significance of difference (Mann-Whitney test) in individual response					
Levy body	Service providers		Organic matter	Structure	Water erosion/runoff	fertility	biology	Poaching
1	2	Cross compliance	ns	ns	ns	*	*	*
4	4	Organic matter		ns	ns	ns	ns	ns
3	3	Structure			ns	ns	ns	*
2	1	Water erosion/runoff				*	*	**
3	4	fertility					ns	ns
5	5	Biology						ns
6	6	Poaching						

Table 1: Median scores (1 most important to 5 least important) and statistical differences for responses to service provider survey of knowledge transfer priorities.

3.3 Current levy body service provision

1. Organic matter

Levy bodies generally regarded their coverage of this issue as partial. There is a large amount of sector-specific information available on the effects of the use of organic inputs (manures and composts) in the arable sectors, but little on other options for increasing soil organic matter (e.g. the use of rotations, crop residue incorporations and reduced tillage operations).

2. Soil structure

Both the BPC and BBRO have already done substantial work towards the provision of soil structure management information, reflecting the fact that compaction is a large issue for quality and yield of these crops. The HGCA have also made significant steps towards providing this information, through the soil2crop initiative and related fact sheets. Soil structure is included in coverage of grass+ programme for dairy farmers provided by the MDC.

Although there is a fairly good sector-specific coverage, there is more limited information relating to the effect of different crops in rotation, and management options for improving soil structure. A particular area not currently well provided for by the levy bodies is techniques for the assessment of soil structural problems.

3. Water erosion/runoff

Levy body activities in this area are limited, particularly on the links with structure and organic matter management, although the main priority identified is short term risk management in relation to cross compliance and entry level schemes (in England). There is generally an absence of technical advice provided by the levy bodies in this area.

4. Wind erosion

Wind erosion is generally a localised problem. Where wind erosion can be problematic (such as in the sugar beet industry) current management advice appears adequate.

5. Poaching by animals

There appears to be a good coverage of this issue by the MDC/MLC, although there is limited information on recognition of damage to soil structure (see above).

6. Soil fertility

Managing crop fertility is an area of knowledge transfer in which the levy bodies have been extremely successful in providing the relevant information to farmers to maximise productivity, hence there is a large amount of sector specific advice available.

7. Soil biology

Although there are large amounts of ongoing research and development, there appears to be an absence of information relating to the effects of different soil management on specific crop pests and diseases, and more general information providing best practice information for maintaining soil health and function.

3.4 Gaps in levy body provision

The main gaps identified in the provision of soil management information are in the following areas:

- Organic matter - increasing through amendments, tillage and rotation (direct and indirect benefits).
- Soil structure - methods of assessment and influence of rotation and cultivation (direct and indirect benefits).
- Water erosion/runoff risks and management.
- The effect of soil management on incidence of pests and diseases.

4. Provision by other sources

The availability of information from non-levy body services was assessed through feedback to a survey of service providers, plus a wider data search. Information was collated on currently available soil management knowledge in the UK according to the categories described above, and further subdivided into a number of forms of provision. This data was tabulated and is summarised in Appendix C. While there are likely to be programmes and information sources which will compliment the existing KT provision of the levy bodies in all the subject areas identified, the next section will concentrate on availability of information in those areas identified as levy body priorities which are not currently well provided for by current levy body programmes (outlined in section 3.4). The availability of KT programmes from non-levy body sources is discussed.

4.1 Organic matter

Farmers are unlikely to be interested in increasing organic matter for its own sake. Even in the organic sector, training courses concerned with the management of organic matter are often linked to management of soil fertility, maintenance of soil biological activity and mitigation of soil borne disease. However, as a result of GAEC requirements within the Single Farm Payment scheme, maintaining and/or increasing soil organic matter is now on the agenda for farmers. Only 24% of service providers mention OM as an aspect of their training. Options for increasing organic matter are rarely presented as a stand alone issue; in contrast cultivation practices have been the focus of a large amount of KT activity. Consequently there is lots of very good practical information available (particularly through the Soil Management Initiative) on reducing cultivation related costs while optimising soil condition. This approach directly links soil management with cost implications for farmers. This sort of presentation helps farmers make the most of the options available to them through the single farm payment scheme, while maximising productivity. Sustainability and productivity do not necessarily need to be antagonistic. Knowledge transfer activity on this topic could focus on the benefits of increasing organic matter on arable land (water, nutrients, cultivation costs etc), together with better information for all farmers on the likely effects of other management practices on the organic matter status of their land. Farmers also need to be given tools to help assess their options for increasing organic matter within the context of whole farm management. A programme which provides farmers with the skills to identify problems which are caused by or could be ameliorated by changing organic matter levels could be of particular value.

Verdict: more to be done

4.2 Soil structure

50% of the service providers responding to the survey carry out knowledge transfer directly relating to soil structure. The Soil Management Initiative (SMI) and Environment Sensitive Farming (ESF) Programme run by ADAS have done a lot of work to collate the existing information and present it in ways that meet farmer requirements. There are now a number of systems for field assessment of soil structure. SMI are providing training (mainly to farmer advisors) in the use of at least one of these assessment techniques. However, there may be scope for levy bodies to add value to a field training and workshop programme that also trains farmers to identify their most appropriate options to mitigate damage and improve soil structure. The SMI system for assessing tillage costs is very useful and levy bodies should take

the opportunity to provide links to a wide range of resources for their levy payers. The ability of arable farmers to identify when a crop or other rotational practice has resulted in structural deterioration, and for livestock farmers to distinguish between suitable and unsuitable out wintering areas, are both linked to knowledge about and ability to assess soil structure in the field. Environmental stewardship options may provide an opportunity to take land out of intensive production and ameliorate structural problems while meeting environmental stewardship goals.

Verdict: Information is mainly available but an increase in provision/access together with some more detailed provision desirable, particularly in the areas of field assessment, causes of problems and management options.

4.3 Water erosion risks and management

Because of the focus of the Soil Protection Review to meet GAEC in England, there is a lot of documentation available from Defra which outlines how risks should be identified and the steps that can be taken to mitigate risk. In England workshops (Defra/Momenta) have been offered to farmers from February 2006 to support understanding and engagement with the written materials. Support for preparation of the more detailed soil management plan in the Entry Level Scheme is also being provided through farm advisors in England. This area was the most frequently cited area of provision in the survey (82% of respondents) suggesting that knowledge transfer provision in this area is already available to farmers from a number of sources.

Verdict: At the moment there is a need to stand back in this area and evaluate the effectiveness of the training provided. Links should be provided to materials by the Levy Bodies to facilitate farmer access.

4.4 Soil biology: soil management to reduce pests and diseases

Only 3 of the service providers who responded stated they provided training in this area. Training on soil biology is only mentioned explicitly for the organic sector. Little practical information is available on management effects (for example the effects of compaction, pH or increased soil moisture as a result of measures to reduce runoff). Some information is being made available relating to the role of soil biology in soil function and maintaining soil health. Soil biology has been anecdotally reported as a 'wow factor' for farmers beginning to think about soil – few have a good understanding of the diversity of life in soil and its importance in soil function.

Verdict: Long term need for further practical information into sector-specific management problems. There is a possible need to provide farmers with general information regarding the importance of soil biology in soil functioning as part of standard soil management advice.

5. Review of forms of knowledge transfer

Service providers identified 4 main ways that they were providing KT to farmers and their advisors – publication of information (leaflets, booklets); interactive and less-interactive web resources; courses (including BASIS/FACTS accredited training) and workshops (including farm walks and open days). A video which considers the implications of changing cultivation practices on soil structure (amongst other issues) has also been produced (SMI). 82% of respondents communicated soils knowledge by workshops, 34% through one-to-one advice to farmers, 26% via publications, 24% through courses and 9% through the web. Educators recognise a clear distinction between the provision of information (transmission) and learning by the recipient (Ramsden, 2003). However this study suggests service providers seek to achieve both aims, often not clearly distinguishing between them; though this may be an outcome of the questionnaire design. In the majority of cases service providers indicated that they would be prepared to provide information in a range of formats including one-to-one advice on farm but that the key constraint to their delivery of KT activity was funding.

A similar range of approaches is used in other countries, and for other fields of agricultural KT within the UK. Facilitated farmer groups (e.g. the Landcare approach in Australia; Department of Agriculture, Fisheries and Forestry, Australia, 2006) are also a commonly reported means of sharing knowledge and promoting farmer-farmer learning. In New Zealand farmers are able to benchmark the health/quality of their soils (Landcare Research, 2006); this approach is more common for economic indicators in the UK. Wander et al (2002) report a participatory approach to developing such a soil quality benchmarking system as a result of farmer and researcher interaction in cropping systems in Illinois, which highlighted that farmers often have the desire to take soil quality into account in decision making but lack tools which actually enable this to happen in the field. In their carefully considered review of advisory support for land management, Garforth et al (2003) indicate that the appropriate form of knowledge transfer will vary; and except where the task is simply that of making information available, facilitation to provide assistance or support in using the information is important.

Few/no farmers identified by the Levy Bodies were able to respond to our survey in the time allocated. There is clearly a need to engage more fully with farmers to discover what processes of KT (formal and informal) actually have the largest effect in informing and/or changing practice. It is important to note that “an almost universal finding from studies of farmers’ sources of information and influence is that other farmers are their most frequently reported source” (Garforth et al 2003). Drew (2001) also found that the internet was not ranked highly by farmers as a preferred source of information. However, anecdotal evidence suggests that farmer use of the internet has increased significantly since the Foot and Mouth outbreak. Learning in this area will not be restricted to issues related to soil management; most farm management issues require practical in-field assessment and decision making, which distinguishes them from other business decisions and may distinguish the most appropriate form of KT from that applied in other sectors. Levy bodies are in a unique position to be able to inform their KT provision through appropriate engagement with farmer opinion; this should build on rather than repeat the information collated by ADAS as part of "Farmers' Voice", an annual large scale national survey of farmers.

In the tropics there has been an increasing move from KT programmes which take results from research farms and seek to educate farmers to apply these approaches, towards a more farmer-centred approach in the research and knowledge generation processes (Bunch 1982; Chambers et al 1990). This 'rural development perspective' has demonstrated economic and social advantages through supporting farmers in assessment and innovation for land management (particularly Integrated Pest Management) rather than regarding them as passive recipients of a relatively slow technology transfer system (e.g. Bentley and Andrews 1996; Selener, 1997; Ooi, 1998). Links between participatory action research and quantitative analysis have been critical to success in improving soil management in areas vulnerable to soil degradation in Mali for example (Defoer et al 1998). Deugd et al (1998) stress the most effective approach is to support innovation by increasing farmers' control over the processes of research and emphasising the process of learning rather than the teaching of content. Such an approach works best where the main blockage is not access to information, but rather farmers' adoption, understanding and integration of that knowledge into practice.

The development of such programmes in the tropics were a response to the poor uptake of farming systems technology, which had been based upon research station findings, and neglected the realities of farmer decision making which often made these technologies impractical or unsuitable in the real world. Although knowledge transfer in the UK has proven much more successful, there are important parallels. Sherwood and Uphoff (2000) see the challenge for improving soil management as one of engaging farmers rather than changing them. Approaches taken should engage farmers in processes of identifying and prioritizing problems and opportunities, testing and evaluating innovations and being partners in sharing the information gained. Within the UK the Levy Bodies have an important gatekeeper role with regard to meeting farmer needs for research. It would seem appropriate that they should take the lead in encouraging and supporting structures that better support facilitated learning by researchers and farmers alike. In this way the findings of soil management research can be best transferred into real soil management improvement and future research acknowledge the existing barriers to implementation in developing the most practical solutions.

6. R&D Gaps: Making best use of existing research

The audit of UK Soil Research carried out for Defra (Research project SP0524) highlighted some concerns about the skills base amongst researchers but generally noted that there was much research of international status carried out into soils and soil function in the UK. It is not our intention to bring this audit up-to-date here. However, it should be noted that Levy Body funded research represents only c. 2% of the funding into soil-related research in the UK. Hence knowledge transfer by Levy bodies needs to draw much more widely and consider the results of a much wider body of research than simply that which is specifically commissioned.

The research audit found that there was generally a poor awareness of the scale and scope of UK soils research amongst those who were expected to apply the results of such research, such as farmers and land managers. It was noted that businesses have little time available to them to find and make sense of the results of scientific research; consequently there is a need to identify user groups during any project and provide results to them in an appropriate form. However, the audit concluded that it was not sufficient simply to rely on knowledge transfer activities associated with individual projects and carried out by individual scientists; for knowledge transfer to be effective there was a need for additional resources focussed on integrating and translating the results of individual research projects. There was concern about the small number of people within the UK who were experienced and able to communicate soil research in language that made sense to farmers. The audit also highlighted the importance of involving farmers and land managers in all aspects of research that aims to produce outputs aimed primarily at them to maximise the likelihood of a successful uptake of the results.

Within the UK and similar farming systems there is a wealth of published research (and even more research only available in the so-called “grey literature”) which provides information for specific climate/soil/management combinations relating to the knowledge transfer gaps highlighted in this study i.e. soil organic matter, soil structure, runoff and erosion. Although gaps in currently available knowledge suitable for direct transfer to farmers have been highlighted in the previous sections, it does not seem appropriate to commission new primary research in these areas before making best use of the information that currently exists. This is not to say that no new research is needed (what scientist will ever say that) but that to support effective knowledge transfer it is essential that the relevant practical knowledge sitting in back issues of scientific journals (often pre-dating the digitisation of scientific journals) is integrated and translated so that it can be shared with farmers and their advisors in relevant and engaging ways. However, it must be recognised that because of the nature of soils and the issues associated with their management it is unlikely that simple prescriptive messages can be developed that will have wide applicability within sectors, let alone across sectors. Instead farmers will need to assess information they collect on soil condition and then use their best judgement in the light of the range of possible options available to determine the best management practices for their soil/crop/environment combination. Supporting this kind of farmer learning is likely to need a different approach than simply providing the direct outputs of research projects, even if they are compiled in a farmer-usable way.

Specific R&D gaps

While any detailed analysis of the gaps in research and development is beyond the scope of this project, the following are the views of the project team on the availability of R&D outputs in the areas identified as gaps:

Organic matter

While there is a shortage of transferred research information in this area, there is a large amount of historical research information available. This reflects the fact that this area suffered a relative neglect in recent decades due to a reduced focus on agricultural soil management.

Soil structure

A large amount of research has been translated relating to the effects of cultivation. Significantly less information is available on the relationship between structure and organic matter. This can again be attributed to the lack of focus on soil management described above.

Water erosion and runoff

Until the 1990s soil erosion was not viewed as a serious problem in the UK. Consequently while historical data exists, there is significantly less research information available than in other countries. However there is a large amount of new and ongoing research in this area which is being taken up by Defra in particular.

Soil biology

A recent review paper (Stockdale and Brookes, 2006) highlighted a large amount of existing research, plus new opportunities using molecular techniques to characterise and interpret the links between soil biology and soil function. However, they concluded that there is a lack of transfer of existing knowledge into robust guidelines that inform and/or improve agricultural practice.

Overall while there is no real shortage of research information in any of the identified gap areas, there is a need to interpret and present the outputs of research in ways that support knowledge driven farmer decision making. There is also a need to integrate research on soil management with consideration of the impacts of soil management actions on other farm management practices and consequently on profitability. Little work has been carried out to quantify the impacts of changes in management practices (to support best practice soil management goals) on profitability (e.g. work in the US by Valentin et al 2004). At present much of our understanding of soil function lacks this critical application to real farming systems.

7. Conclusions and recommendations

7.1 Summary of findings

The following were identified as high priority areas for levy body knowledge transfer:

- Meeting cross compliance
- Water erosion and runoff – identifying and mitigating risks
- Soil structure
- Organic matter – options for enrichment

A higher priority was placed on information on poaching by animals and soil fertility within the livestock sector. A higher priority was placed on soil structure information in the arable sector. It is recognised that soil structure and poaching by animals are closely related issues which do not preclude collective action. Other areas (soil fertility, soil biology) were regarded as slightly lower priority, but still of relevance.

Levy body activities

After reviewing the current levy knowledge transfer activities the following areas were identified as gaps in levy body provision:

- Organic matter - increasing through amendments, tillage and rotation (direct and indirect benefits).
- Soil structure - methods of assessment and influence of rotation and cultivation (direct and indirect benefits).
- Water erosion/runoff risks and management.
- Soil biology - the effect of soil management on incidence of pests and diseases.

Knowledge transfer from other sources

After a detailed data search and using information from service provider survey the following conclusions were made on the availability of information in these gap areas:

- Organic matter – Low availability of relevant information – action by levy bodies recommended
- Soil structure – information is mainly available – levy bodies should aim to improve access to information. There is a gap in the provision of a detailed training programme in the area of field assessment, causes and management options.
- Water erosion/runoff risks and management – There is a lot of information and training available. No immediate action by levy bodies recommended, although evaluation of training provided through cross compliance is desirable. Levy bodies have a role to play in ensuring farmer access to the information/training resources available through other organisations.
- Soil biology – Little information currently available – need for ongoing applied research and development in sector specific areas relating to pest and disease control. There is however potential to provide more general information to farmers on the role of soil biology to provide interest as part of wider training programmes relating to soil condition/health.

7.2 Recommendations for further action

It is felt that there is both a need and an opportunity for the levy bodies to fill gaps in soil management knowledge currently available to producers, with great potential to improve cross-sector productivity. Furthermore, it is important that timely action be taken while there is industry focus on the issue arising particularly from the new requirements of legislation.

In suggesting a plan of action for the ARF, the emphasis has been placed on areas where it is felt there is scope for cross-sector collaboration. A number of different options are suggested. None of the suggested options are exclusive of others. We have also attempted to provide the ARF with the necessary information regarding the ability of organisations to provide services for the development of knowledge transfer programmes (either to meet our recommendations or to develop others as appropriate). To that end, information from service providers relating to their *potential* knowledge transfer activities is included in Appendix D.

In launching any activity, a detailed roll-out plan will be required that includes relevant cost/benefit data and takes account of case studies where financial reward from change in practice can be accrued.

1. Soil management information gateway

This action is seen as an essential short term priority, and a cornerstone of any further activity. It is recognised that the levy bodies have a key role to play as ‘gatekeepers’ of soil management information. The ARF would seem to represent an ideal forum to facilitate centralisation of resources available to producers. Information and contacts for organisations holding the best available soil management information in a range of forms and topic areas could be made available to farmers through the ARF website, (and through newsletters). This would provide links to other websites and where possible downloadable soils information documents by arrangement with owner organisations. Updates on soil management training events could also be made available to farmers, ideally by cooperation with other organisations, to inform producers/advisors of all upcoming training opportunities. A similar dissemination of information could be made via postal distribution of an ARF newsletter or individually via those of member levy bodies. Information sources/links should be based upon, but not exclusive to those provided in Appendix A.

2. What do farmers really want?

Although this study has identified the areas seen as priorities by both the levy bodies and by soils experts, this is not a substitute for the views of the farmers themselves. In order to accurately assess producer priorities (the demand for and the most appropriate forms of knowledge transfer for soil management), consideration of the views of levy payers should be taken into account, either formally or informally. The absence of such consideration makes prediction of demand difficult, particularly relating to regional differences related to different state provision of farmer training and legislative compliance of the devolved governments.

3. Field assessment of soil condition

This would involve ARF development (with appropriate individuals/organisations) of a programme of field training. The programme could and should be altered according to audience, although the majority of issues are common to all arable sectors (structural stability, risk of structural damage by cultivation when wet and capping and other erosion problems associated with low organic matter for example). In particular, the training should focus on identifying soil problems, causes and discussion of solutions (potentially to link with option 4).

There are already a number of organisations providing training for producers in field assessment techniques, notably SMI (UK) SAC (Scotland) Environment Sensitive Farming (England) and NSRI (England). Other than the SMI these programmes are focussed on soil structural assessment, and there would appear to be a need for a wider programme also incorporating identification of problems associated with low organic matter, erosion risks and biological condition. Existing programmes are likely to require adaptation to the proposed purpose – that of enabling farmers to identify poor soil condition (affecting productivity) and develop solutions to these problems, particularly those related to organic matter and particular soil types. The Soil2Crop initiative undertaken by the HGCA in collaboration with SMI in 2005 would seem a logical starting point to build a suitable programme. Adapting a scheme to suit the livestock sector would require more programme development work, as there does not seem to be a suitable existing scheme. A number of organisations who include poaching by animals as a topic in workshops and training provision are detailed in Appendix C.

While the provision of fact sheets/documentation may offer support, there is no substitute for genuine training in field assessment techniques, and this should not be considered a viable alternative. However supporting documentation could provide additional sector advice on specific management issues (either through separate sections in the same document, or a tailored document for different levy body sectors).

4. ‘Soil management for profit’

The Single Farm Payment Scheme represents a new challenge to farmers, but also an excellent opportunity to take actions to increase productivity through better soil management, offsetting short term costs (direct set up costs or reduced output) with subsidy payments, while reaping the benefits over a longer timeframe. This programme would focus on enabling farmers to take advantage of the single farm payment scheme, particularly at entry and higher level, by making use of environmental management options eligible for subsidy payments to improve soil management (organic matter levels, structural condition, erosion control). Examples include the use of beetle banks for erosion control, improving organic matter and structure through conservation tillage or identifying poor out-wintering land and creating alternative low intensity management wildlife habitats. The cost implications and technical considerations of different management strategies are complex. Levy bodies appear well placed to fill the gap which exists in relation to these aspects of GAEC which do not appear well provided for by existing training programmes. A suitable programme should take account of the review of knowledge transfer in section 4 of this report, to create a problem-based programme centred on farmers’ own experiences. Farmers should be encouraged to innovate and develop solutions which are most suited to their circumstances.

5. Back to the future? - Incorporating existing research into knowledge transfer provision.

The new requirements and options for soil management of the Single Farm Payment Scheme place a renewed emphasis on land husbandry techniques, which have been relatively neglected over recent decades. While the potential and opportunities of new research to improve agricultural performance should not be overlooked, the most cost effective option is to first make best possible use of existing research. There is a vast amount of forgotten research into relevant areas on which CAP reform has placed renewed emphasis, such as managing rotations, organic matter, tillage and use of organic amendments (for example Lowe, 1972, which reviews the accumulated experimental evidence for the effect of cultivations on soil physical conditions in both arable and grassland sectors in the post war years of intensive research in the field) Importantly, this includes highly applied research for particular crops/farming systems and soils/localities. However, much of this research predates digitisation of resources, and to locate it would require a thorough investigation of archives.

Although (agronomic) technology has developed greatly in the intervening years, this is not necessarily a barrier to the application of this previous research. Where research intervention is seen as necessary, the findings of research in this period should first be reviewed. Due consideration of the implications of technological development for the findings of this research will inform new research directions. The alternative, which occurs too often, is to invest heavily in new research which replicates forgotten past research and therefore returns predictable results, resulting in inefficiency in both financial terms and in the rate of development of suitable knowledge transfer.

An example of the application of past research to modern farming

A positive way forward for crop production is location-specific treatment - precision farming - where the inputs are targeted based on either off-takes, in the case of nutrients, or at pesticide inputs in the case of visual imaging and real time sensors attached to the sprayer. Neither of these approaches however, deals with the causes of areas of low yield or presence of weeds or diseases. Such problems are often related to the physical conditions in the soil such as water stress, poor drainage or root growth restrictions. The high tech solutions only optimise the use of the input resources but do not correct the underlying fault. In fact the scientific principles on which precision farming is based were developed following the work of Mercer and Hall at Rothamsted in 1911; they admitted at the time that their results were interesting but the technology did not exist to enable the knowledge to be used profitably. Now that technology has reached a stage where precision farming is a practical reality, the effects on soil condition of management options such as choice of rotation for example, become highly relevant. Long term data sets from the historical archive in particular may hold the key to predicting effects of management choices. Thus, for example, where at Rothamsted wheat has been grown in the same years on a monoculture (at Broadbalk) and in a rotation (at Agdell park) we can compare the yields for these two systems and the year to year variation in yield with weather. This published research would in many cases be viewed as too expensive to carry out today, and in any case could require 20 or more years before it yielded useful information. Thus a small amount invested in researching published information could provide useful output in a short period.

Large amounts of other research has been carried out on the long term changes in soil as a result of agricultural use, and buried within the reports of these experiments lies

information that is of increasing value to us as prices decrease and costs increase, forcing us to become more efficient in how we manage crops. No longer is the option of using more powerful machinery or increasing fertiliser use, pesticides or irrigation an economic solution to correct defects in the soil's physical properties, which restrict growth of desirable species but often have a smaller effect on their competitors. In many cases this involves us today in making use of results in ways the authors had not originally intended.

References

- Bentley, J. W. and Andrews, K. L. (1996). Through the road blocks: IPM and Central American Smallholders. IIED Gatekeeper Series Volume 56. International Institute for Environment and Development. London.
- Bunch, R. (1982). Two ears of corn: A guide to people centred agricultural improvement. World Neighbours. Oklahoma City,
- Chambers, R., Pacey, A and Thrupp, L. A. (1990). Farmer first: Farmer innovation and agricultural research. Intermediate Technology Publications. London.
- Defoer, T., De Groote, H., Hilhorst, T. Kante, S and Budelman, A. (1998). Participatory action research and quantitative analysis for nutrient management in southern Mali: a fruitful marriage? *Agriculture, Ecosystems and Environment* **71**, 215-228.
- Department of Agriculture, Fisheries and Forestry Australia (2006) National Landcare Programme Overview 2004-08. www.affa.gov.au/content/output.cfm?ObjectID=58F9E43F-95A0-46CE-85A6286176710B18 Last updated June 2006. Viewed 28th June 2006.
- Deugd, M. Röling, N. and Smaling, E. M. A. (1998). A new praxeology for integrated nutrient management, facilitating innovation with and by farmers. *Agriculture, Ecosystems and Environment* **71**, 269-283.
- Drew, B. (2001). Knowledge transfer to the livestock industry. Progress in the new Defra initiative. ADAS/ IGER/ University of Bristol, Bristol.
- Garforth, C., Angell, B., Archer, J and Green, K. (2003). Fragmentation of creative diversity? Options in the provision of land management advisory services. *Land Use Policy* **20**, 323-333.
- Landcare Research (2006) SINDI Soil Quality Indicators on the web. Version 3. <http://sindi.landcare.cri.nz/> Last updated not known. Viewed 28th June 2006.
- Low, A. J. (1972). The effect of cultivation on the structure and other physical characteristics of grassland and arable soils (1945-1970). *Journal of Soil Science* **23**, 363-380.
- Ooi, P. A. C. (1998). Beyond the farmer field school. IPM and empowerment in Indonesia. IIED Gatekeeper Series Volume 78. International Institute for Environment and Development. London.
- Ramsden, P. (2003). Learning to teach in higher education. 2nd edition. RoutledgeFalmer. London.
- Selener, D. (1997). Participatory Action Research and Social Change. The Cornell Participatory Action Network. Cornell University, Ithaca, NY.
- Sherwood, S. and Uphoff, N. (2000). Soil health: research, practice and policy for a more regenerative agriculture. *Applied Soil Ecology* **15**, 85-97.
- Stockdale, EA and Brookes P. C. (2006) Detection and quantification of the soil microbial biomass – impacts on the management of agricultural soils *Journal of Agricultural Science* , 144, 1–18.
- Wander, M. M., Walter, G. L., Nissen, T. M., Bollero, G. A., Andrews, S. S. and Cavanaugh-Grant (2002) Soil Quality: Science and Progress. *Agronomy Journal* **94**, 23-32.
- Valentin, L Bernado, D.J. and Kastens, T.L. (2004). Testing the Empirical Relationship between Best Practice Adoption and Farm Profitability. *Review of Agricultural Economics* **26**, 489-504.

Appendix A: Levy body soil management knowledge transfer priorities and activities

1 = Highest priority

5 = lowest priority

Provision options Adequate/Partial/None

BPC	Area	Priority level (1-5)	Key Topics	Provision	Details
	Organic matter	3	options for enrichment (without compromising quality). Meeting cross compliance.	Partial	Info on use of organic fertilisers and composts from R&D. Cross compliance meetings (1200 growers) Compaction review includes information on relationship between surface capping and organic matter.
	Structure	1	Linking quality and yield Cultivation methods and timing Rotation Assessment methods How to take ameliorative action.	Partial	Compaction review widely circulated. No particular guidance on improving uniformity. Cross compliance meetings (1200 growers)
	Water erosion and runoff	1	Identify and split of risks Irrigation risks Water conservation Water framework directive.	Partial	Included in coverage for soil management plans. Campaign on water to encourage direct producer involvement. Concepts covered cross compliance meetings but with little experience of practical management.
	Wind erosion				
	Soil fertility	3	Possibly need to consider effect of rotation on rented land	Partial	Leaflets and web site to support management on fertiliser recommendations. Awareness of ongoing R&D via field days.
	Soil biology	2	Control of soil borne diseases.	Partial	Ongoing R&D projects on impacts and control of soil pests and diseases. Outputs via meetings, web tools organised as part of BPC campaigns.
	Other	2	Rotations on rented land past management and contractual obligations for subsequent occupation.		
	Other	2	Consequences of nitrate directive on any above		

BBRO	Area	Priority level (1-5)	Key Topics	Provision	Details
	Organic matter	3	Maintaining and increasing OM Options for enrichment without compromising quality	Adequate	Beet growers guide, electronic format sugarbeet portal, Beet review magazine
	Structure	2	Ensuring good structure for crop establishment. Making link with quality and yield Subsoiling timing and methods	Adequate	Beet growers guide, electronic format sugarbeet portal, Beet review magazine
	Water erosion and runoff	1/2	Identifying and splitting risks for cross compliance	Adequate	Beet growers guide, electronic format sugarbeet portal, Beet review magazine
	Wind erosion			Adequate	Beet growers guide, electronic format sugarbeet portal, Beet review magazine
	Soil fertility	2	Use of soil analysis to maximise yield.	Adequate	Beet growers guide, electronic format sugarbeet portal, Beet review magazine
	Soil biology	3	how to maintain	Partial	Beet growers guide, electronic format sugarbeet portal, Beet review magazine
	Other	1	Consequences of nitrate directive on above		

HGCA	Area	Priority level (1-5)	Key Topics	Provision	Details
	Organic matter	2	Linking quality and yield How to measure and assess. Options for enrichment	Partial	Project progress 6: Using animal manures on arable crops 2 page doc (ADAS produced 2000) Topic sheet 64: Using manures and biosolids on cereal crops – summary of findings of HGCA sponsored research by ADAS (Winter 2002/2003). 2 page doc. AFR workshop Sustainable use of organic wastes on agricultural land. 7&8 th Sept 2004 for 40 invited delegates. Field demos in 2000, 2001. Report (£10) on integrating organic manures, slurries, biosolids as nutrient sources in arable rotations May 2003.
	Structure	1	Effects of cultivation; how to recognise and prevent problems, effect on germination and rooting. Making link with quality and yield	Partial	Soil and crop management issues insert in Crops sent to 25000 in Sept 2004. Soil2crop initiative 2003/2004 1500 growers attended. Funded by HGCA and BPC, led by Vic Jordan of SMI. Included consideration of effects of compaction, how to avoid and sub soiling as the solution Topic sheet 65: Reducing costs of establishing and managing wheat. Winter 2002/2003. 2 page document reporting findings of research by arable research centre on direct drilling, min tillage and ploughing. Summary of soil2crop.
	Water erosion and runoff	2	Identifying risks. Tramlines and importance of soil structure. WFD	None	
	Wind erosion				
	Soil fertility	2	link with quality and yield, and options (manure Vs NPK) and when to apply.	Adequate	Topic Sheet 67: P nutrition of winter oilseed rape Topic Sheet 66: Diagnosing & correcting S deficiency in wheat & rape Topic Sheet 44: Non-NPK nutrient needs of cereals Topic Sheet 19: Diagnosing P & K requirements of winter wheat P&K fertiliser planning guide Sponsor of "Tried & tested" leaflets on nutrient management for farms, printed in 2005 Many Topic Breakfast meetings, workshops and roadshows around the UK, also soil2crop events

HGCA (cont)	Soil biology	3	General awareness of fact soil is alive, and that this links to growth and yield.	None	
	Other	1	Nitrogen Revision of RB209 Changes to NVZs Water Framework Directive		Topic Sheet 68: N management of strobilurin-treated winter wheat Topic Sheet 63: Managing arable crops in NVZs in England & Scotland Many Topic Breakfast meetings, workshops and roadshows around the UK, also soil2crop events Also, see relevant entries under soil fertility above
	Other	2	Precision Farming Tool to indicate soil and nutrient variability Cost savings Environmental benefits		Topic Sheet 70: Assessing within-field soil variability Precision farming of cereals - practical guidelines & crop nutrition (leaflet - spring 2002) Various workshops and meetings

MDC	Area	Priority level (1-5)	Key Topics	Provision	Details
	Organic matter	2	Composting practicalities. Limited understanding of why and how to increase organic matter.	Adequate/partial	Grass+ programme
	Structure	2	Need to recognise soil in poor condition	Partial	grass+ chapter 10
	Water erosion and runoff	1	WFD, slurry spreading, FYM.	Partial	grass+ chapter 10. also promote other programmes.
	Wind erosion	N/A			
	Soil fertility	1	Maximising efficiency of use, replacing chemical fertilisers.	Partial	grass+ chapter 11.
	Soil biology	2	Pests and diseases important. Increase awareness that biology and fertility are linked.	None	
	Poaching	2	Access to pasture, timing of return outside to minimise feed costs.	Partial/Adequate	grass+ chapter 4&7. Considerable work through grazing management programme.

MLC	Area	Priority level (1-5)	Key Topics	Provision	Details
	Organic matter	3	Manures and maintaining organic matter levels. Assessment methods Options for enrichment	None	
	Structure	2/3	poaching (outdoor livestock), other management affects, how to reverse. Linking quality and yield Cultivation methods Assessment methods	None	
	Water erosion and runoff	2/3	Identify and split risks Reduce damage (Not an issue indoor livestock)	None	
	Wind erosion	3	risk in upland and hill beef and sheep farms	None	
	Soil fertility	2	Use of clover, maximising returns from FYM	Partial	Within leaflets on clover, part of best practice information
	Soil biology	4	Understanding processes occurring in soil	None	
	Poaching	1	Reducing damage	Partial	Within secondary guides to back up other information from Action for Profit, available on EBLEX web site
	Other	1	Reducing nitrate and phosphates		

HDC	Area	Priority level (1-5)	Key Topics	Provision	Details
	Organic matter	2			
	Structure	2			
	Water erosion and runoff	2			
	Wind erosion	N/A			
	Soil fertility	2			
	Soil biology	1		Adequate	HDC has completed two fact sheets looking at options for soil sterilisation without the growers using methyl bromide. In addition, HDC has completed many technical fact sheets on soil-borne diseases such as Strawberry red core (<i>Phytophthora fragariae</i>) which includes cultural control measures. The vast majority of these will be specific to the crops covered by the HDC.

Appendix B: levy body priorities (provided by ARF)

		BPC	BBRO	HGCA	MLC
Legislative compliance	Understanding GAEC	1	1	1	1
	Complying with GAEC	1	1	1	1
	Nitrate directive consequences	2	1		
	Establish and review soil action plans				1
	Livestock assurance schemes				4
	Effect on water quality (WFD)				3
Structure	Linking quality and yield	1	1	1	1
	Linking better NPK utilisation			2	1
	Linking better water use		2	3	
	Influence of cultivation methods	1	2	1	1
	Influence of cultivation timings	1	2	4	
	Influence of cultivations in rotation	1	2	2	
	Assessment methods (pros and cons)	1	2	1	1
	Subsoiling timing and methods	1	1	2	
Organic matter	Linking quality and yield	3	3	2	
	Linking better NPK utilisation	3	2	3	1
	Linking better water utilisation	3	3	3	
	Influence of cultivation methods	3	3	2	
	Influence of cultivation timings	3	3	4	
	Influence of cultivations in rotation	3	3	2	
	Assessment methods (pros and cons)	3	3	2	
	Causes of depletion		3	2	
	Options for enrichment	1	1	2	1
Erosion	Identifying risks	1	1	1	1
	Splitting the risk	1	1	2	1
	Mitigating the risk	2	2	2	2
	Irrigation and erosion risk				
Grassland production	Choice of varieties				2
	Practical management of stocking densities				2
	Fertiliser application				3

Appendix C: Soil management knowledge transfer – other sources of information

Organic matter

Form	Source	Details
Web	SMI (SMI.org.uk)	Access to publications, contacts for publications, list of events, FAQs
	Environment Sensitive Farming (Environmentsensitivefarming.co.uk)	Link to ppt presentation on GAEC for soils, soil husbandry (2006) Link to word doc describing organic matter and GAEC (2005)
Publications	SMI	Contributions and interactions of cultivations and rotations to soil quality, protection and profitable production
	NSRI	Reports maintenance of organic matter status
Workshops/Practical	Environment Sensitive Farming	Workshops/farm walks on soil husbandry, GAEC for soils (England)
	SMI	Meeting cross compliance Needs – soil protection reviews (UK) Meeting cross compliance requirements – GAEC 1-4 (UK) Benefits of increasing OM in arable rotations (UK) Organic manure and crop organic returns effects on soil quality SMI (Mid's) Member days (UK) Part of national workshop programme (UK)
	LEAF	Soil health Demos (England)
	FWAG	Resource protection workshops (ELS soil management plans) UK
	NSRI	Workshops maintenance of organic matter status (E.&W. England)
Courses	Harper Adams University College	BASIS certificate short course in soil and water management Short course agricultural awareness
	NSRI	BASIS certificate short course in soil and water management
Other	IGER	Grassland Development Farms

Soil structure

Form	Source	Details
Web	<p>SMI (smi.org.uk)</p> <p>Environment Sensitive Farming (Environmentsensitivefarming.co.uk)</p> <p>FWAG (www.fwag.org.uk)</p> <p>SAC www.sac.ac.uk</p> <p>Environment Agency (http://publications.environment-agency.gov.uk/epages/eapublications.storefront)</p> <p>NSRI</p> <p>Macaulay Land Institute (www.macaulay.ac.uk/aweg/soilphysicaldamage.pdf)</p>	<p>Access to publications, contacts for publications, list of events, FAQs</p> <p>Links to PPT presentations on soil management for soil structure, potatoes, outdoor pigs, crop specific guidelines, GAEC (2006)</p> <p>Practical advice on cultivation</p> <p>Compaction in organic farming technical summary Ploughing date for grass-clover leys technical summary A guide for assessing your soil</p> <p>Best Farming Practice (2003) available online</p> <p>A Guide to better soil structure 2001 available online</p> <p>Fact sheet soil physical damage available online</p>
Publications	<p>SMI</p> <p>NSRI</p> <p>Environment Agency</p> <p>Macaulay Land Institute</p>	<p>Guide to crop establishment 2002 Improved soil management for agronomic and environmental gain by SMI 2002 Visual soil assessment booklet (free from Vaaderstadt) Contributions and interactions of cultivations and rotations to soil quality, protection and profitable production (2004)</p> <p>Free booklet on managing soil structure, reports soil structural assessments, soil types, their cropping and management A Guide to better soil structure 2001</p> <p>Best farming practice (2003)</p> <p>Fact sheet soil physical damage</p>

Workshops/Practical	Environment Sensitive Farming	Presentations/Workshops/farm walks on soil husbandry, soil structure, GAEC for soils, sector specific advice (e.g. potato producers, outdoor pigs) (England)
	SMI	Meeting cross compliance Needs – soil protection reviews (UK) Meeting cross compliance requirements – GAEC 1-4 (UK) Improving soil structure workshop E. Mids & SE Reduce compaction technical workshop E.Mids and SE Part of National workshop programme (UK)
	FWAG	Resource protection workshops (ELS soil management plans) UK
	The Arable Group	Cultivations and their impact on agronomy field events (England)
	NSRI	Soil structure assessment workshops soil types, cropping and management (E. &W. England),
	SAC	Understanding the soil - importance of soil structure talk to farmers (Scotland)
	Elm Farm	Soil physical assessment as part of advisory visits on organic conversion (England & Wales)
Courses	Harper Adams University College	BASIS certificate short course in soil and water management Short course agricultural awareness
	Cranfield	BASIS certificate short course in soil and water management Short course soil and land assessment methods Short course soil tillage traction and compaction
	The Arable Group	Cultivation selection training courses (E.England)
Other	SMI/ADAS	video ‘Changing Cultivation Practices’
	IGER	Grassland Development Farms

Water erosion/runoff

Form	Source	Details
Web	<p>SMI (SML.org.uk)</p> <p>Environment sensitive farming (Environmentsensitivefarming.co.uk)</p> <p>DEFRA (http://www.defra.gov.uk/ENVIRONMENT/land/soil/information/publications.htm)</p>	<p>Access to publications, contacts for publications, list of events, FAQs</p> <p>Links to PPT presentations on soil management for soil erosion causes and consequences, potatoes, outdoor pigs, crop specific guidelines, GAEC (2006) Word document describing options for autumn drilling to prevent soil erosion plus preventing pollution from pig and chicken manures and slurries (2005) available online</p> <p>Controlling soil erosion: a manual for the assessment and management of agricultural land at risk of water erosion in lowland England, revised 2005 (PB4093) available online</p>
Publications	<p>DEFRA</p> <p>SEPA</p> <p>SMI</p>	<ul style="list-style-type: none"> • Controlling soil erosion: a manual for the assessment and management of agricultural land at risk of water erosion in lowland England, revised 2005 (PB4093). • Controlling soil erosion: an advisory booklet for the management of agricultural land, 1997 (PB3280) • Controlling soil erosion: an advisory leaflet for preventing erosion caused by grazing livestock in lowland England, 1999 (PB4091) • Controlling soil erosion: a field guide for an erosion risk assessment for farmers and consultants, 1999 (PB4092) • Controlling soil erosion: an advisory leaflet for preventing soil erosion in the uplands, 2001 (PB5820A) • Controlling soil erosion: an advisory leaflet for preventing erosion by outdoor pigs, 2001 (PB5820C) • Controlling soil erosion: incorporating former advisory leaflets on grazing livestock, wind, outdoor pigs and the uplands, 2005 <p>SAPG review of agricultural pollution including role of soil protection (2003)</p> <p>Improved soil management for agronomic and environmental gain by SMI</p>
Workshops/Practical	Environment sensitive farming	Workshops farm walks soil conservation, reducing diffuse pollution (England)

	SMI LEAF FWAG The Arable Group ADAS NSRI Landcare	Meeting cross compliance Needs – soil protection reviews (UK) Meeting cross compliance requirements – GAEC 1-4 (UK) Mini settlement pond benefits (E. Mid’s) Water Framework Directive – modifying tillage practice (E. Mid’s & S.E.) Reduce compaction, runoff and soil erosion (Midlands, S. & SW) Soil protection demos (England) Resource protection workshops (ELS soil management plans) (UK) Erosion workshops on behalf of DEFRA (E. England) ENSUS (Env sustainable farming club) Farm visits, workshops, demos (S.W.Eng) Workshops enhanced runoff and soil erosion, avoidance of muddy floods (E.&W. England) Free workshops soil management plans and diffuse pollution(S.Eng)
Courses	Harper Adams University College Cranfield	BASIS certificate short courses in soil and water management, agricultural awareness. BASIS certificate short course in soil and water management (1 week) Short course erosion control
Other	SOWAP IGER	Soil management open days (UK) Grassland Development Farms

Soil wind erosion

Form	Source	Details
Web	DEFRA http://www.defra.gov.uk/ENVIRONMENT/land/soil/information/publications.htm Environment Sensitive Farming EnvironmentSensitiveFarming.co.uk	Controlling soil erosion: incorporating former advisory leaflets on grazing livestock, wind, outdoor pigs and the uplands, 2005. Available online Links to PPT presentations on erosion control
Publications	DEFRA	<ul style="list-style-type: none"> Controlling soil erosion: an advisory leaflet for preventing soil erosion by wind, 2001 (PB5820B)
Workshops/Practical	SMI ESF	Meeting cross compliance Needs – soil protection reviews (UK) Meeting cross compliance requirements – GAEC 1-4 (UK) Workshops/farm walks
Courses	Cranfield	Short course erosion control

Poaching by Animals

Form	Source	Details
Web	<p>Environment Sensitive Farming Environmentsensitivefarming.co.uk</p> <p>Environment Agency http://publications.environment-agency.gov.uk/epages/eapublications.storefront</p> <p>NSRI www.silsoe.cranfield.ac.uk/nsri/pdfs/structure_brochure.pdf</p> <p>Macaulay land institute www.macaulay.ac.uk/aweg/soilphysicaldamage.pdf</p>	<p>Links to PPT presentations on soil management for soil structure</p> <p>Best Farming Practice (2003)</p> <p>A Guide to better soil structure 2001 available online</p> <p>Fact sheet soil physical damage available online</p>
Publications	<p>Environment Agency</p> <p>Macaulay Land Institute</p>	<p>Best Farming Practice (2003)</p> <p>Fact sheet soil physical damage available online</p>
Workshops/Practical	<p>British Grassland Society</p> <p>SAC Farming Connect</p> <p>ELS</p>	<p>Grazing discussion groups/farm walks (UK)</p> <p>Grazing discussion groups/farm walks (Scotland)</p> <p>Grazing discussion groups/farm walks (Wales)</p> <p>Workshops/farm walks</p>
Courses	Netherfield centre	Grassland management 1 day course
Other	IGER	Grassland Development Farms

Soil Biology

Form	Source	Details
Web	SMI (SMI.org.uk)	Influence of Cultivation Practices on Arable Crop Diseases (2003) (available online)
Publications	SMI	Influence of Cultivation Practices on Arable Crop Diseases (2003)
Workshops/Practical	Elm Farm	Soil biodiversity talks and presentations (UK)
Courses		

Other	SOWAP	Soil biodiversity open days (UK)
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Soil fertility

Form	Source	Details
Web	DEFRA (http://www.defra.gov.uk/enviro/pollute/rb209/)	Fertiliser recommendations for agricultural and horticultural crops (RB209), 2000 available online
Publications	DEFRA	Fertiliser recommendations for agricultural and horticultural crops (RB209), 2000
	SAC	Fertiliser guides
Workshops/Practical	Environment Sensitive Farming	Nutrient planning for yield and the environment workshops for planet computerised system
	Elm farm	Soil nutrient management (organic) on farm seminars (Eng) Soil fertility management and physical assessment as part of advisory visits, talks and presentations (organic) (Eng & Wales)
	ADAS	Nutrient and manure planning farm visits/advisory reports (Wales)
Courses	Harper Adams College	Soil nutrition (BASIS)
	ADAS	Horticulture FACTS training courses (S.East)
	Cranfield	Short course introduction to soil management Short course soil assessment methods
Other	IGER	Grassland Development Farms

Appendix D: potential service provision (non levy body service providers)

Subject area	Source	Details	Form	Coverage
Organic matter	Enviros	soil improvement using composted materials and organic manures	Awareness training	UK
	Rothamsted	Soil management for cross compliance SOM quality indicators	advice to farmers advisory leaflets or direct farmer contact	UK UK
	Netherfield Centre	Topdressing with organic matter Composting FYM training and advice	training and advice	High/Low Weald
Structure	Elm Farm	Physical assessment and diagnosis, remediation	Training sessions and demonstrations	England and Wales
	SOWAP	Economic cost:benefit of soil management for arable farmers	open days, newsletter	UK
	The Arable Group	cultivations tyre choice and management	training events, publications	England
	Harper Adams College	Basic soil assessment	short courses and technical open days	W.Midlands/national
	SAC	soil structure management and nutrients preventing soil compaction	talks, website, open days/events	Scotland
	NSRI	arable structure assessment repairing degraded arable soil structure machinery work days	seminars, good practice days	UK

Water erosion and runoff	Lancaster University	diffuse pollution control and soil erosion control	Open Days, short courses	UK
	The Arable Group	diffuse pollution and erosion	training events, publications	England
	FWAG	specialist advice on soil management linked to catchment sensitive farming	Workshops, events and one to one advice	England
	SAC	Outdoor pig units soil management	Workshops, events and one to one advice	Eastern England
	Durham University	Soil conservation	talks, website, open days/events	Scotland
	NSRI	nutrient export, soil and peat erosion	Stakeholder advice	UK
	ADAS	integrating soil and water management recognition erosion risks runoff from grasslands	Creation of management network workshops seminars, good practice days	UK UK
Poaching by animals	SAC	soil structure and livestock	seminars, workshops, farm demos, publications	UK
	NSRI	assessment of grassland soil structure safe grazing days compacted grasslands	talks, website, open days/events	UK
Soil fertility	Elm Farm	Organic farming soil fertility remediation	workshops seminars, good practice days	UK
	Enviros	nutrient budgeting including composted materials and organic manures	Training sessions and demonstrations	England and Wales
Soil fertility (cont.)	Rothamsted	Fertiliser recommendation Sulphur recommendations	Awareness training	UK
			model revision sulphur supply mapping	UK UK

	The Arable Group IOTA Netherfield Centre ADAS	soil fertility and nutrient management soil analysis types and use, trace elements, fertility management (organic) Albrecht analysis system FYM as a fertiliser soil nutrient and manure planning	training events, publications workshops or seminars training and advice seminars, workshops, farm demos, publications	England UK High/Low Weald UK
Soil biology	Elm Farm IOTA NSRI	General coverage General coverage Research into soil biology under crops and grassland	Demonstrations, lectures and field days workshops or seminars N/A	England and Wales UK N/A
Other	The Arable Group Harper Adams College FWAG Cresswell Associates SAC NSRI	pesticide leaching to water value of soil in the environment soils issues awareness training Managing soils for habitat restoration soils and the environment development of best practice management plans	training events, publications short courses and technical open days workshops and events training courses talks, website, open days/events linking farming community to scientific/engineering,	England W.Mids/national England UK UK UK