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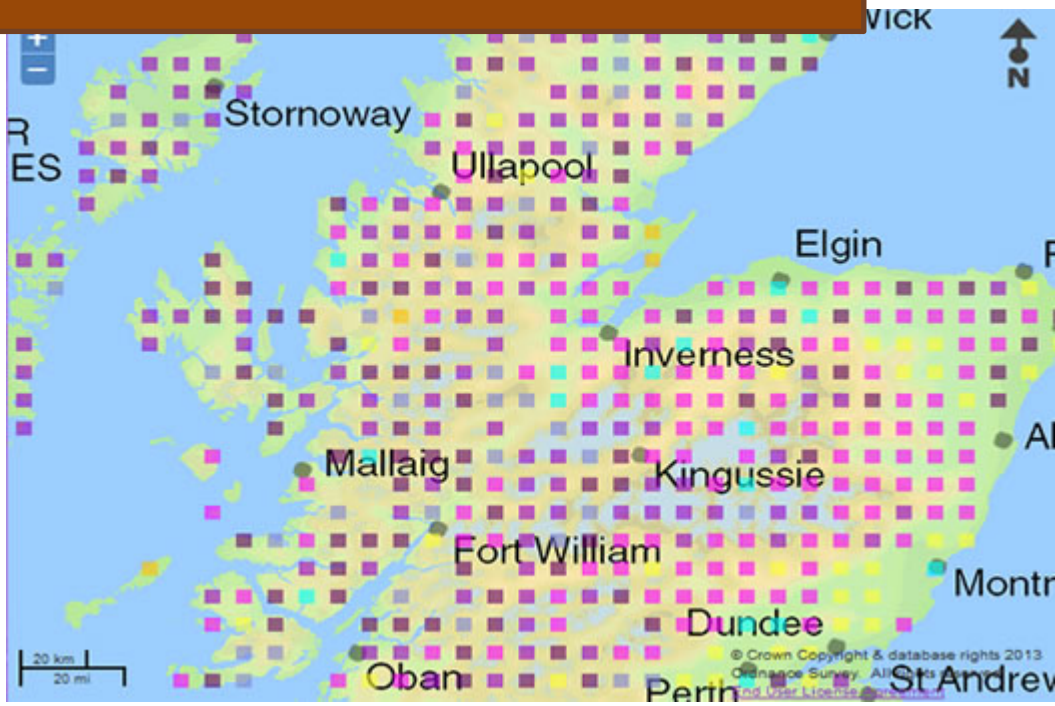
Use and awareness of soil data and information

among local authorities, farmers and estate managers



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Executive Summary

This report was prepared for the Soil Focus Group with funding from Scottish Government RESAS research programme to explore the use and awareness of soil data and information. Telephone interviews were conducted with three different groups of 'end users' of soil information and data (namely local authorities, farmers and estate managers) to supplement previous consultations contributing to the Soil Monitoring Action Plan, discussions of the Soil Focus Group and Scotland's Soils Website. The report highlights:

- the different requirements from different users;
- the lack of awareness of what is available from some individuals within the three groups;
- the need to raise awareness of what can be done with what is available;
- the need for data provision to be coupled with contextual information, interpretation of data and possibly training;
- the fact that to provide a one-size-fits-all data and information source will require a large amount of time and effort and may still not be appropriate for all users of soil data

In local authorities, soil data is most often used by Planning and Contaminated Land departments, although different types of soil data and information are required (for instance, geological and chemical rather than land capability information respectably). Local authority current and future soil data needs are driven by national policy. Predominantly 'broad scale' information is considered necessary for planning purposes, while site specific soil data is necessary to determine contamination risk and migration.

In contrast, members of the farming community interviewed expressed their need for detailed and field-scale soil data in order to make decisions regarding nutrient application and improving soil health overall. Farmers access soil data through a range of soil testing and interpretation techniques, including sampling and laboratory-based analysis, GPS soil mapping and soil structure scanning, provided by commercial companies. Whilst benefits of a shared online soil resource are noted, including benchmarking between farms and recognising good practise, there is uncertainty regarding whether any further soil data could be provided beyond that already available at present and at the scale necessary.

Finally, estate managers explain that they do not directly seek soil data as this is typically in the interest and responsibility of the estate agricultural manager or tenant farmers. Instead, land capability maps are consulted during the valuation, marketing and rent reviews of properties. As with the other end user groups a lack of awareness of the data available was a key barrier in access by the estate managers.

This report illustrates the drivers for accessing soil data (predominantly due to policy, environmental legislation or business needs), the scale of data necessary to fulfil needs and the key barriers to accessing soil data and information, including cost and lack of knowledge. In principle, making soil data and information available online was welcomed if different end user preferences are taken into account. Based on further discussions with the Soil Focus Group, this report should ideally be complemented with a commentary which would highlight:

1. Actual gaps in existing soil data and information;
2. Perceived gaps in soil data and information where interviewees believe this data does not exist;
3. The role of accessibility (including cost) and how it impacts on actual and perceived soil data gaps; and
4. Possible next steps to address issues of soil data and information gaps and accessibility.

1 Introduction

The Soil Monitoring Action Plan[1] is part of the activities that are progressed under the Scottish Soil Framework and linked with the CAMERAS Environmental Monitoring Strategy. A report on the Soil Monitoring Action Plan acknowledged that a comprehensive assessment of Scotland's soil data needs will require communication with a range of stakeholders[2]. Consultations and a survey carried out for this report yielded insights on soil data and information needs of some stakeholder groups but other groups were difficult to reach. In response to this knowledge gap, the Soil Focus Group expressed a need for a study of specific user groups that shed light on 'Who needs soil information and what for? What specific data and information are needed?' This information was also expected to be useful to the development and further improvement of the Scotland's Soils website[3] by providing insights on user groups' preferences regarding the type of soil data/ information that could be provided.

The study aimed to answer the following research questions:

1. What soil information/data needs do different users have and what barriers do they perceive to accessing and using soil data/ information?
2. Who is seen to be a suitable interpreter of soil data and provider of advice drawing on soil data?
3. How can approaches to provide soil information and interpretation be enhanced for different user groups, and what is the best format for different users to access soil information?

2 Methods

We conducted a total of 23 semi-structured interviews with three different groups of 'end users' of soil information and data. They included local authorities (10), farmers (9) and estate owners/managers (4). The question guideline was similar for all three types of interviewees but adjusted to their respective context.

2.1 Local Authorities

Sampling of Local Authorities was based on the whole population of 32 local authorities with the exception of those eight councils (Table 1) involved in parallel consultations and feedback exercises directly related to Scotland's Soils website. The remaining 24 local authorities were contacted by email, either addressing their general information email, or their planning or environment department. The first ten to respond were selected for interview (Table 1).

Table 1: Councils interviewed for the study and councils exempt from the study

Councils interviewed for the study	Councils that were exempt from this study
Aberdeenshire Council	Dundee City Council
Argyll & Bute Council	East Dunbartonshire Council
Edinburgh City Council	East Lothian Council
Falkirk Council	Fife Council
Highland Council	Inverclyde Council
Moray Council	Midlothian Council
Orkney Islands Council	Scottish Borders Council
Perth & Kinross Council	South Lanarkshire Council
Stirling Council	
West Lothian Council	

[1] www.environment.scotland.gov.uk/PDF/Soil_Monitoring_Action_Plan.PDF
[2] See www.environment.scotland.gov.uk/our_environment/environmental_monitoring/soil_monitoring_action_plan.aspx
[3] www.soils-scotland.gov.uk/

The fact that councils responded to the request for providing a contact for a member of staff to be interviewed may indicate, overall, how well a council is organised to respond to queries of this kind, as well as what importance soil, as a topic enjoys. We assume that in councils where soil-related issues fall under the responsibility of a designated team or an officer, it will be more straightforward to provide that contact upon request. In councils where soils are dealt with as a side issue (perhaps because there is little pressure on soils) or no one holds identifiable knowledge or interest in this topic, this contact will be harder to provide and might have resulted in a non-response.

Interviews were carried out over the phone and lasted around 30 minutes. Notes were taken during the interview. Interviewees gave their views as an individual officer rather than representing the council's viewpoint (two interviewees explicitly mentioned this point and we infer that the others would also prefer their interviews to be interpreted this way).

2.2 Farmers and Estate Managers

Members of the farming community previously known to the researchers were invited to participate in a telephone interview. In this purposive sampling method, individuals were approached from a diverse range of farm types, sizes and locations (e.g. upland, coastal) from across Aberdeenshire and Moray (Table 2). Eight farmers were interviewed over the telephone and one in person. Two interviewees are also independent farm consultants, in addition to farming themselves, therefore adding experience from their wider experience of farming systems in the North East of Scotland.

Table 2: Farm characteristics

Identifier	Farm Type (detail where available)	Total Area Farmed (acres)*	Main Activities/Outputs
1	Mixed	1550	Poultry, sheep, wheat and barley
2	Mixed	400	Barley, oats, potatoes, swedes, grass, cows and lambs
3	Mixed (upland)	800	Sheep, cattle, stubble turnips, barley
4	Mixed	1300	Cows, sheep, cereals
5	Mixed (undergoing organic conversion)	300	Cows, sheep, cereals
6	Mixed (organic)	170	Pigs, sheep, oats, carrots, potatoes
7	Mixed	450	Cows, sheep, barley, oats
8	Mixed	1000	Cereals, grazing
9	Mixed (including forestry)	1152	Arable, grass, Sitka spruce

Note: As the purpose of the interview was not a full characterisation of the farms, the information reflects what interviewees mentioned in responding to other questions. (conversion 1 ha = 2.47acres)*

In addition, several individuals who manage large land holdings (estates) across Scotland and who were previously known to the researcher were invited to participate in a telephone interview. Individuals were approached from a range of estate ownership types, sizes and locations. Therefore, views were gathered from private, community and charity-owned estate managers, as well as those involved with commercial land agency. The estates involved range in size from 2900 to 11300 hectares and vary in location from lowland, peri-urban areas to hill and upland moorland areas, both inland and on the coast. Estate activities include farming (tenanted, contract and in-hand, predominantly mixed), sport shooting and fishing, forestry, property rental and renewable energy. In total four estate managers were interviewed by telephone. One interviewee is employed as a land agent/rural surveyor with a rural estate management agency, in addition to undertaking a management role on their family-owned estate, therefore could provide input from their wider experience of Scottish estate management.

Interviews typically lasted between 30 – 40 minutes. Notes from the interviews were typed and thematically coded according to the interview guide.

3 Findings

The findings will be presented separately for each of the three end user groups because their awareness and use of soil data differ considerably. Note that contradictions are possible because opinions of different people were grouped according to topic. Opinions and comments reflect the interviewees' knowledge and experience of what soil information / data is available and being used. For example, some may not see a need for new data but others ask for data that does not exist at the scale they require.

3.1 Findings relating to Local Authorities

From the interviews it became apparent that the departments within councils that are most likely to use soil data are:

- Planning (both Policy and Development): key concerns are protecting agricultural land (grade 3.1 and above) from development, land allocation for development purposes, as well as securing soil carbon/ peatland and its trade-off with renewable energy from wind turbines
- Contaminated Land (as part of the Environment/ Environmental Health Department): key concerns are the assessment and monitoring of individual development sites for pollution

Other departments (flood risk, property, forestry) are marginally working with soil-related information. It was observed that staff in planning are often generalists with geography, town planning or environmental planning background with little soils knowledge, whereas staff in contaminated land tend to have environmental science or even soil science degrees.

3.1.1 Soil data/information currently used

There are differences between the council departments as to what soil information they predominantly use. On the one hand, the Environmental Health departments and contaminated land officers use geology maps (from BGS or SEPA), historic maps and records, and BGS bore hole logs and classification of aquifers. The planning policy and development planning departments, on the other hand, predominantly use the Land Capability for Agriculture (LCA) classification, and in fewer cases referred to 'the old Macaulay soil maps' and peat maps that they used. The LCA map tends to be used both in paper and electronic format (partially available). The majority of councils use GIS layers of agricultural classification and other constraints to decide on land allocation for development.

In the context of revising the Local Development Plan, two interviewees said that there was not much need to re-establish what the quality of soils was and whether they were adequately protected because soils do not change much over time and they had been protected early for other reasons (e.g. greenbelts). There were also comments that suggested the land quality (and inferred soil quality) could be derived from looking at the land.

In a next step, soil information might be needed when processing and determining planning applications. If particular issues with regard to soils are highlighted either in the main issues report or in the Local Development Plan, the development management team would request the developer/ applicant to undertake and provide a soil analysis. This analysis would be site specific and carried out by a consultant. The checking of this analysis is typically undertaken by colleagues in the building standards unit who grant the building warrant. In one council, soil is an issue that has not been a significant material consideration for the majority of planning applications.

Land capability maps and data are also used to determine the woodland expansion strategy (and in future may feed into the Land Use Strategy) and greenbelts. However, the central issue for green networks is the availability of land rather than the soil's suitability for woodland (species selection is carried out at the planning application stage). Council staff in the Property unit are interested in more detailed maps to determine property values.

Soil data does not tend to be used in relation to Sustainable Urban Drainage Systems (SuDS). Interviewees were of the opinion that drainage systems play a role at the planning permission stage and are determined by design and availability of open space. Where drainage systems are located is generally determined by the topography but less by the soil. Some councils have worked with SEPA to develop flood risk management plans and flood risk on the proposals map.

3.1.2 Soil data/information needs and interpretation needs

Interviewees were asked about soil data and information that are currently not available to them but might be needed in the future. The soil data/ information needs of councils are to a large extent driven by national policy. Examples are Scottish Planning Policy (SSP) 2010 which requires Local Authorities to seek to maintain soil carbon; the Scottish Soil Framework (SSF) which expects Local Authorities and land managers to assess the impact of activities on carbon storage; as well as SPP (2013) which states that development plans should aim to minimise the release of CO_2 from soils, in particular in the consideration of proposals for wind turbine developments, and encourages the use of the carbon calculator.

These national policies are reflected in council policy, in particular in the Local Development Plan which typically includes a policy dealing with 'Soil Conservation and Agricultural Land' and a policy on 'Protection of Carbon Rich Soils'. With the requirements to take action for climate change mitigation and carbon sequestration, there is an emerging need for data on carbon rich soils and peatland. One interviewee mentioned that they expected mapping of carbon rich soils to be forthcoming from SNH. He emphasised that this would be essential data helping to implement the soil-related council policies. Other interviewees had less exposure to the concept of soil carbon but mentioned their forthcoming or recently revised Local Development Plan included a policy on this issue.

Peat depth information is needed when assessing wind farm applications and is of particular relevance in upland areas. However, the existing peat maps only show the extent of land covered in peat and not peat depth so individual site visits are necessary.

Several interviewees responded that they are unlikely to use any other soil information in addition to the information they currently use. If soil information is not directly required in order to comply with a policy or if there is no direct application for the soil data, it is unlikely that councils will draw on soil data. When asked about any further information on soils that they might need, a typical comment from the planning perspective was that they do not have to go 'to that level of detail' with regard to soil. When soil data is needed, it tends to be on a site specific basis rather than on a broader scale. One interviewees emphasised that local authorities need 'an application of the science', an interpretation of 'what does it mean' in terms of where the most valuable soils are located.

There was interest in a number of specific and more general aspects relating to soils:

- more accurate/ up to date layer of the land capability for agriculture map
- the GIS layer of class 3.2 of land capability for agriculture map, and having access to the whole classification rather than classes 1,2, and 3.1 merged
- access to the land capability for agriculture boundaries as shape files
- natural quality of the soil (the background chemistry of soils)
- location of (semi) natural soils and their depth; GIS layers on undisturbed, disturbed and degraded soil
- data to get "a good idea of the soil profile" to give an idea of how successful the drilling on the site might be
- availability of the location of a soil sample in the GIS system to be able to click on it and see what the analysis of the sample is
- any chemical data available on the soil

- soil classification maps in electronic format - any spatial scale would be useful, even just the basis information
- information that traces changes to soil quality or type
- types of soils that can be identified on a map
- information on erosion in places other than coast (e.g. landslide risk or severity) and where it might have potential impact on housing developments. Information that would help councils assess how serious peat slumping is for roads (safety issue) and where areas of risk are
- availability of the option to quickly pull out information relating to soil that is amalgamated from different maps to allow for broad brush approach to recognise what is important in particular areas

In some instances, interviewees were very generic in the description of soil information that they might need. One interviewee said 'anything we might be able to get might be useful for us but there is nothing specifically that we are looking for', and another reported 'we always try to improve the quality of the data we have, so the more information we have the better'. Generally, there was an interest in up-to-date information, or at least knowing that the latest available information was being used.

3.1.3 Perceived barriers to access

Barriers to access appeared to originate from two distinct areas. One is related to information not being (freely) shared between organisations, the other to the skills and capacity to use and interpret the data.

Not all soil data and information is freely available. Licencing was mentioned as an issue which meant that Local Authorities only had limited access or were charged for accessing data. An example given was that BGS charge for some of the bore hole logs or make some of them limited access. This is coupled with insecurity whether available data is recent or outdated, e.g. one officer mentioned they have access to older SEPA hydro-geological classification but not the newer, revised classification which they felt would benefit their work. One interviewee described the situation as 'some organisations kind of keep it close to their chests'. Other interviewees, however, said they had no problems accessing data held by BGS or SEPA. There was the perception that because of the limited availability of soil information and the more readily available information on geology most of the work of contaminated land officers goes through the geological route rather than considering more detailed information on soils, so they operate on a coarser level than a soil scientist would.

A related point is the lack of knowledge of what soil-related information is available and where data is held. If data is dispersed across various organisations, this will be a barrier to accessing it. In one case, the interviewee reported they did not know what the threshold for deep peat is in relation to wind turbine planning permissions, and questioned whether such a threshold existed.

The lack of a soil science background can be another barrier to using soil information, even if the data itself is accessible. We observed that staff in planning are often generalists with geography, town planning or environmental planning background with little soils knowledge, and thus limited understanding of soil specific terminology and what the data actually means (e.g. what particular soil types or attributes might mean for the decisions that Local Authorities have to make). Two interviewees stressed that 'it needs training to go with the data' and 'there needs to be a context'.

It also became apparent from the interviews that planners and other staff at the local authority rely on a technical officer or GIS officer to pull together the data and GIS layers. They are typically the ones who know in more detail what specific spatial soil data is available. A problem arises when these officers work only part-time or the communication between those requiring the data and those compiling it does not work well. There was also one case where there was only a hard copy

available so that the council needed to set aside technician time to redraw boundaries of land capability map to create a shape file.

3.1.4 Preferred way of provision and access

Many interviewees highlighted that a central point where soil information could be accessed was preferable to having to get different pieces of information from various sources. Whether this central point is a website or a named organisation was less important. If there was a central website for environmental or soil data, it should advertise where people can access more detailed information or certain maps. The main contact (which organisation, which department) should also be provided.

In this context, interviewees emphasised that they would want to have the confidence that this data is kept up to date. For example, all maps, data and webpages should be labelled with a date or year.

Currently, SEPA, SNH and BGS are the source of soil information for councils. The James Hutton Institute (still often referred to as the Macaulay and the Macaulay soils maps) is only a secondary source of information (agencies would provide information or data that they in turn have received from the James Hutton Institute. In some cases, council staff personally know Institute staff and would access soil information through these channels.

It was suggested that working with Royal Town Planning Institute (RTPI) and Institute of Ecological and Environmental Managers (IEEM) could help provide the necessary training for planners with no specialist soil knowledge.

Because councils hold the information they use for local development planning on their GIS systems, any additional information would be most useful if it was available as a shape file that could be downloaded. In that way it could be integrated in the council's data sets and easily overlaid with other information. If viewing and interrogating information was only possible online, it would limit the way planning staff could use it in their work. Handling the GIS files appears to be delegated to a technician or GIS officer so these would be able to provide more information on technical details and requirements.

Providing access to soil data/information via a smartphone app was considered to be of some use but interviewees stressed that most of their work is desk-based and hence the frequency of expected use might not justify the investment.

3.2 Findings relating to farmers

3.2.1 Main concerns about soil

The farming interviewees emphasised the value of the soil as it forms the basis and 'heart' of their farming activity. Their main concerns regarding soil may be grouped into the following key themes:

i) Overall soil health;
ii) Soil compaction and erosion; and
iii) Legislative/regulatory demands.

Firstly, the concern of overall soil health includes the concern to maintain fertility, especially on arable ground and areas of continuous cropping, through 'feeding the soil' and returning organic matter. These management practices involve the application of organic fertiliser/farmyard manure, through crop rotation and clover-based fertiliser on grass, plus soil aeration through grass 'harrow' and leaving stubble over the winter, subsequently only ploughing directly before the next sowing period. Soil health is also maintained and improved through reducing chemical inputs in general, and maintaining pH levels.

Soil compaction is a further serious concern, as a result of animal trampling, the use of heavy machinery and ploughing when conditions are not suitable (e.g. soil is waterlogged). Compaction creates an impermeable top layer, often waterlogged but with dry soil underneath, and interviewees

explained that 'when it rains all the goodness gets washed away'. There is a concern that compaction is exacerbated by 'short windows of time' to complete key tasks in the farming calendar, often due to weather and changing seasons.

Issues of compaction can then lead to soil erosion due to run-off. Soil erosion is highlighted as of concern to the interviewees, through 'wind-blow', 'run-off' or 'wash-off'. Similarly, 'soil slumps' are of concern due to the large volumes of soil removed and resultant blocking of ditches and drains. Farmers take action to prevent erosion such as 'stitching in' (keeping grass on vulnerable areas) and applying seed where necessary, as well as avoiding poaching due to trampling by cattle. The interviewees also described the clearing of drains and 'wet holes' as an associated concern.

Finally, the farming interviewees also highlighted legislative demands as a concern regarding their soil resource, not least cross-compliance requirements and the need to create margins along water courses.

3.2.2 Soil data/information currently used

The interviewees described the current soil data and information that they currently use in their farming activity. The main drivers for their accessing this data and information is to understand nutrient levels on their farm and in turn be able to use variable rate application of seed, and to ensure the right fertilisation levels. The interviewees were also conscious of their responsibilities regarding Nitrate Vulnerable Zones (NVZs) and the risk of soil run-off near water courses, therefore take care in applying both organic and non-organic fertilisers (due to nitrogen level restrictions), applying muck on sloped areas in winter, as well as the location of dung middens, feed rings and cattle feed areas.

Soil data is accessed through a range of soil testing and interpretation techniques, not least through 'traditional' soil sampling and laboratory-based analysis, for example, as undertaken by SAC Consulting. Other commercial providers providing precision-farming techniques (such as 'SOYL') are also employed to provide field scale data and interpretation of the pH, organic matter, phosphorus and other micro-nutrients.

Similarly, interviewees use GPS soil mapping techniques and data, to gain a picture of the levels of phosphorus, nitrogen and potassium (and to establish whether a top-up of levels is required). Other soil analysis methods used by this group of farmers include land conductivity mapping (that highlights the best growing areas) and soil structure scanning by 'Soil Quest'. This technique permits the cultivation or sub-soiling of key areas according to the resultant maps, as well as targeted soil sampling and application of nutrients, in order to avoid blanket applications. Other soil mapping techniques mentioned by interviewees identify soil characteristics and variability. These methods provide the opportunity to pursue precision farming and contribute to reducing inputs overall.

Furthermore, paper-based Macaulay soil maps (as opposed to land capability maps) are used by the interviewees in composing NVZ plans and farm nutrient budgets in general. Paper maps are also helpful in checking soil types when applying for environmental schemes within the SRPD, for example, to see if it is possible to create a habitat mosaic given the soil series and characteristics.

Finally, interviewees noted the value of 'future proofing' workshops[4], which provide a useful chance to obtain immediate analysis and interpretation from soil samples taken to an event, as well as the opportunity for discussion.

3.2.3 Soil data/information needs and interpretation needs

The interviewees noted several aspects of soil data/information that are not currently available, for example, online NVZ maps, in addition to farms mapped outwith NVZ areas. Data on whether soil

[4] Examples of workshops previously attended by the interviewees were organised by the SAC and Soil Association, amongst other organisations, although 'future proofing' was not necessarily the focus (rather a wish of the interviewees).

improvement measures are cost-effective are not available. Furthermore, farmer interviewees showed an interest in soil as a living organism being 'more' than quantifiable nutrient levels but found that information supporting a holistic understanding of soils is not available.

There are mixed views regarding the need for certain soil data/information in the future. Some interviewees did not believe that there are future data needs and asserted that they have sufficient data/information for the requirements of their farm activity. Furthermore, soil health can be determined from observable physical indicators such as worm activity, and through observation developed with experience. Others explained that their priority is to 'get to grips' with and understand what soil data and information are currently available, and asserted that there is currently a 'wealth of information'. For example, one interviewee explained that they would like to utilise GPS technology in order to apply lime more precisely. There is subsequently a need to support farmer collaboration to access technology and associated soil data. It is perceived to be not economically viable to use GPS on a farm of less than 1000 acres, therefore farmer collaboration may provide the economies of scale required to ensure such technology is accessible (i.e. not too expensive for the individual farmer). One interviewee described the potential to install a satellite receiving system located centrally for use by a group of neighbouring farms, and therefore sharing the cost of upgrading to GPS technology.

The interviewees acknowledged that great advances have been made in agricultural-focussed technology, but there is a need for more information on the new technology, e.g. the potential of aerial and infrared photographs of crops (colour assessment) to identify nutrient requirements throughout the season. Similarly there is a perceived gap in technical knowledge, e.g. regarding seed rates and weed spraying. Furthermore, the interviewees stated that they would like to know more about the benefits of different soils and their management for livestock, e.g. regarding copper levels, and deep-rooted chicory and comfrey which can draw up subsoil minerals. More input on drainage is requested, and it is believed that historic knowledge and practices to maintain drainage have been forgotten. Concerns regarding erosion and drainage issues are linked to flood management and soil capability, for example the impact on drains and ditches from potato washing.

Barriers

The interviewees noted several barriers to their accessing the soil data necessary for optimum farming practice and soil management. The central barrier is that of cost, in particular initial technology cost associated with GPS, which is not considered economically viable on a small scale and on certain farm types (e.g. upland livestock farms). Lack of time to engage with new technologies such as the GPS or the 'Hutton card'[5] is also a barrier. There is also a perception that no further data is necessary for current farming practice, for example, the 'Macaulay Land Classification' maps are only used when farmers are looking to buy more farm land, or where the farmer has accumulated experience and knowledge of the soil types on their farm.

Interpretation

The interviewees believe that access to the interpretation of soil data is necessary and helpful. Currently soil data interpretation and further advice is provided by: agricultural merchants and consultants (e.g. SAC and other private individuals), through machinery rings, direct engagement with government agencies such as SEPA, as well as other organisations such as the Soil Association, and - until 2009 – the Farming and Wildlife Advisory Group (FWAG)[6]. Interpretation is also generated from the individual farmers' own observations, personal research/reading, and participating in local discussion groups.

[5] A colour card for use with the Smart Phone application to provide indicative soil carbon levels; see SOCIT website.

[6] Indeed, the demise of FWAG is said to have left a significant gap in data interpretation and advice particularly around biodiversity and environmental issues.

The interpretation of soil data has several key benefits for the farming community. Firstly, professional input removes the need for the individual farmer to be a 'specialist', while allowing them to gain specialist or expert knowledge. Secondly, it is valuable from a business perspective in order to target inputs and use resources wisely, contributing to better yields and profit. The interviewees also highlighted the importance of 'getting beyond the farm gate' and gaining interpretation of soil data through discussions and external interactions with peers and specialists.

There are concerns amongst interviewees regarding the potential for bias or misinterpretation from those who provide soil data interpretation. There is also a perceived danger that analysis or interpretation is not holistic enough. Indeed scientists are accused of focussing on only one problem in their analysis, whilst 'forgetting about the whole'. This perception highlights the need to involve practical, on-the-ground perspectives in interpreting data. The interviewees thus called for workshops covering all aspects and influences on soil health and output, for example comparing conventional and minimal tillage systems, on which there are mixed views. Such soil workshops are hoped to raise new questions regarding soil data and interpretation, and some have found events organised by e.g. the Soil Association helpful.

There is a split between those interviewees who wish to be 'hand held' with regards to soil data interpretation and those who do not seek advice. The interviewees also felt that farmers have had sufficient knowledge and education to interpret soil data and ultimately it is 'their responsibility', as is the resultant decision-making. Some interviewees requested a 'key' for better self-interpretation of lab results ('just a start is needed'). A lack of computer skills or sufficient broadband to access soil information must be overcome, and training is requested on technical developments to support on-farm interpretation.

Interviewees explained that they would be happy to pay for 'extra' interpretation of soil data and specialist advice. They do not see interpretation of soil data as a responsibility of Government, instead, should be offered by private companies and paid for by the farming community. Some cautioned that this 'argument is flawed' with regard to environmental issues and instead request government to incentivise more and encourage retail-driven change to achieve national goals.

Interviewees described how they approach and discuss soil data interpretation directly with Government agencies and request advice, for example through attending SEPA 'catchment walk' meetings. Direct discussions with Scottish Water and SGRPID ensure soil information is not misinterpreted through a third party. Nonetheless, interviewees noted farmers may be fearful of contact with SEPA and raised concerns regarding the consistency of their regulatory enforcement.

3.2.4 Views on soil data website

There are mixed views regarding the purpose and usefulness of an online soils data resource. Some interviewees stated that they would be interested in gaining information on rotations and other soil data when they are considering renting or buying land. There may also be benefits if online resources are map-based and if accompanied by further learning opportunities, including 'soil days' and awareness raising for farmers regarding soil management. The interviewees wished to be 'challenged' in their current practices. In particular, the interviewees suggested making specialist information available online, considering 'how soils work' and the differences between soil series. There may be further benefits from a soils website in terms of benchmarking between farms and recognising good practice.

However, the interviewees are concerned that an online resource would only provide broad level soil data, and not at the detailed field scale that would be necessary to support farmer decision-

making. There is uncertainty about the likely quality of the database at the field scale, given the multiple soil samples necessary to capture the soil picture of individual fields (e.g. pH level)[7].

Given the necessary detail and likely input required for construction, the interviewees questioned whether such an online resource should be a priority for Government funding. There is uncertainty that any further soil data would be provided beyond what the interviewees have access to at present. Nonetheless, were the online resource able to zoom into farm scale (1:15,000 or 1:10,000 rather than 1:25,000, which is currently available), this would contribute to more accurate understandings, for example, of changes over small distances (e.g. across a road, between seasons, etc). The interviewees also highlighted the wish to print soil maps from the online database of individual farms, and admitted that they would be curious to view a neighbour's land or if considering to buy another farm, or if sending cattle away for the summer (with regard to cobalt or copper levels, which can effect cattle value). Despite the widespread believe that 'most farmers know their soil', interviewees also acknowledge that such an online resource would provide reassurance and the opportunity to compare soil data and interpretation provided by private companies with an independent third party.

As an overall point, interviewees suggested that continued efforts to raise awareness of the Scotland's Soils website and available information are necessary, and recommended a link or banner from the Scottish Government's website.

3.3 Findings relating to estate managers

3.3.1 Soil data/information currently used

The interviewees suggested that soil is not a major focus of estate management, but acknowledged that issues around soil need to be understood and the asset protected (including the application of lime and other fertilisers). Broadly, soil data are not sought directly by the estate management, as depending on the tenure systems of farming on the estate, this is the responsibility and interest of the tenant farmers or estate agricultural manager. Indeed, any aspects of legislative compliance are typically included in tenancy agreements. Therefore, farm tenants or in-hand farm managers are known to take soil samples and receive analysis in order to establish pH levels, fertiliser requirements, etc. As one interviewee stated 'we don't have any reason for that sort of data', however others described that they can get 'involved' and influence farmers/estate tenants when 'things are looking bad'. The interviewees felt that perhaps a better awareness would be helpful, in particular, of long term soil information, in working together with tenants in order to maintain yields and monitor the long-term impacts of farm practices.

Soil becomes a focus and pH levels are tested when new forestry plantations are planned, and soil may be sampled by the estate's forestry interests (in the example described by the interviewee, a separate forest trust had a role in estate management). Furthermore, interviewees with in-hand farm management responsibilities described that soil tests are carried out when grassland is 'tired' or to assess nitrogen requirements (or fertiliser in general). Soil cores are either collected by the estate manager or a contractor (e.g. SAC) and undergo lab-analysis. Testing in this example was for establishing a game crop.

Of more direct interest and use for the estate managers interviewed were the Macaulay Land Use Classifications or land capability maps, which are widely available in paper form in the offices of those interviewed. These maps are used for reference in the valuation and marketing of properties, and to compare land types for rent reviews. The interviewees explained that the land capability is very influential in the perception of quality and therefore on land value per acre. However, one

[7] It is acknowledged that with traditional sampling methods only an average pH is provided across the whole field, sufficient for blanket applications of lime and other fertilisers.

interviewee noted that the maps only cover the 'better land' and not the upland estate that they primarily focus on.

Other soil-related issues that were raised by the interviewees include the need for clearing silt run-off from ditches for flood alleviation, overgrazing and soil compaction. Soil compaction issues have led to the 'sacrifice' of fields and the need for soil pans to be broken up. Finally there are concerns regarding the loss of soil and the need for advice on how to protect soil e.g. buffer strips to minimise soil run off, and specific detail is requested on where soil is being removed. As one interviewee stated, 'nobody wants to lose soil.'

3.3.2 Soil data/information needs and interpretation needs

The interviewees noted that soil 'underpins everything', and they are concerned regarding their own lack of knowledge. They highlighted several aspects of soil data/information that they consider would be helpful in their estate management. In particular, they believe that a more holistic picture of soils is necessary for estate management decision-making, and that the more detailed, reliable, and time-dated soil data available the better. For example, detailed data on soil type, e.g. field-by-field, and on the quality of drainage (and the investment required to return a field to production) would be very useful for desk-based research and in valuing large properties, especially where time constraints exist. However, interviewees are concerned that such data could not be time-specific if built into a database.

Further detailed and accurate analysis on the quantity of soil lost annually in catchments (or the rate of soil run-off) would be of interest to the estate managers, as they are losing an asset and could provide guidance to farmers through the renewal and creation of leases. The interviewees suggest that the 'Macaulay maps' could be updated to take account of gradual improvements or decline of soils overtime, as a result of human action or inaction.

Generating creative ideas for 'wild land' (i.e. unused) not under woodland cover and beyond grazing may require an assessment of available soil data. If carbon is to provide an extra income source for land managers, then further soil data and information is considered necessary. Finally, the interviewees mentioned spot-testing, for example to establish lime requirements, as an opportunity to improve soil management, but again suggested this may be used primarily by tenant farmers and may have cost implications.

Furthermore, better coverage of maps was requested, including 'decent land at the bottom of glens', which would be helpful to have clarified; however, this is anticipated in the near future for Single Farm Payment purposes. A soil map and a map of subsoils would provide 'at a glance' information on the Macaulay assessment of soil classification, and may contribute to overcoming farmer reliance on their own experiential knowledge of land (field scale) quality.

Barriers

The interviewees felt that their main barrier to accessing soil data and information is their lack of awareness of what is available or may be useful to them, coined as 'I don't know what I don't know'. There was agreement that if there was more publically available soil information they might make more use of it and also use it to advise others. Given their limited soil data needs, as mentioned, they also felt that there are no barriers to accessing their required information, other than the possible cost (which may be prohibitive) of employing external advisors/consultants (e.g. SAC). Others explained that past soil analyses are helpful, but only if the interviewee is able to read and understand the results, and that the attached recommendations for practice are most useful (rather than the historic results).

Interpretation

The interviewees believed that soil data requires skilled interpretation, and that human error can arise with application of information. Nonetheless, the scale of interpretation necessary depends on the nature of the estate business. At times having access to the raw data (e.g. lab analysis) is seen as

useful rather than having access to the interpreted results only. On other occasions, basic information available on soil types for different land uses is assessed to be sufficient, and specific information would be pursued when required later. Immediate in-depth interpretation is therefore not always essential.

Others noted the advice and management options provided through the interpretation of 'scientific' soil data by the SAC and the James Hutton Institute. In particular, SAC has the capacity to disseminate this information through agricultural advisors and their newsletter which interviewees assume to be effective as most tenant farmers will be members. The interviewees also note other sources of interpretation, including independent consultants, estate manager friends, colleagues and other estate staff, government organisations (SNH, SEPA and SGRPID) and NGOs such as the John Muir Trust.

3.3.3 Views on soil data website

The interviewees described their wishes for a website or online resource for soil data, in particular highlighting the wish to access very specific information about certain small areas, and that as detailed maps as possible would be necessary (zooming in and using 1:25,000 scale). There is also a wish to find out about current conditions, and knowledge of soil data and interpretation, for example, when a farm or other property is to be sold, re-let or if exploring alternative land use systems. There is a perceived benefit of incorporating local knowledge.

An online resource would therefore be of use to the estate managers interviewed if it provided date-specified 'spot points' of land/soil quality, and if it was possible to change 'layers' of information (e.g. add soil layer to OS map), as well as download and print such maps. There is a wish for information more detailed than land classifications, and pH levels are already gathered by farm tenants. A 'soil types' application for smart phones is welcomed as long as OS maps are also a visible layer. Overall, the interviewees noted that they currently must look for geo-spatial information in a range of different locations[8], and they would find it very useful to be able to compile this information in a central and useable format, incorporating flooding, designations, and soil information, for example.

[8] For example, the interviewees mention that the SNH mapping resource is useful and may be a good location to incorporate 'soils layers'. The archaeology website 'pastmap.co.uk' is also noted as a helpful resource.

4 Conclusions

The three 'end user' groups interviewed – local authorities, farmers, estate managers - have markedly different needs regarding soil information and data. To a large extent, soil information needs are driven by policies (e.g. the Local Development Plan policies for councils; regulation and cross compliance policy for farmers) and business needs (soil nutrient management for high yields, forestry planning).

Soil data/ information needs of different user groups

Councils use soil information to determine land allocations and longer term/broader scale planning, as well as decision making with regard to contaminated sites and remediation measures. Farmers, on the other hand, need much more detailed and almost 'real time' information regarding their soil to aid day to day decision making regarding crop and soil management. They voice concerns that an online resource would only provide broad level soil data, and not at the detailed field scale that would be necessary to support farmer decision-making. Estates use soil information for reference in the valuation and marketing of properties, to compare land types for rent reviews, and to guide decisions on new forestry plantations. They require soil data in less detail than farmers but still prefer scales larger than 1:25,000.

Farmers believe they know their soil (types) well and there is no need for further data or updates to the Macaulay Land Classification maps. Such maps are only used when farmers are looking to buy or rent farm land. This aspect is similar to the councils' Property units when they need to determine land values.

A repository of maps showing agricultural drains appears to be a useful piece of information due to the link between drainage, waterlogging, compaction and erosion. Farmers requested such 'historic knowledge' in order to maintain drainage. Similarly, council interviewees showed an interest in information and maps on peat depth, natural quality of soils, degree of disturbance, chemical data and erosion.

Barriers to accessing soil data/information

A lack of knowledge about what types of soil data, maps and information is available and where to access it became apparent among both, local authority and estate interviewees. Farmers, in contrast, predominantly get their soil data from field soil testing. All three groups had an interest in the availability of up to date soil information, coupled with an acknowledgement that often they were not clear how quickly or slowly soils change and hence what time frames are adequate.

The lack of knowledge among the council interviewees regarding the availability of soil data (in particular which digital maps and at what scales are available) may have led to additional work. Shape files have been available free of charge since 2011 for non –commercial use (SNH communication) however the information about which data (e.g. GIS files) are available does not seem to have diffused sufficiently within local authorities. In some cases, staff do not know whether soil and land capability maps are available (electronically) within the council which might be due to the arrangement that there are separate GIS officers or technician that e.g. a planner asks for certain information when it is needed. There are also concerns around licencing, costs associated with access to data or data not being made available (selected bore hole data held by BGS).

Hence, barriers to access relate to lack of knowledge what data is held by the councils, but also the perception fact that some data is not available or only at a cost. These barriers are exacerbated in cases where staff do not have soil specific knowledge and thus would not be able to interpret certain soil data even if available.

Farmers' barriers to accessing soil data relate more to the costs of technology (e.g. GPS) and the time available to learn about new technology. In addition, they may lack the computer skills or sufficient broadband, as well as the time to search online for certain information, or not see the

need to access additional soil information. Estate managers find the cost of consultants a limiting factor in accessing soil information.

The results illustrate what user groups utilise data for and this should be used to identify where available data can help users in their daily decision making. Overall, the interviews suggest that a targeted effort to raise awareness of the Scotland's Soils website and data available is necessary, which would also help to remind people what is (now) available, from which sources and how it can be used. There is benefit in enriching such a 'campaign' by highlighting how selected soil information can be used in selected areas of work (for example, what a GIS layer on soil types at a certain scale could add to the councils ability to address their policy on carbon-rich soils; or how a certain soil type is likely respond to a cropping regime with barley/oilseed rape rotation under reduced tillage).

Interpretation of soil data and advice

A number of agencies (SNH, SEPA) as well as the James Hutton Institute, and BGS were consistently mentioned as sources of advice on soil and help with interpreting. Council staff also draw on colleagues in other council departments. Consultants (mainly SAC was mentioned), other agricultural advisors, agricultural merchants and agronomists are of particular importance for farmers and to a lesser extent for estate managers. Farmers also draw on their peers and farming organisations for advice (e.g. machinery rings, Soil Association), and may use Scottish Water and SGRPID to check third party interpretation of soil analyses. Estate managers access advice via independent consultants, estate manager friends, colleagues and other estate staff, government organisations (SNH, SEPA and SGRPID) and NGOs such as the John Muir Trust.

Enhancing approaches to provide soil information and interpretation for different user groups - Preferred formats for different user groups

In principle, the idea of making soil data and information available on a website was welcomed. This was seen to be even more useful if all available information was deposited in this one location so that different sources and types of information could be drawn on. A number of aspects were mentioned that would enhance the usefulness:

- Users wanted to be ensured that they were using the most up to date information.
- For local authorities it is best to download shapefiles so they can be integrated in the council's own GIS system. It was perceived as limiting if the interrogation of data was only possible online.
- Farmers would appreciate further learning opportunities alongside the soil data on the website, including 'soil days' and awareness raising for farmers regarding soil management, and taking a holistic approach to how soils work and their functions.
- Planners with no specialist soil knowledge would benefit from training provided through their professional bodies, so opportunities for collaboration with the Royal Town Planning Institute (RTPI) and Institute of Ecological and Environmental Managers (IEEM) should be explored.

The latter two points emphasise that users feel that simply putting data on a website does not immediately make it meaningful and useful.

The website should:

- advertise where people can access more detailed information or certain maps;
- provide contact details so questions can be followed in person;
- provide soil information with contextual information (e.g. soil types overlaid on OS map)
- allow maps and details to be printed;
- allow for integration (overlay) with other information such as flooding or designations
- include links on the website for training and guidance; and
- be clear on what scale data and maps are available (farmers will require more detailed maps, estates are interested in 'spot points', councils require broader maps).

One suggestion put forward by farmer interviewees was to investigate opportunities for bench-marking between farms and recognising good practice which could be tied into a soils website (note that the sample of farmers interviewed included farmers with high environmental awareness).

While recognising the potential benefits of a soils website, there were also concerns from interviewees that an online resource would only provide broad level soil data, and not at the detailed field scale that would be necessary to support farmer decision-making. There is uncertainty about the likely quality of the database at the field scale and whether any further soil data would be provided beyond what the interviewees have access to at present. This leads some interviewees to question whether such an online resource should be a priority for Government funding.

A 'soil types' application for smart phones is welcomed as long as OS maps are also a visible layer. Through another project, a soil carbon app has been identified as useful for farmers but uptake is not widespread (yet) as this app is a recent development. Depending on what a smartphone app could provide it may be of use to council officers, however, there is limited application because most of their work is desk-based.

The results reported in the 'findings' sections represent the views of the interviewees. In particular, soil information requested by interviewees should be carefully crosschecked with what is already available. However, where interviewees perceived that certain information was not available, this should form the basis to guide targeted information distribution.

Results are not generalisable across any of the end user groups due to the small sample size, the wide variety of farming systems and estate types, and the diverse departments in councils using soil information in different ways.