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Project identification

1. Defra Project code: SP0562

2. Project title:
   Co-ordinate an Expert Group to assemble UK-wide data on soil carbon (greenhouse gase fluxes) in the context of land management.

3. Contractor organisation(s):
   WCA Environment
   ADAS
   University of Aberdeen
   Roger Unwin
   University of Durham
   Environment Agency

4. Total Defra project costs (agreed fixed price): £ 40124

5. Project: start date ..... 29 October 2007

   end date ..... 31 March 2008

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Executive Summary

7. The executive summary must not exceed 2 sides in total of A4 and should be understandable to the intelligent non-scientist. It should cover the main objectives, methods and findings of the research, together with any other significant events and options for new work.

The impact of climate change upon soils and land management in the UK could be highly significant. In order to provide certainty around this statement there is a need to understand the transfer and fate of carbon, and other potential greenhouse gases, from soils in response to climate change and land management practice. Policy-makers across Defra and other government departments have a key requirement for reliable data on soil carbon on which evidence-based policy decisions can be made. Recent evidence suggests that carbon is being lost from soils in England and Wales (Bellamy et al. 2006), but the cause of this loss is unclear (Smith et al. 2007). Therefore, it is likely that the impacts of any specific mitigation measures to reduce or halt this loss could not currently be quantified.

Yet it is the belief of both Policy-makers and UK soil scientists that sufficient information *already* exists to enable the impact of existing government policies on soil organic carbon losses and other greenhouse gases to be examined. However, it also widely recognised that in the UK this information is currently highly fragmented and poorly integrated.

The main objective of this project was to assemble a small group of soil science experts to develop a practical strategy to knit together these fragmented UK data sources on soil carbon (and greenhouse gas fluxes) in the context of land management. In order to meet this objective the group was charged with both identifying the key datasets with which to set a baseline for soil carbon stock in the UK and establishing how these data could be best collated. Again through the use of existing data, understand some of the key land use changes and processes affecting soil C (and other soil-based sources of greenhouse gases) to occur over the next 50 years and establish some of the key tools and models for the prediction of soil C fate and behaviour in the UK. Finally, there is a need to provide a strategic and coordinated programme of work to deliver integration of these key areas, fill significant data gaps and describe residual uncertainty and underlying assumptions remain.

In order to meet these objectives of this project there was a requirement for an Expert Group with a range of skills across several disciplines. These requirements were met by the use of an expert group consisting of respected members of the UK soil community with knowledge and understanding of soil carbon behaviour and fate, land use and management and UK soils research and policy. The following experts agreed to take part in the project: Professor Brian Chambers, Dr Fred Worral, Professor Pete Smith, Dr Declan Barraclough and Dr Roger Unwin.

A meeting of the Experts and Defra Policy and Science leads was convened to provide an opportunity for a structured discussion of the project objectives. The approach taken initially was to detail the data

requirements needed to enable the impact of existing government policies on soil organic carbon losses and other greenhouse gases to be determined, then to compare these requirements with *existing* UK and international datasets. It was decided to split land use and management into two initial groups: lowland and upland. Lowland land uses and management practices were thought to be already well scoped out and generally understood in terms of soil C stocks and fluxes. It was suggested that the use of a simple spreadsheet tool could provide both a framework for discussions and a focussed endpoint for the numerous data streams required to deliver soil policy leads with guidance on the likely impact of certain soil C strategies.

The tool would be in the form of a matrix of land use changes through which changes from one to another would provide an indication of the per hectare soil C stock change and fluxes. The tool would also have the facility to differentiate changes in C stocks and fluxes on the basis of management intensity factors such as fertilizer practice, stocking density, changed tillage, etc. A number of key datasets were identified through which soil carbon stocks and fluxes could be predicted and responses to land use and land management changes estimated through the use of the tool. For lowland uses it was felt that relatively accurate and precise predictions of changes in soil carbon stocks and fluxes in response to land management could be made. However, for uplands this would not be possible, although the direction of change in stocks and fluxes in response to management could be reasonably determined. Finally, in order to interpret the outputs of the spreadsheet tool, with an output in "change in C per hectare", it was decided there was a need to define the spatial extent of land use change. It was suggested that a range of situations should be delineated, which represent the reasonable extremes of land management in the UK. For example, the worst case situation, in regard to excessive soil C loss, could be considered to be represented by increases in rates of ploughing (such as indicated by records from the early 1940's) and the reasonable best situation being arable reversion in groundwater protection zones, reinstatement of set-aside and full uptake of the Higher Level Stewardship Scheme.

Key areas identified for which it was known that relevant data existed, but additional effort was needed to integrate these data to reduce uncertainty and the need for board assumptions included;

- Accounting for the carbon in organo-mineral soils - effectively soils which have less than 50% organic matter are often not considered in either upland or lowland research programs, but may represent a significant stock and subsequent flux of C.
- Re-examination and interpretation of existing databases and data sources – a number of national soil datasets have been used previously to estimate soil C stocks and fluxes. Mismatches between these are potentially a significant source of uncertainty.
- Establishing the linkage between DOC flux via fluvial pathways and soil C loss – data for both exist but limited efforts have been made at integration.

This project has identified a strategic and coordinated programme of work to deliver integration of existing UK data on soil carbon (and greenhouse gas fluxes). Furthermore, it has established a practical methodological framework, in the form of the spreadsheet tool, through which data can be integrated and importantly gaps and uncertainties quantified. Through the identification of a number 'worst' and 'best' case land use and management situations it will be possible to make judgements of policy-based scenarios in regard to soil carbon on a national scale.

Project Report to Defra

8. As a guide this report should be no longer than 20 sides of A4. This report is to provide Defra with details of the outputs of the research project for internal purposes; to meet the terms of the contract; and to allow Defra to publish details of the outputs to meet Environmental Information Regulation or Freedom of Information obligations. This short report to Defra does not preclude contractors from also seeking to publish a full, formal scientific report/paper in an appropriate scientific or other journal/publication. Indeed, Defra actively encourages such publications as part of the contract terms. The report to Defra should include:

- the scientific objectives as set out in the contract;
- the extent to which the objectives set out in the contract have been met;
- details of methods used and the results obtained, including statistical analysis (if appropriate);
- a discussion of the results and their reliability;
- the main implications of the findings;
- possible future work; and
- any action resulting from the research (e.g. IP, Knowledge Transfer).

The overall objective of this project was to assemble UK-wide data on soil carbon (and greenhouse gas fluxes) in the context of land management. Specific objectives to achieve this were;

- Form and manage an expert group to identify the key areas of investigation to achieve the overall objective, specifically:
    - Identify the existence and value of UK datasets for use in setting a baseline for soil carbon stocks in the UK. Determine how best existing data can be collated and used in meeting the overall objective, but flag any significant data gaps.
    - To understand some of the key land use changes and processes affecting soil C (and other soil-based sources of greenhouse gases) to occur over the next 50 years in regard to stocks and possible fluxes. Determine how best these data can be collated and used in meeting the overall objective and also to identify data shortfalls.
    - Identify the key tools and models for the prediction of soil C fate and behaviour in the UK. Consider the validation and 'truthing' of these tools and assess the data requirements needed to reduce uncertainty of outputs if used to understand the processes driving spatial and temporal properties of carbon in soil in the UK.
- Provide a strategic and coordinated programme of work to deliver integration of these three key areas and fill significant data gaps.
- Prioritise the items in this programme in regard to the potential value for providing evidence for policy makers for the management of soil carbon. Additionally, clearly describe likely residual uncertainty and underlying assumptions that will exist in relation to this evidence.

The multifaceted and complex nature of the data needs for this project meant that there was a requirement for a range of skills across several science disciplines. These requirements were met through the selection of an expert group, through consultation with the Defra Project Team, consisting of respected members of the UK soil community with knowledge and understanding of soil carbon behaviour and fate, land use and management and UK soils research and policy. The following experts agreed to take part: Professor Brian Chambers, Dr Fred Worral, Professor Pete Smith, Dr Declan Barraclough and Dr Roger Unwin.

The experts were brought together, along Defra Policy and Science leads, for a two day meeting in Bristol at which there was a full discussion of the project objectives. The discussion was structured through the use of a series of pre-seen questions (see below) and seminal papers and initially followed a 'what if' approach where by the data requirements were detailed in a situation in which there were no resource limitations. These requirements were then compared to the known data and information sources. This rapidly enabled gaps and linkages to be established. The deliberations and decisions by the experts were recorded, in order to allow the reasoning and evidence to be transparently followed. This is in line with guidance given on the use of expert groups in this type of project by the Royal Commission's 21st Report of Setting Environmental Standards (http://www.rcep.org.uk/standards.htm). A meeting note was drafted at the meeting close and then circulated to the experts and Defra colleagues for comment and clarifications. The text of the final agreed meeting note is given below and forms the basis of this project report.

Possible future work is addressed at the end of the meeting note and is to be used to draft the second phase of this work which will enable the delivery of practical, readily interpretable and reliable evidence to enable policy makers prioritise methods for the management of soil carbon (and greenhouse gas fluxes).

Note of the Expert meeting to assemble UK-wide data on soil carbon (and greenhouse gas fluxes) in the context of land management.

4th and 5th of February 2008
Bristol

Attendees

Declan Barraclough, Environment Agency	Fred Worrall, University of Durham	Phil Goodliffe, Defra
Pete Smith, University of Aberdeen	Roger Unwin, Independent Consultant	Sal Burgess, Defra
Brian Chambers, ADAS	Graham Merrington, Watts and Crane Associates	Julia Duzant, Defra

1. Background

Recent workshops held by Defra asked policy makers and scientists for the best way forward to reduce uncertainties related to the behaviour and fate of soil organic carbon (SOC) in UK soils. There were several outputs common to both meetings, one of which was a clear view that greater emphasis should be placed on the use and interpretation of *existing* soil-related datasets.

This Expert Group was convened to address this broad issue in the light of recent evidence suggesting that carbon is being lost from soils in England and Wales. The cause of this loss is unclear (Bellamy et al. 2006, Smith et al. 2007a), so the impacts of any specific mitigation measures cannot be understood or quantified. There have been numerous calls for more research and detailed collection of data. But how much of the information needed to address these uncertainties already exists? Specifically the aims of this Expert Group are to:

- Assess the existence, availability and provenance of data on UK soil carbon stocks, fluxes *and* land use influences.
- Appraise the potential limitations of these data and draw conclusions on how these limitations may be reduced.
- Establish the data and research requirements to deliver better, more certain, outputs from existing models for C turnover, fate and behaviour.

The Group was charged with recommending pragmatic approaches that would provide policy-makers with an evidence base on which to build a soil C management strategy. The following is a brief minute of the meeting of this Expert Group, with the key outputs highlighted. The questions are those asked of the Group in the order in which they were asked. Initially the discussion was directed to an "ideal world" situation in there were no limitations on resources that could be put to data gathering. The second part of the discussion was aimed at attempting to map what is currently available onto this ideal situation. A summary and way forward indicates how this information may be used.

2. Questions

What would we want?

1. If you started with a "blank sheet" what data would be gathered in order to establish UK soil carbon stocks?

There is a requirement for accurate soil maps with associated physico-chemical characterisation data (including soil depth, bulk density and SOC determined by dry combustion). Furthermore, land use (which for the purposes of this exercise includes land management) and land use change data, on an annual basis, should also be available. This information, supplemented with climate data may be used to begin to construct a change matrix for SOC across the UK.

Land use cover maps are currently poor for peat soils and there is also limited mapping detail for soils at the margins of upland peats, i.e., where are the boundaries between peats and organo-mineral soils and of organo-mineral soils with mineral soils Improved mapping and sampling density compared to what is currently available would be helpful (as the Countryside Survey is not soil-based it is not that helpful here). Remote sensing data and LIDAR outputs (and maybe ground penetrating radar) could both be used to improve estimates of C stocks and give high quality land use data, especially for peats and organo-mineral soils. The area and extent of peat soils are a key variable if C stocks are to be established.

It was suggested that while, in many cases, the stocks of C in some upland soils may be very large, the fluxes may be very small. If the focus was only on SOC fluxes then only an understanding of whether the peat was deep or shallow would be required. For example, the inactive deeper layer of the peat or catotelm will be of limited importance in regard to fluxes and therefore attention would focus on the upper, active peat layers. Nevertheless, it was stressed that to have an accurate assessment of C Stocks this was likely to be a key policy requirement.

The use of "benchmark" sites was proposed as an excellent way to gather data and provide training data sets for models. Fully factorial design for land use and land use management could be used at these sites. Such sites would not only be used to monitor the status of soil C over time but to determine the influences of imposed land use/management changes on soil C under controlled conditions. Such sites would include upland and lowland sites.

2. What data should be gathered for soil C flux to be accurately measured?

Individual C pathways need to be measured in a fully factorial design to derive complete C budgets. Therefore, data would be required on the 5 key losses from soils:

- dissolved organic carbon (DOC),
- particulate organic carbon (POC) excess,
- methane,
- nitrous oxide, and
- carbon dioxide.

Information on land use and land use change would also be required as this would enable "hot spots" for losses to be targeted. By implication, baseline fluxes would also be determined.

Benchmark sites were again discussed as presenting a sensible means to assess soil C change. This would enable prioritisation of soils, land uses or management strategies, which may account for large parts of the variance in the flux. It was thought that the data collected from these sites should be open to public scrutiny and free for independent use. The UK is poorly served in this way and examples of freely available data sources similar to this exist in other countries (e.g., Canada, France, US).

3. What data would you require on land use and management practices?
The Group initially split land use and management into two groups: lowland and upland. Lowland land uses and management practices were thought to be already well scoped out and generally understood in terms of soil C stocks and fluxes. However, there was a view that significantly more gaps in current data exist for uplands. Again, the Group stressed the importance of understanding the direction of soil C change associated with land use change, as a first priority before being able to define its form and magnitude accurately.

It was suggested that a simple spreadsheet-based tool (a meta model?) could be used to provide an indication of the per hectare soil C stock change and fluxes, and associated land use change scenarios and management. Furthermore, such a tool would be a focussed endpoint for the numerous data streams required to deliver soil policy leads with guidance on the likely impact of certain soil C strategies. For example, the relevant lowland land use changes to be fitted in the spreadsheet tool would include:

- Permanent Grassland to arable/bio-energy crops as below
- Ley-arable system (oscillation)
- Ley grassland to arable/bio-energy crops as below
- Bioenergy crops, i.e. trees (e.g. willow), short rotation coppice and *Miscanthus*
- Forestry
- Flooding (water table management).

All cultivations are assumed to have the same effect because there is likely to be deep cultivation periodically. A question was raised here as to the importance of salt marshes in terms on soil C stocks. The current estimate from existing databases of the spatial extent of salt marshes in England and Wales is put at > 5%. Questions were also raised in regard to the potential impact of managed and unmanaged retreat.

It was envisaged that within the spreadsheet a matrix would be set up in which all the above land uses could be changed to any of the others in the list above. The outputs would be ranges of change in soil fluxes per unit area. For the upland land uses/management the key changes were thought to be:

- Drained (or gripped)
- Burnt (and type of burning)
- Cut – i.e., the vegetation, not the peat
- Eroded
- Grazed
- Restored (revegetation, rewetting)
- Forestry

Attention was again drawn to the potential importance of fringe or marginal land (not the same as 'in-bye' land) which generally falls between those who work on peats and those who work on lowland soils – i.e. organic mineral soils.

The spreadsheet tool would also need to have the facility to consider intensity, i.e., fertilizer rate, stocking density, etc. and possibly soil texture, although such information may be limited for upland soils.

It was a widely held view amongst the panel of experts that much of this data is currently in existence for UK soils. While precision and accuracy may be lacking for relatively minor perturbations in SOC it was felt that there was enough certainty to provide "no regret strategies" for land use in which the direction of change in SOC was understood. For example uncertainty may remain in regard to magnitude of soil C change, but the direction of change would be certain and would represent other management benefits, therefore presenting 'no regrets'. Attention was also drawn to the continued digging of peats for fuel, and especially for horticulture, which is unlikely to represent appropriate management of soil C stocks.

What have we got?

4. What data are currently available in order to establish UK soil carbon stocks?
There is a significant amount of data available to provide a start in attempting to derive soil C stocks in the UK. The available data were divided into two clear groups:

- those datasets that provide information from which to derive baseline stocks across countries, which included: the NSI, Agricultural Census data, Countryside Survey, possibly the Representative Soil Sampling Scheme, Global MODIS (which will give NPP at a 1 km resolution on an annual and sometimes monthly basis - http://modis.gsfc.nasa.gov/) and Land cover Map and HOST – a hydrologically-based classification system for soils (http://www.ceh.ac.uk/products/publications/documents/IH126HYDROLOGYOFSOILTYPES.pdf)
- those datasets which may be more spatially limited but provide detailed information about specific sites and land use management and changes, including: the John Miles Birch Plots, Rothamsted/Long Ashton, Soil QC (Defra project SP0530), ADAS Fen Silt Sites, SOMNET

(http://www.rothamsted.ac.uk/aen/somnet/), Forestry Commission reference sites (Robert Matthews),ICP Forests(http://www.icp-forests.org/) and ECN (http://www.ecn.ac.uk/)

For uplands, data were considered to be less available and attention was again drawn to those soils that do not fall into the category of peats (i.e., < 50 % organic matter), but which still may represent significant C stocks and fluxes.

It was thought that any benchmark sites were unlikely to be set up *de novo*, but that "piggy backing" on some of the many existing soil benchmark sites established for numerous other reasons (some listed above) seemed possible.

5. What data do we already have that will enable soil C flux to be accurately measured?
The aim of data gathering on soil C flux is to close the carbon balance. However, there are few sites for which the five key C measurements are made (plus measurement of nitrous oxide). These sites are generally those in the ECN or in the new carbon catchments programme, and include Plynlimon, Moor House and Auchen Corth Moss.

Some sites do exist for which only a limited number of the key 5 measurements have been made. These were still thought to be extremely useful and include the work undertaken under the auspices of CarboEurope (http://www.carboeurope.org/) with flux towers on arable and forestry sites.

There are a significant number of sources of DOC and suspended sediment data held by the Environment Agency from the Harmonised Monitoring Scheme, and in their routine monitoring data which are available under licence. However, a concern was raised about the lack of linkage in this data between the fluvial transport of C and soils in the respective catchments. Also, the acid monitoring network set up by Defra and including 11 lakes and 11 streams may provide useful data.

Measures of rates of erosion from mineral soils (using Cs^{137} tracers) are to be reported in the summer in a Defra funded project (SP0413).

It was suggested that for lowland soils it would be possible to make some quantitative statements about soil C fluxes, with the focus on CO_2. The other fluxes may be assumed to be relatively small in comparison if the site is freely draining with a low angle of elevation (Smith et. al 2007b; 2008).

For upland soils there are, as with the assessment of C stocks, relatively limited data and crucially the assumptions for other fluxes from these soils are not valid. There are few sites with all 5 key measures; sites will likely have only 3 of the 5, at most.

Through the use of the spreadsheet tool gaps in fluxes (and stocks) data would be readily and easily highlighted. The possibility of filling these gaps with model output data was also discussed, specifically in relation to adding weight-of-evidence to a particular literature or measured value. Guo and Gifford (2002) provide some C stocks and flux data for a number of land use changes that could be used in building up the spreadsheet tool.

6. What data do we have on land use and management practices?
Consideration of this question was driven through the desire to populate the spreadsheet tool, and therefore land uses were divided into lowland and upland.

Lowland soil, land use and management were thought to be adequately well covered with existing data, although limitations in land use data (such as for the NSI) were highlighted. Land use change factors in relation to stocks and fluxes of C were thought to be readily calculable from existing data and, while the accuracy of these may not be high, the direction of change would be known. The influence of forestry practices on C stocks and fluxes has recently been reported in a Defra funded project (Milne and Mobbs 2004). However, tillage is key for arable and ley arable systems and the Farm Practice Survey could be used to provide interpretive information for the outputs from the spreadsheet (i.e., 50% of all land is ploughed every X years). The Group also suggested that the Internal Drainage Boards should be contacted for information on the management of water tables.

For the upland soils there was a view that information sources were available through remote sensing and aerial photograph data. Rather than suggesting more research there was a call for reinterpretation of these information sources. Data on cutting and burning may be available from records kept by Natural England or Scottish Natural Heritage specifically in relation to management of SSSIs. A current Defra project, *the protecting and enhancing peat soils: phase 1*, is looking to develop a number of policy leavers and management options for peats and may well provide an additional multi-agency data source from upland soils.

Again, the importance of soils in the margins – i.e., organo-mineral soils were discussed as potentially representing a new category in the spreadsheet beyond lowland and upland. Estimates for Scotland suggest these soils may represent up to 22% of land area, whereas for England and Wales estimates were between 6-

9%. Land use (and change) information was thought to be difficult to obtain for these areas. However, recent Agricultural Census information is readily available at the Ward level, which would give some localised management and intensity (stocking density, etc) data.

A number of predictive models were discussed in relation to the value of the outputs and constraints in use and interpretation. This topic was discussed further at the meeting and a summary of this discussion is given below (Question 9).

How could we improve the use of the current data?

7. Reducing the errors and uncertainties using existing datasets?

As there are several sources of data currently available for the derivation of soil C stocks (Question 4) it was suggested that the mismatches between these data sets, when they are used to calculate C stocks, may represent a significant area of uncertainty. This would be especially highlighted for the different land uses, for example a comparison of NSI and Countryside Survey information. This exercise would also show where there was good agreement between, and potentially greater certainty in, calculations. The extent of peat soils (and organo-mineral soils) could also be compared and under-representation and mismatches highlighted.

The cross-validation of land cover and potentially even ground-truthing would also provide certainty about the six key lowland land use change scenarios mentioned previously (perhaps use Tier 1 of the Countryside Survey and initially check against the Agricultural Census data, although this is likely to be spatially limited).

For soil C (and other GHG) flux there was confidence amongst the Group that the spreadsheet tool could be reasonably populated for lowlands in terms of direction, if not magnitude, of change. It was thought that the GHG Inventory Project was likely to be collecting little information of direct relevance to this work, but that periodic reference to the outputs from this should be made. However, for the uplands, considerable uncertainty was thought to remain about fluxes of nitrous oxide, with only very limited data sources. It was thought that for methane there existed enough data to begin to populate the spreadsheet.

The use of international data was considered. Where there are gaps in the spreadsheet or matrix then it was considered appropriate to use data from similar situations. However, they should be clearly flagged and attempts should be made to replace them with relevant UK-based values.

8. What research is required and how would that reduce the uncertainty?

Confidence in current estimates of C stocks is somewhat limited due to the paucity of data on peat depths. The current mapping units and measures are limited and data reported in ECOSSE suggest that in some cases errors may be significant. This work would build the validation exercise mentioned in paragraphs 1 and 2 in Question 7 and would be aimed at increasing the confidence in soil C stocks calculations through the use of existing datasets. Potentially this work could be supplemented by the re-examination of recent aerial photos and LIDAR data.

Currently there is only a limited link between DOC flux via fluvial transport and soil C loss in the respective catchment. As mentioned previously, there is a significant amount of data on DOC in freshwaters and catchment information is available from the Environment Agency. The link between land use/management and fluvial transport of DOC and therefore C flux may be relatively straightforward to gauge. It was thought that by selecting a “reasonable worst case” catchment (i.e., high rainfall, uniform soil type and land use/management) any potential linkages could be readily identified. Examples of catchments in south-west England were suggested where there were large non-peat soil catchments, e.g. River Tamar where DOC flux is of the order of 2ktonnes C/yr. The impact of this linkage on the outputs of the spreadsheet tool can then be assessed. This work would be aimed at re-working existing data to refine C flux estimates.

In order to reduce the uncertainty in determining C stocks and fluxes in UK soils its was agreed that there was a clear need to clarify the importance of the soils at the fringe or margins of upland peats and elsewhere i.e. the organic rich soils (20-50% organic matter) which are not classified as peats. These soils could represent a potentially significant source error in carbon stocks and fluxes as they currently fall outside much of the modelling estimates (although they are included in ECOSSE). The Group agreed that significance should be judged not only in terms of spatial coverage (i.e., 6% of current England and Wales soil area) but also potential for change. The land use change scenarios on these soils were thought likely to fit into the lowland scenarios. However, greater understanding of the form and extent of these areas may suggest that a separate grouping, between upland and lowland, would be appropriate. The work associated with this project would use existing data, but would deliver greater certainty about the importance of these fringe soils for C stocks and fluxes.

In order to interpret the outputs of the spreadsheet tool, with an output in “change in C per hectare”, there is a need to define the spatial extent of land use change. It was suggested that a range of situations should be delineated, which may represent the reasonable extremes of land management. For example, for the lowland land use scenarios there are three situations that could be run:

- The worst – 1941, maximum rate of ploughing out of pasture.
- Business as usual – what we are currently doing now.
- The practical best, in terms of C stocks and fluxes, which would include arable reversion in groundwater protection zones, reinstatement of set-aside and full uptake of the Higher Level Stewardship Scheme.

For uplands the situations would be similar, with:

- The worst – 1941, historical grazing pressure on uplands with relatively poor management.
- Business as usual - what we are currently doing now.
- The practical best, every peat managed to good status for C, and full uptake of the Higher Level Stewardship Scheme.

Data to parameterise the first two situations for lowlands and uplands could be obtained from Agricultural Census data.

9. Validation and assessment of outputs

It was decided that validation was not the appropriate term to be used for soil C flux models such as RothC, ECOSSE and PNET; instead the pedigree of these models needed to be stated. The use of the models and the spreadsheet tool were discussed and it was agreed that a two tier system of use would be appropriate.

Tier 1 would be to populate the matrix for the land use change scenarios for soil C stocks and flux using measured experimental data. The model would then be reviewed and any cavernous holes could potentially be filled with outputs from previous modelled data or international data, both of which would be identified as such.

Tier 2 would involve the extrapolation of data produced from the spreadsheet tool on a per unit basis to national land use change situations given at the end of Question 8. This extrapolation would be undertaken using a number of C stocks and flux models (RothC, ECOSSE, PNET, etc.). Effectively the spreadsheet tool would be used to define the rules/inputs in running the models on a national scale for the situations. The models would be run on the basis of what was going on in the soil for those situations at a national scale.

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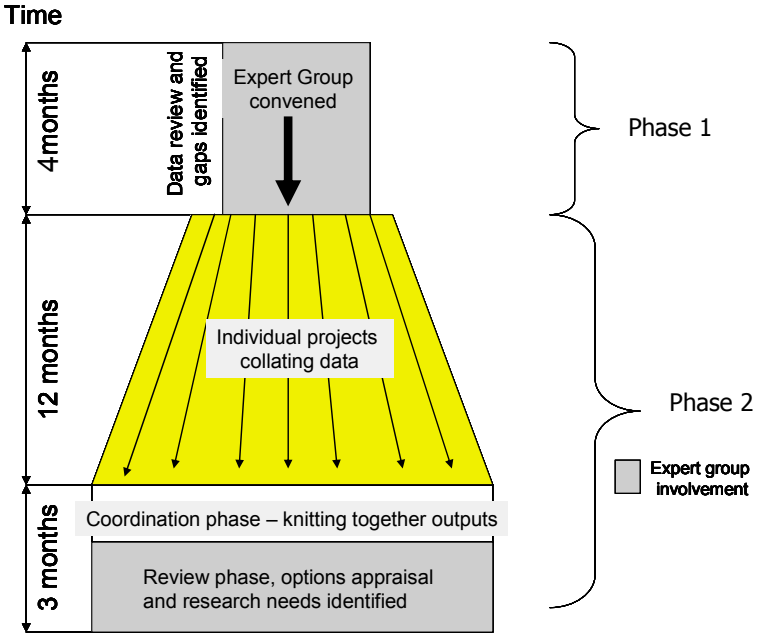
3. Summary and way-forward

This meeting note will be used to draft several project description which, through the use of existing data, would deliver better, more certain, outputs from existing models for C turnover, fate and behaviour in UK soils. The areas covered by these projects are likely to be those discussed in Question 8.

The Figure below presents a way forward for this work. The yellow box in the mid-section of the diagram represents projects and the lines represent individual workgroups through which one of the work areas in Question 7 and 8 may be furthered. The workgroup would consist of a main contractor and a number of members who would support the project through the supply of data, expertise, peer-review and guidance. The coordination phase of these workgroups would enable the delivery of the finalised spreadsheet screening tool (Tier 1). This would then be used to run Tier 2 to assess the land use implications of the situations identified in Question 9. The output from this would be current estimates of UK soil C stocks and fluxes in the context of land use management and changes with a given level of confidence.



The final review phase would present Defra with an options appraisal for land management and any additional research needs required to increase certainty and knowledge to a level sufficient for evidence-based decisions to be made.

References to published material

9. This section should be used to record links (hypertext links where possible) or references to other published material generated by, or relating to this project.

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