



Environmental Audit Committee

Oral evidence: Soil health, HC 653

Wednesday 9 March 2016

Ordered by the House of Commons to be published on 9 March 2016.

Written evidence from witnesses:

- [Committee on Climate Change](#)
- [Soil Association](#)
- [Professor Richard Bardgett](#)
- [Professor Paul Hallett](#)
- [Rothamsted Research](#)

[Watch the meeting](#)

Members present: Mary Creagh (Chair), Peter Aldous, Peter Heaton-Jones, Mr Peter Lilley, Caroline Lucas, John Mc Nally, Rebecca Pow.

Questions 37 - 133

Witnesses: **Lord Krebs**, Chair of the Adaptation Sub-Committee, Committee on Climate Change, **David Thompson**, Senior Policy Analyst supporting the Adaptation Sub-Committee, Committee on Climate Change, and **Peter Melchett**, Policy Director, Soil Association, gave evidence.

Chair: I declare our meeting open. Welcome to guests and members of the public who are joining us for our second Committee hearing into the state of the UK's soil. We are joined today by David Thompson and Lord Krebs from the Committee on Climate Change and Peter Melchett from the Soil Association. We have had a fascinating first meeting, where we discovered all sorts of things that we were unaware of—not least that we only have 11,000 years of soil in this country, which is something I cannot quite get over. But I am going to ask my colleague, Mr Heaton-Jones, to begin the questioning today.

Q37 Peter Heaton-Jones: Chair, thank you very much indeed, and thank you very much to the panel for joining us. It has indeed been a very interesting series of discussions that we have had so far, and we are hoping to add a little bit more to it today.

Can I start with a very open question, which is how are the UK soils likely to be affected by climate change and what can we do to make sure that our soils are sufficiently resilient? We might as well start from left to right. Mr Thompson.

David Thompson: Maybe I could pass it on to Lord Krebs to start.

Lord Krebs: Just to set the scene, I am Chairman of the Adaptation Sub-Committee of the Committee on Climate Change, which has the job of advising the Government on the likely impacts of climate change on all aspects of our life, including the health of our soils. The particular way in which we are doing that at the moment is that we are producing the second climate change risk assessment, which will be published later this year, which will set out the risks to the UK from climate change. But from the previous work we have done that will feed into that, we can say that soils in this country, agricultural soils, are already under threat from over-exploitation from agricultural practice, from drainage and over-grazing and so on, but climate change will exacerbate those threats. In particular, there is the increased likelihood of—and these are projections from climate models—periods of aridity that will cause drying out of soils, particularly peat soils, which will make them more vulnerable to erosion and drying out, and periods of—again, from climate model projections—intensive rainfall could also lead to greater soil erosion. So we think that the impact of climate change will be an added threat to the potential of the UK to have productive soils.

There is another side of the story, which is about mitigation, but perhaps I will leave that, because that is more to do with how soils can be part of the story of capturing carbon or preventing the release of carbon to help to meet our legally-binding climate change mitigation targets.

Q38 Peter Heaton-Jones: Can I tease out one particular thing that you have said there, which chimes in with something that Defra have said to us when they are talking about the effect of climate change on soils? They say, and I quote, “In the long term, climate change is projected to affect our food production system”. That is a pretty big catch-all sentence. Can you elucidate? What might they mean by that?

Lord Krebs: I am just trying to find a map. I will send you a copy of this, if you like—this is from Defra, it was done by Cranfield University and ADAS—and what this shows, you can see a map of England and Wales on this side and one on that side. All you have to notice is that the one on this side is yellower—I hope you can see that—than the one on this side. What does the colour coding mean? The darker the colour, the blues and the greens are high-grade agricultural land on which you can grow arable crops. The yellow and the brown are land on which you cannot grow arable crops. This is the baseline on this side, that is 1961 to 1991, so that is roughly where we are now.

This is one projection under a particular climate scenario of 2050, not very far away, 35 years hence. Simply looking at the change in colour, that says under this particular scenario we will be really hard-pushed to grow any arable crops in England at all in 35 years’ time. So that gives you a measure. I am not saying this is the definitive fact, this is an illustrative model under quite a high climate change scenario, but it gives you a measure of the likely impact of climate change on our ability to feed ourselves from our own crop production.

Q39 Peter Heaton-Jones: Would you agree with something else that Defra have said, which is that the impact of climate change will be more severe on our soils than it will be even through changes in temperature and rainfall, for instance—that that will be a bigger impact on our food production?

Lord Krebs: I do not know that we have the quantitative evidence to be completely firm about that—I will ask the others to chip in—but I think what we can say is that the potential benefits of climate change that people talk about, higher CO₂ levels acting as a fertiliser to allow plants to grow more quickly, warmer temperatures resulting in longer growing seasons, those benefits would only be realised if we have enough fertile soil and enough water to grow the crops that we want to grow.

If we had things right, if we could steward our soils properly, if we are more prudent in our use of water—a separate story, but also highly relevant—then there might be the ability to take advantage of warmer temperatures and therefore longer growing seasons, but at the moment we are not heading in that direction at all.

Peter Heaton-Jones: Anything to add, Mr Thompson?

David Thompson: Yes. As Lord Krebs says, the driver that is potentially causing this scenario is primarily increased temperatures, but it is also changes in water availability. There is a lot of uncertainty, obviously, about both. There is more certainty about changes in temperature; the changes in rainfall patterns are less certain. But what we have seen over the last few decades is a decrease in average rainfall in the summer and that is partly what would drive this increase in aridity and the risk of soils being too droughty to be able to grow crops in the way they are at the moment. Of course one solution to that would be to increase irrigation, but then that would require water to be available in areas that projections suggest there would be very limited resources, particularly in the eastern half of the country, East Anglia and those sort of areas.

Chair: I am going to bring in Ms Lucas now, if I may, just to ask a couple of the follow-ups.

Q40 Caroline Lucas: I just wondered if you could say to what extent current policies reflect the need to cut down on practices that are making our soils vulnerable to climate change. I think you indicated a moment ago that we are probably going in the wrong direction. To what extent is that a major concern?

Lord Krebs: I do want to give Peter the chance to chip in here, but I will just kick off. Defra has a strategy—a policy ambition, I should say, not a strategy—that all soils will be managed sustainably by 2030, which is an aspiration that we at the Committee on Climate Change would absolutely support. But it is not, in our view, likely that it will be delivered under current policy. It is not clear which policy levers Defra wishes to use to deliver this ambition, nor how they are going to monitor progress towards that ambition.

If you do not measure whether you are moving in the right direction, you will not know, so we think there is a lack of clear policy, effective policy, levers connected to something at the other end, and there is a lack of a clear plan to measure progress towards this ambition. The hope we have—and it is no more than a hope at this stage—is that when Defra publishes its 25-year environment strategy some time late this year, they will tell us how

they are going to deliver this 2030 ambition. But at the moment I do not see how it is going to be delivered.

Peter Melchett: First of all, I am a representative of the Soil Association, which has been concerned about the quality of our soils for over 70 years. I am really pleased about the Committee inquiry. I certainly agree with everything the Committee on Climate Change have published and have said today, so there is no difference between us.

Maybe I can add a couple of things. I think how soils are affected by climate change, as John has just said, will depend on what we do with our soils in the next 20, 30 years. They could be very severely affected or we could take steps that would also reduce greenhouse gas emissions to increase soil carbon and soil organic matter. That would significantly reduce the impact of climate change. I think farmers in many parts of the country—maybe all over the country—are already experiencing some of the predicted effects of climate change, which are more unpredictable weather and more severe weather. We have had on my own farm, since my father bought it in the 1950s, the longest drought we have ever had a few years ago, nearly three months without any rain. We have certainly had the wettest harvest in 2012 that we have ever had since the 1950s. That is what science predicted.

Q41 Mr Peter Lilley: Since the 1950s?

Peter Melchett: Yes, since the 1950s.

Q42 Mr Peter Lilley: That is not long ago, is it?

Peter Melchett: If you are suffering through a wet harvest all of July and August as a farmer, it feels like a severe impact, I can assure you. It is what scientists predicted and what has been agreed by scientists is now happening globally—more severe weather patterns. For that you need more resilient soils and that is where adding organic matter to soils as an implementation of a strategy is so important, which is why we have suggested we need a target of a 20% increase in soil organic matter over the next 20 years.

I agree with John: there are other things at the moment. While there is this aspiration—and we mentioned this in our evidence—to get soils in a sustainable condition, we see no evidence of any way that that is going to be implemented. The current pillar 2 common agricultural policy, as implemented in England, does not help much. We need a series of measures to implement that strategy, which I hope the Committee will focus on in your report, getting some action.

Q43 Caroline Lucas: Just one follow-up question for each of you. To Lord Krebs, I think in the evidence from the Committee on Climate Change, you say that increased mechanisation, use of agrichemicals, synthetic fertilisers and the introduction of maize have all increased the vulnerability of arable soils. I wanted to know how much or how many of those trends were reversible, if any.

Lord Krebs: I think if we want to look at what practical measures would make our soil use more sustainable, farmers are not necessarily aware of what they are doing, because these changes are very, very slow and we are talking about a few millimetres a year of soil loss—not easily detectable in the lifetime of an individual farmer, but over decades or

centuries it makes a big difference. We are not talking about going back to a pre-mechanised agricultural practice, that would not be feasible, but about thinking carefully about crop types that we want to grow; I know that Peter has a particular view about maize, using cover crops to prevent soil erosion and help to build organic matter, minimum tillage agriculture.

One of the problems is deep ploughing, which then loosens the soil, which either then washes off or blows away in the wind in periods of storminess. I think we are looking not necessarily at reversing the development in agriculture that we have seen in the last 50 years, but getting much smarter about how we deploy technology and combining technology with thinking about the soil as an ecosystem service that we want to sustain for the future, for our children and grandchildren.

Q44 Caroline Lucas: I wanted to ask Peter about maize, in fact, because you called for the Government to halt what you call a dramatic rise in maize production for anaerobic digestion. I wondered how you think that can be done and in particular would there be any unintended consequences of so doing?

Peter Melchett: No, I think the dramatic rise in maize production—and now in East Anglia sometimes sugar beet production—for use in AD units is an unintended consequence of what is in effect a double subsidy from taxpayers. It is a subsidy to grow the crop under the common agricultural policy, if anything, encouraged by the three-crop rule that is now being introduced under pillar 1 and the subsidies that are given to AD production, which do not, up until now, distinguish between the source of the fuel that is put into the AD unit.

An AD unit taking slurry from cattle or pig waste or chicken waste and turning it into gas and a fertiliser is a sensible use of the technology. Growing hundreds of acres of maize or sugar beet with huge inputs of fertiliser and pesticides, which is then subsidised from the public purse to the farmer putting it into an AD unit, which is subsidised from the public purse to the AD operator, makes no sense. I think the Committee on Climate Change have drawn a question mark about the use of crop material in renewable energy, certainly without carbon capture. We just think this is a nonsense. That is one example.

There are other cropping practices: the growing of intensive vegetables on sandy ridges that have been destoned, which encourage the loss of soil, for example. But if we are going to take action—and I thought in your first session you were given very clear evidence from the National Trust, for example—we know enough about the problems to need to do something and get on with doing something. This would be an easy one and it would save public money or allow the Government to put more public money into encouraging the recycling of waste, which is what we recommend.

Q45 Peter Aldous: Very quickly—and I do declare an interest as a partner in an East Anglian farm—would the Committee agree that the trend perhaps over the last 50 or 60 years in East Anglia away from mixed livestock and arable farms has had an influence on the degradation of soils?

Peter Melchett: Yes, I would, certainly. Another of the points we made, the huge greenhouse gas emissions from lowland peat, equal to all the buses in the UK, for example, or all the trains—staggeringly high emissions, slightly more than the chemical

industry. As a boy, the Fens were mixed farms. There were dairy farmers, there were outdoor pigs and a lot of the peat was in grass for at least part of the rotation, which would have significantly reduced the losses. That is true over the whole country. As John said, how you get carbon back into soil is fairly settled science, I would say: you use green cover crops in the winter, you do not leave the soil exposed, you use, where you can, crops with deeper roots so you have more biomass to put back into the soil. You put the crop waste, the straw, ideally through a cattle shed and then it is farmyard manure or compost back into the soil. You use rotations that include grass, exactly as you say, because that will help. It is not rocket science.

What seems to be very difficult is to get Governments of all parties to recognise the problem and to recognise the need for action. It is becoming more urgent. The potential is huge, we could put huge amounts of carbon back into soil. There is a fascinating bit of work at Rothamsted that shows for about 160 years you can still detect the impact of just 20 years' addition of farmyard manure in the 1870s. It can be very, very stable as well.

David Thompson: I just wanted to say that the evidence of increased mechanisation, particularly on lowland peat soils, is that it has a significant impact on the amount of carbon that those peats can store. There is clear evidence over time, as Lord Krebs was saying, of a steady reduction in the amount of carbon in the deep peats in the Fens particularly.

Just going back to maize, I certainly agree with what was said earlier—that it is a very high-risk crop when it comes to soil erosion. There was a study in the south-west of England that showed that three-quarters of fields under maize, the soil was so damaged that the rain is unable to penetrate, so the water just runs straight off into rivers, into water courses. That is one of the reasons why dredging is arguably needed in some areas, because of that loss of soil from maize, particularly when it is cultivated on slopes. There has been a sevenfold increase in the area of maize since 1988 across England and Wales.

But just a little caveat on that, to add that not all of that is for AD—in fact, the majority of it, about 85%, is for livestock feed. That is the primary driver. AD is certainly one of the drivers, but it is not the only driver causing that increase in maize.

Q46 Mr Peter Lilley: Can I come back to this amazing map that you showed us first of all? Were you saying that on the right, if these forecasts are correct, the land would be not suitable for agricultural production?

Lord Krebs: Yes.

Mr Peter Lilley: That is all I wanted to know.

Lord Krebs: This is one scenario.

Mr Peter Lilley: This is one scenario. No, all your caveats, I just thought that I had not heard properly, so I had heard properly.

Lord Krebs: Yes.

Mr Peter Lilley: Can I get to my question, please, now that I understand?

Lord Krebs: I just wanted to explain: the darker the colour, the higher the quality of agricultural lands, and there is a classification from grade 1 down to grade 5. Generally grade 1 to 3(a), I think, is suitable for arable crops and the lower grade is what we would use for pasture for livestock. This is saying that the richest arable areas would become less suitable for arable under this particular scenario.

Q47 Mr Peter Lilley: That is primarily due to climate change rather than soil erosion?

Lord Krebs: Yes, this is due to the impact of drought—so periods of drying out—on the ability to grow crops, which would also impact upon soil loss.

Q48 Mr Peter Lilley: So less rain rather than the more rain we are normally promised?

Lord Krebs: No. We expect less rain at certain times of the year and more rain at other times of the year.

David Thompson: Less rain in the summer and higher temperatures.

Q49 Mr Peter Lilley: We are now halfway through from the mid-point of your starting point to the end point. Have you seen any signs of any of this happening?

Lord Krebs: It is not quite like that, because this is a baseline figure drawn on a 30-year period.

Mr Peter Lilley: I was taking the mid of that point: 2050, 75 years, we are 37 years through, halfway.

Lord Krebs: This relates to a question you asked us the other day in a different inquiry about the signatures of climate change. What we are definitely seeing, and we have it absolutely in the temperature record, is that the average temperature in southern England is now about a degree higher than it was in the period on the left-hand side of that chart. Yes, we are detecting climate change.

Q50 Mr Peter Lilley: No, I mean are we halfway to the land not being agriculturally productive? Have yields fallen?

Lord Krebs: Certainly yields have stopped increasing as a result of the green revolution, by putting on more fertiliser, more pesticide and mechanisation. Yield increases were quite steep, but since the 1990s that gain has more or less levelled off. What proportion of that is due to climate change and what proportion is due to diminishing returns in a particular technology one cannot tell, but certainly we are in a period of decreased gains, I think I would say.

David Thompson: In fact, wheat yields have declined by 2% over the last 15 years across the whole of England.

Peter Melchett: That does not tell the full picture, because what is clear is that resource use efficiency has declined dramatically, so to keep the yields stable farmers are having to use significantly more to maintain yields, or to even see them drop slightly; as David says,

we have had to use increasing amounts of nitrogen and phosphorus and pesticides. So the resource use efficiency has dropped significantly.

As to your question—this is just experience from farming, not peer-reviewed science—there are certainly areas that used to be capable of growing very productive vegetable crops, carrots, potatoes, things like that in the Fens and even in parts of north Norfolk on the sandy soil, that now are not capable of growing those crops. Whether that is because of the continuous growing of the crops and the problem that causes or because of the impacts of climate change, nobody, as far as I know, has pulled those two things apart. But the idea that we are not seeing pressures on farming is wrong.

Chair: That is fascinating. I am particularly interested—sorry.

Q51 Mr Peter Lilley: Could we just ask how much you are expecting the temperature to increase to by 2050 in this scenario?

Lord Krebs: This scenario is between 3 degrees and 4 degrees. That is a global mean.

Q52 Mr Peter Lilley: That includes the one degree that has already occurred, does it?

Lord Krebs: Yes.

Q53 Mr Peter Lilley: So we would be about the same temperature as the Loire Valley, roughly, which is not notably infertile?

Peter Melchett: But as I understand it, and as I said earlier, I think farmers are experiencing more extreme weather effects, drier summers, which does affect farming, particularly if it happens in May/June, which is when we had our really bad drought, or much wetter harvests—or, as we have had this winter, almost continuous rain, which for north-west Norfolk is pretty unusual.

Q54 Mr Peter Lilley: Though as Lord Krebs would remember, at his last hearing he had to acknowledge that he had no evidence of increased frequency or intensity of rain.

Peter Melchett: I am speaking to you from the farming organisation and as a farmer.

Chair: I am going to exert the Chair's privileges. We are not going to get drawn into what happened at the last hearing. I am interested in our hearing today. We are going to move the questioning on. We will be able to come back and Mr Lilley is going to have a question in a minute, but I am very keen other Committee members get a chance to put their questions. Mr Mc Nally.

Q55 John Mc Nally: Thank you, Chair. It is extremely interesting. My question is basically on the European Environment Agency. They have said that the particular effects of climate change are extremely complex, making it difficult to project how soil will be affected. How confident can we be of the speed and direction of change in this area and if there is a cliff-edge coming, how will we know?

Lord Krebs: I think it is difficult to be confident about the speed and magnitude of climate change over the next few decades. We—when I say “we”, the climate scientists—can make general projections, so if your question is could we tell what state we are going to be in in 2048 and is there going to be a cliff-edge, the answer is, frankly, no. What we have to do, and it is sort of like an insurance policy, we have to say we know that there are changes coming, we are very confident about that, and we know that those changes will have impacts on, in this case, soils. We should, as a prudent society, having a care for our children and grandchildren, take steps to make sure that we are as resilient as possible against the range of impacts that climate change will have on us.

It is, quite frankly, one of the difficulties of making recommendations about how you adapt to the future climate, because we do not know exactly what it is we are adapting to and therefore we should adopt measures that, first, are sensible in any case, and stewarding the soils, as Peter says his organisation has argued for many decades, is a sensible thing to do independently of climate change, but also things that will give us resilience in a range of possible outcomes.

So rather than thinking of a particular cliff, think of a range of future scenarios and say, “How can we make our food production system or soils as resilient as possible?” The recipe remains the same over a whole range of scenarios: prevent soil loss, which has been a major issue up until now, increase the soil organic content and steward our soils as part of our natural capital, rather than something that we are using up selfishly for ourselves and to hell with the future. I think it is very simple in that regard.

Peter Melchett: Maybe I could just add that it is not of course just climate change that is affecting the soils and will affect soils. We have had an increase in the size and weight of machinery over my lifetime in farming that has led to widespread recognition of the problems of compaction. We have had the introduction of mechanisation—for example, of ridging of soils, destoning and the introduction of crops that were not grown in this country, Mediterranean crops like maize, all of which have led to soil erosion and run-offs as well. You saw maybe in our evidence the picture of the United Kingdom surrounded by brown sea, which is soil that we have lost.

Thirdly, and less discussed, but I think likely to be of great significance, is this period we have had of 60 decades, roughly, of dosing ourselves in chemicals, which are tested for biodiversity above the ground, what effect they have on birds and hares and other wildlife. Very little science is done on what effect these chemicals and the continuous cropping of modern farming, non-organic farming, might be having on the biodiversity of the soil. The soil, as you have heard in evidence from nearly everyone, I think, is a living organism and what happens to that life is crucially important to soil quality and to the ability of soil to produce crops for us to eat.

Q56 Peter Aldous: Very quickly, just taking that point a little further, Peter Melchett, I just wonder about your views on the move in probably the last decade towards minimal cultivation on arable land. What impact does that have?

Peter Melchett: I think it certainly has advantages in less energy use, from a selfish farming point of view, and the organic movement is very interested in it. There are big field trials going on in farms by the biggest organic research centres in Switzerland and Austria. The science of the amount of carbon you get back in the soil is, I think, it is fair to

say, not completely clear-cut, because there are questions about the depth of the soil and where the carbon is.

Weed control is a problem I guess for non-organic and organic farmers, it is likely to be, although some of my colleagues in the organic movement say it is not, but we have seen the spread of blackgrass through non-organic farming. The recommended solution to that is to bring back the plough usually and cultivate and very often to move to spring cropping, which is something on the whole organic farming tends to do anyhow. I think it is a complex picture, but from an energy-saving point of view, there is little doubt there are benefits.

Lord Krebs: Probably also in terms of soil erosion.

Peter Melchett: Yes.

Q57 John Mc Nally: I think you made a very good point there. We all tend to look at the birds in the sky and that is the easiest way to assess how things are; the birds in the sky are eating the worms coming out of the ground and the organisms that come out of the ground. I think we all understand that, so I would quite like you to explain to me how you assess the soil in the climate change risk assessment and whether—I think you have touched on this a wee bit as well—you think the Government is taking these warnings seriously enough.

Lord Krebs: Two parts to that: one was how is soil health measured, and I think the answer is at the moment there is no systematic national scheme for measuring soil health. Individual farmers may do their own measurements. I was talking to one of my colleagues in the Lords, Lord Currie, who said that he is involved in a company that sells a soil health kit that includes measuring not just the minerals and the soil organic matter, but also the microbial communities, so there are ways of doing that, but it is not done systematically. As I hinted earlier, if the Government wishes to have an ambitious plan to improve the health of soils, I believe that plan has to be accompanied by some way of measuring what is going on. That was the first part. The second part of your question was—

Q58 John Mc Nally: Are the Government paying attention to the warnings?

Lord Krebs: Our statutory role includes not just producing the climate change risk assessment, but also producing a Parliament report, which you will have, in principle, received last summer on the Government's national adaptation programme, which is about how the country is preparing for the impact of climate change. As we have said many times, and Peter has just reiterated, any impacts of climate change are added to other pressures, and in this case the pressures from mechanisation and the pressures from over-intensive use of soil. We did make a set of recommendations. Has the Government fully embraced them? I would say only to a limited degree. They could do more.

Peter Melchett: I think I would go further and say no, but I think that is in common with all recent Governments, so this isn't a party political issue.

John Mc Nally: I think you are right. We need to prepare for the future.

Peter Melchett: I would just pick up one thing about the Government's plans. They, as has been mentioned, have a 25-year environment plan due to come out this year and a 25-year farming plan. We think soils and how to protect soils and enhance soils and increase soil organic matter should be central to both those plans. It should not be something relegated, as it were, to the environment and real farmers do not have worry about, because the future of farming productivity depends on soil.

Lord Krebs: Sorry, could I just come in on that or are you going to ask about the environment?

Chair: Yes, we are. We have a range of questions and it is in our second panel as well. I am going to move us on, Mr Mc Nally, if that is okay. Did you have anything burning?

John Mc Nally: No.

Q59 Mr Peter Lilley: Apparently, soil organic carbon levels have been declining in arable and peat soils. What effect does this have on the fertility of soil?

Peter Melchett: Peat soils are tending to oxidise and disappear, but yes, the organic matter levels certainly in arable soils have been declining. The evidence base is not particularly good, but it is clear that you can increase the organic matter levels in soils. There has been a global meta-analysis of lots of different research projects, which shows that by adopting the techniques that organic farmers use, you can significantly increase soil organic matter.

It takes time, as John said, and the effect on farming is that more organic matter means soils are more resilient to drought because they will hold water for longer. They are also better at reducing flood risk because they absorb water rather than it all shooting off the surface of the field, I think as John mentioned earlier, a problem we have seen in arable fields. Particularly as arable farming has moved into areas that used historically to be grassland, the amount of run-off in the winter from a winter cereal field can be enormous and rapid. It is that rapid release of the water off the hills that adds to the impact of catastrophic flooding. So organic matter can help in that way. The more organic matter, the more life in the soil.

Again, this is an area that is poorly-researched, but it is clear that plants draw nutrients from the soil using fungi and other living organisms in the soil. Greater levels of organic matter increase the greater biodiversity, greater weight of living organisms in the soil, so the ability of crops to absorb nutrients from the soil rather than simply relying on artificial non-renewable inputs some farmers put on from above is enhanced by higher levels of soil organic matter.

Lord Krebs: Perhaps I could just build on that. I know that in the previous session you asked about the figures I had given on the loss of lowland peat in East Anglia. The figures I gave were that about 84% of lowland peat has been lost in the last few hundred years. That was based on a report that Cranfield University produced for us, which in turn—I have drilled down into this—was based on a study published in 1987 by two authors called Burton and Hodgson. They calculated that the maximum extent of deep peat greater than 40 centimetres in the early 17th century was about 1,480 square kilometres.

In the last systematic survey in the mid-1980s—and it is interesting there has not been a survey since then—that had been reduced to 240 square kilometres remaining. So the bits that are remaining are still fertile soil to grow crops on, horticultural as well as arable, but if the current rate of loss continues, then—and this is the point we were making—that could well be exacerbated by climate change and we will have lost all the deep peat soil in the east of England within the next generation.

How has it happened? It is the things that have already been mentioned: the removal of water drainage leads to the peat shrinking, then it gets compressed, and as it dries out it decomposes, releasing carbon dioxide into the atmosphere, then it eventually is eroded by the wind, so it is a successive process of shrinkage, compression, decomposition and erosion. If you want to see a compelling example of that, Peter and I were just talking about it beforehand, if you go to a place five miles south of Peterborough, there is a cast-iron post that was sunk into the peat six metres deep in 1850. Today it is still there, but it is four metres above the surface. That tells you how much peat has disappeared since 1850 or shrunk and compressed and blown away.

So your question, is this going to affect productivity? It has obviously reduced the area in which we can farm at that productive level and eventually that will all disappear if we do not do something about it. The sort of thing that Peter has talked about is what we need to do.

Q60 Mr Peter Lilley: I am grateful that our clerk, with your help, managed to get those sources. So it is a decline in area primarily of 84%?

Lord Krebs: Also this post, the home post that I talked about, refers to the loss of depth.

Q61 Mr Peter Lilley: So the 84% is a loss of area?

Lord Krebs: Yes.

Q62 Chair: It is volume, isn't it, because it is three-dimensional? If it is height and width, it is volume?

Lord Krebs: Yes.

Mr Peter Lilley: No, it is in square kilometres, not cubic kilometres.

Lord Krebs: That is the area, but the loss will be, as the Chair says, a volumetric loss.

Q63 Mr Peter Lilley: So there are two factors. There is one where it has just gone, 84% of it has just gone. I wonder what happens in that land now, is it sort of infertile? I thought East Anglia was pretty fertile.

Lord Krebs: It is referred to as mineral soils.

David Thompson: It will be less fertile. Some of it will still have some traces of peat, so it is Skirtland type soils, but nowhere near as fertile as when it is deep peat soil.

Q64 Mr Peter Lilley: But when it is shrinking—is that primarily because it is shrinking? I seem to remember learning at school that once you have drained the Fens it all shrank and now the Fens are below sea level. That was not because of loss of soil; it was because of shrinking, although there may have been loss of soil as well. But what is the sort of proportion? If it is 90% shrinking and 10% loss of soil, that is very different from 50:50.

Lord Krebs: I do not have the figures as to what percentage is shrinkage and what percentage is actual loss, but as I said, draining leads to an inexorable process of shrinkage and then compression, then decomposition. The whole point about peat when it is wet is that it is not a subjective, aerobic respiration by microbes, so it is not decomposing and giving off carbon dioxide into the air. As soon as you dry it out, it starts to break down and eventually, as it becomes more friable, it will be lost to wind erosion and rain erosion. It is not either/or. One leads to the other.

Q65 Mr Peter Lilley: Is there any way of farming peat soils that does not lead to their eventual disappearance?

Lord Krebs: I am going to hand to a peat soil farmer called Pete.

Peter Melchett: No, but I have had some experience of it. We are on light and chalky soil. The answer is that any farming is likely to lead to some loss of peat. The only way of stopping the loss of peat is for it to be thoroughly wet all the time, and even then there might be some greenhouse gas emissions from methane. Certainly you can radically reduce the loss of peat by keeping it covered, particularly with a permanent grass crop. Temporary grass rotation will not do as much but will do something. That is pretty obvious. Keeping it covered, even if it is not grass, so for example you have the cereal crop, you under sow it with a cover crop, if you do either, till or plough it immediately and put another crop in, the time the peat is exposed to the air is minimised. There are techniques of that sort.

There is a very interesting example of a model system of farming, agro forestry, in the Fens on the black peat where the farm has strips of trees, in this case apple trees, two combine widths apart, so between the apple trees is arable farming and the apple trees provide a crop every year, of high value to the farmer. They do an enormous amount to prevent wind erosion, which is one of the features of the Fens. Anyone who has lived there will have woken up some mornings with the whole house covered in black dust. It gets in everywhere.

There are things you can do, yes, that we have recommended in our evidence, because this is a complex problem and one that has been largely ignored, certainly by policymakers. Some scientists have looked at it but not many, but we think there should be a special area designation given to the remaining black peat in the Fens—particularly valuable for future food production but particularly vulnerable—and a whole range of options explored. There are some being already implemented, turning some of the Fens back into nature reserves through wetting, planting reed beds, the Great Fen Project. There are others, RSPB and National Trust, working on projects of that sort, but we would like to see as a Soil Association view continuing agricultural activity, and economic activity, because that is very important in that area. There is little alternative employment.

Q66 Mr Peter Lilley: One final question, not about peat, just about the rest of the country, anywhere but peat. Is it not in the interest of landowners to constantly improve the quality of their soil? That was what I was brought up to believe, but if it is constantly being degraded, are they not cutting their own throats?

Peter Melchett: Yes, I think that is true.

Q67 Mr Peter Lilley: To the first question or the second question?

Peter Melchett: That they are cutting their own throats if they do not maintain the quality of their soil. Some landowners, and you heard from the National Trust in your first session, are taking a very long-term and farsighted view of this. They are not the only ones. I think there are other major landowners. Crown Estates is an example, who are looking at what more they can do here, but as you will know much of farming now is conducted on very short-term business tenancies, two-year tenancies, five-year tenancies, with every incentive to the person farming the land to make as much money as quickly as possible and very little, if any, incentive, to think about what the soil is going to be like in 20 years, 30 years, 50 years or 200 years' time. That long-term view needs to be the one you take about soil. It is a long-term project.

Q68 Rebecca Pow: How lovely to see you, Lord Melchett. You might think this is a bit wider, but it is a very good point that Peter Lilley makes. Do you think that in that case our whole food policy—and, for example, our supermarkets with the drive for local food—is forcing our farmers to abandon their raw material of the soil and to do this intensive production? Is it a much wider problem? In a nutshell?

Peter Melchett: It is the sort of question that needs a lengthy answer, but I will try and be quick. I do not think you can blame the food chain, the commercial pressures on farmers entirely. It is partly the decline of the landlord-tenant system where three generations might have farmed the farm and thought about what their son and their grandson was going to inherit. It is partly the drive for high tech farming, of heavier machinery and more chemical use. It is partly, frankly as John said earlier, the fact that the green revolution seems to have hit the buffers and to just keep yields up, and therefore expectations, you have to drive the land harder and harder as a way of farming. More continuous arable cropping, simpler rotations and so on.

I think it is a great deal of different pressures that have come together along with changes in the legal mechanisms by which much land is farmed, contract farmed. There has been a compaction of the industry, so we have relatively few vegetable wholesalers farming and producing carrots and potatoes, farming the land on all sorts of farms but just taking it for a year.

Lord Krebs: I would add to that. I do not know if Peter would agree, but I suspect part of it is also lack of awareness. In many cases the technology is not difficult; it is just getting that knowledge across to farmers that they need to think of a longer-term approach to managing soil sustainably. The technologies in many cases exist. It is not to say there is not room for a lot more research, but we do have some measures that we could take straight away. I think a lot of evidence suggests that not all farmers but some farmers are relatively low-skilled and relatively low in their knowledge base, so I agree with Peter,

one should not point the finger at the supermarkets. If one does we should point the finger at the consumer who wants to shop in the supermarket and have cheap food.

Chair: Sorry, we will end that discussion now. We only have about 10 minutes left and we have another three questions to ask, so Mr Heaton-Jones, your question.

Q69 Peter Heaton-Jones: We were interested in the map, not only because of the effects that it apparently shows but also just because of the diversity of different grades of soil that exist. What I want to explore, gentlemen, is surely that makes it very difficult to develop effective policies when there are so many different grades and qualities of soil across the whole country. You cannot have a one size fits all answer. Do you think we are clever enough at making policy to make sure that all the soil everywhere, whatever its quality is, can be assisted, improved and sustained?

Lord Krebs: I will have a go to start with. You are absolutely right that it is horses for courses, however I think what we have been saying is there are some general features of soil health, so while there is no one indicator, no one measure of soil health, I think the NFU in their evidence were against having a single measure; it is a composite. It is to do with the susceptibility of the soil to erosion, the organic matter, the soil carbon, moisture holding potential and so on—microbial communities about which we understand a little bit and are immensely important.

One could develop a composite measure of soil health that would be applicable in my view. I am not a soil scientist but I can see it being applicable, across a wide range of soil types. As long as you did not have too simplistic a way of measuring it and were sufficiently subtle I do not see why there should not be a national monitoring scheme to ensure that if we have this ambitious target that Defra has that we know whether it is successfully implementing it.

Q70 Peter Heaton-Jones: So there are common themes, whatever the grade of the site? I, for instance in North Devon, have sort of middling soil quality. In East Anglia it is very high quality. So despite those differences there are common themes?

Lord Krebs: You might weight the different components of this composite measure differently in different parts of the country.

Peter Melchett: I think you have discovered a slight different in emphasis between John and I. Of course he is right that this is complex and there are a lot of different factors, but I think the politics here are that what is needed to drive the changes that all the science suggests are needed—and we all know roughly what to do, although as we say it is going to be complex—is an overall target, which should focus on soil organic matter. We proposed this last year, the 20% increase in 20 years. After that we were pleased to see the French Government introduce at the Paris climate summit a very similar target point, a 4% increase. They looked at all agricultural soils globally, so it is a different area, but nonetheless a similar sort of target.

We think that would help concentrate the minds of policymakers in departments like Defra and DECC, in organisations like the National Farmers Union. I think in your first session the scientists who gave evidence did say that the best proxy for a measurement of soil quality was soil organic matter and that is something we would certainly agree with. We think a

target would help implement all these different, disparate things and 20% in 20 years would make a huge impact on climate change emissions, and we think is achievable.

Q71 Peter Heaton-Jones: Just to clarify if I may quickly, such a target would presumably have to have a different starting point and therefore a different finishing point depending on what the base quality of the soil was. Do you see the point I am making?

Peter Melchett: Yes, I do. You would have the target of increasing soil organic matter overall by 20% in 20 years. In some soils your objective would be to stop continuing losses, the peat soils we have talked about. If we could reduce the losses or even get them down near zero that would be a huge contribution, but there are soils like the ones where I farm, chalk soils, where the soil organic matter is typically around 1% where a doubling in 10 years is achievable through the sorts of mechanisms we have talked about, from 1% to 2%.

That is a lot of carbon if you can do it over all the arable soils. You will not be able to double it everywhere. Some soils you will increase by 1% or 2%, but we think it is an achievable target and without a target we do not think your inquiry will lead to action, I have to say, any more than any of the other anguished discussions we have had over the decades about the quality of our soils has led to any action.

Q72 Peter Heaton-Jones: The target you suggest is 20%?

Peter Melchett: Some 20% by 20 years and we set out in our evidence a sound scientific basis for that, which we think justifies it. As I say, we were pleased, unexpectedly and I am sure totally unconnected, to get some endorsement from first the French Government and then all Governments around the world, including ours, who are now signed up to this voluntary target, because it was part of the Paris agreement.

Q73 Peter Heaton-Jones: Do the CCC share that view?

David Thompson: We know already how much carbon is being lost from soils in the form of CO₂ because we measure it as part of the inventory towards our total greenhouse gases, so we know it is 4% currently of all UK greenhouse gases are from losses of soil carbon, that is 22.5 million tonnes of CO₂ a year, so we could measure progress from reducing those losses, and determine whether we are doing enough. Soil organic matter would be a very useful proxy as well.

Q74 Mr Peter Lilley: How is it measured?

David Thompson: It is based on equations around soil carbon losses under the different land use change scenarios that have happened in the past, and there are emission factors given for how land is used, being cropland, grassland or different categories of that.

Peter Melchett: Measuring soil organic matter is a very cheap and simple thing for individual farmers to do, and you can measure it every few years. It is fascinating. You can measure the soil organic matter in the hedge and compare it to the field. Somebody did that on our farm recently as part of some assessment. You can learn a lot, and it is quite a cheap and simple test.

Q75 Chair: Do you think that Defra's new Environmental Analysis Unit is going to help in the measurement of soil health across the country? Do you know about it?

Lord Krebs: I do not know about it.

Chair: Okay, we will leave that. Thank you very much indeed.

Peter Melchett: *I think the answer is no.*

Chair: *Such scepticism. Mr Aldous?*

Q76 Peter Aldous: Very quickly to sum up, and I think we have touched on this, we have talked about the degradation of soil over the past few years and the Soil Association have the 20% target over 20 years for increasing soil organic material. I would welcome a bit of detail about the practices and policies to achieve that, and perhaps a little bit more about the Soil Association's soil protection area in the Fens?

Peter Melchett: I think we have touched quite a bit in the evidence today, and you did hear in your first session, on the practices. As I say I think the surprising thing maybe is just how much scientific agreement there is about the things you need to do to improve soil quality. For example, everyone agrees that returning animal waste to soil is good, and the scientific evidence for compost being best, composted farmyard manure being next best with an immediate return of farmyard manure third, and then slurries fourth. That is pretty much clear cut. If you can encourage farmers, for example, to compost farmyard manure, store it for a year and return it, you will get more organic matter coming back into the soil.

We are not talking about difficult things. Some things do involve some changes in systems. The Fens is a particular problem. We were staggered when we learned the level of greenhouse gas emissions from what is a relatively small area, and as I said earlier the idea that one small bit of the farmed environment could be releasing as many greenhouse gas emissions as all of our trains or all of our buses is surprising, but it is complicated. We want to see continued economic activity in the Fens. It is an area, and those who know it will know, where farming, food processing, food storage and distribution are very important.

The difficulty is going to be to bring together those economic interests with the environmental interests. It needs, for example, a change in the remit so that the drainage regime for the Fens that were drained in the 1800s by Dutch engineers is not only focused on keeping the land drained and preventing flooding, but also thinks about the impact on the environment and climate change, to give you one example. This is a difficult problem and it needs concerted energy under, what we would say, is a clear target so that we can measure, as Dave said, progress against something, rather than just talking about it.

Q77 Peter Aldous: Final supplementary from my perspective. Would you say that the network we have previously had of MAFF officers and ADAS advisers throughout the country, institutionalised good soil management so perhaps their demise is to be regretted?

Peter Melchett: The "I wish we had ADAS" is a fairly familiar and recurrent theme in many discussions of agricultural policy and as somebody who certainly felt it should be kept at the time I would agree, but there are other mechanisms to get information to

farmers, particularly farm-based research. The Soil Association has a big programme with farmers coming together with academics to do research on the farm problems they have identified, so I think yes, there is a need to get the information to farmers.

However, the first step before that is not to worry too much about the detail of implementation, but to have a clear target and stop the most outrageous and damaging wastes of public money that are also destroying the soil, like the growing of maize or other crops for AD and which the taxpayer is subsidising twice for no benefit to anybody, the environment or anybody else. There are things that can be done quickly here that would start to send a signal to everyone that action is necessary.

David Thompson: Can I just add, there is also an issue of enforcement and inspection? Under CAP to quality for single farm payments farmers need to ensure that there is no erosion happening on their land and if there is they need to take measures to prevent it and to ameliorate it. The inspection of whether those actions are being taken is pretty minimal, I think it is fair to say. So there is a mechanism there but it is not really being strongly enforced, and that is an issue that needs to be looked at as well.

Chair: Thank you. Our final question comes from Ms Lucas.

Q78 Caroline Lucas: To wrap up the session, I wanted to refer to the Defra's upcoming 25-year plans. We have heard evidence suggesting that soil should be considered not only as part of the environment plan but also as part of the food and farming one. Evidence also that it may be an idea to integrate the two plans. I wonder what you think about that and in particular what is the most important thing that either or both 25-year plans should contain in reference to soil. I guess Peter already has targets up there heavily underlined and no maize, but in addition to that what else would you be putting in there?

Lord Krebs: I think in a way it is disappointing that Defra has planned to produce two different strategies. Particularly in the UK, where essentially all the land that is not built on is in some sense farmed, or virtually all of it, to have two strategies that are separate to me does not make sense, and that is a bit disappointing.

To give one for instance, in the other place, when I was sitting on your side of the table taking evidence from the Minister for Farming, Food and Environment, I asked him whether the agriculture strategy would include some reflection of the potential impacts of climate change on farming and food production in this country and he said, "Well, no, that is really for the environment strategy". You can look at the exact words he used, but that was my summary of it. That underlines the fact that there is a really high risk here that the central issue, which is natural capital, and we have been talking about soils as part of the natural capital, will not be brought together in an effective way in the future Defra policy. If I had a one-liner I would say, "Let us think about soils, let us think about farming, as part of the way in which we use the natural capital of this country".

Peter Melchett: I agree with all that. Our opposition to maize is maize for AD. The maize for silage can have some serious consequences, but that is fairly stable. It is the huge projected increase in maize for AD that worried us, and which has already happened in Germany and caused huge problems. I agree completely with what John says about the nonsense of having two plans.

Then looking at the future of farming in the next 25 years and apparently ignoring the two things that most people, even in the industry and certainly outside it, I think would see are likely to drive what we as farmers do. One is climate change. It is not just the effects of climate change on farming, or mainly that, but it is the need to cut greenhouse gas emissions from farming. The European Commission recently calculated that farming would be 30% of Europe's emissions by 2050 if we do not cut.

Lord Krebs: That is the same for the UK.

Peter Melchett: The Committee on Climate Change have done some shorter-term work showing a significant increase in the proportion of greenhouse gas emissions that farming delivers as all other industries cut back, except aviation maybe. That is going to affect how we farm, and what we can do as farmers. It has to be in the plan and of course the other missing thing—I am not sure “elephant in the room” is the right metaphor—is obesity, diet: that is going to affect what the demand for food is and what sort of food we need to produce. That is also, according to Defra, not going to be in the 25-year farming plan. I doubt that it will make the environment plan either, so that is going to be ignored, although all sorts of politicians are saying if we want to continue to have an NHS we need to tackle that problem as well. It should not be two, it should be one plan.

Q79 Caroline Lucas: Okay, that has come over loud and clear. Very finally, are there lessons to be learned from the way the Scottish Government, for example, has tried to integrate soils policy across Government through their soils framework, or indeed the Welsh approach to include soil quality in the wellbeing indicators?

David Thompson: The Scottish Government of course have a statutory requirement to produce a land use strategy under their Climate Change Act, which is not the case for the rest of the country. It is early days still, but that looks to be at least developing a central view, as it were, of what the priorities and the allocations around it should be. It is not a map saying, “This should go there and this should not go there” but it is still giving a sense of strategic vision for future land use.

Peter Melchett: I would agree with that. What is interesting looking back 10 or 15 years ago, the Scottish Government were already looking at the science of this much more carefully, and the science was linking with the politics much more closely than I have ever seen happen in England. I have been impressed for many years about the quality of the science that the Scottish Government are commissioning and drawing on in looking at this. That has been lacking in Defra, I would say.

Chair: Gentlemen, that is the end of our session. Thank you very much indeed for bearing with us. We ran slightly over but we are keen to keep to time with our next group, so thank you very much indeed for coming.

Examination of Witnesses

Witnesses: **Professor Paul Hallett**, University of Aberdeen, **Professor Richard Bardgett**, University of Manchester, and **Professor David Powlson**, Rothamsted Research, gave evidence.

Q80 Chair: If I can call the Committee to order, we have our second panel. We are one person light, but we have with us Professor Hallett from the University of Aberdeen—thank you very much for joining us today—and Professor David Powlson from Rothamsted Research. We understand Professor Richard Bardgett is on his way from Manchester and currently stuck on a—

Professor Powlson: He is stuck in a flooded train, or something.

Q81 Chair: Oh, bad luck. We have all been there, so our sympathies go to him. If he is able to join us we will ask him to join as the panel goes on.

We were going to kick off this panel by asking you, first of all why do you think that soil is generally not on the public radar? You sat through the previous discussion. Secondly, how successful do you think the UK is at managing soil vulnerability? What can you add that the previous panel have not told us?

Professor Powlson: As a soil scientist, I obviously have axes to grind, but it has always seemed a bit bizarre that there are legislation and policies that directly affect water and air but many of us would think that soil was pretty important in a similar sort of way, yet the legislation that affects soil is exceedingly indirect. So for example the water framework directives and nitrates for water have implications for the way that soil is managed, important implications, but it is indirect. That just seems something that has grown up.

It is true that soil is rather complicated and I am not going to hide behind the, “Oh, it is too complicated; we cannot do it”. I think we can. In the sense that water and air are substances that can be seen as pure, in some sense, so you can start setting limits that you must not have more of chemical X in them or something of that sort, soil is not like that. Soils are all very variable, as we have said earlier, so you cannot say, “This is a pure soil and this one is not”.

With soil it is a bit more complicated. I think you can set targets. I have some sympathy with what Peter Melchett said, and I think you can look at trends in certain properties, so it is not quite as simple but I would be very keen on seeing some policies that do directly affect soils, partly because things in soils do change slowly. If you are on the wrong trajectory you may not even know it or it certainly may not show itself for five years, 10 years, 20 years or even more. That is an issue.

No, I do not think we are particularly good at managing soils in this country. Again, Defra in the past have produced various documents. I think there was one in 2009 called, “Safeguarding our Soils”. Now, as far as I know this has almost completely been not acted on, so there are lots of fine words and good stuff in that. Indeed, I think some of us probably contributed to its writing at the time, I do not know, but nothing seems to have happened. Just going back to the last session, I think the Scottish devolved authority and have done a better job of raising the profile of soil somewhat.

Q82 Chair: Thank you, Professor. Professor Hallett?

Professor Hallett: I want to disagree with the comment about the public being disconnected with soil. I think there is a portion of the public who are very concerned about it. We would not be sitting here if that was not the case.

Just as David has said, it is a very difficult medium to put simple values on to, but it is possible to put values on to it so that we can classify its quality or whatever else. I am sure if you put a group of us in a room and said, “Look, here is your X amount of pounds, how are we going to test the quality of the soil?” we would come up with a solution for you. I do not think it is something that is as elusive as is being put across, and I think the public does have an interest in it.

Another aspect that we have to put across as well is that internationally the threats to soil are a lot bigger than they are in the UK and that is going to put pressures on to the UK as well, and we need to keep a note of that. A lot of the science expertise that is in the UK right now is going overseas at the moment with Newton funds or whatever else to help find solutions.

Q83 Chair: Which areas do you think are particularly at risk, or particularly vulnerable?

Professor Hallett: In terms of soils?

Q84 Chair: Pressures. The US?

Professor Hallett: So basically as you get towards equatorial latitudes, things get worse. Sub-Saharan Africa is where the apocalypse is happening at the moment. The US is another area where if you look at drought maps from two years ago they were worse than you have ever seen before in your life—the worst on record. So there are various areas with huge pressures on them. The other areas where there are big pressures would be India and China where there is again huge population pressures.

Professor Powlson: If I can add to that, you have different pressures. So, for example, in sub-Saharan Africa I have been involved in reviewing some work from there and you have the situation of soils that have had very low inputs; they are infertile for all sorts of historical but also management reasons and they are under enormous pressures from climate. Just because it is hot and dry erosion happens easily, but you then also have to combine that with social and governance issues.

You have very small farmers who cannot afford to buy things, so things like micro-credit come in, so that there are interactions there. Whereas in other places like China where I shall be in a few days’ time, you have rather different situations where agriculture has increased its production enormously over several decades but at an environmental expense, because things like pesticides and fertiliser use, which I think are sensible, have gone up to ridiculous levels in places like that, so that has impacts as well. There is a whole plethora of issues in different places.

Q85 Chair: Thank you very much. What can we do to ensure that the soil is resilient and to minimise the effects that we heard about in terms of the impact on climate change? One or two things that you would suggest? Professor Hallett?

Professor Hallett: The simple one is organic matter, so that was raised by the previous group and also last week as well. Organic matter potentially is the ability to sequester carbon from the atmosphere, but that is just one aspect of it. It is basically the building block of the soil and what makes it different from rock, basically. It is something that

gives it stability; it will hold on to more water, and any policy put in place to boost up the organic matter in the soil is going to have positive implications both to farm incomes and also to resilience to environmental threats.

Professor Powlson: I fully agree with that. There is an important issue about monitoring, and I think John Krebs referred to this earlier: if we do not measure things to do with soil over time you do not know whether they are getting better or worse, other than in an anecdotal way. The problem is that with organic matter content, which is measured as organic carbon, the total amount changes pretty slowly. I have been working at Rothamsted for many years and we have long-term experiments that have gone on for 170-something years, and so fortunately we, and a few other places around the country and around the world, have long-term data. This is fairly rare, but we know from that that things like organic matter content change slowly. You are looking at decades, really.

Now, that means that if you are monitoring by only measuring that it is not very sensitive. You will not know if things are getting better or worse. There are fractions within that total that we know about and I will not bore you with the details, but soil scientists know a lot about these. There are certain fractions that you can identify chemically or physically and there are biological groups within the soil that change more quickly and can give you a bit of an early warning, or you can look at ratios of these different things to total organic carbon, and where they are different from what is expected and normal that can tell you if things are getting better or worse.

I would be very keen, as Lord Krebs said, to see a monitoring scheme particularly connected with organic matter but the other things as well. It is not rocket science, as Paul said. Soil scientists know a lot about these things, and with some work and a bit of discussion we could sort something out. You could have a range, you could have the Rolls-Royce end where you measure lots of things but might be too expensive and impractical, or you could have the very simple end, but somewhere in between this can be done. This is not easy. We are dealing with a difficult material, but it is a tractable issue, I would say.

Chair: I remember my visit to Rothamsted looking at the seeds that you had collected over 150 years including through two World Wars, so the commitment to scientific knowledge went on even when there were no glass jars to store things in.

Q86 Rebecca Pow: While you said the organic matter changes very slowly, of course we have whole areas in the UK where we have massive soil erosion where there is hardly any organic matter at all, so surely that is a no-brainer in that we have to do something about it, and that is not even difficult to measure because it would not take you very long to come to the conclusion that there is none, or there is very little. Your monitoring is not going to help those areas. That is already destroyed and what do we do there is the crucial thing?

Professor Powlson: Erosion is a special case, and terribly important. In this country its focus is in particular areas, but it is a particular thing. If you are monitoring organic matter content that has huge implications for many properties of soils other than direct erosion. With erosion we already know the risk factors. The ways to combat them may not be put into practice because again it is back to the point that was discussed in the last session, I think, that farmers, who are increasingly highly intelligent, well-educated business people, are driven by short-term economics. The practices that might be sensible in the long-run

may not be economic in the short-run, so people may end up doing or not doing things that would be sensible.

Q87 Rebecca Pow: Those eroded areas are not to do with wind and things here like they are in the Sahara. They are to do with the type of cropping that the farmers are doing, largely, in the east?

Professor Powlson: Yes, in part. Okay, if you are on a slope you are more likely to erode, whatever you do. If you kept the soil under grass and it is not over-grazed you are unlikely to erode. If it is over-grazed you will get erosion. Other people know much more about that than I do. Any time that you have soil that is bare with nothing growing on it between crops, or big spaces between the plants, like in the situation of maize, all of those factors are likely to increase the likelihood of erosion, particularly under climate change where it is expected that there are likely to be rather more extreme events, such as rainfall.

We know quite a lot about erosion. What we do not do really is put into practice the things that we know to slow it down.

Q88 Mr Peter Lilley: I must declare an interest, as Rothamsted sits in my constituency.

Chair: Have you seen the seeds?

Mr Peter Lilley: Yes. Can sequestration of carbon in soil play a significant role in reducing carbon emissions?

Professor Powlson: A bit. I declare an interest here. I think I can claim to be one of the people way back in the late 1980s, and certainly through the 1990s, who pushed this idea quite a lot together with other colleagues. Perhaps we got a bit overexcited at the time and some of us have scaled down what we might have said 20-odd years ago. Some of my colleagues still, I think, push a bit too hard on this. The fact is that the organic matter in the world's soils, put it like that, your country soils, is a very large quantity. It contains about twice the amount of the carbon in the CO₂ in the atmosphere. There is much more in the ocean, but that is another matter. You have a very big stock there, and this is where words become confusing. I like to use the word "stock" of carbon. A sink, an active sink, is where a lot of carbon is going into something.

With a big stock you have inputs and outputs but that stock might remain constant. For example, if you start a new forest now, you have a bare bit of land and you grow some trees right now from seedlings these will be taking up carbon in the trees; they will be putting carbon through their roots and letting it fall into the soil. That area will certainly be a sink for carbon, so it will be sequestering carbon that would otherwise have been in the atmosphere, quite clear. Because you have this big stock in the world soils already, it is both an opportunity and a threat. It is a threat because you might lose some of that stock, and so deforestation, draining of peat soils have been talked about. These are all things that lead to release of carbon from this big stock.

I now put more priority in a sense of looking after those places where we have big stocks. Don't drain peat, absolutely minimise deforestation. A mad thing in my view, not in this country but it is a relevant thing, is clearance of semi-natural vegetation on peat soils in

South-East Asia to grow more palm oil some of which goes to make biodiesel. A lot goes into food things as well. This is releasing carbon because you are draining the peat. It is total madness, in my view. You have to be very careful to preserve and keep those places where you already have big stocks.

Where your stock is low, such as in long-term arable soils, you do have some potential to increase that stock, so doing that can indeed contribute to some extent to slowing climate change by locking up carbon that would otherwise be in the atmosphere, but they are not as big amounts as I think some people claim. It all goes in the right direction, so we should do it, but there are some of my colleagues worldwide who I think use overoptimistic numbers for the quantity of carbon that can be locked up in that way.

Professor Hallett: I will add on to where David ended off. Regardless of whether or not it is locking up carbon in an arable system, it is improving the soil somehow, so there is a benefit there in improving the soil. The other thing is carbon dioxide is just one greenhouse gas. Nitrous oxide is far more potent from arable systems, and if you have better structured soil that does not become anaerobic so often you are going to get less nitrogen loss to the environment through nitrous oxide. You are going to have to apply less fertiliser to the land and basically it is a win-win.

Q89 Chair: Is that nitrogen coming out just from that fertiliser, the nitrous oxide?

Professor Hallett: There are lots of nitrogen sources within soil, but a large proportion will be the inorganic fertiliser that is added on or the organic matter that is added on.

Professor Powlson: Or from manure.

Chair: Thank you.

Q90 Mr Peter Lilley: How significant could no-till agriculture be in reducing greenhouse gas emissions?

Professor Powlson: I would say a bit. Again, I have published papers that make the argument that no-till does not sequester as much carbon as some people claim—often I think because their methodology of measurement is not right—but it does sequester some. So it is generally a good thing from that point of view. The other thing that no-till does, because you are not mixing up the soil first of all it almost certainly will decrease erosion risk, but it does concentrate the organic carbon near the soil surface. That is a very good thing because it gives you better soil quality near the surface. That is good for emerging seedlings and it is good for water infiltration as well.

No-till has some part to play, not as much as is sometimes claimed—it is not a panacea, it is not going to save the planet—but it does a bit and it has many other benefits in most but not all situations, but weed control is a challenge, which Peter Melchett talked about.

Professor Hallett: I would just add it probably depends where as well. So in the US mid-west or something, no-till probably is a very good practice to put into place. In the UK the evidence base really is not there, so in monitoring of greenhouse gases from no-till versus ploughed plots in Scotland the trends were all over the place. It is very difficult to predict which system was better than the other.

Professor Powlson: In some cases no-till gives you more nitrous oxide.

Q91 Chair: Sorry, Professor Hallett, can I just clarify? Did you say that in the US there is an evidence base for it?

Professor Hallett: The evidence base is much stronger because of that.

Chair: In the mid-west.

Professor Hallett: But they have much lower yields than you get in the UK.

Q92 Mr Peter Lilley: Lower?

Professor Hallett: Yes.

Q93 Chair: Lower, yes. Is that part of the trade-off?

Professor Hallett: No, it is the farming system is you put lower inputs into the system because you get lower outputs out of it so financially you want to not spend much money on your farming practice.

Q94 Mr Peter Lilley: I am not sure if it is your sphere, Professor, but last time I was at Rothamsted your colleagues were taking about potentially increasing the yields of grain anyway. My figures are probably wrong but, from memory, 14 tonnes per hectare to New Zealand levels of 20 tonnes per hectare. We just heard from the previous speakers that yields are declining, which was not what I was told.

Professor Powlson: It is a bit more complicated than that. It is not my field, I am not a plant scientist, but in fact we have had some very high yields recently in our long-term experiments at Rothamsted and also there are situations in this country where again very high yields have been obtained. A farmer in Lincolnshire last year had a world record for wheat yields of 15 point something tonnes per hectare and I think he might have had one for rape as well. So, it can be done. To be fair his inputs are very high as well, which rather worries me. There are cases where very high yields are obtained.

Yields in this country have been generally stagnant; I do not think you can generally say that they have been going down—they have been stagnant. They increased a lot in the past but they have been stagnating and indeed at Rothamsted we have had discussions about why this should be. Getting yields up in the past is a combination of plant breeding, better varieties, input and general management and these have all had their effects, but in the last 10 to 20 years the average yields in this country have been rather stagnant. So, within that you will find some places where soils have degraded and they have gone down but then a few cases where a world record holder is doing very well.

Q95 Peter Aldous: Would that be down, do you think, to a change in outlook in the common agricultural policy from yield food maximisation to environmental management?

Professor Powlson: I do not know is the answer to that. I am not going to waffle about it because I do not know the answer.

Q96 Rebecca Pow: Just very quickly on the point about high yields in your experiments at Rothamsted: when you are getting those high yields are you also advocating good soil management practice to get those high yields or are they high yields because of GM modification and extra inputs?

Professor Powlson: Not GM modification because that is not legal apart from doing specific experiments.

Q97 Rebecca Pow: Better plants science. Are you giving advice about the soils? Are they high yields with good soils or are you giving the opposite advice?

Professor Powlson: I hope we are not giving contradictory advice. We are where we are on the soil that we have. We do work with people on other soil types, very contrasting ones. Our soil happens to be really quite a resilient one just by chance. On our very long-term experiments we get high yields with a treatment that has had very large farmyard manure applications over many years and a very high organic matter content—unrealistically large as a practical input. We also get high yields on treatment that has had chemical fertilisers over many years. In fact the very best yields have been with manure plus some extra fertiliser so you can achieve high yields in a number of different ways it would be fair to say.

Q98 Chair: Thank you very much. Have you anything to add, Professor Hallett, before we move on?

Professor Hallett: No, not to that.

Q99 John Mc Nally: You mentioned earlier that soil organic carbon has decreased over the last 30 years in arable and peat soils. How worrying a trend is this for you?

Professor Hallett: I am not convinced the evidence is there that it has decreased but it has definitely in arable systems decreased in some areas and there was probably a worrying trend even before 30 years ago in terms of the amount of organic matter in the soils. Just to go back to what I said earlier to boost that up is going to have positive impacts in terms of soil quality.

Professor Powlson: There are a number of bits of data on that. Because we do not have in this country really systematic and probably routine monitoring, the database is not good. The countryside survey is one source of data. One I am more familiar with is some work that was done called the national soils inventory run by the Soil Survey Group as they were at Cranfield University. It was a joint bit of work between them, Rothamsted and ADAS and there was a survey of soils on a grid all across the country where many things were measured in around the early 1970s. That was partly repeated about 20 years later in the early 1990s.

So, you can look at a trend. You can look at two time points—not nearly good enough, but it is something. Some work published from that on soil carbon showed—my interpretation of the data is a little bit different from the authors' interpretation—that the soils that were very high in organic carbon had indeed declined over that period and peat soils were a special case of that but I think there were other high organic matter grassland soils, some of which had been overgrazed during that period, causing erosion and degradation.

Then you have the mid-range organic carbon soils that had also declined in organic carbon over that period and part of that I am sure is because of the decline in what we would call lay arable farming—several years of pasture, several years of arable. Partly because of just economic pressures but also because of the impact of foot and mouth and BSE some farmers going out of animals so they did not need grass anymore, unfortunately.

But a little counter to that was the soils that were already pretty low organic carbon level in the 1970s, because they had been arable for a long time had increased a little bit in soil carbon over that 20 years and my interpretation of that is bigger yields, better varieties and so on, and also straw incorporation because the ban on straw burning came in during that period. So, slightly counter-intuitively I completely agree that many soils have gone down in organic matter but slightly counter-intuitively some that you might say had been the worst have become a bit better over that period according to that data set.

Chair: It is beginning to sound complicated.

John Mc Nally: It seems there are contradictions going on here with the different levels and the deterioration of the levels. I do not know if I am any clearer than I was five minutes ago.

Chair: That is the purpose of this inquiry.

Professor Powlson: Some that were good got worse.

John Mc Nally: I am aware of that.

Professor Powlson: Some that were good got worse. The ones that were the worst got a wee bit better.

Q100 John Mc Nally: A wee bit better, so the deterioration is not that too concerning?

Professor Powlson: It is concerning because we need our soils to be in the best possible physical and biological condition not only for agricultural purposes, although certainly for that, but because of all the ecosystem services, to use the nerdy term, that we get from soils to do with cycling of water, habitat for organisms and so on. Those things as well as agricultural productivity will almost always be better if soils have a bit more organic matter and therefore better structure. So, it is concerning but there are things we can do about it, albeit not always easy to do but we know a bit about what can be done.

Q101 Peter Aldous: We have very variable soils across this country. Does that make it difficult, do you think, to develop policy at a national level?

Professor Hallett: Yes, it does. You can be a bad farmer on very good soil and come across much better than a good farmer on very poor soil if you put policies in place, so it is difficult to implement that. It is also difficult with the complexity to work out what targets you should be aiming for. If you were, let us say, aiming for a 20% increase in carbon it could be very easy in some areas, much more difficult in other areas. So it adds complexity to it definitely.

Q102 Peter Aldous: Do you feel there are lessons to be learned from other policy areas as to how one might address that? I am thinking such as in water management.

Professor Hallett: Definitely. There would also be benefits from looking at how other countries are looking at soil monitoring and soil protection strategies as well. For instance, many Scandinavian countries have quite detailed policies in place. Scotland is moving toward that direction as well, so there is a lot to be learned.

Q103 Peter Aldous: Just talking about Scandinavian and Scottish countries, perhaps they do not have the natural advantages that parts of England might have had for a long time and therefore they have been more prudent in the way they have managed their soils.

Professor Hallett: In terms of my own research area, which is soil compaction, then yes, definitely, because their soils are incredibly vulnerable to soil compaction so they spend a lot of research in that area and they put a lot into education of farmers and also implementation of policies to try to reduce that. So, in Denmark soil compaction is viewed as one of their greatest environmental threats. You are completely right with that statement that it has been more obvious to them. They have been working in a more stressed system.

Q104 Peter Aldous: When we look at areas like the United States, Canada and the Ukraine where we are looking at a completely different type of agriculture, what do they do, if anything?

Professor Powlson: It is a different type of agriculture. All those places are all pretty large scale agriculture, larger scale than ours but big rather than sub-Saharan Africa scale. Again I think there is a mixture of things there. I am sure in the US there isn't legislation as such but there is very strong advisory type work going on through the Soil Conservation Service, part of the USDA, for example. There are also a lot of farmer-led activities, as there are in this country as well now.

For example, zero tillage has been mentioned. I think this has a lot of benefits, benefit for soil carbon in terms of total quantity. It is smaller than claimed but it concentrates near the surface so it is good. In this country there are some highly innovative farmers, one of which is near Rothamsted in Mr Lilley's constituency, Ian Pigott—all the best people clearly—who have decided that their soils are deteriorating and they need to do something about it. These farmers are going to a zero tillage system using new equipment that has only recently become available. They are also moving to more spring-sown crops rather than autumn-sown ones—I will come back to that in a moment—and then having cover crops during the winter. Cover crops are sometimes proposed as a way of mopping up nitrate from a water quality point of view and nitrate vulnerable zone legislation has this in it but they are growing these simply as a way of getting some more organic matter and plant material to go in the soil.

So, there are some farmers who are taking initiatives and grabbing hold of new equipment as it becomes available and so on. I think there are issues there because having more spring-sown crops can be economic for the farmer. The yield is lower but the input costs are lower. But on a world basis the total grain production will be lower so nothing is quite straightforward.

Chair: Thank you very much. We are going to move to the next question. *[Interruption.]*

Peter Heaton-Jones: Thank you very much indeed. Professor Bardgett, welcome, by the way. You have come in at a particular point. We will let you—

Chair: We have done an inquiry into flooding and resilience of the transport network.

Q105 Peter Heaton-Jones: How very appropriate. We will let you catch your breath before we launch straight into your questions. Let me ask Professors Powlson and Hallett, thinking about the way we can encourage landowners—incentivise them perhaps is a better word—to take measures to ensure that soil protection is pretty much high on their agenda. Are we clever enough at that? Do we need to do more to incentivise landowners on soil protection, Professor Hallett?

Professor Hallett: Definitely you have to incentivise them more. The levy boards of the HDB in Britain put a lot of money into trying to look at better soil management practices so there are a lot of programmes open at the moment and that is basically money paid to the levy for generating the crop gets put back into both research and also education on how to manage soils. Likewise the various government agencies do the same thing. Groups like the Soil Association also push towards that. But there has never been enough education and it is something where I think both through education and also through specific policies you may be able to encourage farmers to perform better soil management. And there are a quite a few different constraints that they are working against.

Q106 Peter Heaton-Jones: Before I come to you, Professor Powlson, how might farmers be encouraged, to use that phrase?

Professor Hallett: On organic matter, giving them a source of organic matter is probably the best way, so whether it be encouragement of residue incorporation rather than selling it off to produce fuel or livestock feed or whatever is one aspect. Providing them with new plant varieties that may be better in terms of returning carbon to soils, generating anaerobic digested or composting on farm is another possible approach that could be used. Also municipal sources of compost or other organic sources so there are a lot of potential areas there. There is encouragement off putting in break crops, using education about cover crops as well, so there are various mechanisms that are possible.

Professor Powlson: Again, recycling of waste better would be one way to go. From a policy perspective, I would love to see some way in which there were payments in a way for good practices. For example, organic products can command a higher price—not always that much higher, but that tends to be a small market for people who can afford that or make those choices.

There are other things. For example, there is an organisation called LEAF, which stands for Linking Environment and Farming, doing an absolutely excellent job of working with farmers and so on and indeed bringing farmers and consumers together. They monitor farms and give accreditation for good practices and so on but is nobody pays more for that, so that is one thing.

On the positive side the organisation in England, Natural England, do quite a lot of good things. They call it catchment-sensitive farming, which must be funded directly or indirectly through Defra I think. They do some quite useful work with farmers on catchments; the clue is in the name. So, there are some good things going on in what you

might say in an educational sense but being sensible, not experts telling farmers what to do but having proper involvement with farmers.

Q107 Peter Heaton-Jones: I am interested in this grey area between education and incentive. Are we saying that there are landowners who generally speaking know full well what needs to be done but frankly need some incentive to do it, or are we saying they just do not know what needs to be done in the first place?

Professor Powlson: I am sure there will be the whole range.

Q108 Peter Heaton-Jones: Generally is it possible to say which direction do you think we should go in? Is it purely education or do we assume they know but they are not doing it and they need some incentive to do it?

Professor Powlson: I think for larger arable farmers I might go to your second option, which takes me back to the short-term economics versus long-term good practice, but I could be wrong.

Professor Bardgett: Just to add, I agree with everything my colleagues said and I think waste management is absolutely essential to this in terms of recycling waste on farms but also bringing other waste in. In relation to your other question my impression is it is really, as David said, a combination of those and in some situations there are probably already farmers who are very knowledgeable about what needs to be done to maintain their soils but I suspect in other places there is quite a lack of knowledge about it not through any other reason that they have not just had that information or it has been exposed to them. I think there needs to be a combination but those incentives probably need to be targeted at particular areas where something can be done to improve soil fertility but also there could be incentives that are more about protection.

To me, it is really three measures. There is a need to protect what we already have in terms of natural systems or semi-natural systems. There is also the need to prevent degradation of soils that is ongoing through different incentives and measures, but also I would say there needs to be more incentive to restore soils as well because there are an awful lot of soils particularly in urban areas and so on that could be restored. Soils are incredibly resilient and I think there is capacity to restore them through incentives as well.

Just one very final thing I would add to make up for my absence: I do think on a positive note that scientists are also working more with farmers from the onset of doing experiments and that kind of thing needs to happen more. When we design our experiments we need to work with the landowners, the land managers to ensure that the science we do is relevant and can be fed into practice.

Chair: Thank you very much indeed. Did you have a follow-up?

Peter Heaton-Jones: I was going to seek your guidance. Do you want me to go back to what was going to be our original first question to Professor Bardgett?

Chair: Yes, let us just quickly do that, very quickly.

Q109 Peter Heaton-Jones: It feeds in rather well as we have been talking about the need for education. If you widen that out to the thought of public awareness, so not just among landowners or farmers but the public in general—we did touch upon this with Professor Hallett earlier on—you say, Professor Bardgett, in your written evidence and I quote, “There is a need for greater awareness among society of the vital importance of soil for human lives”. How do we do that?

Professor Bardgett: I believe that very strongly. As a soil scientist it is a very common thing that you encounter. When you tell people what you do, they are slightly confused about its importance, but when you explain it to them they can see the relevance and to me it is really about education in schools. I am not aware if schools deal with soils in any way other than perhaps in A levels when they may be looking at soil profiles. From an early age, children should be exposed to the importance of soils.

There needs to be more education among the general public. It is quite clear that lots of people live in cities and more people are turning to growing their own food, but there seems to be an awful lack of knowledge about how best to manage soils—how to deal with contaminants in soils to prevent contamination of food and so on. So, I think it is at all levels and also in terms of agriculture through the mechanisms we were talking before about enhancing knowledge and awareness in that sense.

Q110 Peter Heaton-Jones: As a Committee, we should be looking at how we can help that and would that be a Government project? Would that be something that would have to be led at a Government level or are there other ways we could do that?

Professor Bardgett: I think so. At the very core, looking at the national curriculum for teaching and getting it embedded in there. I am not suggesting you have A levels on soil science but I think soil should be embedded within teaching from an early age in terms of its importance generally to mankind and to local communities.

Q111 Peter Heaton-Jones: One brief follow-up: what about those of us who have long since left school, though? You have a great many people who are not taking GCSEs or A levels who need to know this stuff. How do we get to average Joe public?

Professor Bardgett: Again, the Government can do an awful lot. If you look back to the Second World War in the Dig for Victory campaign there were major educational programmes for the general public on how to grow food in often terrible soil conditions and we were enormously successful as a nation in producing food at that time. Similarly in America there were education programmes within local communities about how to manage the soil to produce crops for food production. The evidence is during those times those countries, Britain and also America produced an enormous amount of food through the local communities. A lot of that was driven by public awareness and also education—local education on how to deal with the soil to grow crops.

Q112 Peter Heaton-Jones: So, a bit of wartime propaganda—“your soil needs you”?

Professor Bardgett: Perhaps in a different style but I think local educational programmes on how to deal with soils.

Q113 Rebecca Pow: Just following up on that note, the gardening fraternity have already got it about soils and it is odd we have not transferred that over so we could learn lessons from what you are saying. Also just on that note when students go to study agriculture do they do soil science still? We used to back in the day.

Professor Bardgett: Yes, they almost certainly do and I think most degrees in ecology, geography will have an element of soil science within them. But very often it is embedded within another course so it might be a—

Q114 Rebecca Pow: I believe you cannot do a soil science degree now anymore or anything like that, can you? Is that right?

Professor Hallett: You can at the University of Aberdeen.

Professor Bardgett: But there are not many.

Q115 Rebecca Pow: That is important. On the same note, because plants and the types of plants we grow are so important in this, I believe there are not any botany courses either.

Professor Bardgett: In Manchester we have a degree in plant science.

Q116 Rebecca Pow: I thought you could not study botany anywhere.

Professor Bardgett: I am not aware of—

Q117 Rebecca Pow: I think that is another issue to raise in this whole subject of science and who studies what and trying to encourage anything. Would you agree?

Professor Bardgett: I agree, but I also think that, in university education, the best way to get students interested in soils is not necessarily through a course on soils. It is more through a course on climate mitigation or food security. You captivate them by the bigger issues and then you bring in the educational element of soils and it is gripping them in the same way you might grip them in terms of teaching them about cancer or something.

Professor Powlson: Can I add to that? I am a visiting professor at the University of Reading that is one of the places you used to be able to do a BSc in soil science. You cannot do that anymore there. The soil science group is embedded within a larger school but my colleagues there say on the positive side they are giving some soil science courses to more people than ever before even though nobody comes out with BSc in soil science.

Q118 Rebecca Pow: Thank you very much. To get on to the real emphasis of my question, we have touched a little bit about monitoring schemes, but in a nutshell—perhaps we can start with Professor Hallett—should we have a monitoring scheme for soil health. If so, what would you do and how would you do it?

Professor Hallett: The answer to the first part is yes, definitely. Then how should we do it? I would say that it would be better to have multiple people input into what needs to be measured but definitely carbon has to be measured and it is not just weighing how much carbon is in the soil. You have to go down to quite a deep depth and work out how much there is in the whole entire profile. That is not categorised that well. I know a study that

was done in Scotland predicted that it would be estimated about £400,000 to sample it more effectively, not often but more effectively, just in our country. So, to do it UK-wide would be quite a bit more than that but that is only one measure.

So, there are a lot of other properties related to the fertility of soil, the biology that is in it, how it behaves physically, which is also quite poorly understood so when we look at things such as water storage during drought, flood risk alleviation or whatever else, the way the soil changes over time, the actual flow properties within the soil again are not that well characterised around the UK. So, there are a lot of very simple measurements that can be put in place we could all agree on probably in the next two minutes and then there are other more sophisticated measurements that are needed as well and it is all going to be dictated by how much it costs.

Q119 Rebecca Pow: You specialise in soil physics so are those things you included in that answer or are there more things related to your specialism that we should be including?

Professor Hallett: In terms of what was raised by the previous group that soil compaction was the big issue, I raised the comment about Scandinavia before. Compared to the Scandinavia countries, our understanding of soil compaction is quite poor in the UK. The tests are fairly easy to work out if a soil is compacted or not. There is much more work you could do to look at how to alleviate the problem and how to get around it. In terms of water flow it is not that well characterised spatially. It is done at very big scales but what is happening down at field level where a farmer has control over it is not that well understood. It all depends on the spatial scale and how that integrates together.

Q120 Rebecca Pow: But it is possible?

Professor Hallett: It is possible, yes.

Professor Powlson: I would agree with all those things. Indeed we should have a national monitoring scheme so we know which direction things are going. Otherwise we are talking in the dark. Certainly soil carbon must be part of that as I said earlier. That changes very slowly so you really want some things that show you trends more quickly and there are fractions within or associated with the total, I will not bore you with the details, but a group of soil scientists could agree on some of those, which would be useful. There are groups of microbes or soil fauna that could be included in that and there are ways of measuring them. This would tell you a lot. Earthworms even tell you an awful lot about what is happening and indeed there is a suite of physical properties, again we can debate the details but this could be done.

Q121 Rebecca Pow: Professor Bardgett, in your written evidence you specifically mentioned monitoring soil health. Have you anything to add there?

Professor Bardgett: I agree with everything that has been said. It should be done without question in my mind and, again, we can debate the value of different methods but as a community we could very easily come up with a set of robust measures that could be routinely measured and some of them have been mentioned: organic matter content, carbon would be an obvious one, aggregate stability, compaction.

I think the point Professor Powlson made about more rapid assessments, that is where the biological measures come in and there are some measures and work is being done to identify and rank some of those measures. The beauty of those is they can tell you how soils are changing quickly whereas, as Professor Powlson said, the other measures take several years so it is almost like an early warning sign perhaps.

Q122 Rebecca Pow: If we as a Committee put this forward as an idea about soil monitoring of course the farmers are going to just heave another sigh and say that is another load of bureaucracy and all the rest of it. How would it operate and who would pay for it because I can see this could be costly?

Professor Hallett: We are doing a monitoring programme across four catchments in Scotland at the moment where we have to go out to 120 different farms and get access to the land. Fortunately the person who is doing the work is very personable so she can interact with the farmers very well, but they are all really keen to have her on the land. She is looking at soil physical degradation and we are giving them information back out of it and that is the same thing. We say we are going in to do monitoring but we are going to provide you with information and it is going to help your farm—

Q123 Rebecca Pow: Are they paying you? Are they paying for it?

Professor Hallett: No, this is paid by the Scottish Government.

Q124 Rebecca Pow: That is the sticking point. I know lots of farmers already test their soil, is that just for alkalinity and that sort of thing? I declare an interest: my parents are farmers. They say they already do quite a lot of soil testing.

Professor Powlson: They do indeed, so most farmers, probably the vast majority, would have their soils tested. They would be particularly looking at nutrient availability to guide them as to how much fertiliser they need and that sort of thing. They would also in certain cases be checking on acidity, soil pH, whether to put on more lime or not. Organic matter content is usually a routine thing. If you are paying a lab to do this for you organic matter will be in there but not fractions or things that will tell you about rapid changes, and almost rarely any physical measurements.

Q125 Rebecca Pow: So this would be in addition? It really would help.

Professor Powlson: There are schemes. For example there is a scheme set up by Cornell University in the United States. I think it is called the Cornell soil quality or soil health scheme. It is not a monitoring scheme. Farmers pay \$90 a field and there is a cheaper version I am told at \$60 that includes all the things we have talked about. There is a lot of knowledge of all the things that can be measured and as both my colleagues have said with a bit of effort by the soil science community we could pick a sensible suite, but again there would be a cost involved.

Chair: We look forward to the launch of your programme. There is a final question from Mr Mc Nally.

Q126 John Mc Nally: I should have declared an interest here because I am a member of the Community Green Initiative in my own local area. I want to go back to your point on education. For some time now the Community Green Initiative has engaged with the local schools. They are engaged with the local YMCA where they go out and plant their own food. They grow their own plants themselves so the children, bit by bit through that, are managing to gain an understanding, quite a good comprehensive understanding of how the soil works. To carry that on further there is a huge demand on the soil growing your own locally produces food so you have all these competing interests. Without a doubt you have that.

But to move on to my question, Defra is currently preparing a 25-year plan for the environment and I will just cut to the chase. Do you think there are lessons that can be learnt from the way the Scottish Government is trying to integrate the soils policy framework and including the Welsh approach on their soil quality, their indicators, is England playing catch-up on Scotland and Wales? Unfortunately not on the rugby field, but there you go.

Professor Powlson: If I can come in, I think that is right. It seems to me the evidence is, speaking from an English perspective, that the Scottish and Welsh devolved authorities have done a better job of at least trying to take the quality of soil seriously within a policy framework than has been the case in Defra. Defra, as I said at the beginning, has produced nice documents in the past, but I do not see any evidence of much happening as a result of them.

Q127 Chair: Have you anything to add, Professor Bardgett?

Professor Bardgett: No.

Q128 Chair: Professor Hallett? You are going to start charging those farmers for their field testing.

Professor Hallett: This was Defra funded, very similar monitoring in the south-east of England.

Q129 Chair: So it is not just in Scotland. Professor Bardgett, did you want to come in? We are very keen to hear from you given that you have had a full 18 minutes with us.

Professor Bardgett: Just one very quick thing. I think about the monitoring to me there are also two issues there. There is monitoring that is of use at a farm level and soil kits, education programmes in terms of how to best use that information would be enormously valuable at a farm level in some places. But it is also about natural capital and some of the monitoring schemes are really about monitoring soils change over time and how our soils are changing and their contribution to climate mitigation, nutrient loads and so on. So, for that I guess that to me is more of a government responsibility really.

Q130 Chair: Thank you very much. Can we conclude with a very quick-fire question? It is not often we get three soil health experts here. For those of us who do not have farms, do not live on farms and have very small city gardens, what one thing can we do to improve the quality of our soil? I am going to take each of you in turn, Professor Hallett. In a garden the size of this table.

Professor Hallett: We are all going to say the same thing: add carbon.

Q131 Chair: But how? What sort of carbon? How do I add carbon? When I go home tonight what carbon do I add? Where does the carbon come from?

Professor Hallett: You have me stumped.

Q132 Chair: Food waste, rotting food waste?

Professor Hallett: It depends where you are and what you are growing; it might be trees, it might be crops, so it is carbon is what I am going to say.

Professor Powlson: I agree with that. It could be from plant residues. It could be from food waste, all of those things, but also keep an eye on the acidity. In some places certain grassland soils are becoming more acid because lime costs money, so farmers have in fact saved money on that and that is an issue in this country.

Professor Bardgett: I could give you a whole list but giving you just one I would agree entirely. It is really down to waste management and recycling of waste. The analogy to me quite simply is if you use something and do not refuel it it is going to go into a bad state of affairs.

Q133 Rebecca Pow: Does that include human waste? Have you covered that?

Chair: Five seconds.

Professor Bardgett: Around a lot of cities in the 1800s there were night soil men, around where I live, around Manchester.

Chair: We will see whether that makes it into the final report; I am sorry to put that on you. Thank you very much indeed. Particularly Professor Bardgett, thanks for making the journey. I am sorry if for you the sitting was not long.