



Food, Farming
& Countryside
Commission

Lincolnshire Locally Led Inquiry

Sustainable Soil Practice and Promotion in Lincolnshire



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Sustainable Soil Practice and Promotion in Lincolnshire

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Preface

Launched in November 2017, the RSA Food, Farming and Countryside Commission is a major, two-year independent inquiry, funded by Esmée Fairbairn Foundation.

Chaired by Sir Ian Cheshire, with fourteen Commissioners from across sectors, the Commission is tasked with creating mandate for change across our food system, farming sector

and in rural communities; shaping a long term vision for the future that's fairer, stands the test of time and aligns more closely with changing public values and expectations; and propose solutions to achieve the vision, identifying where communities and businesses can take a lead and where a national policy framework is required.

Role of the locally led inquiries

The issues covered by the Commission are wide-ranging and heavily influenced by context. From policy differences in the Devolved Nations, to cultural and topographical differences across the countries, it was clear from the outset of the Commission that seeking local perspectives would be critical.

In England, the Commission sought to set up three locally led inquiries. These inquiries would create a frame for the counties of Devon, Cumbria and Lincolnshire to investigate the issues of the Commission most relevant to them, with the aim of stimulating local debate and informing the national Commission.

Lincolnshire is a major agricultural county, and soils are fundamental to this agricultural economy. Ensuring these soils are in a healthy state is critical to providing the agricultural sector with resilience against future threats from climate

change and helping long-term sustainability in food production. The Lincolnshire locally led inquiry has, therefore, focused on engaging the local farming community in sustainable soils practices.

This inquiry has been led by the Lincoln Institute of Agri-Food Technology, an institution who use research, technology and education to support food and farming to be more productive, efficient and sustainable. Insights from the work have fed into the RSA Food, Farming and Countryside Commission throughout, and we are grateful to Iain Gould, Isobel Wright and Jenny Rowbottom from LIAT for their expertise.

The following report summarises the work carried out by LIAT between September 2018 and June 2019.

Next steps

The release of these papers coincides with the publication of the RSA Food, Farming and Countryside Commission's report *Our Future in the Land*. The insight from this working group has contributed to the body of evidence reviewed by the Commission and helped to inform their findings and recommendations.

The Commission runs until October 2019 and the next few months will see it work to bring its recommendations to life.

The importance of agriculture and soils in Lincolnshire

Greater Lincolnshire is home to 10 percent of English agricultural production. Its combination of climate, soil type and topography make the county ideal for a variety of crops. There are significant proportions of wheat, oilseed rape, sugar beet and potatoes, with the county producing 12 percent of England's arable crops (Collison, 2014).

Furthermore, the fertile silt soils in the south of the county constitute around a quarter of England's Grade 1 soils by area (MAFF 1988). The fertility and workability of these soils are ideal for growing high value vegetables and ornamentals. As such, Greater Lincolnshire is also home to around 25% of the UK's vegetable production, and 21% of ornamental crop production. This high level of production is vital to the county's economy, generating a Gross Value Added of £446m in 2012 (Collison 2014). To preserve fresh produce and minimise supply chain distance, highly productive food hubs have built up in the south of the county. The importance of this sector for the local economy is reflected in the number of jobs it generates: if this food supply chain is included alongside food retail and catering in the county, the number of employees exceeds 100,000 (Collison, 2014).

Fundamental to agricultural production, and thus underpinning the food economy of the region, is the state of Lincolnshire's soils. The county exhibits a diverse range of soil types including clays, sands, shallow limestone, chalk Wolds, peats and silt soils; all of which have their merits, but also their unique challenges in working. The county's valuable soil resources provide a medium for crop growth and economic benefit and is

essential for providing many of the ecosystem services that our society relies on. Healthy soils can store water, alleviating flood pressures downstream. In doing this, they can also act as a filtration system, contributing to cleaner drinking water. Well-functioning soils can also store carbon, fixing CO₂ from plant photosynthesis into more stable carbon forms below ground. Soils are also home to a vast and diverse biological community, which helps cycle nutrients, enhance soil structure and regulate pests.

Soils function best when they are kept in a good, or healthy, condition yet at both national and a global scale, soil quality is in decline. Over a third of the world's soils are degraded (FAO, 2015), with factors such as erosion, sealing, contamination and salinization causing this deterioration. Closer to home, UK agricultural soils suffer from erosion by wind or water; loss of organic matter because of land use change; soil disturbance and compaction from heavy machinery (Gregory et al., 2015). When quantified, degradation of soils could account for economic impacts of up to £1.2bn a year, with a large proportion of this attributed to compaction and loss of organic matter (Graves et al., 2015). Such threats also impact on those vital soil functions on which society relies, and as such there is a pressing need to reverse this degradation and understand more how we can go about this.

Recent years have witnessed a growing interest in soil conservation in the UK. A degree of soil management practice features in current government agricultural payment schemes. In order to adhere to Cross Compliance, farmers must comply with several Good Agricultural

and Environmental Conditions (GAEC), three of which directly link to soil protection. However, unlike water, soil conservation does not benefit from a Soil Framework Directive. The Water Framework Directive, implemented by the EU, encourages and regulates practice to clean up our water bodies. These activities may, by association, be beneficial to soil conservation, but there is no comprehensive Soil Directive at policy level which specifically aims to improve our soils.

There is a growing movement of organisations and bodies which are championing and promoting sustainable soil management, targeting policymakers and practitioners – organisations such as the Sustainable Soils Alliance, Catchment Sensitive Farming, Soil Association, The Agriculture and Horticulture Development Board, and Campaign for the Farmed Environment, amongst many others that have all been very active in this field.

Going forwards, the specific details of any future Agricultural Bill are yet to be announced, but at the time of this report the recently issued 25 Year Environment Plan (Defra, 2018) highlights the need for appropriate soil management, with a view to managing all UK's soils sustainably by 2030 and finding the most suitable soil metrics we need to assess for this. As such, it is likely that soil indicators may play a role in future agricultural payment schemes.

This report focusses on sustainable soil management practice in Lincolnshire. Specifically, we aim to explore current practices, information sources, knowledge exchange opportunities and challenges faced by farmers, considering any barriers to uptake. We do this by identifying some of the farmers in the region who have implemented practice specifically with a view to improving their soils. In these case studies, we highlight the journey each farmer has taken, what started them off, where they go for information

and what they see as potential barriers for future uptake. Following this, we explore ways to increase engagement with the wider agricultural community. This was a two-phase approach, focussing on (i) developing new links in a geographically defined region and (ii) utilising previously established networks. Via these engagement events, we showcase both a range of sustainable soil management techniques and methods of assessing soil health.

Sustainable Soil Management Glossary

As part of this report, we explore practices which farmers implement to improve soils. Here, we provide a glossary for those practices.

Conservation/regenerative agriculture

Conservation, sometimes known as regenerative agriculture, is a farming system aimed at preventing soil degradation, by adhering to three core principles:

1. Minimum soil disturbance
2. Continual soil cover
3. Diverse rotation

By adhering to these principles, soil condition can be improved, and in many cases, there are economic benefits in terms of input reductions (ie fuel). Globally, conservation agriculture (CA) has grown in popularity, particularly in North America where much of the key literature comes from. In the UK, increases in uptake are relatively recent. Figures show that land under CA in the UK doubled between 2011 and 2016, now constituting over 8 percent of the UK's arable land¹.

We should note, although CA is a widely known soil-friendly practice, there are many farmers who are not practicing CA in the strictest sense, but still have a farm practice with soil conservation and improvement in mind.

Reduced tillage

Soil tillage disturbs the soil surface to prepare a seedbed, aerate the soil and can provide some compaction relief. However, this practice can also lead to detrimental effects. Exposure of previously occluded (and protected) soil organic matter can lead to oxidation and losses of this matter to the atmosphere. Physical disturbance of the soil with metal implements can also harm soil organisms, such as earthworms, which are crucial for a healthy soil ecosystem. Disturbance can also break apart soil structure.

The practice of reduced, or minimum, tillage aims to minimise the damage of this by reducing soil disturbance and is sometime known as min-till. This practice can be undertaken in several ways. For example, by switching from ploughing and power harrows to lower disturbance implements, often used in conjunction with cover crops (see below). No-till systems disturb even less soil, instead planting seed into remains of the previous crop by direct drills. These cut a slot, place a seed and close up. Strip-till is a further system, whereby only the portion of soil that contains the seed row is disturbed (by min-till), thus leaving strips of no till soils between the rows.

Reducing soil disturbance does not only benefit soils as already described. Fuel cost savings can also be made by reduced machinery draft.

¹ According to Conservation Agriculture UK Association: "In the UK, CA area has increased from 150,000 hectares of arable land in 2011 to 362,000 hectares in 2016 (8 percent of UK's total arable land area)". See: www.conservation-agriculture.co.uk/our-story/why-conservation-agriculture/

Controlled traffic and reduced passes

The weight of heavy farm traffic causes soil compaction. When compact, soils lose much of their internal pore space; the space which allows a healthy balance of air and water. This can reduce a soil's capacity to hold water, leading to waterlogging and runoff.

Reducing the air space in a soil also depletes the oxygen supply, leading to anaerobic and undesirable conditions for plants and soil biota. Furthermore, the act of compressing soil creates physical barriers for root growth.

To address compaction issues, many farmers try to reduce the number of passes machinery makes across their soils. This can be achieved by using suitable equipment or altering practices. For example, one such method is controlled traffic farming (CTF), whereby all farm traffic passes on permanent traffic lanes, so that soil compaction is focussed to certain constant locations, minimising the overall spread of compaction (Chamen, 2014).

Cover crops

Bare soils lack the protection of plant cover and are highly susceptible to erosion by water and wind. Cover crops provide soil cover over winter months, where soil may otherwise be bare between harvest and planting of spring crops. Prior to spring cropping, the cover crops are then incorporated into the soil, providing a fertility boost.

Cover crops can also be grazed by animals, releasing nutrients back into the soil. Cover crops are often used in conjunction with a reduced tillage system and have other benefits beyond canopy protection. The rooting systems improve soil structure, provide a habitat and food source for soil biota over winter, and with certain species can fix nitrogen to benefit soil fertility.

Several species can be selected for cover crops, exhibiting a wide array of beneficial traits. Commonly used cover crop species are vetch, phacelia, fodder radish, rye, oats and clovers, often planted in mixtures to combine beneficial traits.

Soil amendments

Several amendments can be applied to soil to benefit soil fertility, structure, organic matter and biology. Farmyard manure (FYM) can sometimes be sourced, providing a nutrient boost and increasing soil organic matter, and compost can also work in similar ways. Some other amendments we found to be employed, but less widespread, are practices such as compost tea, where compost is brewed in water to produce a liquid fertiliser. Anaerobic digestate, a product of the anaerobic digestion process, is another increasingly used and available soil amendment applied to improve fertility status.

Sustainable soil management: Case studies

An objective of this study is to see what practices farmers in Lincolnshire are undertaking to improve soil health: specifically, to find out how and why they adopted these techniques, where they gained the knowledge from, and explore ways this could be used for increased uptake in the wider farming community.

We interviewed farmers in the Greater Lincolnshire region who have adopted some of the practices described in Section 2. Here, we present summaries of four of these conversations, focussing on the following points:

- What they are doing, and what started them off on this journey
- Their sources of key information
- Their approach to measuring improvement
- Their opinions of how uptake in the wider farming community can be increased

Case Study One

This farmer farms 330 hectares North Lincolnshire and is known to the University as a farmer with a growing passion for soil improvement. The farm comprises two units, one on chalky Wold soils where he farms vining peas, wheat, oilseed rape and barley. The other section of the farm spreads across a variety of soils, where he grows wheat, rape, vining peas, barley and contracts out pig production on the lighter land.

What they are doing, and what started them off on this journey

The farmer started their journey around 10 years ago by switching to minimum tillage. The primary aim of this was to save on fuel costs via reduced ploughing. They bought a new drill combining winged legs, disc and press roller in a move to features reduces field passes, thus reducing compaction and reducing fuel costs. It is interesting to note that in this case, it was a cost saving objective that was the driving factor for the change in practice, and not an ambition to improve the soil condition.

Around four years ago, the farmer wanted to refine the drill and purchased a new one capable of strip tillage, which they still use today. The ongoing aim is to achieve a gradual change on the farm. The farmer sees strip till as the stepping stone from min till toward no till and direct drilling, which is the eventual goal for the practice. The farmer favours a gradual shift towards no till, rather than switching from normal cultivations to no till overnight, in order to that they can take steps to reduce risks and assess change over time.

Although the original impetus was cost related, after a few years of reduced soil disturbance the farmer started to notice more worms in the soil. This kicked off their interest in improving soil health.

Today, the progression continues. The farmer has had two years of cover crops and has applied for a grant to buy a direct drill, which will allow them to move finally from strip till to no till.

However, the journey will not stop there. They plan next to focus on reducing fertiliser inputs. They feel that the improvements in soil structure and biology which they are already seeing should lead to enhanced nutrient cycling, and thus more nutrient availability for plants, and a reduced need for inputs.

Sources of key information

Upon noticing earthworm numbers going up, the farmer's interest in soil health began in earnest. They started by using Twitter to follow people with similar interests. From these connections they became aware of literature on the subject coming out of the US (including *Growing a Revolution* by David Montgomery, and *Dirt to Soil* by Gabe Brown. Their latest book purchase is *Maverick to Mainstream: A History of No-Till Farming* by Frank Lessiter).

When they first started, there was little coverage in the farming press of min till practices and soil health, around one or two articles a year. However, it was at around this time that BASE-UK (see section 3.1) had started up and running and its members were experimenting with direct drilling. The farmer joined BASE-U, and began attending the associations meetings, and other events like Groundswell (section 3.1). These events and networks reassure them that they're on the right track and gives them confidence in the journey.

Their approach to measuring improvement

At present their key measure of improvement is money saved on fuel costs and on labour, as well as time that is freed up through reduced tillage.

When looking at soil improvement, the farmer has undertaken visual soil assessments in the past and has been doing worm counts (following the '60 minute worms' study (Stroud, 2019).

Their opinions of how uptake in the wider farming community can be increased

The shift of this farmer's motivation from a purely financial interest into a deeper interest in soil health is interesting. Now they themselves seek to get other farmers on board, using their own experiences. The farmer has written a presentation about the journey they have been on, which they have presented before agronomists and farmers. They are planning on presenting their story to a Young Farmers group in the coming months. They present the journey as a win-win situation, one which reduces costs, frees up time and improves soil.

The farmer is continuously improving their knowledge by accessing new reading material and research.

The farmer noted that many of the principles they've adopted are not taught at traditional agricultural colleges, and this is something that needs to change if we want greater uptake. They feel that the UK is far behind North America, South America and Australia in terms of regenerative agriculture.

They identified that persuading farmers to use cover crops is a specific challenge. Unlike the direct fuel and cost benefits of reduced tillage, with cover crops there is an initial outlay on seed which can be high, and which could put farmers off. This can be hard to justify for a farmer, unless the benefits being sought are long-term soil health gains, rather than short-term financial gains.

Animal performance within each system differed drastically, with the best and worst performing animals varying by 33 percent (PP), 52 percent (WC) and 54 percent (HS) in emissions intensity. Steers also performed better than heifers on the WC and HS systems. Notably, whilst the HS heifers finished quicker due to lower target weight and ease in meeting carcass specifications, the relative emissions savings were not large enough to offset the benefits from higher target growth of the steers.

PP systems therefore may allow for less stringency in animal selection and offer a comparative advantage as a stable system, presenting strong evidence for their maintenance and benefits within South West food production.

Additionally, strategies for WC and HS systems such as spatial separation, overseeding and precision agriculture may need to be explored to reduce sward spatial variability. Ultimately, land use change to other types of production were not included in the LCA because “grasslands in the southwest of England are typically located on hilly land with soils that become supersaturated...[therefore] unsuitable for arable crop production”. Thus, promoting grazing systems where grass is the land’s best output makes sense from a strategic land use standpoint.

Case Study Two

This farmer farms on the chalk soils of the Lincolnshire Wolds. They were first introduced to LIAT at a soil health event held by UoL, following which they kindly invited LIAT team to visit the farm.

What they are doing, and what started them off on this journey

The focus of their practice is a systems-based approach adhering to the three principles of conservation agriculture: minimum soil disturbance; continual soil cover; diverse rotation.

Interest started around 15 years ago after the farmer listened to an influential talk as part of their local training group. This started them thinking about the impact that ploughing/cultivating light land has on oxidation and loss of organic matter from the topsoil.

Actions to address the issue on their own farm were put into practice about four years ago. A trip to Brazil gave them the opportunity to meet with world experts in Conservation Agriculture. That spring they put in mixed species cover crops and the results were encouraging, with no soil inversion, and as such no destruction of soil food webs.

The following Autumn, they started to direct drill after cover crops, trying out several models before settling on a preferred drill. The farmer has also widened their rotation to an eight year rotation, and where possible grazes off cover crops with sheep.

This year, whilst drilling the farmer is putting in a biological mix with the view to stimulate soil biology, which could stabilise phosphates and fix nitrogen, thus contributing to plant availability of nutrients. Their aim is to reduce fertiliser inputs in the longer term through the creation of a soil that provides plant nutrition through the action of microbial communities.

Sources of key information

When the farmer started these practices, they felt very much in the minority amongst their peers. However, they were aware of organisations of like-minded farmers, such as BASE UK. Much of the research they have carried out has been from online sources. They started to learn more from the writing of Gabe Brown¹ and work of Elaine Ingham², followed by attending a training course. Aside from the reading and training, the farmer does a lot of trial work with research partners and companies, which seems to be a good platform for knowledge exchange.

Their approach to measuring improvement

The farmer focuses on worm counts, and visual soil structure assessments.

Their opinions of how uptake in the wider farming community can be increased

The farmer is careful to stress that their approach may not suit all soils. They note, for example, that cover cropping might not be as effective on heavier soil, those where there is more water storage and colder soils over winter might not be ideal for cover crop growth. The seed cost is an initial capital cost which they note may not pay dividends in the short-term, and therefore they see the expense of cover crops could be a barrier for uptake by others.

1 Gabe Brown is a pioneer of the soil health movement, based in North Dakota.

2 Elaine Ingham is an American microbiologist and soil biology researcher.

Case Study Three

This farmer farms near the city of Lincoln on a variety of soil types over 460 hectares, mostly limestone heath soils, but also some sand, clay and silt. They are aiming for an eight year rotation, growing wheat, barley, peas, oilseed rape, beans and linseed.

What they are doing, and what started them off on this journey

The farmer undertook a Nuffield Scholarship in 2000 looking at the potential for no-till in root crop systems. At the time they were growing sugar beet, which raised the question of whether it was possible to practice no-till in such a system. Undertaking this scholarship increased their knowledge of no-till, and kick started their implementation of the practice.

The farmer hasn't ploughed their soil since 2004, adopting a Min Till approach to the whole farm, and then adopting controlled traffic farming in 2009. More recently much of their farm has been switched to no-till. The farmer uses two drills: a disc drill and tine drill, which gives flexibility for which to use depending on crop choice or soil condition.

Cover crops have been going in for the past three years, which are part of a Countryside Stewardship scheme, which helps with the cost of seed.

Sources of key information

The Nuffield Scholarship gave the opportunity to learn about much which they have since put into practice. It allowed them to travel, and visits to Canada and the United States provided lots of information. Since then, they have also travelled to other parts of the world meeting with farmers and sharing information.

The farmer has been a member of BASE UK since it started, and gains a lot of information from talking to other farmers both inside the association and in wider farming circles.

The internet also provides information, particularly YouTube. The bulk of the information online tends to stem from North America

Their approach to measuring improvement

The farmer noted that it can be difficult to measure the improvement, but they believe that you can get a feel for improvement in the soil. They undertake visual soil assessments whilst walking the field, and undertake worm counts.

Their opinions of how uptake in the wider farming community can be increased

The farmer noted that there are several challenges that farmers growing root crops may face when adopting to a no-plough system, on account of the soil disturbance at harvest and the ability of the plough to 're-set' the soil

They were also keen to stress that whilst in the coming years, agricultural support may manifest towards a more soil-focussed payment scheme, caution needs to be applied on how we measure soil improvement. Their opinion is that this is a complex issue based on soil type and past farm practice, and therefore that any future support or grant system should factor in the intrinsic soil potential (for improvement) of a site, and the management that farmers have already been employing.

Case Study Four

LIAT were first introduced to this farmer in 2018 at the Groundswell event. They farm 230 hectares near Gainsborough and have a diverse rotation including wheat, barley, beans, maize and linseed. They are particularly interested in soil biology, specifically in mycorrhizal fungi.

What they are doing, and what started them off on this journey

The farmer started trying out new things four to five years ago with a view to improve their soils and suppress weeds, but also with the potential financial benefits from reduced inputs in mind. In the first year they started out with cover crops. Now they are trying much more. The farmer has their own brewer for compost tea; they are putting in grass paddocks; and are importing manure. They also aim to have the most diverse rotation as possible, moving away from the original cycle wheat-oilseed rape rotation to now include maize, beans, linseed, barley.

Sources of key information

The farmer does online training and noted the teachings of Elaine Ingham as a key influencer. They also attended the Groundswell conference which they consider to be a good platform for knowledge sharing between farmers.

Their approach to measuring improvement

The farmer is interested in soil biota, particularly mycorrhizal fungi, and have their own microscope where they look for mycorrhizal associations with their crop roots. The research team for this report went out with the farmer into the field to dig in to the soil, looking for soil improvement by checking the structure and form of the soil.

Case study summary and recommendations

Farmer motivations

Farmers' have a variety of motivations for adopting practices which improve soil health: seeking financial savings; an intrinsic interest in soil biology; or a commitment to improve soil quality for long-term gain. Despite differing motivations, these reasons can go hand in hand. Savings costs on fuel and labour, for example, align with reduced soil disturbance. One case where financial savings may not always be

delivered is in the use of cover crops. In this situation the farmer would need to weigh up the initial cost of seeds against the expected long-term benefits on farm in soil structure and biology.

The process of implementing new practice is not an 'overnight fix' instead, our case studies show farmers which have been on, and are still on, a journey of transition. This may manifest as a gradual switch from ploughing (high soil disturbance) to min-till, to strip-till and eventually to no-till (very low soil disturbance) with other components such as controlled traffic and cover cropping also implemented at various stages.

Two of our farmers also discuss a further stage of the journey – the view to reduce fertiliser inputs after their gradual improvement in soil biology in recent years. This could be another potentially positive draw of the approach, and a further cost saving.

Where farmers source information and support

Farmers found information from a wide range of sources: traditional media, including books and magazines; social media, including Twitter and YouTube; digital media online; in-person training courses; formal and informal networks. These routes provided insight, confidence and reassurance for the case study farmers. Several noted that a significant proportion of information is coming from North America, which appears to be leading the field in this type of practice. In the UK, uptake may not be as widespread, but groups such as BASE UK² and events like Groundswell³ provide important opportunities for knowledge exchange.

We heard that farmers working on soil health have felt, and continue to feel, like first movers amongst their peers. Inherent in this position are feelings of risk and uncertainty. The information farmers were able to source on practical techniques was important for reassuring them of the likelihood of their interventions working. Peer support, either directly, or via hearing the stories of others who had been on a journey of

improving soil health, was identified as being important. Indeed, several of farmers were now encouraging and supporting other farmers to follow their lead.

Incentives for encouraging more widespread soil health practices

The benefits of improving soil health are now more widely publicised amongst the farming community. However, encouraging the uptake of wide sustainable soil practice remains a challenge. One potential mechanism for incentivisation is promoting the cost savings which can be achieved, as described by several of our farmers, including Case study one. Their initial focus on fuel savings lead to soil improvement almost as a by-product. The farmer sees this as a positive message to encourage new farmers into the conversation.

Where the ‘cost saving story’ may struggle is in introducing cover crops, where seed costs equate to greater inputs in the short term whilst the expected gains are in long term soil improvement, rather than in short term financial (yield) benefits. Cover crops can be integrated as part of wider soil improvements schemes, thereby balancing their increased inputs with a decrease in inputs via the other techniques already discussed. However, for uptake of cover crops to significantly increase the farmers note that systemic incentives may be needed.

2 BASE UK (Biodiversity, Agriculture, Soil and Environment) are an organisation of farmers and other individuals with an interest in conservation agriculture. It provides a format for members to share their experiences, and has been both an education source, and reassurance to our farmers.

3 Groundswell is an annual farming event in England with a focus on conservation agriculture and regenerative systems. It has been running for four years and provides an opportunity for farmers to showcase their experiences in practices such as no-till, direct drilling and cover crops.

Increasing peer support and learning

Farmers who have themselves undertaken a journey of improving soil health are well placed to support their peers and should be encouraged to share their experiences. This could range from informal conversations with neighbours through to more formal presentations. The farmer in Case study one has been ‘championing’ soil health by giving talks about their own experiences, and is receiving positive feedback.

Online sites and forums, and social media are proving to be useful ways for farmers to access and share information between them. This is particularly beneficial for accessing information from North America, where practices are more established.

Formal learning networks and associations

Farmers evidently gained a lot of knowledge from associations such as BASE UK. These organisations are playing a critical role in supporting the transition. However, membership of such organisations remains in the minority. As well as supporting these organisations to increase their reach, other established farming associations should encourage farmers to take steps to improve soil health.

Indicators and measures

Farmers used a range of indicators and measures to track the progress of their soil health interventions. Along with educational support, having a framework of clear, affordable and manageable measures by which farmers can chart development would be beneficial. This would allow farmers to have clear targets and pathways for development their practices.

Putting recommendations into practice

In Lincolnshire there are seeds of positive soil health practice amongst farmers. To accelerate this transition this project opted to focus on an insight that arose from the case studies: the value of peer learning and support to encourage farmers to change their soil practices. In the next chapter we explore two methods which were implemented to use peer learning and support to engage with a greater number in the agriculture community in Lincolnshire.

New networks: Increasing uptake of sustainable soil practice through peer support and community building

Our case study research demonstrated that farmers currently engaging in soil improvement agriculture in soil benefit from networks, associations and events – such as BASE UK and Groundswell – which provide a platform for knowledge exchange. However, membership of such associations only represents a small proportion of the UK farming community.

If the UK is to increase uptake, we need to explore the platforms in which to engage with the wider agricultural community. The case study research identified that peer learning and support were critical to helping farmers make changes in their practice.

In the second phase of the research, we put into practice these insights by adopting two approaches to engage a wider consortium of Lincolnshire farmers in the issues:

1. Catchment-based approach

Our first approach was to engage with farmers defined by a geographic region. Here, we might expect similar farming types, soils and climate, and as such, sharing practice has the potential to be more relevant farmer-to-farmer. For this, Jenny Rowbottom (UoL) developed a Knowledge and Innovation Day (KID) which is detailed in Section 4.2.

2. Agronomist-based approach

One of the outcomes of our work at catchment-based level was to highlight the importance of the role in agronomists in knowledge exchange. Therefore, the next approach was to engage with farmers via their agronomist. We did this by hosting an event inviting farmers from one agronomy firm's client base, with the intent of engaging with a wide range of farmers (Section 4.2).

New Networks: The Catchment-based Approach

Rationale

UoL are involved in a Horizon 2020 (H2020) project focussing on the impact of nitrates and pesticides diffuse pollution from farmland on the quality of drinking water; UoL work closely with both ADAS and Anglian Water to establish a case study region in the Cringle Brook catchment in Lincolnshire. This provided an ideal opportunity for introducing farmers in that area to innovative approaches to soil health engagement.

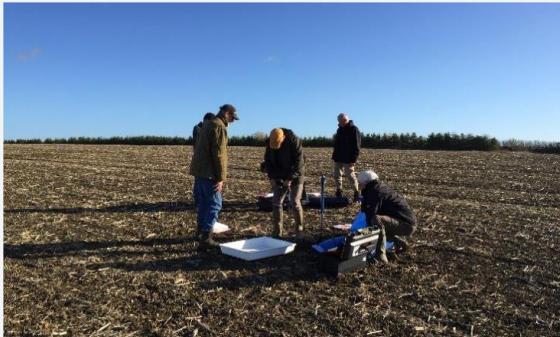
There is increasing awareness of the need to approach engagement from the 'bottom-up' to encourage exchange of ideas between the farmers and the researchers/scientists/businesses involved in soil health and related topics. In this vein, Jenny Rowbottom (UoL) designed and implemented the Knowledge and Innovation Day (KID).

The initial hope was to target the farmers in the Cringle Brook catchment, along with their agronomists. As such, 55 postal invitations were sent to farmers in the catchment, and 10 invitations to their agronomists. After a period of two weeks, just five replies from local farmers and one agronomist were received. Whilst five from 55 may seem a low number for attendees, this is completely in line with expectations for farmer events when the event is a 'cold one,' ie not part of a regular programme. As a result, it was decided to market the event wider through longstanding networks of the University and associates; the final attendee number was 26, with 50:50 ratio of farmers and agronomist/agribusiness support industry. Attendees were able to claim CPD points for the event and were provided with lunch.

Format

The focus of the event was to maximise hands-on participation from delegates in the field, coupled with bringing in leading experts from industry to showcase practical skills and short talks. The format of the day included:

- Hands-on soil health assessment activity. Here, we explored a range of useful, quick and inexpensive methods to assess soil health. The aim was to provide delegates with useful skills and information so that they could undertake similar assessments on farm. To ensure up-to date industry relevance, the techniques explored linked directly to a current AHDB Great Soil project (Griffiths, 2018). An introduction to some of the techniques discussed can be found in Appendix 1. The soil health assessment was demonstrated by UoL staff, Becky Carter (Anglian Water) and Phillip Vickers (Aztec Ag).
- In-field soil pit discussion to explore soil structure and root depth. Lead by Dr Felicity Crotty (RAU) and Prof Roger Sylvester-Bradley (ADAS).
- Short talks: Miscanthus, blackgrass and soils, by William Cracroft-Eley (Terravesta); Grass leys and soil improvement, by Dr Lizzy Sagoo (ADAS); Deep soil health, by Prof. Roger Sylvester-Bradley; Lincolnshire Rural Support Network, by Alison Twiddy (LRSN). The purpose of these short talks was to present a flavour of the topic, with the chance to discuss further over lunch, if the delegates required more input.
- Soil demonstrations: Demonstrations of soil infiltration, soil biology and soil aggregate structure were set up in the coffee break out area. These ran throughout the day, offering a visual focus and talking point for delegates.
- Discussion environment: Following the demonstrations and talks, a sit-down hot meal was provided which allowed delegates and experts to sit in an informal setting to discuss the topics.



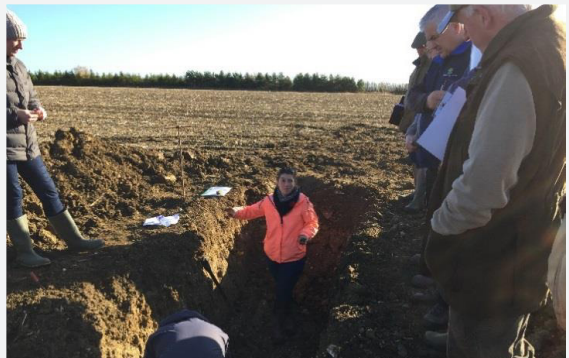
Small break out group trying practical soil assessment methods taught at the KID event



Closing the event with a sit-down meal provided an ideal platform for follow up discussions



Soil demonstrations on show: Soil biology and compaction demos



Soil pit: Dr Felicity Crotty discussing soil structure and biology

Learning and recommendations

Initiating new networks requires substantial resource

Creating a new network requires obtaining the farmers' trust in order for them to invest their time. The event highlighted the challenges of a cold event, whereby a new event or initiative is set up from scratch. It was initially challenging to attract adequate numbers of attendees to the event and doing so required sustained efforts.

Despite this initial challenge, the event was well attended, and all delegates indicated that they would like to attend annual KID events if that were to be available. To increase knowledge exchange opportunities whilst building up trust and commitment with delegates, building on this momentum with a future would be an ideal next phase.

We recommend that events such as this are held regularly across the region to build momentum and awareness amongst farmers, and that resource is made available to support these.

Practical and hands-on learning is effective
Delegates praised the practical and hands-on nature of the KID event, describing it as being different to training they had experienced before. Providing delegates with an opportunity to experience techniques for themselves ensures that the skills and knowledge obtained is useful and delegates indicated they would put these into practice on their farms.

Independence and a range of hosts is valued by delegates

The event brought together a number of stakeholders, including UoL and external industry professionals from ADAS, Anglian Water, Lincolnshire Rural Support Network, Terravesta and Aztec Ag. It also provided collaboration with other researchers, such as Dr Crotty (RAU). This helped to widen the network for the farmers and ensured that the event felt independent and welcoming.

Creating an informal and friendly environment enables engagement

Scheduling time for and providing a sit-down lunch created a positive ambience for discussion. It enabled farmer to farmer, farmer to agronomists, and farmer to expert discussions in a friendly and non-confrontational arena. Ending in this way enabled farmers to stay if they wanted, with many remaining after the official end-time. Facilitating the opportunity for social interaction in this way is critical to building trust and encouraging long-term relationships to form. Whilst requiring extra resource, we recommend that those seeking to engage new networks of farmers place a focus on creating this social space.

Include agronomists in networks

Originally, we planned only to include farmers as delegates. However, the event soon attracted agronomists too and, given their ability to spread information throughout their networks, we included them in the event.

This raises two points. Firstly, that attracting agronomists may be easier than attracting farmers to new events. And relatedly, ensuring that agronomists are on board with soil health practices is a strong way to both educate farmers and engage them more widely.

Existing Networks: The Agronomist-based approach

Rationale

Following the success of the KID day, we were approached by one of the agronomist attendees to replicate a similar format for their network of farmers at a CPD event which would have attendance from farmers across a wide geographic area (Northern Lincolnshire) constituting a range of soil types and soil practices. The goal was to engage with a group of farmers who are taking various approaches to soil conservation and improvement. Unlike the KID event, the invite list stemmed from the agronomist' client bases, and as such, we benefitted from a higher turnout rate. 55 farmers were invited, and the final turnout was 44 attendees, composed of four agronomists, one representative from Anglian water and 39 farmers (89 percent of attendees were thus farmers).

Format

The day was split into talks and presentations in the morning, followed by field demonstration in the afternoon. The talks featured included a focus on soil health by Anglian Water's Catchment Team, a discussion on the next five years in agriculture by Assured Agronomy, and an update on research and technology in agriculture by the University of Lincoln. A key talk was provided by a local farmer who discussed his journey of reduced tillage and cover cropping to improve soil condition. In the afternoon, groups were taken out into the field to partake in soil assessment methods, like the activities undertaken in the KID event.



UoL presentation on soils and future directions



Local farmer talks about his journey into regenerative agriculture

Summary

Connect with existing networks to spread information

Whilst UoL regularly hosts events for the Lincolnshire farming community, it was noted that most farmers we engaged with at this event had not been to University talks or demonstration events before. Connecting with this agronomist opened up a new network to engagement in soil health practices. Given the resource required to form new networks from scratch we recommend seeking out partners with existing networks. Agronomists provide an excellent conduit to do this.

Bring issues to life with farmer experiences

As noted in our case study research, it is beneficial for farmers to hear the experiences of peers and can be reassured by this process. The delegates at this event benefitted from a talk by a local farmer who has been developing his soil health practices for several years. When designing events such as this, we recommend using it as an opportunity to support farmers to share their own experiences.

Engaging Lincolnshire farmers in soil health practice: Conclusions and recommendations

Much like soil itself, increasing the take up of sustainable soil practice requires a variety of approaches, and may have no one-size-fits-all approach. What can work on one farm and one soil type may not always provide the same results or may have a slower response than others. As such, incentives to take up more soil-friendly practice also can be manifold. A top down approach, providing payment for soil improvement is one way forward, and it may feature in a new Agricultural Bill. However, the challenges here are to find a way to assess practice and soil condition across a range of soil types which have seen a contrast in management history. For example, simply assessing soil organic matter levels will favour some soils more than others, and perhaps not favour management systems which have been building up organic matter already.

A grassroots, local approach provides a key mechanism for increasing uptake: in person events and activities which provide farmers with independent advice, practical knowledge and an opportunity to meet and learn from one another appear to be important in promoting the take up of sustainable soil practices in the county, particularly when placed in an informal setting to allow discussion afterward. This approach can utilise existing farmer networks, but also build up new ones.

Encouraging take up of sustainable soil practices via grassroots, local approach
The Lincolnshire research highlighted several recommendations for those seeking to run activities and engage farmers at a local level:

Invest in networks and let them evolve

Obtaining farmers' trust and commitment takes time. It is important to respond to the energy, interests and needs of the farmers involved. Identifying these can, in itself, take time.

Achieving long-term change in practice is likely to require sustained engagement. In achieving this it is the peer relationships, as well as any relationship formed with a training or organising group, that are important to nurture.

Networks and relationships, either formal or informal, which already exist amongst farmers can act as good platforms through which to introduce information about sustainable soil initiatives. Local knowledge of how, where and who holds these relationships is valuable when seeking to engage farmers.

Respond to needs and interests

It is important to understand what the drivers are for change and the areas of interest amongst the group and network. Focussing on the needs of the farming community helps build trust, shows that their issues are cared about and makes it easier to engage.

Cultivate peer relationships

The greatest benefits from activities which bring farmers and other practitioners together to discuss soil health come from the potential for peer learning and connections. The farmers involved in the research found the reassurance from their peers to be important in encouraging them to continue developing their sustainable soil practices. Online communities can also provide this support, but in person and local relationships remain important.

Providing a hot lunch in a welcoming environment is a simple step which creates a friendly and convivial ambience for informal discussion and networking which helps to build trust and connections. Farmers often work in isolation and creating a social space provides additional benefit and appeal to a skills-based workshop.

Keep it practical

Farmers responded particularly well to practical learning activities. These included 'in-field' demonstration sites and talks where they both heard from experts about the latest research and were also able to try activities themselves; and lab-style demonstrations of soil testing techniques. Ensuring that CPD points can be collected during training provides another incentive for farmers to attend. In the vein of large events such as Groundswell, these more-local engagement events could build momentum by occurring annually or bi-annually, with a smaller community of neighbouring farmers attending, sharing knowledge and benefitting from hearing the latest from farmers, industry, and research.

Involve a range of voices and expertise but keep it independent

Bringing together a range of practitioners, academics and other stakeholders, such as water companies, provides an excellent opportunity for knowledge sharing. To get the most out of this opportunity it is important that activities and agendas instil trust and encourage openness amongst participants. Independent events with a range of activities and inputs can provide this. Support for such activities is likely to continue to require support from the third and public sectors to remain viable.

Clear and simple indicators and measures give farmers confidence to start

Providing farmers with a range of useful, quick and inexpensive methods to assess soil health reduces barriers to action and ensures that they can easily undertake assessments on their farm. Appendix 2 is a summary of basic soil health assessment techniques.

Agronomists can act as ambassadors

Agronomists provide soil health advice to farmers throughout the county. Through their wide client bases, they can promote the take up of sustainable soil practices. Encouraging agronomists to attend events and form part of soil health networks is important.

Best practice exists locally, continued work is needed to spread this practice

We found evidence of farmers implementing best practice on soil health within the county. The next step is to find a mechanism to translate that reassurance to a wider base.

To do this, the case for support could be two-fold: (i) financial benefits; (ii) soil and other environmental benefits. As business owners, the financial benefits could work as a key message to farmers, however we must stress some caveats. For example, the cost of cover crop seed, the fact that it is not a one-size-fits-all soil types approach, and the potential for additional investment costs for new machinery (although grants are available). Whilst the benefits to soil health are clear, the activities required by changing practice should be viewed as a long-term investment in the land, rather than a short-term financial boost.

Some of the soil benefits, particularly biological benefits, are also harder to quantify. Soil is a complex medium and there an array of useful methods and measures available to assess the health of a soil, but no one universal metric. We recommend, therefore, that individualised advice is available to farmers. This could be delivered through a range of pathways, from agronomists to formal and informal networks.

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Appendix one: Soil assessment guide

Dr Iain Gould, Lincoln Institute of Agri-Food Technology

It is important to be able to assess the overall quality of the soils we work with by looking at their chemical, physical and biological condition. Many soil properties that are essential to plant growth are best assessed with laboratory testing (eg nutrient levels, organic matter content, pH). However, there are several other methods we can use to diagnose soil health in the field.

Anyone can carry out these tests, they are relatively inexpensive and can be applied year-on-year. This makes them great for measuring the impact of changes or introductions made on a farm to soil structure.

Soil physical properties

Good soil structure creates the ideal conditions - sufficient aeration, drainage and water retention - for plant growth. Soil structure is dependent on the arrangement and stability of the materials that make it up. Unlike some of the chemical properties of soil, the physical condition is best assessed in-situ. As such, some of the following simple techniques can be used to great effect.

Two of the more commonly used techniques to assess soil structure are the visual soil assessment (VSA) and the visual evaluation of soil structure (VESS). These both similarly involve breaking down as-dug soil into their smaller constituents and assigning a scoring system. Where the aggregates, or clods, are still large after breakdown, this could indicate low porosity, poorer structure and as such a lower score. Conversely, finer aggregates after breakdown indicate the opposite (Fig 1a).

It is important to note not only the size but also the shape of the soil units. Angular aggregates indicate a poorer soil structure – likely a result of damage by machinery or undesirable conditions. Some structures are known as ‘platy’ – flat structures that break horizontally under pressure (Fig 1b) – these indicate a degree of compaction. This information is all incorporated into the scoring system.

Another simple way to assess soil structure in the field is with an infiltration test. This can be done by pushing a small pipe offcut into the soil (making use of a mallet and a plank of wood), filling the pipe with water and timing how long it takes to drain (Fig 1c). The water will find a route through the soil by exploiting channels and pore space. Greater infiltration means better drainage and rooting potential, likely a result of good soil structure.

Soil biology

Soil is a living system, and the life within a soil is essential to its healthy functioning. Some of the more detailed tests for measuring soil biology can be expensive, however, there are cheaper and simpler methods. For the keen biologist, investing in a microscope and becoming familiar with the important species living in soil is a possibility. Here, we discuss some of the other methods adopted on farms around the country.

Worms are a vital ecosystem engineer in soil – recycling nutrients and influencing soil structure with their burrowing. Worm counts are a great way to start and can even be incorporated into other soil structural assessment (like the VSA). A cube of soil the width of a space is dug from the ground and sifted through for five minutes, counting the number of worms. These can be

compared year-on-year or carried out in different areas to build up an overall picture of the soil system of a farm/field. Recently, the 60 minute worms and 30 minute worms initiative, led by Dr Jackie Stroud, proved very popular – see www.wormscience.org.

Another important thing to consider is the microbiology of a soil. This can be tricky, given that microorganisms, such as fungi and bacteria, are invisible to the naked eye. Instead, we can measure decomposition – how much of a food source is broken down by microorganisms over time. Two of the more popular ways to look at this are the ‘tea bag index’ and the ‘underpants test’.

The tea bag index (www.teatime4science.org/) is a test in which two unused tea bags are weighed, and then buried for 90 days. The tea bags are then dug out, dried and re-weighed (Fig 2a). The loss in mass indicates the rate of the decomposition of tea carried out by the microorganisms.

The underpants test (www.farmersguild.org/soil-my-undies-challenge.html) is a more visual test based on a similar principle. Burying cotton underpants in different locations can provide a comparison of the rate of decomposition (Fig 2b), indicating the health of the biological community below ground.

Soil chemical properties

Soil chemistry is more challenging to measure in the field, which is why it is beneficial to combine the techniques discussed above with laboratory testing. Under current practice, plant-available nutrients are measured by the processing of samples in a laboratory, however, handheld kits are available to measure soil pH and electrical conductivity in the field.



Fig 1a: Soil aggregate size distribution following VSA breakdown



Fig 1b: Platy soil structure – horizontal cracking



Fig 1c: Soil pipe infiltration test



Fig 2b: UoL staff demonstrating the Underpants test – high decomposition (left) and low decomposition (right) after burying in different soil environments



Fig 2a: Tea bag index – Two teabags buried in adjacent holes

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