The knowledge challenge within the transition towards sustainable soil management: an analysis of agricultural advisors in England

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Abstract

The sustainable management of soils, while constituting an important resource conservation concern in some contexts, has been neglected in the UK. However, this all seems set to change, with implications for various actors within the agricultural knowledge system. New policies designed to encourage the more sustainable management of soils in England together with the introduction of Soil Management Plans (SMP) as part of cross-compliance under recent Common Agricultural Policy reform mean that demands on agricultural advisors' knowledge about soil will increase. This paper reports the findings of research into the nature and extent of agricultural advisors' knowledge about soil best management practice. Specifically, it examines the 'know-what', 'know-why' and 'know-how' of soils among agricultural advisors through analysis of data collected from an extensive postal questionnaire survey of 162 advisors across England supplemented by qualitative data from semi-structured interviews with 64 advisors. The results show that as a community advisors are generally knowledgeable about soil best management practice and appear to be observing soil degradation, undertaking training, using guides, tools and recommending soil best management practice to a relatively large extent. The data however do indicate that different types of advisors hold different forms of knowledge to a different extent. They also reveal gaps in knowledge gained through practical experience about cultivation and using the nutrient value of manures. The paper concludes that advisors' knowledge about soil and its sustainable management is considerably greater than earlier research on advisors' environmental knowledge has suggested but that some areas will have to be significantly enhanced and standardised to meet the new policy challenges. The significance of the results is discussed in

terms of the wider role advisors play in the transition from 'production only' goals towards those concerned with more sustainable practices in agriculture.

Key words: agricultural advisor, knowledge, sustainable soil management, soil best management practice, policy, CAP,

1. Introduction

In some geographical contexts, the soil has constituted a major environmental concern and has been the focus of considerable conservation effort (Conacher and Conacher 1995; Morgan 1995; Hartemink and van Keulen 2005). Meanwhile, in the UK, despite mounting evidence of threats to the soil; this crucial resource represents something of an 'agri-environmental lag issue', both in policy and industry terms. Compared to biodiversity and landscape, and also to the resources of air and water, soil has attracted little regulatory commitment and policy interest. While a 'Code of Good Agricultural Practice for Soil' (the Soil Code) has been in place since 1993, adherence to this by farmers is voluntary; a reflection perhaps of the limited formalised interest in soil amongst the 'conventional' farming community[1] and industry in general. At the same time, within social scientific research into policy and agri-environmental management issues in the UK, soils have remained an 'unseen' factor on the farm[2]. When compared for example to nature and landscape conservation, research on soils and their sustainable management has been insignificant. Recent policy developments in Europe and in England, such as the 'First Soil Action Plan' published by Defra[3] in 2004 mean that land managers will be unable to ignore the issue of soil management on the farm. With growing policy attention and the introduction of Soil Management Plans (SMP) proposed for each farm from 2006,

[1] The organic movement attribute particular value to sustaining the soil resource seeing it as part of the trinity healthy soil, healthy plants and healthy people. Organic agriculture however currently constitutes a small proportion of farmers and utilisable agricultural area in the UK.

[2] There has of course been a considerable volume of soil science research (Royal Commission on Environmental Pollution 1996; Drew Associates. 2003.

[3] Department of Environment, Food and Rural Affairs, formerly the Ministry of Agriculture, Food and Fisheries (MAFF).

demands on farmers' soil management competencies will increase. It has already been recognised that sustainable soil management practices, along with other sustainable farming practices, are more demanding on the skills and knowledge of farmers (Kloppenburg 1991; Roling and Jiggins 1994), highlighting that knowledge is the crucial 'fourth factor of production' (Winter 1997).

However, and in spite of Doran's (2001 p.1) assertion that 'the ultimate determinant of soil quality and health is the land manager', it is not only farmers and other land managers who will be challenged by the new soil policy agenda in England. While social scientists with an interest in policy implementation are often all too quick to focus on farmers as the principal target group of new agri-environmental policies, other actors are also significant in this process. Among them are the 'street level bureaucrats', the civil servants (and equivalent professionals in the private sector) who are responsible for 'delivering' policy (both directly and indirectly) to target groups (Lipsky 1980; Lowe et al. 1997; Cooper 1999). In an agricultural context these are the agricultural advisors, a diverse and increasingly fragmented community in England. New policies designed to encourage the more sustainable management of soils will mean that demands on knowledge equivalent to those faced by farmers will be made of the agricultural advisory community. As such, this paper reports the findings of research into the nature and extent of agricultural advisors' knowledge about soils and their sustainable management. This is undertaken as an initial step towards evaluating these actors' 'fitness for purpose' in supporting the transition to sustainable soil management on farms in England that policy now seems to be demanding. Specifically, by drawing on Lundvall and Johnson (1994), it examines the 'know-what', 'know-why' and 'know-how' of soils among agricultural advisors through analysis of data collected from an extensive postal questionnaire survey of 162 agricultural advisors across England. These quantitative data are supplemented by qualitative data from semi-structured interviews with 64 agricultural advisors. The paper initially provides a brief review of the problems facing the soil resource in the UK and details the nature of the policy response, specifically in England, to these

problems[4]. It then moves on to discuss the changing structure and operation of the agricultural advice system and describes the on-going significance of agricultural advisors on farm. Consideration is then given to how agricultural advisors and their knowledge is conceptualised within the study and this is followed by an elaboration of the research methods. The empirical material on the nature and extent of advisors' knowledge about soil best management practice is then presented. In conclusion, the paper highlights the range and depth of advisors' soil knowledge in England, but also points to where gaps remain (notably in relation to the vital area of cultivation) which require both a policy response and further research effort.

2. An emerging policy agenda for soils in Europe and the UK

Decline in soil quality in the UK has been largely attributed to intensive arable farming encouraged by the Common Agricultural Policy (CAP) where farmers reacted positively to support payments during the 1970s and 1980s (Boardman 1990; Baldock and Mitchell 1995; RCEP 1996; DETR 1998; Boardman et al. 2003a). Emphasis on efficient food production has encouraged continuous arable cropping, winter cereals, increased cultivation with heavier machinery, ploughing up of pasture, minimal rotations, the inappropriate use of marginal lands which are more sensitive to degradation, and overgrazing in upland areas all resulting in negative consequences for the soil (Baldock and Mitchell 1995; DETR 1998; Joint Nature Conservation Council JNCC 2002). More recent reports suggest that the problem is continuing and the farming community have been urged to improve their understanding and husbandry of soil (Environment Agency 2004a,b). These are all problems recognised internationally (Global Assessment of Soil Degradation (GLASOD) 1990; World Resources Institute 2005).

A number of policy initiatives have emerged in recent years in recognition of the increasing threats to the agricultural soil resource both in Europe and in UK. In Europe concerns about soil degradation have culminated in the European Commission's (EC) communication 'Towards a Thematic Strategy for Soil

[4] The focus on England rather than the UK as a whole is justified as policy making is devolved to the agricultural departments of the constitutive countries i.e. England, Wales, Scotland and Northern Ireland.

Protection' adopted by the European Parliament in 2003 (Commission of the European Communities 2002). However, this was preceded in the UK by the Royal Commission on Environmental Pollution's publication, in 1996, of 'The Sustainable Use of Soil'. This was a significant step and it recommended a soil protection policy for UK, with agricultural soils as a central element. Developments since then in England have included the publication of 'A Draft Soil Strategy for England – a consultation paper' (DETR 2001) and more recently the publication of 'The First Soil Action Plan for England' (Defra 2004a), which outlines the key actions the government needs to take to achieve the aims of the strategy. Together with a number of other key documents (e.g. Environment Agency 2004a,b) this heralds a new era of policy concern for the soil. The EC's Water Framework Directive also focuses attention on soil in its multifunctional role as environmental protection and pollution prevention medium. The Directive has a particular focus on diffuse pollution and increasing pressure through this and regulation (more than 50% of England have been designated as Nitrate Vulnerable Zones), is expected to be applied to farmers to manage their soils and take effective action to control soil, pesticide and nutrient losses in many vulnerable catchments (Defra 2004c,d,e).

However, it is the introduction of 'Good Agricultural and Environmental Conditions' (GAEC), as part of environmental cross compliance associated with the Single Payment Scheme in the most recent CAP reforms[5] that heralds the greatest challenge for land mangers with regard to soil management (Defra 2004b). A Soil Management Plan (SMP) proposed for each farm will become central to GAEC. From 2005 land managers will be expected to retain and follow the consolidated GAEC guidance management of agricultural soils on their land and in accordance with this draw up risk based SMP in 2006 to be implemented from 2007. The farming community recognise the significance of this. For example, the popular trade journal Farmers Weekly stated 'Farmers have been warned they must wake up to soil management or risk losing their Single Payment Scheme' (Farmers Weekly 2004a). The appearance of a Soil Focus web page on the journal's interactive website, which aims to keep

[5] The 2003 CAP reform package adopted a new deregulatory approach to farm support, by decoupling agricultural subsidy from production. Ten major CAP payment schemes will be replaced by one new Single Payment Scheme. As part of the reform, payments to farmers will have to meet new 'cross-compliance' standards designed to protect the environment, animal health and welfare, public health and plant health.

farmers up to date with developments, demonstrates that the industry are starting to take soils seriously (www.fwi.co.uk).

All these developments emphasise the desirability of a shift towards the more sustainable 'best management practice' or 'good soil husbandry' of soil as set out in the 'Soil Code' (MAFF 1998), the document 'Best Farming Practice' (Environment Agency 2001); echoed in 'catchment sensitive farming' (Defra 2004d,e); detailed in numerous Defra funded publications (DETR1998; ADAS et al. 2000; UK Soil Management Initiative SMI 2005); and now described in the Cross Compliance Guidance for Soil Management (Defra 2005). These best management practices are based on a number of fundamental principles including: maintenance of soil structure through enhanced soil organic matter content and careful cultivation to avoid compaction, overworking and runoff; as well as the management of soil as a buffer for nutrients by targeting artificial and organic fertilisers effectively.

These soil best management practices can be non-prescriptive and demand attention to detail, observation as well as an understanding of the scientific principles on which the practices are based for their successful implementation (OECD 2001). Farmers can lack familiarity with and experience of such practices. As such there is a clear requirement for more information and on-farm advice to support them in their transition to using soil best management practice. This has also been demonstrated for other knowledge demanding practices which provide environmental and soil benefits such as integrated farming systems (Park et al. 1997; Morris and Winter 1999), reduced tillage (Tebrugge and Bohrnsen 2001; Coughenour 2003) and organic farming (Burton et al. 1999). It has also been acknowledged by Defra in their statement:

> 'We recognise that the development and implementation of a risk based soil management plan addressing the GAEC measures adequately, even at the simple level proposed, may be a large step for some farmers. We will achieve this if we develop first the knowledge base and understanding of farmers /land managers' (Defra 2004b p.16).

A further complication is the high level of variability in farm types and practices, landscape, climate and soil type. All these factors influence the condition of soil and

the practices required to maintain good condition. This, as Defra accepts, makes defining a set of national standards difficult:

> 'We do not propose this prescriptive approach but an individually tailored risk based SMP produced by each farmer. The SMP approach will require farmers to understand and analyse risk on their farm prior to undertaking measures that target a practical problem. It allows farmers some choice selecting measures appropriate to their situation' (Defra 2004b p.17).

Defra intends to develop the knowledge base through publication of a new guidance on soil management[6]. However, past experience has shown that farmers rarely consult such literature due to lack of inclination and/or time (COI 1996; Dampney et al. 2001). Furthermore such individuality and local farm based planning needs more than a standard guidance publication, and requires in addition detailed and tailored local knowledge. Arguably it is the advisors providing on-farm advice who have potentially the most important role in supporting farmers to prepare and implement SMPs. Their role is considered to be particularly significant given the complexity of the practices and the need to adapt them to each farm's soil types and practices. It is to the advisory system and the advisors who comprise this that the discussion now turns.

3. Agricultural advisors in the transition to sustainable soil management

Within the policy developments outlined above emphasis is being placed on increasing the amount of advice and 'knowledge transfer'[7] to farmers in the recognition that, as Garforth et al. (2003) note, information and advice are important tools in the achievement of policy objectives. The planned introduction of the SMPs as part of the GAEC and the First Soil Action Plan will make new demands on advisors, something which has not escaped the attention of industry (Farmers Weekly 2004b). Defra (2004b) and other commentators also recognise this; as Professor Godwin of the National Soil Resources Institute (NSRI) recently remarked:

[6] The 'Single Payment Scheme - Cross Compliance Guidance Notes for Soil Management' was published by Defra in 2005 and distributed to all farmers.

[7] It is acknowledged that 'knowledge transfer' is a problematic term. Its use in this sense is to imply communication of policy objectives and associated practices to farmers. As Garforth et al. (2003: 326) state 'knowledge transfer' may be the convenient shorthand for a process in which knowledge generated by research is integrated with technology used within the agricultural industry'.

> ‘To maintain GAEC, farmers will need advice and guidance to help them assess their land to identify problem areas and select measures to tackle issues such as curtailing erosion, minimising run-off and managing soil compaction’ (Farmers Weekly 2004a).

In the same way Defra acknowledge that ‘catchment-sensitive farming’, which has been proposed to combat diffuse pollution, will require additional advisory support (Defra 2004e). Plans are already underway for Defra to develop a strategy for providing farmers and other land managers with practical information and advice for building good soil management into overall farm planning as part of Action Three of the First Soil Action Plan, whilst Defra’s *Rural Strategy* (Defra 2004f) proposes a new advisory package to support the introduction of the cross-compliance requirements. All of these initiatives are based on an understanding that advice to farmers is crucial to achieving sustainable farm practices. Agricultural advisors are central to providing this advice.

Through their on-farm visits agricultural advisors are well placed to support the farmer in the context of local conditions, and farmers particularly value the interpretation of information at the farm level that advisors provide (Jones et al. 1987; Dampney et al. 2001). Of all methods of communication, the individual farm visit by an advisor remains one of the most powerful and effective, and is most valued by the farmer (Jones et al. 1987; Eldon 1988; Cox et al. 1990; Fearne 1991; Angell et al. 1997; ADAS 2000). The growth in numbers of both independent agricultural advisors and conservation / environmental advisors in England is testament to this. Of course, the agricultural advisor has always been an important and influential actor on the farm. Government advisors were a central component of the British state advisory service during the productivist years of the 1950s to the 1980s, helping farmers exploit opportunities to improve economic efficiency through delivering specialist technical advice. Agricultural advisors have also been influential in assisting policy makers in the implementation of policies and in changing farmer behaviour (Long and van de Ploeg 1989; Rogers 1995; van den Ban and Hawkins 1996). Those commenting on the implementation of agri-environmental and pollution policies in the UK recognise and provide evidence for this (Baldock and Mitchell 1995; Burton et al. 1999; Cooper 1999; ECOTEC 2000; Juntti and Potter 2002).

Whilst it cannot be denied that other mechanisms that promote farmers' learning, such as demonstration farms, farmer-farmer interaction and group learning are increasingly important (Cerf et al. 2000; Roling and Wagemaker 2000; Garforth et al. 2003), advisors remain an essential component of the agricultural knowledge system. This is particularly so given farmers increasing reluctance to share knowledge with their peers as each tries to retain a competitive advantage (Angell et al. 1997). In addition, it is argued that the unfamiliarity of many environmental problems and their technical solutions means that farmers are themselves often ill-equipped to deal with them and need specialist inputs from advisors (Vanclay and Lawrence 1995).

Furthermore, no single land manager can be expected to be fully conversant with markets, technologies of production, legislation changes, environmental processes, catchment agendas and other related issues and so the advisors' role today is more essential than ever. Increasingly, there is a need for advisors and consultants who can provide the necessary specialist inputs to farming operations. Advisors continue to span the interface between science and practice and as such introduce technical innovations and provide understanding of new demanding policies, regulations, technologies and practices. Given this influential role, the potential role of consultants in relaying policy messages about environmental protection and sustainable practices has been already been identified (Archer 2001; Dampney et al. 2001) and has been given specific recognition within Defra's Learning, Skills and Knowledge Programme Review (Defra 2004g).

However, whilst it is accepted that advisors are an important and influential actor on the farm little is known about the role played by different types of agricultural advisors in the transition to sustainable farming systems, and their level of competence and knowledge in relation to soil management in particular. Although more recently attention has been directed towards farmers' knowledge and skills in soil management, albeit in other countries (Romig et al. 1995; Walter et al. 1997), advisors knowledge and skills have been ignored in this resource context, representing a significant research gap[8]. Studies of agricultural innovation or extension have

[8] Similarly, Dove (1992) has recently argued that more attention needs to be paid to the environmental knowledges held by 'state officials', including advisors, when examining resource management

conceptualised advisors variously as disseminators or change agents (Rogers 1995), field level bureaucrats delivering agri-environment policy (Cooper 1999), mediators between the land manager and multiple sources of information and expertise (Garforth et al. 2003), purveyors of expert knowledge (Burgess et al. 2000); representatives of commercial organisations (Hawkins 1991; Lyon 1996); or as facilitators who act to connect and empower farmers and assist in their structural learning and reskilling (Bager and Proost 1997). There is also a suggestion that commercial advisors in particular promote intensification and exhibit, what Wilson (2001) has called, 'productivist modes of thinking'. This is attributed to a 'structural inertia' in providers due to a heritage of production advice which is considered to be enduring within all advisory services (Gasson and Hall 1996; Winter 1996; Curry 1997). Research has focused less on advisors as holders of knowledge and as competent, knowing and active actors. However, there is increasing recognition that advisors are professionals with expertise, skills, techniques and individual competencies; that they define problems and information needs, acquire information, learn skills and handle a diversity of sources and types of information (Engel 1990). This paper provides detailed empirical evidence on the nature and extent of advisors' knowledge about soil best management practice and their contribution to on-farm soil management decisions. It is based on research, which uses a combination of quantitative and qualitative techniques, on all types of agricultural advisor associated with the provision of soil management advice in England carried out between 2000-2003.

4. Theoretical considerations

A number of commentators (Murdoch and Clark 1994; Roling and Jiggins 1994) have identified a paradigm shift in the understanding of knowledge in relation to sustainable agriculture. Sustainable practices, in that they are complex, locally specific and knowledge intensive, are thought to be qualitatively different from conventional farming techniques (Kloppenburg 1991). The knowledge and management 'richness' or intensity of such practices as integrated farming systems (IFS) and reduced tillage are emphasised (Coughenour 2003); the need for 'clever'

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conflicts in developing world contexts. Robbins (2000) reveals how these knowledges may sometimes be more closely aligned to those held by 'local people' than research has previously given them credit.

soil management which deviates from existing concepts of land use as well as more emphasis on observation, monitoring and judgment are also stressed (Park et al. 1997; Auerswald and Kutilek 1998; Morris and Winter 1999; Tebrugge and Bohrnsen 2001). These practices demand that advisors, rather than acting as simple messengers, need to be informed about developments in soil best management practices, must understand the scientific principles that underpin these practices, and acquire practical experience and skills in recommending them. The extent to which advisors are 'equipped' with these elements of knowledge for sustainable soil management is a central concern of this study.

The typology of knowledge proposed by Lundvall and Johnson (1994) provides a useful conceptual framework for examining advisors' knowledge about soils[9]. They identified four forms of knowledge: know-what, know-why, know-how and know-who, the first three of which are relevant to this research[10]. Know-what refers to knowledge about facts, which is largely codified. According to Mokyr (2002) know-what includes observation, classification, measurement and cataloguing of natural phenomena. Know-why is the knowledge of principles, rules and ideas of science and technology. Know-how refers to skills, the capability to do something at practical level, as reflected in action and has a significant tacit component. As such these three elements of knowledge can be used to frame the research questions: what facts do advisors hold about soil management (know-what)? What is their understanding of the principles that underpin these facts (know-why) and how skilled and experienced are they in recommending soil best management practice on-farm (know-how)?

[9] Other conceptual frameworks understand knowledge as the outcome of behavioural change (Napier et al. 1984); of interpretative struggles (Long 1992; Juntti and Potter 2002); of social construction and culture (Burgess et al. 2000; Tsouvalis et al. 2000); of learning and experience (Ison et al. 2000); or of communication through systems and networks (Latour 1987; Roling 1992; Curry and Winter 2000). Lundvall and Johnson's typology however, in that it helps to reveal the many different elements of knowledge that advisors might hold and use about soil, provides the most useful framework in the context of this study.

[10] 'Know-who' is the knowledge of individuals gained through shared interactions and networking. Although considered in this investigation, it is not central to the analysis for this paper.

Morgan and Murdoch (2000) refined these knowledge forms further into two main types codified (know-what and know-why) and tacit (know-how). The former is described as explicit, standardised knowledge which can be systematised, written, stored and transferred while the latter is described as implicit, local, context dependent, inherently intangible and results from talents, experience and abilities[11]. However, whilst Morgan and Murdoch (2000) emphasised the differences and tensions between codified (also known as scientific) and tacit (also known as local) knowledge forms[12], others argue that these knowledge forms are complementary and relational (Molnar et al. 1992; Nonaka and Takeuchi 1995; Pretty 1995; Black 2000). For example, Mokyr (2002) suggests an interdependence between these forms and argues that know-what provides the basis for know-why[13] and that know-why, although mostly codified, relies considerably on tacit knowledge for interpretation particularly at the level of individual understanding. This perspective accords with those who propose that, rather than discrete categories, knowledge is comprised of hybrids or blends of all knowledge forms (Murdoch and Clark 1994; Clarke and Murdoch 1997). In accordance with this view, this study understands that the knowledge forms know-what, know-why and know-how are mutable and relational.

5. Methodology

The data on agricultural advisors and their knowledge of soils, which are presented in the subsequent section, are derived from research which combined an extensive postal questionnaire survey of a range of agricultural advisors and semi-structured interviews with a selected group of advisors. The former was used to quantify the nature and extent of advisors' knowledge about soil best management practice while the latter enabled understanding and explanation of these figures. It is proposed that a methodology that includes quantitative and qualitative methods will capture the

[11] What Thrift (1985) termed 'practical knowledge' shares many features of tacit knowledge or know-how, being informal and learnt from experience of watching and doing .

[12] This is central to the wider debate about scientific and local knowledge and their respective suitability for sustainable agriculture (Kloppenburg 1991; Molner et al. 1992; Clark and Murdoch 1997).

[13] Mokyr (2002) defines know-what as propositional knowledge which can be used to create know-why or prescriptive knowledge otherwise called techniques. This suggest that know-what (episteme) provides the basis for know-how (technique), that one knowledge form feeds on another.

different forms of knowledge as well as the relationship between them, as discussed above.

Given the proliferation and resulting diversity of advisors in the Agricultural Knowledge System (AKS) in England since the privatisation of the state advisory service ADAS in 1997 (Winter 1995; Dampney et al. 2001; Winter et al. 2001; Garforth et al. 2003), there was a need to identify those most likely to make some contribution to soil management decisions on-farm. As soil best management practices are not specialist technologies but integral to all farm practices they become the potential remit of a wide range of arable, environmental protection and conservation advisors offering commercial and public good advice. Also, opportunities for involvement in soil best management practice are expanding in a more open and flexible AKS. In particular, advisors' engagement with farmers within project[14] and NGO contexts, rather than exclusively on a one-to-one basis on-farm, needs to be recognised. Consequently the target population for the questionnaire survey was all agricultural advisors in England whose advice might have some impact on soil management decisions on the farm.

Synthesis of information from a number of recent reviews of advice provision in the environmental protection and conservation communities (Archer 2001; Dampney et al. 2001; Winter et al. 2001) provided a sampling frame and 304 questionnaires were sent to individual advisors in four categories as follows: conservation advisors in the Farming and Wildlife Advisory Group (FWAG) and National Trust; agri-environment scheme advisors in Defra's Rural Development Service (RDS)[15] (including advisors in the Organic Advisory Service); independent agronomists (crop consultants) identified through the Association of Independent Crop Consultants (AICC) and

[14] Advisors are becoming partners with other state, private and NGO actors within initiatives aimed at promoting soil best management practice for example the Soil Management Initiative UK, and the Upper Hants Avon Landcare project.

[15] The Farming and Wildlife Advisory Group is a well established NGO which offers on-farm, tailored environmental advice. FWAG advisors are farm conservation specialists. The National Trust is an environmental charity which owns land and buildings throughout the UK and has been actively developing the environmental management of its tenanted farms. Defra's RDS project officers manage and administer government funded agri-environment schemes.

British Institute of Agricultural Consultants (BIAC); and ADAS advisors. A fifth category, commercial agronomists working for agro-chemical and seed distributor companies, were approached separately through the Fertiliser Advisors Certification and Training Scheme (FACTS)[16]. Due to the different approaches to identifying potential advisors non-probability sampling was used to target certain sectors. However, in most cases all advisors providing soil management advice were approached ensuring that as far as possible the full population was contacted. In total 163 questionnaires were returned with an average response rate of 40% for the first four categories. It was not possible to estimate a response rate for the FACTS respondents[17].

Quantitative data from the questionnaire were complemented by qualitative data derived from semi-structured interviews with a range of advisors from the same categories. These advisors were associated with three soil management initiatives in England which were promoting targeted use of nitrogen (N), use of nutrients within manure and good cultivation practice to improve soil structure. Selection of advisors for interview within these initiatives was based on geographical location (where the initiative was in a distinct area), involvement, and or, likely interaction with the initiative. Sampling was undertaken using lists of advisors participating in the initiative, local directories of advisors and the snowball technique. Sixty-four advisors were interviewed in total.

These interviews provide different accounts and interpretations which both add to the multiple sources of evidence and assist in the triangulation of quantitative material. In the sections presenting the empirical material, the know-what and know-why of advisors' soil knowledge will be examined, that is, their knowledge about soil best management practice and the application of this knowledge and understanding of the principles of soil best management practice. Although it is hard to distinguish the know-what and know-why elements of soil knowledge, it is proposed that the extent of advisors' observations of soil degradation, of training undertaken and of advisors'

[16] FACTS provides a national training syllabus and accreditation for arable advisors.

[17] Questionnaires were emailed on our behalf through the FACTS organisation to an unknown number and sector of the membership.

use or reference to guides produced which describe and explain soil best management practice, will be examined to reveal the know-what element. The extent of advisors' use of Defra tools available to assist farm soil management decisions and their recommendations of soil best management practice gives some measure of their understanding and use of scientific principles and rules in the context of soil management[18] and will be used to reveal the know-why component. The interview data will also provide some insights in the know-what and know-why elements but principally it will reveal the tacit know-how element of advisors' (principally agronomists') soil knowledge, by examining their experience, skills and competence in practical soil management. Table 1 shows the relationship between the methodology, research questions and the conceptual framework.

[18] RB209 Fertiliser guide, MANNER software, Managing Livestock Manures booklets for example are all based on scientific understanding of N mineralisation.

Table 1 The relationship between knowledge forms, research questions, methodology and method

Knowledge form	Know-what	Know-why	Know-how
Knowledge type	Codified	Codified	Tacit
Source	Facts and information	Scientific principles and laws	Skills acquired through experience
Organisational level	Shared databases	Shared interpretations	Shared routines
Research questions/data to be collected	What do advisors observe about soil condition? To what extent do advisors know about the Soil Code and other DEFRA guides? To what extent do advisors undertake training?	To what extent do advisors use DEFRA tools? To what extent do advisors interpret observations, guides and tools into recommendations?	How many years experience do advisors have in the job? What are advisors skills in soil best management practice on-farm?
Methodology	Quantitative	Quantitative Qualitative	Qualitative
Method	Questionnaire	Questionnaire Interview	Interview

(All other tables and figures at end of paper)

6. Advisors' knowledge about soil best management practice

This section of the paper examines the know-what and know-why elements of knowledge about soil best management practice held by advisors by analysing their observations of soil degradation, their training, their knowledge of soil best management practice guides, their use and recommendation of tools and the extent of soil best management practice recommendations made.

6.1 Advisors' observations of soil degradation

It is striking that more than 50% of all the questionnaire respondents had observed what they described as 'severe' water erosion, compaction, capping and poor drainage

attributed to inappropriate land use over the last two years (Figure 1). Obviously some soils are more vulnerable to degradation than others and, as this data cannot be related to any particular soil type, care must be taken in its interpretation. For example, the small percentage witnessing wind erosion is likely to be the result of its restriction to specific soil types predominantly found in East Anglia. Nearly all respondents stressed the localised occurrence of degradation. This is demonstrated by different observations even within the same geographical area, as these contrasting statements from agronomists[19] working in the Upper Hants Avon catchment reveal:

> I think everyone's very conscious about erosion … it's very noticeable on roads. It's a big thing particularly on the Greensand. Some of the gullies in Hants are a foot wide and a foot deep, they all got ploughed in and with more rain it got washed out again, unbelievable, quite extraordinary (Distributor agronomist R).

> From my experience driving around South Wiltshire not very much is washed straight out of the field onto the road, there are not huge amounts of soil moving down the road, but there is a fair amount that comes down tracks (Distributor agronomist G).

Despite localised differences the questionnaire data do, however, give an impression that many advisors are observing a range of soil conditions which they interpret as symptomatic of degradation. In accordance with these observations of soil degradation, more than 65% of all respondents thought that soil degradation was a problem in English agriculture (Table 2). Notably approximately the same proportion of agronomists as ADAS advisors thought it a problem compared to a higher percentage of non-arable advisors, RDS (83%) and conservation advisors (100%). Again most agronomists noted the localised and irregular nature of degradation, and its occurrence being coincident with extreme wet conditions; they were reluctant to call it a universal problem.

6.2 The extent of advisors' training and FACTS registration

A large number of advisors from all sectors claimed to have undertaken training to assist them with soil best management practice recommendations, as Table 3 shows. Agronomists are increasingly required to train in environmental practices both to get

[19] The term agronomist is used here synonymously with crop consultant.

Professional Development points for FACTS/BASIS and to be able to meet more challenging farmers' requests. Although soil management training is not given *per se*,[20] it is integral to the FACTS courses; to the training provided by ADAS as part of Defra's campaigns to promote RB209, MANNER and the efficient use of manures and the control of erosion. Advisors also attend workshops and presentations, for example, those run by the UK SMI, as well as in-house courses within commercial firms and consultancy groups. The conservation and RDS advisors community appear to receive the same level of training as arable advisors although levels of FACTS certification is noticeably lower for these two categories.

6.3 Advisor knowledge of soil best management practice soil guides

The extent of advisors' use of soil management guides gives some measure of the know-why element of advisors' knowledge. The extent to which advisors know about and use the Soil Code[21] and other Defra/ADAS soil best management practice guides was explored. Figures from the survey suggest that use of the Soil Code is reasonably high, with 11%, 55% and 34% respondents respectively using it never, sometimes and always; that is the majority of respondents use it at least sometimes. Figures for individual advisor types (Figure 2) demonstrate that Defra, ADAS and conservation advisors use the Soil Code the most, whilst distributor agronomists use it the least with 31% of this advisor type never using it.

Fewer advisors use the Soil Erosion Manual[22]; the data show that 58% of all respondents never use it, 37% sometimes using it and 5% never using it. These figures need to be set against the 57% of all respondents who observed severe incidents of soil erosion (see Figure 1). Compared to the Soil Code the Soil Erosion Manual is a less established document, addresses more specific problems and soils and is not a

[20] It has since been announced that a certificate in soil and water management will be offered to farmers and advisors by BASIS, an independent standards scheme for the pesticide and fertiliser the industry.

[21] The Soil Code is a Defra publication that was first issued in 1993 but revised in 1998. It is sent to all farmers and owning and abiding by the Code is a requirement for most farm assurance and agri-environment schemes.

[22] A manual and field guide were published by MAFF in 1999 to help land managers assess erosion risk (MAFF 1999a,b).

formal requirement for schemes; however, it has been the subject of relatively recent campaigns and training. ADAS and conservation advisors made greatest use of the Soil Erosion Manual (Table 4). As a community conservation advisors claimed to use both these documents more than the other advisors which is surprising given that their core area of advice is farm conservation rather than arable support. The questionnaire data also show that nearly half of all respondents [conservation (56%), independent agronomist (44%), distributor (54%) and ADAS (61%)], with the exception of Defra RDS advisors (21%), refer to soil survey maps and accompanying bulletins which provide technical and management data.

6.4 Advisor use of tools that assist them with soil best management practice recommendations

The extent to which advisors use soil management recommendation tools such as fertiliser guides, soil survey publications, decision support systems and soil analysis is shown in Tables 5 and 6. A very small proportion of advisors use soil analysis which may be due to the cost that has to be passed onto the farmer. Alternatively, advisors may lack the skills and understanding in taking soil samples and interpreting the analysis. Limited use of Decision Support Systems (DSS), which assist on-farm decisions about nutrient management, also suggests that advisors have yet to embrace PC tools. The MANNER PC model[23], however, is a popular tool for estimating the nutrient contributions made by manures, amongst ADAS advisors, with independent and distributor agronomists using it to a much greater extent than conservation and RDS advisors. According to one ADAS advisor 4000 copies of the model are in use amongst farmers and advisors. Its popularity was attributed to its simplicity and ease of use. Agronomists have more exposure to such DSS tools which support arable decisions and this explains their higher use compared to the conservation and RDS community.

Both the survey data (Table 6) and interviews revealed that the use of the fertiliser guide RB209[24] is widespread among all advisors with 95% of all respondents from

[23] MANNER (MANure Nitrogen Evaluation Routine) is a PC tool developed by ADAS to assist farmers and advisor in use the nitrogen within manure in their nutrient budgets.

[24] RB209 'Fertiliser Recommendations for Arable and Horticultural Crops' is a well established fertiliser recommendation system developed by ADAS in the form of a book, revised in 2000.

the arable sector using it at least sometimes. It also suggests that conservation and RDS advisors are using these tools as well, albeit to a lesser degree, indicating a move beyond their core activities of habitat and wildlife conservation support.

Higher use of the Managing Livestock Manure booklets[25] among mainly independent agronomists and ADAS advisors suggests that they are integrating nutrients from manure into arable fertiliser schedules (Table 7). Although results indicated agronomists made less use of these, 50% of distributor agronomists use the booklets at least sometimes. Not surprisingly there is higher use of RB209 and the booklets (both of which are published by ADAS) by ADAS advisors than other advisor types.

6.5 Advisor recommendations of soil best management practice

Relatively wide usage of tools and guides described above suggests that advice based on best management practice principles is being given. Indeed questionnaire results indicate that a large proportion of respondents are already recommending best management practice for soil. Increasingly, advisors appear to be accounting for nutrients in manure (although this is not across the board) with 82% of all respondents stating that they had recommended this in the last two years. Wide distribution and use of MANNER and Managing Livestock Manure booklets support this high figure. A large proportion of all respondents (77%) also claimed they had recommend targeted nitrogen (N) in the last 2 years and more than 70% have recommended carefully timed cultivations, minimum tillage and buffer strips (Table 8)[26]. Fewer advisors recommend the more specialist practices such as precision farming and bi-cropping.

[25] Managing Livestock Manure booklets (ADAS et al. 2000) help land managers in nutrient budgeting.

[26] Using correlations, three categories of recommendations relationships between the practices listed in the Table 7 were identified. Significant (at 0.01) correlations (2 tailed Pearson) were found between numbers of respondents recommending the cultivation practices of carefully timed cultivation, low compaction machinery, earlier autumn sowing and minimum tillage; between numbers recommending fertiliser practices of targeted N and N value of manure; and between numbers recommending the anti-erosion measures of buffer strips and contour ploughing.

Figure 3 shows that advisors from all sectors recommend these practices to a similar extent apart from RDS advisors, who in all cases, except buffer strips, recommend these practices the least. This is most likely because these are practices integral to arable cropping but not to habitat or agri-environment scheme management. Commercial and conservation advisors appear to recommend soil best management practice to the same degree as ADAS advisors. Conservation advisors recommend cover crops, buffer strips and contour ploughing more than other advisors and surprisingly recommend the other arable practices to the same extent as arable advisors. The high numbers of conservation advisors claiming to recommend targeted N is not coincident with levels of usage of RB209 or FACTS training amongst this community suggesting that although recommending these practices they might not have full understanding or competence in these areas. Significantly, as a group agronomists recommend practices to the same extent as ADAS advisors and in most cases independent agronomists recommend practices to a greater extent than distributor agronomists.

This section, which has examined advisor knowledge about soil best management practice and application of this knowledge, reveals that as a community advisors are generally knowledgeable about soil best management practice and appear to be observing soil degradation, undertaking training, using guides, tools and recommending soil best management practice to a relatively large extent. Clearly use of guides and tools is just one of a number of indicators of advisors' knowledge of soil best management practice as level of use alone cannot always reveal the nature of the advisors' engagement with, acceptance of, and understanding of the principles underpinning them.

The data indicate that different types of advisors hold different forms of knowledge to a different extent. In terms of the different categories, ADAS advisors demonstrate consistently high levels of training, use of guides, tools and recommendations suggesting that these advisors hold considerable know-what (facts) and know-why (understanding) knowledge about soil. However, the ADAS advisors with expertise in soil management tend to restrict their involvement to mass extension campaigns rather than on-farm, one to one advice which will inevitably limit the impact of their soil management knowledge. Conservation and RDS advisors are clearly becoming

increasingly aware of the importance of soil best management practice to conservation matters such as polluted habitats. The data suggest that they are knowledgeable about soil best management practice and provide recommendations. However, low use of specific tools to assist soil management such as RB209 and the fact that only 12% of respondents were FACTS registered compared to 100% of agronomists confirms that they are not involved in day to day arable decisions that directly affect the soil. This suggests that, although they demonstrate both a high level of concern for soils and make reference to guides, they lack the competence required to provide advice on soil management in an arable context. Although they appear to have considerable know-what knowledge about soil, they have yet to develop the know-why element. Traditionally these advisors do not get involved in soil management advice. Remarks from advisors suggest that they still regard this as peripheral to their job specifications, and they feel ill equipped to provide it, as one Defra RDS advisor (Q) remarked 'Personally I feel unqualified to provide detailed soil management advice. Most FWAG, RDS and other advisors I believe are in the same position'. Levels of agronomists' knowledge about soil best management practice and application of this knowledge through use of tools and recommendations is comparable in most cases to ADAS advisors, suggesting that as a community agronomists are well equipped, both in terms of know-what and know-why, to advise on soil best management practice.

7. Advisor experience, competence and skills on-farm

The remainder of the paper focuses on those elements of advisor knowledge that comprise experience, skills, and competence, defined earlier as know-how. First, data on experience is analysed, and then advisor competence in two areas of soil management will be examined: N recommendations and using manures as a source of N; and cultivations. In this latter context, specific reference will be made to agronomists.

7.1 Length of experience as an agricultural advisor

As a community ADAS advisors have the most experience in terms of years working as an advisor with 32% advisors having been in the business for more than 20 years (Table 9). Agronomists are similarly experienced although the figures would suggest

a younger cohort with the majority (77%) with 10-19 years experience. In comparison, conservation and RDS advisors have significantly less experience in the field, the majority of conservation advisors having for instance less than 10 years experience.

Agronomists have more experience than the conservation and RDS advisors both in terms of number of years spent being an advisor (Table 9), but also in regular crop walking. Some farmers are appreciative of the breadth and range of knowledge agronomists accrue through this on-farm experience, while advisors themselves put great store in it, particularly with regard to soil. As one agronomist remarked, '40 years of personal experience of handling soils is invaluable' (Questionnaire respondent: Independent agronomist).

The following section, which examines advisors' know-how in recommending N and cultivations, will focus on agronomists. This focus is justified on the basis of the evidence presented on the considerable soil best management practice knowledge held by agronomists. Of all advisors, agronomists have most opportunity to influence farmers' soil management behaviour through regular on-farm contact, and agronomists provide arable advice which impacts soil management.

7.2 Recommending targeted N and managing nutrients in manures

A number of fertiliser recommendation systems (FRS) are available to assist agronomists in providing advice on N, these include guides like RB209, PC operated management tools or models to help growers and advisors predict inorganic nitrogen (N) fertiliser requirements which enable both desired yields to be achieved economically and in some cases nitrate leaching to be minimised. As indicated in the earlier section agronomists are using RB209 extensively. However interview data presented here, which allows an exploration of their understanding and competence in recommending N and manure rates at the field level in more detail, suggest that the questionnaire data should be viewed more circumspectly.

Rather than depending entirely on formal processes or technical FRS when recommending N fertiliser applications, agronomists have built up experience and

intuitive feelings through being deeply engaged in their work. They describe this 'user knowledge' in terms of intuition or 'gut feel' as these comments show:

> I use a certain amount of user knowledge and it's difficult to replace that, that's the most valuable thing (Distributor agronomist T).
>
> Having worked in the fertiliser industry I live and breathe N recommendations intuitively (Independent agronomist S).
>
> We're living with it all the time. Agronomists do this job the whole time they know-what's missing (Independent agronomist D).

Agronomists rely on this locally derived experiential (or tacit) knowledge to different degrees. They tend to use this knowledge as a reference point against which to compare outputs from FRS, judging these in terms of whether they are 'comfortable' with the figure, or if 'it's what you would expect it to be'. Some agronomists prefer to rely entirely on this 'gut feel' and do not value FRS at all, for example, one agronomist (Q) said of FRS models 'real world experience is more important than most models yet developed'.

Management recommendations from FRS models need to be adjusted to suit the diversity of local conditions and farming styles, and because of this they are dismissed by some agronomists. They feel that models are inadequate to reveal conditions in the field; one independent agronomist (W) commented:

> 'I don't think models are accurate enough. It's a great idea but you do everything from the seat and not going out of office and I'm afraid growing crops don't work like that, you always have to tweak for local conditions anyway'.

Generally FRS outputs are used only as a starting point by most agronomists. Modification of recommendations from FRS by agronomists to suit local circumstances is the norm, and FRS outputs are constantly queried and changed. Agronomists bring together experience and practical and local factors such as timing, soil type and where the crop is in the rotation to modify results from FRS to arrive at a recommendation they are comfortable with. This process was described by agronomists as follows:

> You have to have something as a guideline and then modify it; there is a lot of that. None of the soil N tests or models give the answer on their own, it's a case of using that as an indicator as to what the trend might be, then using gut instinct and historical knowledge to tweak that and make it into a recommendation. That's a lot of what agronomy is about. It's a case of understanding all the different factors, what's the weather, the crop, the soil? (Distributor agronomist R).

Agronomists are confident that their locally derived and experiential knowledge provides a reference point in normal situations, however, this becomes less effective when circumstances are unfamiliar, as the following remark demonstrates:

> Yes, so your local knowledge and experience helps you with normality because you know where your bench mark is but it's when it becomes unfamiliar and it happens outside anyone's control you encounter problems (Independent agronomist L).

Interviews revealed that adjusting nutrient budgets to allow for N supplied in manure applications is particularly challenging in this respect. Although agronomists have built up experience recommending N, they do not have the experience of high fertility situations where organic manures have been added.

> You could say that in known conditions with a regular arable rotation there is an intuitive level which we could establish with a reasonable level of confidence but in high fertility situations, this is where we come unstuck and struggle (Independent agronomist P).

> I appreciate that N applications and getting the rate right is one of the most difficult things we have to do as advisors and this is particularly the case in cases of high fertility where manure or sewage sludge are added. What we're doing, advisors and farmers alike, we're all scratching our heads asking how much should we allow for that? (Independent agronomist E).

Consequently for many agronomists, achieving the required soil and crop nutrition is a complex process for which they are often feel ill equipped. As one independent agronomist (N) noted 'In terms of how do I know whether I've got the N rate right? I don't…I'll have a stab at it'. In the same way using the nutrient value of manure, as promoted in the ADAS Managing Livestock Manure booklets, requires some understanding of nutrient dynamics in the soil and being able to estimate amounts, and the nutrient content, of manure. These have proved unfamiliar skills for many

agronomists, for example, one independent agronomist (P) said 'Well who can cope with manures? You have to make a stab at it and estimate what's going on'.

These comments suggest that although agronomists are becoming FACTS registered using FRS tools to recommend efficient use of fertiliser N and consulting Managing Livestock Manure booklets, as indicated in questionnaire survey (Tables 6, 7 and 8), they often refer to (and emphasise) their own experience or user knowledge and combine these formal and informal knowledges to derive advice for a particular situation. This user knowledge however is challenged in unfamiliar situations. Consequently in a number of cases agronomists are not always confident with the recommendations they derive. Whether this is a reflection of their limited experience, their scientific understanding of the processes involved or the limitations of the tools themselves needs further exploration.

7.3 Cultivation skills

Decisions about cultivations are seen as some of the most important on the farm but the interviews revealed that this is an area where agronomists are least involved and have minimum confidence and experience. Agronomists recognise these limitations, they acknowledge that farmers have the hands on practical skills and are aware that there are borders they do not cross and talk of the risk of transgressing these.

> I'm an advisory agronomist who has a lot of technical information at my finger tips but I'm not a practical farming manager and we are stepping over the borders here a little bit …most farmers are experts in machinery or like to think they are, so for me to step over. They will listen to me but what they say when I've gone, I don't know. I think a practising farm manager or practising foreman can talk to farmers about practice of setting a machine or going across the hill and will come over with more credence than an agronomist like me –it's 20 years since I sat on a tractor, machinery has changed and I'm not the most experienced tractor driver anymore (Independent agronomist J).

Many see the fact that a lot of agronomists are not providing very much advice about cultivations as a weak link, and the absence of hands-on experience of cultivation is held up as a big gap in their knowledge. The emphasis on needing to be a practitioner to understand soil capability in respect of cultivations is echoed in many interviews, as in the comment below.

> A lot of people I know who work in the soils field and agronomy advisory field are actually very weak on soils, on hands-on soils they really are. They just haven't got their minds around it. One of the fundamental things is timeliness and soil moisture. The only way you'll understand about soil capability and timeliness is by doing it and doing it for quite a while and that's the problem, these people, they don't actually do it (Project advisor R).

Agronomists realise they have to tread carefully in areas where their competence might be questioned, as this agronomist observes:

> I am very careful how I put the advice I might bang the gong and say you must do this but when it comes to 'you must set your machine this way' or' you should consider this machinery' they do listen but I have to be more circumspect in how I put the information across. One has to be very careful when talking about cultivation to farmers, that is sacrosanct, if you start querying or questioning his ability to cultivate his land you are on very dangerous ground –we discuss it but have to be careful - some farmers know their land and how to cultivate it (Independent agronomist J).

Others support this view suggesting that advisors' knowledge of soils and cultivation is lacking.

> There has got to be a much better informed advisor group in this country able to look at farm and interpret and ensure they are using the right equipment and discuss with farmers in a knowledgeable way which way their cultivation should be going. At moment an awful lot of farmers suck it and see (Project advisor J).

This analysis presents a complex picture of the agronomists' know-how about soil management. The principal inference from the results is that agronomists rely to large extent on their own experiential knowledge, which in many cases is well developed, however this can fail them in unfamiliar situations. The apparent lack of hands-on experience and involvement in cultivation practices, is significant considering that such practices are central to maintaining good soil structure.

8. Discussion and policy implications

This paper describes the broad range of knowledge held by advisors about soil management and the consequent variable contribution the advisor community makes to facilitating sustainable soil management. Previous research has suggested that the diverse advisor community operating within a complex AKS in England has a range

of environmental skills (Eldon 1988; Curry 1997; Marshall 2002). These results, which provide new evidence about advisors' fitness for purpose with regard to soil, confirm that this is also the case in the context of advisors' knowledge about soil management. The data reveals not only the considerable breadth of knowledge forms held by advisors, in terms of facts known about (know-what), understanding of (know-why), and competences in dealing with soil (know-how), but also the complex relationship between these knowledge forms.

Regarding the know-what element of knowledge about soil, as a community advisors observe a considerable range of soil degradation symptoms which they perceive as severe. Use of the Soil Code was not insignificant with 43-61% advisors using it at least sometimes. Training levels would also indicate relatively high levels of know-what about soil amongst the advisor community. High levels of registration with FACTS amongst arable advisors would also suggest a commitment to improving their soil best management practice knowledge. In terms of applying this knowledge, the use of specialist tools such as RB209 and MANNER is well established, particularly amongst the arable advisory communities, indicating that the know-why element is well developed. Recommendations of soil best management practice appear to be high with more than 70% questionnaire respondents recommending carefully timed cultivations, minimum tillage, buffer strips, using nutrient value of manures and targeting N, again suggesting considerable know-why soil knowledge.

The questionnaire data indicates an advisor community well informed and active in using tools and guides and recommending best soil management practices. However, the interview data, which sheds light on the know-how aspects of advisors knowledge, suggests that we should be more cautious in this interpretation. These reveal that this is a critical area in which where advisors have variable skills and competence. Practical experience contributes to the know-how element of knowledge, in this respect advisors working in arable advice will have the most relevant experience. They also, incidentally, have the longest field experience. Agronomists in particular claim that they 'live with it all the time' and 'live and breath N recommendations'. They develop what they call 'user knowledge' which equips them well for familiar situations, however this is challenged when they encounter unfamiliar situations such as high organic N additions in manure. Lack of hands-on experience with cultivations

also means that know-how in this critical area of soil management is poorly developed.

Results suggest that only by having a full complement of know-what, know-why and know-how can advisors be fully 'equipped' to provide advice on soil best management practice. These forms are acquired in different ways: know-what through training, observation and reading; know-why by developing, interpreting and implementing the principles derived from know-what, and know-how through practice and experience. It is clear, however, that these knowledge forms are not discrete but relational since acquiring facts and information through guides, observation and training provides the basis for the understanding and use of tools and for recommendations; the know-what and know-why are thus intimately linked. In the same way the know-why element relies considerably on the tacit know-how for interpretation particularly at the level of local farm implementation. To be most effective advisors integrate knowledge forms as one agronomist noted 'it's a case of using that [tool] as an indicator as to what the trend might be, then using gut instinct and historical knowledge to tweak that and make it into a recommendation. That's a lot of what agronomy is about.'

In terms of the sort of knowledge held by different types of advisors clearly a range exists. ADAS advisors demonstrate high knowledge of facts and usage of tools which could be attributed to their role as a former government agency contracted to provide environmental protection research and dissemination. Since their privatisation in 1997 the new commercial orientation of this organisation is no doubt driving their need to maintain a client base through consistent high quality advice that delivers customer satisfaction. Furthermore, these advisors have most experience in terms of time in the job. Conservation advisors claim to use the Soil Code more often than arable advisors, to have the greatest concerns about soil degradation and to recommend soil best management practice to a similar extent as other advisors. Winter et al. (2001) reported such a shift in FWAG's role towards advice on fertiliser rates and pollution prevention. However, although these advisors are taking a wider interest in arable issues and would appear to be well informed, low use of FACTS and RB209 tools would suggest they have yet to develop understanding of key soil management principles. This coincides with Archer's (2001) findings, that few FWAG advisors

were equipped to deal with nutrient management. Interview data also show that conservation advisors themselves accept that they remain unqualified to deal with soil and that soil management remains of peripheral interest, to them. Whilst they have extensive know-what, their know-why and know-how are as yet undeveloped. They have yet to acquire the appropriate knowledge to give soil management advice with confidence.

Agronomists, in that they have regular contact with farmers, visit the farm, field walk and advise on issues crucial to soil management, would appear to have potentially the most influence on farm soil management. The data on agronomists reveals that they hold a range of facts, concerns, understanding and competence concerning soil best management practice. The extent of knowledge about soil and the application of this knowledge compares favourably with the other advisors, notably ADAS advisors, suggesting that as a community they are responding to policy messages. These results mirror to some degree those of Marshall's (2002) survey which found that some agronomists' environmental skills were well advanced and that they were already giving sound environmental advice, including fertiliser and FYM use, and ICM, often unprompted, although this still needs to be standardised. As a community they also have length of work experience comparable to ADAS advisors. They appear to be able to develop tacit knowledge about N recommendations which they call user knowledge although this is challenged in unfamiliar situations. However, poor competence in cultivation practices due to limited experience is a key area of concern that is revealed by this study. Despite this, however, evidence from the questionnaire suggests that advisors are recommending these practices. For example, >60% agronomists had recommended timely cultivations and minimum tillage and >78% agronomists recommended use of the nutrient value of manure. Levels of training and engagement with best management practice guides among advisors support these figures. This suggests that although they may lack crucial skills in advising on cultivations and managing N from manures, they are endeavouring to learn and carry out recommendations in response to demands from policy makers and some farmers so that they can survive in a competitive industry.

The implications of advisors' limited competence in certain soil best management practices for the successful implementation of soil protection policy needs to be

considered. This study suggests that advisors need to improve their know-how about cultivations. Since this knowledge is derived not through publications or formal training, but through experience and interaction with those who have experience and competence, options for advisor learning through farmer-advisor interaction in a workshop or on-farm situations should be considered. To some extent this is taking place already through Defra funded initiatives but the need to enhance these and recognise the value of joint learning and practical experience in any training of advisors is clear. This analysis also has wider implications. The extent of advisors' knowledge about soil management suggests that some advisors at least are moving away from market-oriented advice and so called 'productivist modes of thinking' . As a community they have the potential to make a positive contribution to the transition away from production-related practices towards those orientated towards sustainable practices, the goal of agricultural policies in many developed countries.

In conclusion this research suggests that advisors' knowledge about soil and its sustainable management is considerably greater than earlier research on advisors' environmental knowledge has suggested (Eldon 1988; Curry 1997; Winter et al. 2001). This is an optimistic finding. Nevertheless, some areas will have to be significantly enhanced and standardised to meet the new policy challenges of SMP and provide a comprehensive support service for farmers following recent CAP reforms. Likewise, in other countries where privatisation has occurred in the advisory services, calls have been made for professional accreditation schemes (McGuffog 1998; Toohey 2002). A review of advisors' professional development has recently been undertaken within Defra's Learning, Skills and Knowledge Programme (Defra 2004g) to address this issue in the UK. In the context of soil a new BASIS certificate in soil and water management will be offered to advisors and farmers in an attempt to improve advisors' knowledge about soil and equip them for a new era of soil protection policy in England (Farmers Weekly 2004b). These are positive steps which have relevance beyond the UK. Although it has long been recognised that farmers need new skills to take on the new demands of sustainable agriculture (Curry 1997) advisors' needs have received insufficient attention. This research has gone some way to address this gap in the English context.

This study has exposed the importance of the know-how element of knowledge in such practical matters as farm soil management advice and the need to enhance such knowledge. This accords with those perspectives that equate knowing to learning and see knowledge as created through the transformation of experience (Engel 1997; Ison et al. 2000). Since personal interaction in a context of shared experiences is thought to be the only way to communicate tacit know-how (Hassenein and Kloppenburg 1995; Morgan and Murdoch 2000), the significance of 'know-who', the fourth element from Lundvall and Johnson's categorisation of knowledge, also becomes clear. The importance of know-who, in terms of networking, social interaction and joint learning, in achieving sustainable agriculture is already well recognised in the international literature (Pretty 1995; Engel 1997; Murdoch and Clark 1994; Roling and Wagemaker 2000). In the future there is a need to understand what contribution the know-who form of knowledge makes and how it relates to their know-what, know-why and know-how forms of knowledge, to fully appreciate advisors' knowledge about soil in England.

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Figures and Tables

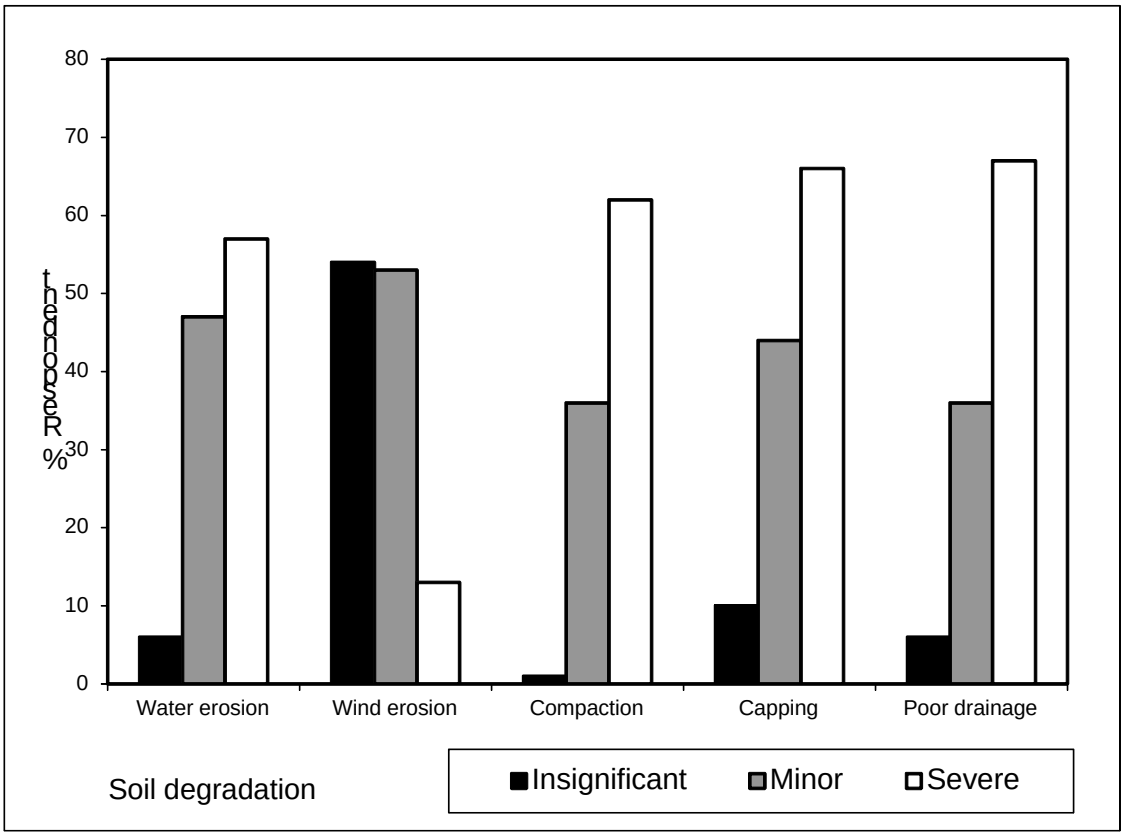

Figure 1 Advisor observations of soil degradation

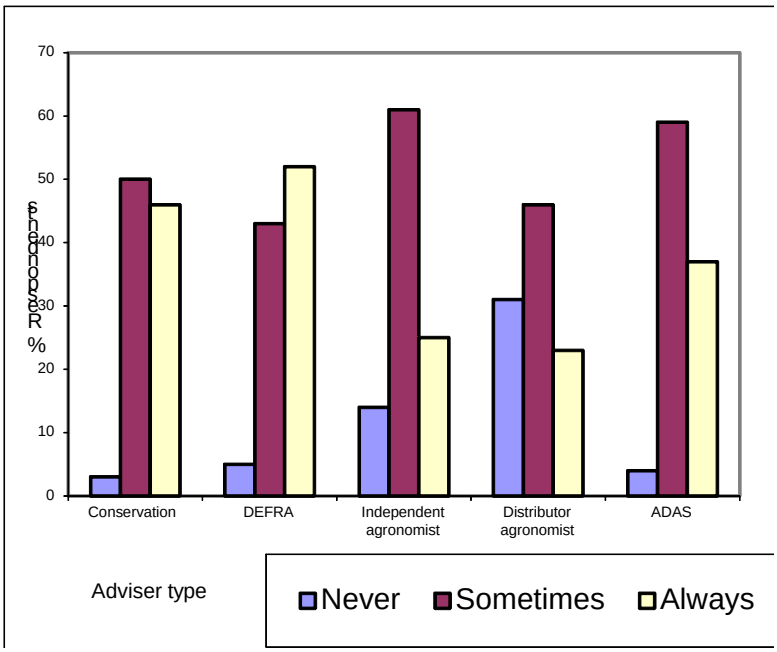

Figure 2 Advisor use or recommendation to farmers of the Soil Code

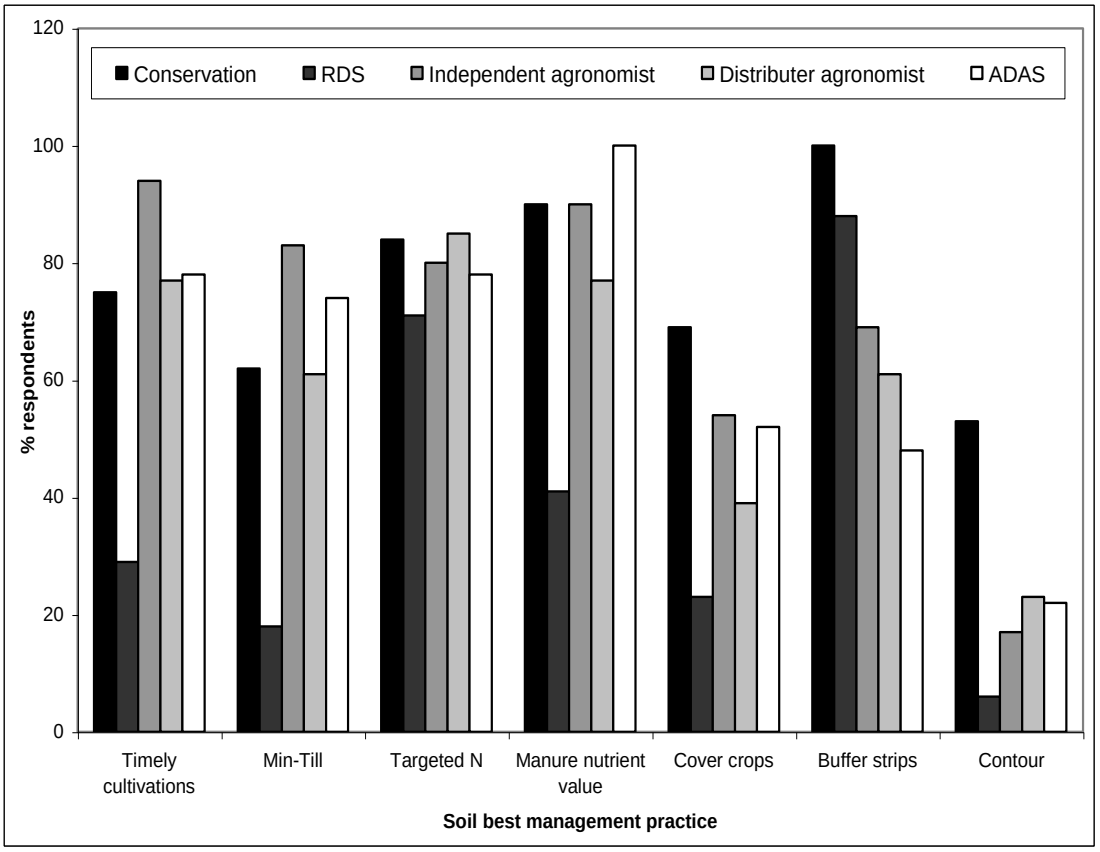

Figure 3 Advisor recommendations of soil best management practices in the last 2 years.

Table 2 Advisor views on the soil degradation problem in English agriculture

	% of respondents within each advisor category				
	Conservation	DEFRA RDS	Independent agronomists	Distributor agronomists	ADAS
No problem exists	0	0	18	0	4
Don't know	0	17	7	25	26
Yes problem exists	100	83	65	75	70
No. of valid respondents	32	23	71	12	23

Table 3 Extent of advisor training and FACTS registration

	% of respondents within each advisor category				
	Conservation	DEFRA RDS	Independent agronomists	Distributor agronomists	ADAS
Training	77	80	90	69	81
No. of valid respondents	31	20	73	13	22
FACTS registered	12	34	79	100	87
No. of valid respondents	32	23	73	13	23

Table 4 Advisor use or recommendation to farmers of the Soil Erosion Manual

	% of respondents within each advisor category				
	Conservation	DEFRA RDS	Independent agronomists	Distributor agronomists	ADAS
Never	25	64	75	62	45
Sometimes	72	29	22	23	50
Always	3	7	3	15	5
No. of valid respondents	29	14	67	13	22

Table 5 Advisor use of soil management tools when advising farmers

	% of respondents within each advisor category				
	Conservation	DEFRA RDS	Independent agronomists	Distributor agronomists	ADAS
Soil analysis	0	0	3	8	9
DSS	9	5	22	30	n/a
MANNER	12	23	53	46	74
No. of valid respondents	32	19	72	13	23

Table 6 Advisor use of RB209 when advising farmers

	% of respondents within each advisor category				
	Conservation	DEFRA RDS	Independent agronomists	Distributor agronomists	ADAS
Never	39	44	7	8	0
Sometimes	57	22	40	38	30
Always	4	34	53	54	70
No. of valid respondents	28	18	72	13	23

Table 7 Advisor use of ADAS Managing Livestock Manure booklets when advising farmers

	% of respondents within each advisor category				
	Conservation	DEFRA RDS	Independent agronomists	Distributor agronomists	ADAS
Never	18	50	16	46	4
Sometimes	78	33	62	31	65
Always	4	17	22	23	31
No. of valid respondents	27	18	69	13	23

Table 8 Advisor recommendations of soil best management practices in the last 2 years

Cultivation recommend-ations	**%**	**Nitrogen Recommen dations**	**%**	**Anti-erosion measures**	**%**	**Others**	**%**
Carefully timed cultivation n = 157	82	Targeted N n=157	77	Buffer strips n=155	73	Green manures n=157	42
Minimum tillage n=157	70	Manure N value n=157	82	Contour ploughing n=156	24	Bi-cropping n=157	10
Low compaction machinery n=157	58			Cover crops n=155	52	Precision farming n=157	28
Early autumn sowing n=155	58					Permanent grass n=155	48

n refers to number of valid respondents

Table 9 Length of experience as an agricultural advisor

	% of respondents within each advisor category				
	Conservation	DEFRA RDS	Independent agronomists	Distributor agronomists	ADAS
<10 years	84	56	10	16	32
10 –19 years	16	26	64	77	36
> 20 years	0	18	26	7	32
No. of valid respondents	31	23	73	13	22