



A Nuffield Farming Scholarships Trust

Report

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**Moving from Sustainable to
Regenerative Agriculture
using No-Till systems**

Tom Sewell

July 2014

NUFFIELD UK

NUFFIELD FARMING SCHOLARSHIPS TRUST (UK)

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A Nuffield (UK) Farming Scholarships Trust Report



*"Leading positive change in agriculture.
Inspiring passion and potential in people."*

Date of report: July 2014

Title	Moving from Sustainable to Regenerative Agriculture using No-Till systems
Scholar	Tom Sewell
Sponsor	HGCA
Objectives of Study Tour	To look at No-Till farming around the world to see how it has improved soils, the environment, profit and lifestyles.
Countries Visited	North America, New Zealand, Australia, Paraguay and Brazil.
Findings	<p>No-Till can be successful in every country if used as part of a system.</p> <p>Soil improvements in biological activity and soil organic matter occur through retaining residues, diverse crop rotations and the use of cover crops. This results in less erosion and nutrient loss as well as improved water infiltration and soil structure.</p> <p>With improved soils, profits and time availability, farmers are better placed to deal with future challenges, expansion and unpredictable weather patterns.</p>

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DISCLAIMER

The opinions expressed in this report are my own and not necessarily those of the Nuffield Farming Scholarships Trust, or of my sponsor HGCA, or of any other sponsoring body. Having travelled and viewed many farming operations, the contents of this report represent my findings as a farmer seeking to implement practical change for the good of agriculture in the UK. This takes the form of anecdotal evidence and my thought patterns rather than hard scientific evidence and replicated field trials!

CONTACT DETAILS

Tom Sewell

The Lodge
Nettlestead Place
Nettlestead
Maidston
Kent ME18 5HA

07977 908378

tom@sewellfarms.co.uk

Nuffield Farming Scholars are available to speak to NFU Branches, Agricultural Discussion Groups and similar organisations

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Southill Farmhouse, Staple Fitzpaine, Taunton TA3 5SH
Tel : 01460 234012
email : director@nuffieldscholar.org
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1.0. Personal introduction

Hi, I'm Tom Sewell, a 37-year-old, second generation arable farmer from Maidstone in Kent.

I have been married to Sarah for 13 years and we have four children (one girl and three boys).

As well as farming and raising a family with my wife, I am on the leadership team of The Vine, Maidstone - a large and diverse church which impacts lives and shapes communities in our local town.

This is one of the reasons that our business, Sewell Farms, doesn't work on Sundays, even during harvest! We believe that Sundays are to rest, enjoy time with friends and family and allow an opportunity to step back from the busyness of farming and appreciate all we have.



Me, Tom Sewell

And we really are blessed in all that we do have! I farm in partnership with my wife Sarah and my parents Jem and Anna. Dad is also a Nuffield Farming Scholar of 1991. Our

farming operation currently extends to approximately 1,000 acres, which is owned by ten different landowners and, of our farmed land only 67 acres is family-owned.

I returned to the family farm in 1998 having spent time at Harper Adams Agricultural College, and then worked for farmer and contractor Harry Wilson in Shropshire and Lancashire. There was also a gap year before university in which I worked at home for a harvest and then spent four months at Methven in New Zealand for their harvest.

When Dad returned from his Nuffield Farming Scholarship in 1992 he brought back one simple message:

“Debt = Vulnerability.”

This has helped shape the way we run our business and currently we farm 100% debt-free. Everything we have is bought and paid for including all land, buildings and machinery. This has been an important factor in our slow but continued growth over the years since my return to the farm.

Aside from the farm I enjoy spending time with my wife and children. I'm a fan of motorsport, particularly off road motorcycle trials, and am also currently chairman of Mid Sussex Farm Discussion Group, which meets once a month November through to March.

My Nuffield Farming journey has come at the perfect time in my farming career, allowing me to explore the next step in progressing No-Till systems and new technology and then having the freedom to implement significant changes to our business.



2.0. Background to my study topic

Since 1991 and the ban on straw burning, the establishment of crops on our farm has taken place using a number of different methods of cultivation.

We are blessed to have some fertile land, which is capable of producing good wheat yields and this results in a good yield of straw/residue, which we have chosen to incorporate into the soil. This has taken different forms from light discing with a 5m He-Va Disc Roller at about 50mm deep, through to a more thorough mixing and subsoiling with a Sumo Trio machine.

The aim of our post-harvest cultivation was to encourage a germination of any weed seeds and also any seeds and chaff that were missed or dropped by the combine. We also took this opportunity to try and level the fields and mix soil with the chopped straw thinking that this was best for rapid decomposition and the following crop. We had a seeder fitted to the Sumo Trio, which allowed us to plant oilseed rape (canola to my Australian and South American friends) directly into the soil in one pass.



Our previous cultivation practice using a Sumo Trio cultivator

The mixture of cultivation practices that we carried out during the nineties and up until last year was reasonably successful allowing us to cover the ground quickly and keep the fields level. However, a number of things happened that started to make me question whether this was the right way to proceed long term.

Firstly, a few years ago we established all our oilseed rape with the Sumo Trio. The subsoiler legs were set at about 250mm (10") and the rape emerged well. In the following spring and early summer we had some very heavy rain which made the land wet. The applications of fertiliser and fungicides that needed to be made to the crop resulted in ruts being created in the ground. The depth of these ruts was the same as the depth to which the soil was cultivated the previous autumn.



Where we had cultivated to 10" depth we had 10" deep ruts and where we had been through with the disc roller at 2" the ruts were only 2" deep.

Secondly, I spend many hours applying fertilisers and sprays to the crops on our farm so I have time to sit and think. I wondered why farmers (including myself) would take a field that had just grown an excellent crop of wheat and was level and free draining - and then plough or cultivate this land. They would turn it over and make big clods, which would then either dry out and go hard or get very wet and soggy. Then they would cultivate it with power harrows and heavy presses to break the clods and make a fine tilth, to then plant the next crop. Finally, they would roll the field to "firm up" the soils and press the soil around the seed. This would be just like the state of the field before the initial cultivation but without the straw and stubble: level and free draining, but with all the residue buried.

My conclusion from this was that the entire process, if the soil was in a good condition/structure, was for the benefit of the drill and its inability to sow directly into the previous crop's stubble. This was resulting in many cultivation passes. These are operations that take place at a very busy time of the year, using extremely expensive tractors and machines, burning diesel and wearing out metal and spending money on staff to carry out these operations. Then there was the fact that the moisture content of the soil was totally dependent on the weather in the days and weeks following the cultivation operation. So many times had I seen cultivated fields either get so dry that "*we can't plant until we get rain*" or "*we could do with the land drying out a bit.*" These thoughts were what made me explore no-till systems for our farm.

Firstly, from the outset you need to realise that two of my strengths on "Strength Finder" are "Maximiser" and "Futuristic". This means that I always want things to be the best and continually improving, and that I'm thinking "*How does this affect the future?*" For example, I will always choose to use stainless steel bolts rather than standard steel bolts when building a machine or making a modification. It is with this in mind that I am striving to find the ultimate crop establishment system: one that will not only establish crops more cheaply than before but also deliver benefits that will continue to improve over the coming years.

If the soil can be maintained with a good structure and new crops can be established into that soil without damage then, as long as yields can be maintained or even improved, the savings to the cost of establishment would be significant, if not huge. Can you imagine eliminating all the costs of cultivation on your farm. Just think! No wearing metal such as disc blades or plough points to buy and replace. No downtime for staff in carrying out this work, plus the time freed up by not cultivating - and the savings in fuel alone associated with cultivation would be significant to say the least. Then imagine having only one drill/planting machine plus possibly a set of rolls to establish all combinable crops.

This was my aim with my Nuffield Farming Scholarship and having seen the picture on the next page - Nathan Williams's cross-slot drill in New Zealand planting right behind the combine - I was keen to explore the possibilities that no-till could offer me.



**Nathan Williams's cross-slot drill in New Zealand
planting right behind the combine**

If this method of crop establishment could be used successfully in the UK without the need for moving soil and burning huge amounts of diesel, then I was keen to investigate what the long-term benefits, and any pitfalls, of no-till would be. Was it one corner too many to cut - or did it give me the opportunity to be even more competitive with my costs in the future?



3.0. My study tour – where I travelled and why I chose those countries

From the outset it was always my intention to visit those farmers, advisers and experts who were the best in their “field” when it came to no-till. I wanted to see those who had long-term experience of not cultivating their soils and who had stuck with no-till through thick and thin, and whether the benefits seen were worth the effort.

So, with that in mind, when it came to looking at countries to visit they really chose themselves as they were firstly where the best no-till experts were and secondly where no-till had been practised the longest by large percentages of the farming population.

Having researched key no-till experts on the Internet, and by watching presentations on YouTube, I wanted to see if the farms in question were really as good as the presentations suggested.

First on the list of destinations was **North America and in particular North Dakota**. This was to visit three main people, Gabe Brown, Dwayne Beck and Jay Fuhrer, although the visit to Kevin Larson was exceptional too. I spent two weeks in North and South Dakota in July 2013, which, in hindsight, was not long enough.

Secondly, I had been following the progress of the cross-slot drilling machines from New Zealand and was particularly interested to see this system at work and in particular meet the designer and company owner, Dr John Baker, who himself had 40 years’ experience with no-till. **New Zealand, out of all the countries visited, probably had the climate and soils most comparable to the UK. I travelled to New Zealand in November 2013 for two weeks followed by two weeks in Australia.** Australia was a huge contrast as I witnessed planting and harvesting in South Australia on land very different to anywhere else that I visited. No-till was practised almost everywhere I visited in these cropping areas, and so speaking to these farmers and learning from their experiences was essential for my studies.

I came across two excellent pioneers of no-till in South America. The first was Rolf Derpsch, based in Paraguay, and the second John Landers, in Brazil. The other huge attribute of these two gentlemen was their ability to speak fluent English and Spanish (in Paraguay) and Portuguese (in Brazil). In fact Rolf was fluent in four languages and could hold a conversation in two others. John Landers is an Englishman who has settled in Brazil and spent the last 40 years helping farmers adopt no-till.

I was blessed to be taken on a week’s guided tour of Paraguay with Rolf, where I met many farmers who had adopted no-till. The average annual rainfall in Paraguay is 1,600 mm, almost twice that of my local UK average, so to see the system working in these conditions was essential.

In Brazil I could have seen so much more but the huge scale of the country and the limited time meant visits to the area north of Brasilia were all that I managed. However, it was excellent to visit different farms, the scale of which was huge, and by this time my findings were being reinforced on a daily basis. This not only encouraged me but meant it was time to return home and begin writing my report.



Having now completed my study tour I can say that I am pleased with how it has turned out. In hindsight I should probably have spent longer in the USA last July visiting farmers across more states but overall my findings have been reinforced and repeated in every country I have visited.

I have been immensely thankful that the main experts in no-till around the world have met me and taken time to show me their own land, or that of other farmers nearby. The experience gained from these giants has been priceless.

As in all areas of life you can always look back and find ways to do things better, but I have been immensely thankful that the main experts in no-till around the world have met me and taken time to show me their own land, or that of other farmers nearby. The experience gained from these giants has been priceless.



4.0. “Everyone copies and no-one thinks!”

If there was one take-home quote from the whole of my travels over the past two years, this is it:

“Everyone copies and no-one thinks”

It came from a very interesting farmer who I met in Paraguay, by the name of Lucas van Ryckgehm.

He is a first-generation farmer who had moved to Paraguay from Belgium in 1982 aged just 22. His father had purchased 9,000 hectares of native bush and forest, which Lucas was sent to develop.

What I witnessed 32 years later was an impressive farm that now extends to 3,000 hectares cropped, 3,000 hectares of grazed grass and 3,000 hectares of forest. There are huge grain storage silos, a highly mechanised cotton gin (where cotton is processed), and a network of farm roads and tracks with a very clever irrigation system that works by gravity.



Lucas Van Ryckgehm on his farm in February 2014

I spent just one afternoon with this amazing man who hosted me for lunch and showed me around his huge farm. In regard to his cattle he was developing his own hybrid beef cross using Aberdeen Angus and Nelore genetics.

What really impressed me about Lucas was that he had made things happen in a country where he didn't even know the language when he arrived in 1982. He had even built a sawmill to enable the farm to have a ready supply of timber to construct houses and buildings as it developed. He had stepped out of the norm and had to sink or swim. His comment implied that many farmers just copy what someone else does, rather than think for themselves and implement their own ideas. This is so often the case at home in the UK, where certain items of machinery can become trendy for a few years, then go out of fashion. So often we believe what we learned at college 30 years ago, or what is written in a farming magazine, or even what Dad or Granddad did rather than thinking for ourselves.

That's where Lucas impressed me. He didn't have a father on hand to tell him that things would or wouldn't work. Instead he had to learn from his own mistakes and I'm sure that allowed him to develop into a better farmer. One thing a Nuffield Farming Scholar has to do is think for himself and his comment - “Everyone copies and no-one thinks” - made as we ran across Lucas's yard to look at machinery before we had to leave, really reinforced in me what this whole process has been about.

Personally, I'm not in farming to be a sheep, to copy what everyone else does and then moan when it goes wrong. I want to make a difference, think for myself and put in place things that I have thought about and planned. On my Nuffield journey I have seen many good ideas and many that I'm happy to leave where I saw them. However, what is important is that I'm able to bring together all the snippets and fashion those into a farming system that can work in the UK. For me Nuffield Farming is about travelling the world to find lots of pieces of a jigsaw, then returning home to piece them together to create something that makes sense at home.



5.0. Making a difference

I love to improve the way we do things. I've always got an idea or am making a modification for something so it works better. For that reason, when I began investigating no-till, I realised it could be something that would improve so many aspects of the way we farm.

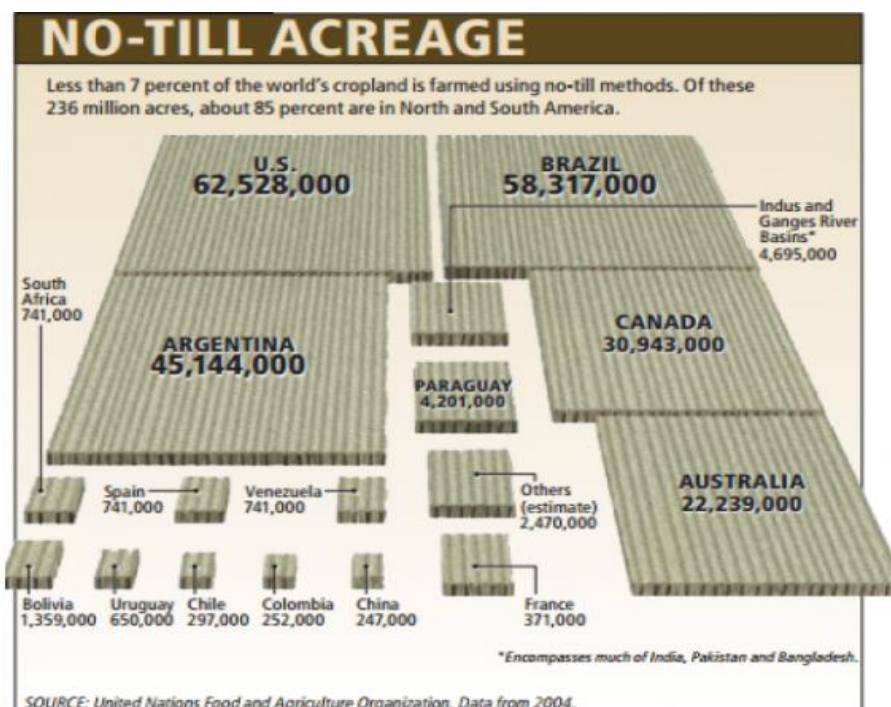
Firstly, there is the financial impact to consider and the savings in the cost of crop establishment. Next the benefit to my soils that needs to be investigated, particularly the claims made by some that retaining residue would build Soil Organic Matter (SOM) over time. There is also the wider benefit to the local community and more widely to the country as a whole of improving the quality of the air and waterways by reducing or even eliminating water and wind erosion.

If we could retain all the topsoil and prevent it from being blown or washed away and improve the quality of our soils by retaining residues, then surely we could grow a higher yielding crop from the same or less inputs.

This would make a real difference on my farm. In doing so with a no-till system there would be huge savings from eliminating cultivation passes and associated operating costs which would benefit me - the farmer - and my family at a very busy time of the year.

Another claimed benefit that needs further investigation is that grass weeds can be severely reduced or even eliminated using a low disturbance no-till drill. Again, if this is true, no-till could result in the knockout punch in the fight against blackgrass.

The chart below shows how many hectares of no-till there are in countries around the world, with America, Brazil and Argentina accounting for 165 million acres between them. However, the UK doesn't even make the list! Why? Surely our soil and climate are not that difficult to prevent no-till being employed?





6.0. What's wrong with sustainable agriculture?

One of the things which has continued to confuse me, particularly over the course of my scholarship, is the whole subject of “sustainability.” I attend meetings and read articles and it seems as though speakers and so-called experts have to use this buzzword in order to gain credibility and drive home a point. However, I haven't met two farmers yet who can give me a slick definition of what it means and how it affects them. It wasn't until I watched a presentation by an Australian farmer named Colin Seis one evening as I was preparing my travel plan that it started to make sense to me.

The dictionary definition states that sustainability is:

'pertaining to a system that maintains its own viability by using techniques that allow for continual re-use or.....

'able to be maintained or kept going, as an action or process.'

This is fine if all we want to do is maintain what we have and not improve. I don't merely want to keep everything going without using up our finite resources.

The whole idea of sustainability does nothing for me in terms of growth, expansion, continual improvement and innovation. Instead, I feel it promotes caution, and a fear that we must not lose what we have at any cost.

I can't help thinking that if I merely wanted to “sustain” my children and their lifestyle then there would be no growth, improvement, trying out new things, or innovation and experimentation for them.

I believe that using No-Till systems in a whole-farm approach - which includes the use of cover crops, retaining residues and diverse rotations - will allow us to build our soils to a standard that is better than we have now.

I guess in essence what I'm really saying is that there's nothing wrong with sustainable agriculture and the sentiment is well meaning but there is something so much better:

“Sustainable maintains, regenerative improves.”

Although this is not a quote attributable to anyone, it is my personal conclusion on this subject.

Sustainable agriculture aims to keep things as they are and leave the planet in the same way we found it for the generations to come. However, I believe that using no-till systems in a whole-farm approach - which includes the use of cover crops, retaining residues and diverse rotations - will allow us to build our soils to a standard that is better than we have now. Surely that is better than being just sustainable?



7.0. So what's regenerative agriculture and why is it important?

The content of this chapter is largely taken from a meeting I attended in London on 27 March 2014. The meeting, organised by Breakthrough Capitalism, was entitled Regenerative Agriculture, and featured speakers and panellists from around the world. These world experts represented some of the best minds on the subjects of Holistic Management, Permaculture, Agroforestry and Ecological Solutions for Agriculture.

The meeting was chaired by John Elkington, the founding partner and Executive Chairman of Volans. The panel included Dwayne Beck from Pierre, South Dakota, Bill Crabtree from Australia, Ademir Calegari from Brazil, Odette Minard from Canada and Frederic Thomas from France.

The calibre of the panel shows the importance of this meeting. The audience was made up of farmers, students, CEOs of large multinational companies, university lecturers and members of the media.

It was a very interesting evening and what got me excited was that all the panellists and speakers expected soils and land to be regenerated through a whole-farm approach including the use of no-till.

... all the panellists and speakers expected soils and land to be regenerated through a whole-farm approach including the use of no-till.

What seemed to be driving this change in thinking from some serious players, decision-makers and influential people was/is the fact that by 2050 the farmers of the world will need to be producing enough food to feed 9.6 billion people. The current population (*according to WRI 2013, Ray et al 'Yield Trends are Insufficient to Double Global Crop Production by 2050' PLoS ONE 2013*) in 2014 is 7 billion people and the predicted yield in 2050 will leave a 51% deficit between predicted and required global cereal production. This means that we will need to produce 69% more food calories by 2050 to adequately feed the world.

Surely carrying on being "sustainable" will not achieve this.

So, getting to the subject of Regenerative Agriculture, Soil Capital defines this:

*"Regenerative Agriculture is a set of agronomic and ecological practices, which together enhance agricultural systems by mimicking natural processes. These practices encourage biological interactions and synergies within the agro ecosystem that provide the most favourable soil conditions for plant growth by **increasing organic matter and biological activity within soils**. As a result such regenerative techniques can improve agricultural yields, limit the production of greenhouse gases, and increase profit margins."*

Regenerative Agriculture is based on the following key principles:

1. Recycling nutrients and energy on the farm rather than introducing external inputs
2. Integrating crops and livestock
3. Increasing soil cover



4. Diversifying species and genetic resources
5. Focusing on interactions and productivity across the agricultural system rather than individual species.

Soil Capital also states that there are various techniques used to implement these principles, namely:

1. **No-till.** Growing crops or pasture without disturbing soil through tillage
2. **Cover crops.** Planting of crops on otherwise bare land
3. **Permaculture.** Creating balanced and self-sustaining site-specific ecosystems that improve soil nutrition and production
4. **Holistic Livestock Management.** Managing herds of domestic livestock in ways that mimic those of wild herds
5. **Agroforestry.** Management of trees and crops and/or animal production in a single agricultural setting.

Whilst many of these techniques are very new thinking to me, I can now start to see how they can improve the soil and then subsequently the yields; which is what must take place in order for the farmers of the world to feed the growing population.

There are areas of un-cropped and poor land that will need to be improved; and also there is good land which is not performing to its potential, and that needs improving in order for the potential to be un-locked.

What I have discovered is that no-till systems with retained residue, cover crops in the rotation plus a balanced rotation, will not only build soil organic matter over time but will regenerate soils; which leads to better nutrient-rich soils that produce consistently higher yields, as well as higher quality crops - as nutrients are retained in soils and can therefore be passed to the growing crops more readily.

To the right is a picture of a field that has been in a no-till system. It is heavy Warwickshire clay and has not been cultivated for over seven years. You can clearly see the dark line between the heavy clay and the top regenerated soil that has been improved through the addition of compost and no-till seeding.

Imagine if all poor soil could be regenerated in the same way!





8.0. Look after the soil and it will look after us

So often in modern agriculture we spend thousands of pounds growing a crop - thinking primarily about the needs of the crop, and what it requires. This is in order to deliver us a high yield with a quality premium if applicable. We throw fertiliser at a growing crop, then spray it with a vast array of herbicides, insecticides and fungicides and possibly a tiny bit of manganese and growth regulator. But all these products are targeted at the growing crop rather than the soil in which it is growing. Quite often a base fertiliser including some P and K is applied in the late autumn or early spring but we tend not to give the soil as much attention and investment as the crop.

Whilst travelling, particularly in North Dakota, I discovered farmers such as Gabe Brown, Dwayne Beck and Kevin Larson whose primary goal was improving soil health. These men were seeing that, by investing in cover crops, mob grazing cattle on grass leys and using diverse rotations, they were able to improve soils. This improvement was particularly focused on improving the soil organic matter percentage of the soil; the structure and the amount of active biological life such as worms, fungi, bacteria and root structures. These farmers were finding that after a few years the soils were improving to such an extent that they were able to not only reduce the amount of nitrogen fertiliser required to give the same yield, but that most of them have completely eliminated the use of artificial P and K fertilisers. This to me was a real highlight as it shows what can be achieved when investing in the soil is our primary goal rather than throwing inputs at a crop and expecting it to perform.

... they were able to not only reduce the amount of nitrogen fertiliser required to give the same yield, but most of them have completely eliminated the use of artificial P and K fertilisers.

Whilst at Gabe and Paul Brown's farm I discovered that they are now at a place where they use:

- No insecticides
- No fungicides
- No roundup and only a selective herbicide one year in three.

In fact Gabe and Paul Brown's chemical use has been as follows over the past few years:

- no glyphosate for five years
- no insecticide for 15 years
- no fungicide for 10 years
- and a selective herbicide one year in three.

See picture of their sprayer on the next page.

NB They were farming about 5,000 acres when I visited in July 2013



Gabe and Paul Brown 's sprayer

8a. Soil erosion by water

Just the thought of water erosion fills me with dread. Why would any forward-thinking and progressive farmer want to throw away their soil by it washing away off the surface, and into a ditch and rivers and seas?

I think farmers often don't realise the effect that cultivation has on the stability of their soils and their ability to resist erosion.

In the next few pictures you can clearly see the effects of soil erosion, not only on the field in question but also, almost more importantly, to the environment. When soil erodes it has to go somewhere and that is usually to a lower point on your farm or onto neighbouring land. It can also wash into rivers, which get full of sludge and need dredging. This causes heavy rainfall - which we have experienced in recent years in the UK - to cause flooding as the rivers are not able to do their jobs properly and take sufficient flows of water away from the land as water levels rise.

If we were to blame recent flooding on farmers and their continued cultivation practices there would be an outcry; but if we think this through, the unstable soils that result from annual cultivation practices will be less likely to resist erosion.

A no-tilled soil will have a structure plus a network of roots and worm holes that not only holds soil together but gives it an in-built drainage system that results in higher water infiltration rates, firmer soil which carries traffic better year round and a soil that has mulch and ground cover year round. This prevents rain from hitting bare soil and causing compaction and run-off, which is the start of soil erosion. The lack of any soil loosening or cultivation results in a soil that is far less likely to wash away, and whose structure is good enough to allow roots to penetrate to the required depth.



The picture below shows Iguassu falls on the border of Brazil and Argentina. The water used to run a red colour years ago when conventional agriculture (with cultivation) was practised. Now that the surrounding region of Argentina, Paraguay and Brazil has almost entirely embraced no-tillage the falls run a beautiful clear colour. This is the result of Regenerative Agriculture playing its part in helping to improve the environment and the water quality to millions of South Americans.



Iguassu Falls were a red colour years ago when conventional agriculture (with cultivation) was practised. Now that the surrounding region of Argentina, Paraguay and Brazil has almost entirely embraced no –tillage the falls run a beautiful clear colour.



This picture shows an eroded channel in a field in New Zealand



The image above really got me thinking and was released during the floods in the UK of 2013/14. The soil erosion going out through the river estuaries is really quite worrying

8b. Soil erosion by wind

This was one of the big issues I came across on almost every visit that I made. When asking farmers what some of the biggest benefits were, having embraced no-till, the one that came up almost immediately was less erosion either by wind or water.

My first visit in America was to Dwayne Beck at Dakota Lakes Research Farm just outside Pierre in South Dakota. Dwayne told of how as a child he often witnessed dust storms and can remember when roads were closed because of the dirt that would blow across them, leaving such a mass of soil that the road was submerged and required clearing. Some would blow from neighbouring states to such an extent that visibility was impaired and drying washing outside without getting it dirty was almost impossible.

This is what led to the wheat -summer fallow rotation that the mid-west of America embraced in the 1960s and 1970s. The soil's structure and water-holding capacity had deteriorated to such an extent that it was drying out and then, when cultivated, would become dust and blow away. Residue needed to be kept on the surface and attached to the soil in the form of stubble to prevent the soil blowing away in winds that often reached 80mph. Eliminating cultivation hugely benefited this erosion too.

Since embracing no-till in both North and South Dakota erosion has become a thing of the past as farmers retain the stubble and don't cultivate. It has also enabled new crops to be grown in the area;



crops that in previous decades had not been an option. These include soya beans, maize and sunflowers. Dwayne quoted figures of \$1.6Bn increase in productivity after 20 years of no-till over 1,600 square miles. This was due to the addition of corn, sunflowers and soya to the rotation. Dwayne Beck is now actively pursuing a rotation which allows him to build residue on the soil that will not only help restrict erosion but also build SOM and feed the soil biology.

Here is a photo of erosion in New Zealand where cultivation is taking place.

The picture shows soil blown into the road and the next field. Can you even spot the tractor?



This photo goes to show the damage and loss to soils that can happen when erosion takes place following soils cultivated in dry conditions.

What blows away and into neighbouring fields, watercourses, towns or roads are the nutrients required to grow a crop.

8c. Water infiltration – The role of roots and worms

It just shows how much you can learn in a year. When I started my Nuffield Farming journey I hadn't even heard of "water infiltration rates." Now that I'm writing up my report it's something that I feel UK farmers should give far more thought and attention to, particularly as our last few winters have seen some very high rainfalls. These have in many cases fallen in a short period of time and caused waterlogged fields and floods to occur.

When I visited farmers in North Dakota who had been farming using no-till over a period of years I heard reports of soil - that once blew away or washed away under a tillage system - that was now absorbing all the rain that fell upon it. Even run-off from the fields into watercourses was greatly reduced.



When visiting Gabe Brown just outside Bismarck we discovered a pioneering farmer who had transformed his farm, initially through no-till, and then by implementing mob grazing. He hadn't cultivated any of his land for over 20 years and now testified that his land had a water infiltration rate of 8 inches per hour.



The amazing and inspiring Gabe Brown of Brown's Ranch, Bismarck. ND

Now, if you are thinking (like I was a year ago) - what on earth does a water infiltration rate of 8 inches per hour mean? - then I will explain. It means that the soil is capable of allowing 8 inches of water over a period of one hour to soak into it without any run-off, ponding or flooding. One way of testing this (and also to find out what is your water infiltration rate) is to knock a piece of drainage pipe firmly into the ground so that there's a few inches below the soil surface and a foot or more above ground. Then pour water into the pipe and measure its depth above ground level – it needs to be about 1'. Come back after an hour and measure again, and the difference between the two measurements is your water infiltration rate.

So you may be thinking, "Why is this important to me?" Well, what I discovered on my travels was that farmers wanted to have as high a water infiltration rate as possible because then, when heavy rain came, it soaked into the soil rather than ran off across the top of the soil. What I discovered was that soil running off would take nutrients with it, and quite often topsoil too. However, in a no-till



system where soil is not disturbed through cultivation two very important things tend to be present in the soil that we often don't think about:

The massive role that **plant roots** and **earthworms** play in no-till systems.

Firstly, **earthworms**. Because the soil is not cultivated in a no-till system, the network of wormholes and burrows under the ground remains intact. This allows not only the worms to move about more freely up and down as they wish, but also serves as a network of drainage channels that can allow very heavy rainfall to be infiltrated into the soil in very quick time. The wormholes also serve the newly emerging plants by allowing their roots to rapidly go deep into the soil by growing into the sides of the wormholes. This not only allows new plants to form very deep roots very quickly but also allows these roots and root hairs to pick up nutrients from the ground efficiently and effectively, whilst giving plants stability and a deep root that will withstand both drought and periods of heavy rain.

Secondly, **roots**. The role of roots in no-till systems is so important that it gets its own chapter later in my report but for now just a few thoughts on how the roots affect water infiltration.

The picture below shows the importance of having something growing in the soil and the effect this has on the purity of any water that drains from the field after a period of prolonged or heavy rain.

It shows that having plants growing (and therefore having healthy living roots) keeps the soil bound together and far less likely to erode or wash. The roots also aerate the soil, which adds to the "honeycomb effect" that all the wormholes create.



Note colour of water draining away from the container growing plants as opposed to bare ground



When the soil is dug from fields that have a healthy earthworm population and good root structures, I have found it just crumbles in your fingers yet surprisingly it doesn't wash away with heavy rain. This is even more apparent in long-term no-till fields where the soil has been left for many years.

One of Gabe's friends and colleagues was Jay Fuhrer. I visited him at his office in Bismarck, ND, where he showed us something called a "Slake and Infiltration Test." This is a very interesting test that anyone can do with their soil to see the effect of it being saturated. This is particularly important in the UK as we seem to have a lot of rain at certain pinch points throughout the year, and finding a way to keep nutrients within our soils is so important to ongoing fertility issues and the building of OM levels.

In the picture below are two clods of soil. One is from Gabe Brown's farm, which has been in no-till for over 20 years, and the other is from a farm that is still in a conventional tillage system.

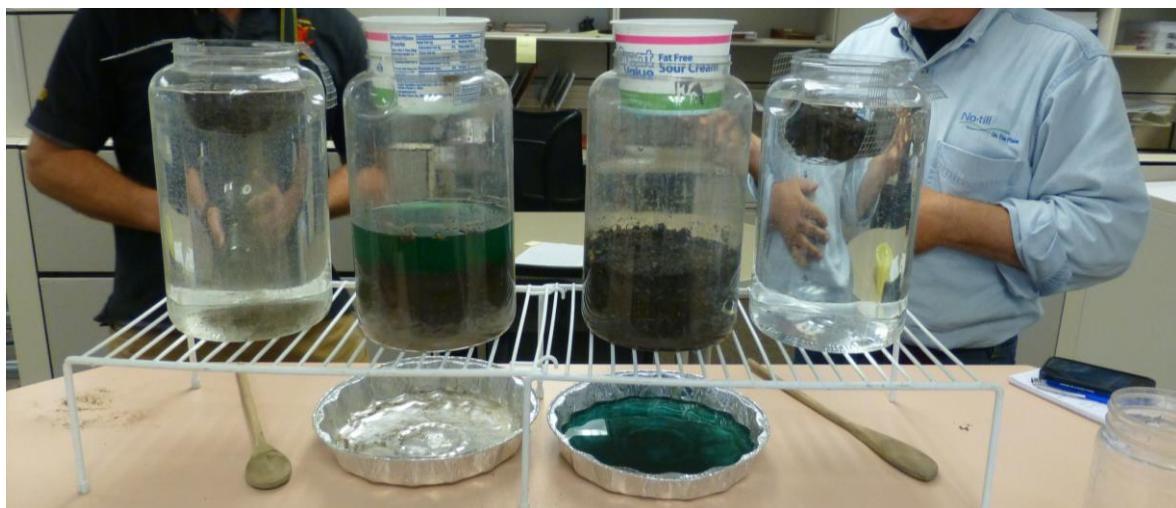
The clod from Gabe's farm remains intact when suspended in the container of water, whereas the clod from the conventional farm starts to disintegrate immediately and within a minute is all at the bottom of the container. The clod from the long-term no-till field is still intact when we leave the office 40 minutes later and was still intact six hours later.

This is the reason when we look at the infiltration test with Gabe's soil that we see the importance of good water infiltration rates.

The soil is packed into the two containers so that when the liquid is poured in, it cannot leak down the side of the soil. Next, an equal amount of coloured water is poured onto the soil through a tube with holes in to simulate rain. This water soaks into and through the soil, eventually draining out through the holes in the bottom of the container and is gathered underneath.

The picture speaks for itself. The no-till soil allows the rain to infiltrate very quickly and the water running out of the bottom of the vessel is the same colour as that poured in the top. NB The water was poured into both containers at the same time.

On the conventionally cultivated soil the liquid poured in causes the soil to puddle and this liquid does not infiltrate very quickly at all. If this was a field scale trial the water would run off the surface of the field taking topsoil and nutrients with it and would cause damage to the soil in the process.



Conventional soil on the left, no-till on the right



8d. Compaction and controlled traffic farming (CTF)

This is potentially a “Hot Topic” and one that I have a few thoughts on in relation to a no-till system that embraces regenerative practices.

There have even been entire Nuffield Farming Scholarships dedicated to the research and justification of CTF and its associated farming practices. I am not going to try to do it justice in one chapter but its relevance to no-till is important, particularly the question of compaction.

One of the main questions that people ask me when I explain the no-till theory is: “How long before you need to subsoil for compaction?”

When I reply that I no longer own a plough or a subsoiler and don’t intend to use either again I get either a strange look or more questions.

... the longer the soil was left untouched and uncultivated, the better the structure was and the better its ability to carry traffic without soil damage.

CTF, as I understand it, is all about keeping the machine wheelings in the same place in the field year-on-year using GPS steering technology. I believe that the theory is that the crop in the wheelings is “sacrificed” in order that the plants growing on the land that is never “run on” grow better and yield more.

Whilst I can see the benefit of running traffic on tramlines, particularly heavy machines like sprayers and combine harvesters, I do question the notion that every machine pass will compact the soil.

The size and weight of the machine, its footprint and the pressure of any tyres will all come into play as well as the soil conditions and the type of soil in question.

However, what most people fail to consider is the structure of the soil, the extent to which roots have developed in the soil, the amount of soil organic matter and the network of wormholes in the surface few inches, plus at depth. If you look at a long-term no-till field where residue has been retained, soil cover maintained and there is a good root network with plenty of worms active, I believe this soil will carry traffic to such an extent that controlling traffic at “every pass” is not necessary.

This does come with a big “But”. Commonsense and good management need to be used by farmers irrespective of the system of traffic used. So often I have seen farmers embrace CTF then fail to examine the soil before an operation or drilling pass is made.

On my studies of long-term no-till farmers I didn’t find many, if any, who had stuck to a rigid CTF practice on all operations. My findings were that the longer the soil was left untouched and uncultivated, the better the structure was and the better its ability to carry traffic without soil damage.

When visiting Rolf Derpsch in Paraguay (<http://www.rolf-derpsch.com/en/>) he gave me three reasons why you won’t get compaction with no-till:

1. Sufficient residue cover
2. Green manure cover crops
3. Diverse rotations.



8e. Water retention in the soil

“Keep the soil cool when it’s hot, and damp when it’s dry” - Dwayne Beck.

For farmers the world over yield is king and achieving a good yield quite often comes down to the soil and weather conditions at the time known as “grain-fill.”

The soil needs to have sufficient retained moisture to allow the plant to remain healthy and alive plus long periods of sunshine to ensure that the grain fills well and gives a good yield.

Well that’s the theory at least. With summer temperatures in the high 30s and warm winds, keeping the crop alive at grain-fill in Australia and North America can be almost impossible.

In North America one of the huge benefits of no-till has been the residue that is retained on the surface. This acts as a barrier/mulch on top of the soil, which reduces moisture loss from the soil and also keeps the soil cooler. Keeping the soil cooler and damper in hot windy weather hugely benefited the health of the crop and thus its ability to produce a good yield at harvest.

In Australia the wheat crops were not really ripening but dying off due to drought situations in the grain-fill period. This had a huge effect on yield. However, those who have embraced no-till and sought to improve residue and Soil Organic Matter (SOM) are now starting to see improved yields.

The picture below shows one of the most important ways in which over time we can seek to improve the water-holding capacity of our soils. By retaining as much residue as possible on top of the ground the mulch protects the soil from the sun’s rays and also slows down evaporation from the soil. The residue builds SOM which leads to a soil that is more able to retain moisture and nutrients.



As I write this in July 2014 there are crops nearby and even on our own farm that, after six weeks with very little rain, have started to show the effects of drought. We must do all we can to hold on to moisture in the topsoil, particularly for times like this when, keeping crops green through the grain-fill period and ensuring there is soil moisture to keep crops alive at ripening, will maximise yield.

It will also aid the planting of the cover crops that will need to be planted after harvest. The same can be said for planting oilseed rape after wheat and wheat after spring beans.



8g. The role of crop residue/mulch in protecting and feeding the soil

We have seen in the last chapter that the retention of straw and residues on the surface of the soil has a huge benefit in retaining moisture in the soil. This residue also makes another huge contribution to the soil and the growing crop, as well as to the soil biology and those creatures living within it.

The residue will act as armour for the soil to start with - as the new crop is planted - but over time and as autumn or spring rains come, this residue will start to be consumed by the soil. This will happen in a number of ways. The main way will be through worms, bugs and insects actually consuming it and taking it down into the soil. This is excellent for the soil quality and the worm secretions are packed with nutrients that the crop can use. Also, in a long-term no-tilled soil, I have observed that fungi and bacteria are present within it and at work which starts to break down the residue as soon as harvest is complete.

Last summer I had a visit from Prof Karl Ritz from the Cranfield Institute and Tom Sizmur from Rothamsted. They came to my farm to see how many earthworms we had and to see if they could be measured. They dug holes and took out the earthworms they found. The next day each emailed me independently and confirmed that I had 12 million earthworms per hectare! These need feeding in order for them to do their fantastic work for me in my soil. By retaining residues and planting cover crops I believe we are feeding our soils and keeping the biology alive which keeps the soil and those living in it healthy.

When I visited Gabe Brown at Bismarck, North Dakota, he reported 60 earthworms per square foot of soil after a cover crop containing 70 species.

I have seen that straw is not a waste problem to be baled or burnt. Its value in the regeneration of our soils is almost priceless.

The retention of residues on the soil will give protection from rain, wind, compaction and excess moisture loss and, again, these fewer restrictions will help the growing crop to develop.

Retained residue also means less traffic problems as the residue acts as a mat on which traffic can travel. There are fewer potential problems and no bare soil which would cause erosion when very heavy raindrops fell and caused soil to wash away.

It is essential that straw is evenly spread and that there are no lumps. As Steve Townsend has always said: *"The combine is your first cultivation pass."* Well it's even more important than that now as, under no-till, there is no cultivation pass. The value of the straw to the soil is huge but it does need to be evenly spread so that all the soil is protected by it.

When in the USA last year the value placed on residue was so high, some farmers were even growing corn after corn to get as much residue as possible. This was to help protect the soil in very hot times and retain moisture. It also served as a protection from wind and rain and was building SOM.

I have seen that straw is not a waste problem to be baled or burnt. Its value in the regeneration of our soils is almost priceless.



8g. Soil organic matter (SOM) and carbon

Before embarking on my Nuffield Farming Scholarship I had never really given any thought to the amount of carbon within my soil or my soil organic matter percentage. Of course I wanted my soil to be healthy and I realised that returning the residues (chopped straw) and adding organic matter in the form of manures or paper waste was beneficial, but I didn't realise the value of carbon or the relevance of soil organic matter to my farm.

This changed right from the first visit I made when in South Dakota with Dwayne Beck. He emphasised the importance of building the amount of residues in the soil as that led to increased soil carbon, and that in turn helped to hold nutrients and water, and keep the soil healthy and more capable of sustaining higher yields than with lower levels. The farmers in North America were all trying to increase soil carbon. All were chopping residues (straw) and adding carbon, and building SOM was becoming a very helpful bonus from adopting no-till.

It wasn't until I visited Dr John Baker at Baker No-Tillage (BNT) in New Zealand that he explained the importance of carbon to our soils and our environment. It is worth noting that Dr Baker has spent the last 40 years researching no-tillage, has written many books on the subject and was a university lecturer at Massey University on soil health and no-tillage. He has been nominated for the World Food Prize and is regarded as one of the leading world experts on the subject of no-till. As I spent time with him for a few days visiting farmers and his offices he explained the importance of carbon and how this is affected by tillage.

The next few paragraphs are taken from Dr Baker's information:

- *While the world debates global warming, water quality and air quality, it has been ignoring an even more important issue – soil quality.*
- *90% of our food comes from annually-sown crops grown in soil and somehow, in the next 20-30 years, we have to find a way of producing more food from the same amount of soil.*
- *Why is this such a big deal? Because we have been “raping” our soils for years – that is, stripping them of their carbon and organic matter contents and giving little back.*
- *We have also been stripping them of nutrients, but these are replaced by applied fertilisers. We also regularly strip them of water, but rainfall, dams and irrigation schemes replace this.*
- *The problem is that man has never made any serious attempt to replace the soil carbon that he has been removing.*
- *Every time a soil is tilled (or cultivated) some of its carbon is oxidised and discharged into the atmosphere as carbon dioxide (CO₂). And it's not just in small amounts. Several tonnes of CO₂ per hectare can be discharged every time a farmer establishes a new crop using conventional tillage.*
- *This source of carbon dioxide is estimated to contribute up to 20% of the total CO₂ entering the atmosphere each year.*
- *This goes on pretty much unnoticed as people cannot see carbon dioxide because it is a colourless, odourless gas. This contrasts with smoke from chimneys or car exhausts which are recognisable pollutants. Even though the visible part of smoke is not actually CO₂, it is usually mixed in with it. The same applies to farmers when they till or cultivate their fields. People see dust during tillage and often surmise that this will eventually settle somewhere else,*



creating relocation issues rather than a net discharge of anything important. But sadly, CO₂ will be mixed in with the dust and disappear into the atmosphere unnoticed.

The end result is that the organic matter and carbon levels in all the world's arable soils have been declining cumulatively since man began tilling the soil. Many of the world's arable soils had 5-16% organic matter before ploughing. Most now have 0.5-2% as a result of centuries of ploughing and other tillage operations.

This low level of organic matter can no longer support significant soil biology, which is otherwise the mechanism that creates and sustains soil health. It is this soil biology that has been forgotten. Healthy soils teem with microbes and other soil organisms like earthworms, beetles, fungi and bacteria.

Unhealthy soils do not. For example:

- Soil microbes hold the soil particles together with their exudates (forming soil "structure") which help resist erosion
- Earthworms transport nutrients from deeper layers to the root zones of plants and convert these nutrients into readily available forms
- Mycorrhizal fungi form symbiotic relationships with plant roots that increase the amount of nutrients and water taken up by the plants
- Other soil microbes fight and destroy common plant pathogens and diseases that man has otherwise had to fight with environmentally unfriendly pesticides
- Surface microbes decompose crop residues into compounds and elements (especially carbon) that are taken into the soil by the soil biology
- Other small animals still eat soil organic matter and deposit their excreta as nutrient-rich casts.

Even the physical properties of organic humus are important. For example, one kilogram of humus physically holds as much water as 9 kilograms of clay. So organic-rich soils have more water-holding capacity than non-organic-rich soils. In limited rain-fed areas (ie most arable soils) this translates into higher crop yields.

The key question is this: Is the cumulative stripping of soil organic matter reversible? The answer is yes, but not in the way most people might imagine. For example:

- Spreading organic manure on the ground certainly helps but the world's arable soils are far too extensive for this to be a widespread practical solution
- Changing to so-called "organic production" methods for annual cropping does not help because most "organic methods" rely on tillage for weed control
- Working cover crops and the residues of previously harvested crops into the ground usually has a net negative effect because the carbon gained from the buried organic matter is usually more than offset by the carbon lost by the working-in process
- Blowing tractor exhaust fumes into the ground does not create a long-term benefit because only 5% of the total carbon released into the atmosphere during tillage comes from the tractor exhaust in the first place.



The one practice that replaces soil carbon cumulatively is Low Disturbance No-Tillage.

This is the sowing of new crop seeds directly into the undisturbed soil after the previous crop has been harvested, without any form of pre-sowing tillage at all. It closely mimics nature, but only if it is done correctly. And sadly most no-tillage is not done correctly.

Plants gather carbon dioxide from the atmosphere and combine this with water and the energy of the sun in a process called photosynthesis. The amount of carbon dioxide gathered by photosynthesis is massive and could never be duplicated by man. Photosynthesis is nature's way of recycling carbon.

When man harvests a food crop like wheat, about half of the plant's carbon is removed and eaten (which is acceptable) but the other half remains available for recycling in the form of cut straw, stubble and other forms of "leftover" crop residues, often called "trash." It is the carbon content of these crop residues that low disturbance no-tillage helps nature to recycle.

To effectively sequester carbon back into the soil from crop residues, the practice of low disturbance no-tillage must:

- Use methods of killing or controlling weeds that do not disturb the soil (eg spraying herbicides, heating, cutting, mulching)
- Leave the surface residues from the previously harvested crop as evenly spread as possible over the soil surface, even after the passage of the seeding machine (or drill)
- Target an arbitrary minimum of 70% residue retention
- Avoid burning, baling, burial or removal of the crop residues
- Avoid cutting stubble tall because standing stubble decomposes more slowly than lying straw
- Avoid as much as possible, any physical disturbance (especially inversion) of the soil
- Even so-called "minimum-tillage" and "strip-tillage" can cause too much disturbance
- Ensure that some form of living or dead vegetation covers the soil at all times
- Use seeding machines that can work through the residues with minimal physical disturbance, while at the same time avoiding "hairpinning" (or tucking) uncut straw into the seed slots
- The fatty acids from decaying "hairpinned" straw can kill seeds in wet soils
- Create a favourable seed micro-environment without excessively disturbing (oxidising) the soil in the process
- Trap water vapour in the seed slot, especially in dry soils by covering the seeds with soil that is overlaid with residues
- This is even more important in dry soils than obtaining good seed-to-soil contact
- Maintain a consistent seeding depth despite the fact that the seedbed will not have been pre-smoothed by prior tillage tools
- Be capable of simultaneously banding fertiliser alongside, but not touching, seeds

These are the demanding functions that only a few specialist low-disturbance no-tillage drills and systems can perform. But the key fact is that such machines and systems already exist. Anything less than this will simply perpetuate the continued "rape" of our soils and will eventually lead to famines in areas of the world with marginal food supplies.



As a matter of priority, science should begin monitoring soils already undergoing true low-disturbance no-tillage regimes (some have been so for as long as 10 years) in order to estimate how long it will take to repair the world's arable soils and get them back to full health and productivity so we can continue to feed an increasingly hungry world.

Soil carbon is the currency of sustainable food production!

I have taken the subject matter on the last few pages directly from the mouth of John Baker (Baker No-Tillage, Feilding, New Zealand). His passion and knowledge on this subject were not only an inspiration to me but also a reminder of the responsibility we, as farmers, have in not only maintaining our planet but improving what we have so that when we hand it on to future generations it is in a better state than when we took it on. That's regenerative farming in action.

One thing that kept happening on my travels was that I almost always found that farmers who had embraced no-till had seen their soil organic matter level rise. This is hugely significant as it changes the way soils perform; allowing them to retain moisture and nutrients more easily, to be less prone



to compaction, less likely to erode and more likely to grow better crops using less artificial inputs and fertilisers.

The picture on left shows me with Paraguayan farmer Roland Wolff. He has seen his SOM rise from 1.2% in 2002 to 2.9% in 2014. His crops looked excellent and we visited a field of his that a few days previously had received 70mm of rain in 20 minutes! Roland got very upset that this rain had delayed his planting but three days later, when we visited, he was planting and the rolling fields had only seen tiny amounts of erosion from erosion channels that are designed to take run-off.

8h. The problems of tillage/cultivations

Where do I start? When I stop and look back over my Nuffield Farming journey over the past two years and the discoveries I've made, there are one or two eureka moments that really changed my thinking on the role of cultivators, ploughs and the like.

The first was actually just before I was awarded my scholarship. In June 2012 I visited a pioneering UK no-till farmer by the name of Simon Chiles. He farms at Edenbridge in Kent and has some of the heaviest land I've seen, with small fields surrounded by hedges and lots of oak trees and it's not flat.



However, what I saw on a farm where he now only uses a low-disturbance disc drill was quite remarkable. The soil was much more friable and there were worm casts everywhere when you parted the crop and looked at the ground.

Simon had managed to consistently crop fields where under the previous tillage regime it was almost impossible to get a crop in and growing. If the weather was hot and dry his heavy yellow Weald clay would bake out when cultivated, and become bottomless slime if rain came after the fields had been disturbed. This then impeded the performance of his previous drill and left him with poor crop establishment and yields.

But now he is able to travel on undisturbed soils and plant sooner after rain giving him much wider weather windows and opportunities to plant when soil conditions are at their best. His horsepower requirement has been kept very low as there is no need for big tractors to cultivate deeply and move all the soil. He now just sows seed into stubble, either in the autumn or spring, and reaps the benefit of huge cost savings in diesel, labour, wearing metal and time.

I'm not the first farmer to have visited Simon and returned home with my head well and truly turned. On reflecting on this visit my thought was *"If it can work for him on land more difficult than mine and only 20 miles from me then why can't it work for me?"*

As I looked more closely at those in the UK who had taken this approach I found more farmers willing to get off what Simon called the "hamster wheel of cultivation." That really sums up what I have seen in regard to cultivation. You seem to spend ages running hard, expending lots of time, energy, money and effort in getting nowhere. It's not until you are willing to stop and get off the hamster wheel that real progress can be made.

Simon visited our farm to plant 50 acres of wheat into linseed stubble in the autumn of 2012. For those of you who can remember, this was an autumn of prolonged wet weather when many farmers failed to plant much/any of their wheat and many reverted to spring drilling. Huge acres of oilseed rape were abandoned mid-winter and the farm was a miserable place to be.

The soils were on the wet side when Simon arrived to plant the wheat. He managed to get 50 acres planted after only one dry day on the 16 November and, although the crop didn't emerge until early January, we had a yield of over 8t/ha. This just goes to show what can be done. The soil had not been touched since harvest and walked very well, without the need for wellington boots.

Had this land have been cultivated, I'm sure much of the topsoil would have run into the river through water erosion and the best we could have hoped for would have been a spring crop into a soil structure that would have been non-existent.



9.0. Roots not iron - the importance of cover crops

The role of cover crops is one that has only really been thought about on a wide scale in the past few years. Of course there are those few farmers who have been experimenting with cover crops for many years but only in the past five years have seed merchants started to develop different mixes for different situations.

From what I have seen on my travels and from talking to farmers both in the UK and abroad, no-till is far easier to master when there are cover crops in the rotation.

Cover crops keep the soil alive and biologically active rather than allowing the soil to become dead after harvest or over a long dry summer. The aim of a cover crop in the rotation is to keep the soil aerated through active roots. Summer sown cover crops will harvest sunlight and, through photosynthesis, will turn this into organic carbon which will feed the soil. Even in a short space of time (4-8 weeks) cover crops can give cover to the soil, plus build good roots structure into the space that was occupied by the roots of the previous crops. Cover crops will also scavenge for nutrients and hold them within their roots. This can be particularly beneficial with an over-wintered crop when the weather turns wet. They also help to prevent erosion through wind and rain as the growing plants shelter and protect the soil, whilst the roots add structure to the soil and help to prevent water erosion when heavy rain and thunderstorms come.

... no-till is far easier to master when there are cover crops in the rotation.

Using a mix of species in a cover crop mix is a great way to give the soils back some organic matter and will give far more benefits than just using one plant type.

On our farm last year we planted a cover crop mix of oats, phacelia, mustard and fodder radish. This was planted direct into the stubble after the wheat was harvested and grew through the autumn and winter. We sprayed this off with glyphosate just before planting spring beans with a no-till drill.

The spring beans established well and now look as good as any conventionally planted crop I've grown. It was such a benefit having the cover crop in the ground over the very wet winter of 2013/14. The large volume of crop helped to prevent any damage to the soil from falling rain, the roots aerated and drained the soil so well that you could walk the crop even after a very heavy rain in normal leather work boots. This helped to aid drainage and there was no run-off from these fields when we had prolonged heavy rain.

I believe that cover crops help build soil structure, plus build soil organic matter through dying back and being consumed by the worms, fungi, bacteria and soil biology.

There is obviously a cost to buying cover crop seed and a cost to establishing it. However, it is a cost that many farmers I have visited are willing to pay for not only protecting the soil but aiding its improvement, structure, SOM% and trafficability at planting.



With crop mixes that contain legumes it is also possible to fix nitrogen into the soil for subsequent crops. Having cover crops in the field when it comes to planting the next crop allows a no-till drill to make a better job of placing the seed. It also protects the soil as the following crop emerges and can help suppress weed seeds from growing.

Planting into a root mass of cover crops when there is phacelia, oats, fodder radish and mustard in the mix is so easy as the topsoil is crumbly and aerated. The soil is soft and the growing roots keep the soil in a state that allows easier establishment with a no-till drill compared to into a soil where there is nothing growing. When soils are bare for long periods they can either dry out and bake or become wet and anaerobic. This is not good for soil biology as any worms, fungi and bacteria will not have a food source and will either reduce in number or die off completely.

we as farmers should be using roots to cultivate our soils rather than iron (cultivators, ploughs, subsoilers etc).

The hashtag #rootsnotiron (on Twitter) was started by fellow Nuffield Farming Scholar Blake Vince from Ontario in Canada. His belief, and one that I now share, is that we as farmers should be using roots to cultivate our soils rather than iron (cultivators, ploughs, subsoilers etc).



The cover crop we grew at home before spring beans

It is also thought by some cover crop experts I met, that cover crops will retain more moisture than they use up in growing. Australian growers were particularly worried about moisture loss from very dry soils and concerned that cover crops would deplete any soil moisture resulting in soils that were too dry to plant into.

However, I did visit Tom Robinson who was planting cover crops into a stripped barley stubble.



His disc seeder was planting so effectively that you could hardly see where it had been. Although only 25 years old Tom was one of the most knowledgeable farmers I met in South Australia and was both enthusiastic and educated about the benefits that cover crops could bring to his soils.

The picture below shows Tom Robinson planting cover crops into barley stubble.



Tom Robinson in South Australia planting cover crops into barley stubble



10.0. Financial benefits of a no-till system

Whilst visiting Dwayne Beck in South Dakota it was fascinating to see farmers who in recent years had built new houses. His explanation to me was that farmers never spend money on their homes. Instead they always invest their money into building their business by purchasing land, machinery or the inputs required to grow crops. However, many farmers who have embraced no-till have not only reduced the number of machines on their farms but in many cases also improved yields and reduced fertiliser usage. This has led to farmers making higher profits and then being able to build smart new houses. In fact one of the main problems that many farmers reported with no-till was the increased tax liability! It's certainly a nice problem to have but in all seriousness no-till can lead to farmers having more choice, more freedom and the ability to purchase extra land or take on more acres. It quite often allowed farmers to take time away from the day-to-day work on the farm, get away and travel and spend more time with their families.

In all my travels I failed to find a farmer whose yields had dropped since embracing no-till. In fact many were saying how much better their crops were yielding. This has so many positive effects on the farmer and his business.

However, for me, the main financial benefit for any farm embracing no-till is the improvement to the farm's main asset, the soil.

Firstly, the input costs are less due to reduced fuel, labour, depreciation on machinery, wearing metal etc. This means that even if yields are maintained at previous levels the net margin is higher. If costs are lower and yields are higher then it's a win-win all round.

The psychological effect this had on the farmer and his business was amazing. There was more money to spend on building improvements, keeping machinery well maintained and up-to-date, investing in soil health through cover crops and any replacement nutrients.

As the machines were working less hours, depreciation was less likely in reality when it came to trading in machines. Diesel use is far lower which is good for the environment as well as the farmers' cash flow at harvest.

On almost all the farms I visited there was also far less reliance on casual harvest labour. This was because at harvest time on a conventional farm, harvest would normally coincide with cultivations and many farms would require extra labour to cope with this. On the no-till farms, the farmer and one or two staff go and harvest. Then the planting is a one-man job so even on farms up to 2,000 ha (5,000ac) there was normally only two or three staff.

However, for me the main financial benefit for any farm embracing no-till is the improvement to the farm's main asset, the soil.

There are so many ways in which the soil is improved through better structure, less erosion, better water infiltration and holding capacity; plus the huge benefit that cover crops and retained residues can bring, that I truly believe that a farm embracing and practising no-till will be a more valuable farm with better soil and better yield potential as years go by.



11.0. Non-financial benefits of a no-till system

Having met so many no-till farmers at their busy times of their year, it has amazed me how relaxed they have been. The really big non-financial benefit that I have seen is that farmers seem to have far more time which gives them more options to make choices about what they do. Many choose to spend more time with their families and take time out to enjoy leisure time and sport. Some use the extra time to take on more land and grow their business whilst others have started another business.

Many no-till farmers that I visited invested time into the local community and many also gave back time and knowledge to other farmers by way of discussion groups, farmers' study groups and by speaking at events and organising events to help educate others in ways to improve soil, crops and margins.

The really big non-financial benefit that I have seen is that farmers seem to have far more time which gives them more options to make choices about what they do

I certainly found that farmers were less stressed. There was less to worry about. They didn't need to keep worrying about whether soil was too dry or too wet. Soil blow has been a problem in large areas of America and New Zealand in the past but with no-till there is less of a problem with wind damage as soil is uncultivated.

Family/work life balance seemed to be excellent and was, for me, one thing that was hugely appealing. As the father of four young children and with a wife who also works in our business, spending quality family time together is so important. Showing the family that there can be a balance between work and play is important. Visiting farmers around the world who were doing this well has certainly inspired me to do it better.

There is also the huge benefit with cover crops that as they grow they aerate the soil, cultivate with their roots and add organic matter, while you can be at home with the family, on the beach or playing golf.

The hassle factor and management of constantly refuelling and repairing cultivation machines is completely eliminated with no-till.

Although it is difficult to quantify these benefits, many farmers were so thankful that they were now farming using no-till. It had regenerated not only their farm, soil, profits, yields and the environment but also their family life and their work/life balance.

It is for this reason that I have not gone in to any detail about the accurate costs of a no-tillage system. Every farm is different with so many variables. What is "typical" for one farm will be completely unrealistic for another. For that reason I'll stick to the principles in this report and let each individual farmer apply their costs and benefits accordingly.



12.0. The effect of no-till on the local community and the environment

It can sound very arrogant to think that embracing no-till can have a positive effect on the local community and even the environment as a whole, but just stop to think of many problems that farmers can cause indirectly or directly by cultivating soils.

Soil erosion would be the first thing that would come to mind. In North and South Dakota before the adoption of no-tillage, the air was quite often thick with dust as summer fallow fields were cultivated prior to being planted. This cultivation was carried out in hot weather and the resulting dust at its worst point closed roads and caused piles of dust to form that required road graders to move.

Dwayne Beck reported how his mother's house was always full of dust but that once no-till had been adopted the state of the local air drastically improved. In the vast open spaces of South Dakota wind-blown soil is a pain but in the busy south east of England it could spell disaster for many people. Farmers should be doing all they can to both improve the air quality where possible and reduce the chance of accidents or disruption to traffic because of poor visibility.

The use of cover crops can build soil organic matter and sequester carbon too by taking in carbon dioxide from the air and converting it to organic carbon through photosynthesis.

There is also the benefit of keeping soil in the fields rather than washing it into streams and rivers. If fields remain intact and not cultivated, soil will not run off and cause erosion. The use of cover crops can build soil organic matter and sequester carbon too by taking in carbon dioxide from the air and converting it to organic carbon through photosynthesis. This is a huge benefit for the environment, air quality and soils plus it helps to keep the environment clean.

There is also less noise as fewer tractors are being used and for less hours. The need to work late into the night to finish cultivating a field or plough a paddock is not there.

Farmers tend to be more relaxed from what I've seen on my travels. There's not the stress of harvest mixed with cultivations and sub-soiling. Farmers tended to be in less of a rush to get work completed as there was far less to do.

Weed burdens were also seen to be reduced on farms that I visited both in North America and South America. This is a big benefit to the local community. With blackgrass becoming one of the most difficult weeds to control of recent times, the spread of weed seeds could be seen to be "antisocial" or "irresponsible." If there is any opportunity to reduce the spread of this weed seed or even start to reduce its hold on some of the UK farmland, that would be a huge benefit to local farming communities and the environment.



13.0. Ways to improve and regenerate soils

If no-till is able to improve soils and allow them to function in an improved way there are three distinct elements that, in my findings, will help UK farmers adopt this practice in a more successful way.

- Ultra low disturbance (ULD) no-till
- Diverse rotations and cover crops
- Retained residues

13a. Ultra low disturbance (ULD) no-till

It would be very easy for me to spend many chapters telling you why one drill is better than another drill and I'm not going to do that.

Machine choice is a personal decision but essentially it comes down to a straight choice between tines or discs or a combination of both. In my travels and in my research my own feelings on this matter are not to do with the colour of the machine but what it does to the soil. There is even different terminology around the world and discussions take place on the difference between no-till and zero till and direct drilling and strip-till. Again I'm not going to spend time entering the debate. However, there is a term that I consider helpful and this is Ultra Low Disturbance No-Till (ULD).

This essentially means that the crop is established by disturbing as little of the soil as possible. I have seen this successfully carried out with a knife tine but more commonly the establishment is carried out using a single disc. This allows the residue on the surface to be retained as mulch and the new crops are able to emerge through the mat of straw and stubble which helps reduce the emergence of weed seeds.

This system also retains the highest amount of carbon in the soil as soil is not cultivated. The cultivation of soil results in oxidisation of carbon into the atmosphere. Retaining carbon helps to build soil organic matter, which then improves the soil.

ULD No-Till also retains the roots in the soil, which help structure and protect the soil from erosion. The structure of the roots and also the network of worm channels and fissures is maintained with this no-till system. This makes establishment after heavy rain or even into dry soil that much easier.

The chapter on carbon (Chapter 8g) helps to explain why the movement and cultivation of soils is to be avoided at all costs.

13b. Diverse rotations and cover crops

The idea of diverse rotations is to give the soil as balanced a diet as possible. The soil will not only allow the crop to grow but will help it obtain its required nutrients for growth and development through soil reserves, green manures and residues as they decompose, and the application of artificial fertilizer. If the crop is a cover crop then it is grown for the benefit of the soil and also makes seeding the following crop that much easier.



By varying the crop type in the rotation the soil will get a variation of food with different root types and sizes. This helps with the following crop too, as the newly emerging seedlings will grow into the space left by the preceding crop.

Some crops such as legumes will help to improve the soil by fixing nitrogen. This has a huge benefit to the following crop particularly in rapid establishment and can reduce the fertiliser requirements of the crop.

Other crops such as oats will scavenge for the leftover nutrients that a previous crop has left behind in the soil. If grown as a cover crop, oats can hold these nutrients in their plants which can prevent leaching into watercourses by erosion.

By varying the crop type in the rotation the soil will get a variation of food with different root types and sizes. This helps with the following crop too, as the newly emerging seedlings will grow into the space left by the preceding crop.

Having a balanced and diversified rotation can hugely help in weed control and gives more chemical control options through the growing season.

According to Gabe Brown, “Crop Diversity Builds Fertility”. He grows a combination of cash crops and cover crops, with cover crops sometimes grown over a full season and then grazed by cattle. The subsequent rise in organic matter that is added to his soils through the decaying crop and the cattle muck is resulting in reduced fertiliser requirements and is even reducing his reliance on chemical inputs particularly the use of herbicides and insecticides.

Since 1991 Gabe has seen soil organic matter increase from 1.7% to 4.4% in many cases.

When I visited Dwayne Beck in South Dakota he told me that my wheat-oilseed rape-wheat-spring beans rotation was “not a rotation!”

What he alluded to was a rotation that included at least:

- one warm season grass
- one cool season grass
- one warm season broadleaf
- one cool season broadleaf.

This gives me food for thought and, even though South Dakota gets some extreme weather from cold to hot, we must consider in the UK what we can do to improve the diversity of our soils.

13c. Retained residues

Many of the benefits of retaining residues have been touched upon during this report. The main benefits and the reasons that they are so important to successful no-till adoption and continued success are:



- They protect the soil surface from rain compaction
- They help to protect the soil from both water and wind erosion
- They feed the soil biology and worms, which in turn builds soil organic matter
- It makes travelling on soil easier as the tyres or tracks run on a matt of residue rather than on bare soil, which can either be too wet or too dry
- It saves baling and removing which is time consuming, damages soil and expensive
- It reduces the amount of replacement artificial fertilisers to remedy the removal of straw

(on our farm we haven't applied P or K to any field for 17 years and indices are remaining at very healthy levels or improving)

- They keep the soil cool when it is hot and damp when the weather is dry. Retaining moisture in the soil is vital in ensuring long and continued crop growth.



14.0. Water quality locally, nationally and internationally

This is a huge issue for generations to come with the unpredictable weather patterns and the increasing world population that needs to drink clean water.

As farmers I feel it is our responsibility to do all we can to ensure that the water leaving our farms through streams, rivers, drains and run-off is the cleanest it can be. Why would we want to lose all those nutrients, washed away?

In some of the photos in this report you can see the difference between the colour of the water that runs off no-till land and land with vegetation growing upon it and within it, as opposed to conventionally tilled land. See photos on pages 14, 18 and 19.

During my Nuffield Farming studies and whilst I have been away travelling the UK, we have experienced some very wet weather towards

the end of 2013 and early 2014, particularly in the south west of the country and the Somerset Levels area. This area remained submerged for many weeks with the rivers seemingly not able to take the water away. I was following this news from across the world on Twitter and the hashtag *#dredgetherivers* gained a huge following. What this represented was the call from farmers and local residents to dredge the rivers and clean out sludge and eroded soil in order for them to flow more easily and take more water away.

This got me thinking. I agree that the rivers need to be dredged so that the flow can be increased but how did they get so blocked up with sediment in the first place? This sediment must have come from somewhere. My feeling is that it has come from water erosion and run-off from the local area, much of which is farmland.

My theory (although unconfirmed) is that cultivation of soils followed by heavy rain has resulted in waterlogging and run-off which, over time, will see the rivers slowly filled with sediment and sludge. These are the quality nutrients and topsoil required to grow quality crops and grassland.

Surely as farmers we must do all we can to reduce or even eliminate any soil run-off and erosion into water courses. Firstly, it is costing farmers money in lost nutrients and topsoil; secondly it's damaging soil structure, worms and root channels, and also costing water companies millions of pounds to clean it up. It's also not good PR for UK farmers who do such an excellent job.

My advice would be to dredge the rivers then ensure no-till systems are used for all subsequent operations wherever possible. The run-off from no-till soils is usually clean due to the non-cultivated structure and good infiltration rates. The soil also holds together well as we have seen in previous chapters.

As farmers I feel it is our responsibility to do all we can to ensure that the water leaving our farms through streams, rivers, drains and run-off is the cleanest it can be.



15.0. The role of no-till in sustained farm expansion

Farm expansion seems to be here to stay. Certainly since I've been at home farming with my father we have seen our acreage grow and my study tour was evidence that this is the same the world over. Many farmers I visited were always on the lookout for more acreage or opportunities that would increase their turnover. However, where No-Till had been utilised successfully it has allowed small family teams to significantly increase their acreage without additional labour and machinery.

When I visited father and son team Ashley and Tom Robinson at Mallalla in South Australia I was amazed at what they could do with such a small team. They had 4,500 acres of crops to plant and harvest and this was all completed by the father and son team plus some help from Ashley's wife at peak times. They were running one combine, one sprayer and one no-till drill and even though their acreage was growing, their list of machinery was not. They were able to accommodate the extra acres, no problem, and were looking for more.

They had 4,500 acres of crops to plant and harvest and this was all completed by the father and son team plus some help from Ashley's wife at peak times.

Their 33ft John Deere disc drill was comfortably planting 10ha/hour and so planting was a one-man affair.

As fewer pieces of machinery are needed to plant crops in a no-till system, farmers are better able to afford the right pieces of machinery that can plant seeds quickly and effectively straight into the stubble.

The future of commercial farming across the developed world looks like it will be undertaken by farmers who can cover large acreages with efficient machinery and who can maintain or improve soil quality and crop yields at the same time.

This system has a big saving on labour requirements as there is no need for staff to be cultivating or "preparing seedbeds" when the combine is cutting. So in terms of harvest logistics for an expanding farm, all efforts are tuned to the harvest and movement of grain. Then once harvest is completed, or the weather is not suited to harvest, the drill can be used as a one-man operation to plant the following year's crops or a cover crop.

Also the fact that soil is not disturbed at harvest means that it retains its structure and is far less prone to erosion particularly by the warm summer winds.

When the Australian farmers come to plant their crops the soil is in a firm state which suits the machinery better and allows rapid planting to take place.



The future of commercial farming across the developed world looks like it will be undertaken by farmers who can cover large acreages with efficient machinery and who can maintain or improve soil quality and crop yields at the same time. No-till certainly helps this aim become a reality.



Kevin Larsons's 45ft Cross-Slot drill, which enables large acreages to be planted by one man



16.0. Discussion

What a journey of discovery I've had over the past 18 months! What started out as a study into the long-term benefits of direct drilling has turned into a study that has looked at farmers regenerating their soils, yields, profits, the environment, water quality and way of life. I have travelled to 5 foreign countries during my studies and have learnt interesting and challenging things in each place but discovered some key things were being repeated time after time. The three main principles I discovered in not only adopting a no-till system but ensuring it is successful in the long-term were:

- Diverse crop rotations
- Retained and increased residues
- The use of cover crops.

In North America what had once been a dry dustbowl, where a crop rotation was wheat followed by a summer fallow, had now become a green and healthy environment where corn, sunflowers, soya beans, cotton, canola (oilseed rape) and many other crops now grew.

This was largely down to the adoption of no-till and the effect this had on the soil, its ability to hold moisture, resist erosion and improve its structure and organic matter level.

The improvement in the quality of the soil by doing less to it seems almost illogical but I have seen on so many occasions and in so many countries that farmers have found massive improvements in the soil organic matter of their soil, its ability to hold nutrients and the effect that this has had on the yield potential of their land. In fact the yields have actually been higher in many cases with the same or reduced inputs and this has to be good for the ongoing aim of producing more and more food for a growing world population.

The improvement in the quality of the soil by doing less to it seems almost illogical

I have also seen and looked into the whole area of erosion both from a wind and water perspective. By retaining residues from the previous crop the soil has a protective layer of mulch that protects it from the heavy battering of rain. The soil is also protected from the wind due to the retained stubbles, use of cover crops and the absence of any tillage; the latter loosens the soil, releases carbon dioxide into the atmosphere and damages soil structure.

It's not only above ground that I have investigated. Underground the big benefits are the increased number of earthworms that seem to live in no-tilled soil. Provided the soils can be kept compaction-free, which I believe they can be with the use of cover crops, diverse rotations and retained residues, the benefits that active, healthy and deep roots give to the soil are almost immeasurable. The roots - in conjunction with earthworm and soil bacteria and fungi - will do all the cultivating and straw incorporation for the good of the soil without any damage to its structure.

The benefits that this brings to the farmer are measured in both financial and non-financial aspects.



The reduction in fuel usage, wearing metal, seed rates, fertiliser, paid labour and machine running costs as well as the benefits of increased yield can lead to a large rise in farm profits. This is something I have seen on numerous occasions.

Looking at the non-financial aspects of a move to regenerative farming I have seen farmers who have more time, more fun, more interest in the job and a renewed enthusiasm for the farm, its soils and the environment.

The benefits to the work life balance have been a noticeable improvement that is difficult to put a value on. I have seen farmers at what would have been a busy time of year, spending time with their children in the evenings as much of the farm work can be completed faster with larger machinery ensuring that the farmer and his family can farm to live and not live to farm.

The Williams family in New Zealand were a case in point. Father Jim had adopted no-till and now his two sons Nathan and Michael were farming in their own right both using no-tillage to establish all their crops. They were spending more time with their families but their farms didn't look to have suffered, in fact quite the opposite.



With Nathan and Jim Williams -singing the praises of no-tillage for their farm and their life.

So not only do we see improvements to the soil in higher organic matter levels and less erosion, we see crops that are grown using less fertiliser and chemical sprays too.

The regeneration of the environment leads me to believe that no-tillage used as part of a whole farm system that employs cover crops, retained residues and diverse rotations, can result in the farmers of the world providing healthy and nutritious food for many years to come, and have fun doing so!



17.0. Conclusions

1. There are lots of ifs and buts in whether or not a no-till system can work efficiently on your farm. From what I've seen on my tour of significant no-till countries, farmers that want to make the change and make it happen have all succeeded.
2. The benefits are fantastic and far-reaching and include improved soil, crop yield, and SOM levels; and this in turn leads to reduced fertiliser rates, diesel use, wear and tear, and hours spent sitting on a tractor.
3. Unfortunately, there are some downsides. For almost every farmer I visited, profits have risen leading to an increase in income tax liability. Yields have improved meaning new storage is required for the same cropping area.
4. Management needs to be improved as there is only one opportunity to plant the seed into the final seedbed and soil conditions on the day are vital.
5. The soil is improved over time to such an extent that SOM percentage has been seen to double over ten years, significantly improving the way the soil behaves and responds to traffic, weather and the growing season. Its ability to hold water at dry times and infiltrate through it in very wet weather will be a big advantage to your farm and cropping abilities.
6. If you're looking to the future when we have little or no subsidies and unpredictable weather patterns are the norm, then no-till will regenerate soils to a place that will cope with extremes more reliably than a cultivation system.



18.0. Recommendations

- Just do it! - if you think it will work and you're willing to make it work
- Sell all other cultivation equipment to firstly finance a no-till drill, and secondly so there is no going back to cultivation. Make sure fields are level first though
- Use cover crops as your cultivators, soil conditioners and subsoilers
- Retain residues/mulch/chopped straw at all times and ensure it is spread evenly if chopped
- Learn from others, share information, watch Internet presentations from around the world and try new things, remembering to leave a control or untouched strip to compare with and without
- Don't listen to those who tell you it won't work, surround yourself with those already doing it and making it work. I didn't meet one farmer who regretted the move to no-till
- Don't expect instant success. Improvements to soil and yields will take a few years as soils get settled, nutrients are balanced and you get used to managing a completely different system
- Don't manage for above-ground cosmetics in the autumn. Crops could be slower to emerge and scruffy stubble will damage your ego if appearance is your priority
- Remember that cost of production and yield are the priorities at the outset and that soil improvements will be one of the rewards for long-term commitment
- Consult Rolf Derpsch's 10 critical factors for no-tillage adoption. These are regarded as some of the best principles worldwide. (www.rolf-derpsch.com/en/)



19.0. After my study tour

This is where things get really interesting. Having travelled the world and studied all things no-till, it would be very easy to return home, write an informative report and go back to farming “the way we’ve always done it.”

For many farmers their hands are tied and the implementation of a change in farming practices is not a simple decision. There are family members or business partners to consider, landlords or farm owners and what can seem an efficient, cost-cutting decision that will benefit profits, the soil and the work/life balance of the farmer and his staff is difficult to implement.

However, I am blessed to farm in partnership with my wife and my parents and Dad is, I’d like to think, forward-thinking and progressive. This has made it possible for my research and formulation of farm ideas and plans to be implemented immediately. So rather than tell everyone how great no-till is and how, as part of a system, it can regenerate your soils, profits and the environment, we have “put our money where our mouth is” and made a complete switch to no-till farming.

Over the past few years we have come close on two occasions to buying firstly a Claydon strip-till drill and then secondly a John Deere 750a disc drill. This investigation was partly what prompted me to apply for a Nuffield Farming Scholarship and the timing was perfect.

The day before leaving to attend the Nuffield CSC (Contemporary Scholars Conference) in London and then Canada, I nearly agreed to buy the John Deere drill but for some reason delayed making the final decision. I was then away for two weeks and whilst in Canada met Australian Nuffield Farming Scholar David Cook, who himself had spent four years researching no-till seeders (drills) and eventually found the cross-slot machine from New Zealand. I had always been impressed by this machine, but the price and power requirement had put me off a bit. ¹

On my travels to New Zealand I visited Baker No Tillage at Feilding in the North Island, who manufacture the cross-slot, and was taken to many farmers using the cross-slot machine.

Without going into the details of every decision and conversation, we decided to put in an order for the component parts required from New Zealand to build and assemble a cross-slot no-till drill. We did this in conjunction with Primewest Ltd who had used a New Zealand built machine on their Oxfordshire farm for the past 10 years and had just designed and manufactured a machine more suited to UK conditions.

So, on returning from my final Nuffield Farming trip to Paraguay and Brazil, we took delivery of the chassis that had been manufactured by JH Ford in Sussex and then set about assembling the machine on the farm.

¹ Farmers always ask about the price of a cross slot drill. A UK built 4m model is from £96k and this is capable of covering 1000/ha/yr of mixed cropping including spring work
A NZ machine which can also apply fertiliser at seeding can be up to 70% more.



The knock-on effect of this (and the means to help pay for it) was that we sold four pieces of machinery that we no longer required. Out went a 140hp tractor, set of 6m rolls, 4m Horsch CO4 drill and a 3m Sumo Trio, with a 7.5m Claydon straw harrow waiting to be sold as I write this.

In came a 300hp tractor and a bigger set of 12.4m rolls plus the new drill.

This was a significant change but gave us three big benefits:

- 1) Firstly, it gave us capacity to cover the land faster and plant more acres per hour and per day. We have also lost our full-time member of staff this last year and no-till allows us to manage more land with less staff
- 2) Secondly, it future-proofed us in terms of the development of the CAP reforms and reliance on farming subsidies. I wanted to be able to consistently remain profitable without subsidies and make the change to no-till whilst we could afford to purchase the machines
- 3) Thirdly, it gave us the potential to take on more land and expand our farming operation without buying lots more cultivators, tractors and drills.



First day out with the new tractor and cross slot drill planting cover crops into oilseed rape stubbles

I have always felt that there are three main machines on an arable farm that need to be right and they are the sprayer, combine and drill. We now have those three machines at our disposal and I feel they are right for our business giving us the capacity to get our own work done and also some spare capacity for expansion.

The crop rotation will remain the same with winter wheat (All Grp 1 Solstice, Crusoe and Skyfall) followed by oilseed rape, followed by a short cover crop which this year will be sunflower, buckwheat, phacelia and linseed. After this short (8-10 weeks) cover crop we will plant another wheat (as above). This is followed by an over wintered cover crop which for the 2014/15 winter will include oats, forage rye, vetch, linseed, buckwheat, phacelia and tillage radish. Following the cover crop we will plant spring beans directly into the cover crop. This rotation allows us to



always maintain 50% of first wheat and 50% break (cash crops) plus two cover crops every four years. It spreads out the workload and allows us to build SOM whilst hopefully maximising yield.

All stubbles will be chopped and straw retained as mulch on the surface to build SOM, feed soil biology and protect it from the elements.



The new drill in action planting cover crops after oilseed rape.

The cross-slot drill will plant all crops and cover crops and we will possibly roll before and after the drill depending on soil conditions, slug populations and how well the closing wheel on the drill performs.

It's a bold move but one that I've seen made on numerous farms that I've visited on my Nuffield Farming Scholarship. With the old cultivation machinery largely sold and gone, it's a system that we now need to embrace and improve over the coming years. No doubt mistakes will be made and lessons learnt, but improving our soils, yields, profits and way of life during a busy time of the year - with the difficulty in finding and recruiting labour - must be right; not to mention the reduction in tractor use, diesel and wearing metal.

However, the one challenge that I am relishing is the battle with blackgrass. Over the past few years this weed has become one of the biggest headaches to UK arable farmers particularly in the eastern counties and no amount of tillage, be it ploughing, cultivating or subsoiling in a physical sense, or chemical sprays, has seemed to make much of a dent in the problem. However, a few farmers embracing a low disturbance disc drill do seem to be reducing its



germination and if this can be another long-term benefit then it will be another reason/result in favour of our bold move.

In finishing, I can say that my Nuffield Farming Scholarship has not only been interesting and informative, allowing me to travel the world and stretch myself; it has also inspired a whole farm policy change in the way we grow our crops, treat our soil and the reliance we place on paid labour, cultivation and soil appearance. We have made changes on our farm based on what I have learnt on my study tour and the benefits of this will no doubt be seen for many years, even generations, to come.

Tom Sewell



Here is the result of my Nuffield Farming Scholarship. No-till cover crops planted after oilseed rape on the 21st July 2014.



20.0. Executive summary

The facts are these: by 2050 the farmers of the world will be expected to produce enough food to feed a world population of 9.6 billion. We will need to produce 69% more calories than we are currently doing from the same land mass. How can this be achieved?

I believe that one of the ways that farmers can improve their yields, profits and lifestyle is by the adoption of a no-tillage system on their land.

As farmers we need to move from being sustainable to regenerative in all that we do and are. We need to regenerate our soils and in particular their soil organic matter levels. This is important in that it will allow soil to hold on to moisture and nutrients better, and then put these into the growing crop at the important times when weather is hot and the land dry.

So how do we do this? I believe there are four main ways in which we can see soils regenerated in the UK:

1. By embracing an Ultra Low Disturbance No-Tillage system of seeding
2. Retaining residues on all fields after harvest
3. Using diverse crop rotations including a spring break crop and a legume
4. Growing cover crops wherever possible between cash crops, to build and maintain soil health.

As the soil quality improves and we see our soil organic matter levels rise there are also likely to come other benefits such as a reduction in the amounts of artificial fertilisers required, improved water infiltration rates and the reduction if not disappearance of soil erosion.

I have seen farmers who have made this change around the world and the effect it has had on them, their business and their families.

Without doubt the overriding conclusion that I have reached is that by adopting no-tillage systems farmers have better soils, improved yields, improved profits, more time for leisure and family and this can only be good for farming and the future.

Not only that. We see the environment regenerated by the reduction in carbon emissions, cleaner water in our streams and rivers, and the elimination of soil erosion through air and water.

I have made the bold move and adopted this system on 100% of my farm as a result of my Nuffield Farming Scholarship and am convinced it will improve our farm, our business and my family life as a result.



21.0. Acknowledgements and Thanks

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Rubens Tonon Filho



22.0. Reading list

No-Tillage Seeding in Conservation Agriculture 2nd Edition. C.J. Baker, K.E. Sexton, W.R. Ritchie, W.C.T. Chamen, D.C. Reicosky, M.F.S. Ribeiro, S.E. Justice and P.R. Hobbs.

The Essential Guide to No-Till Farming. SANTFA (South Australian No-Till Farmers Association)

Conservation Agriculture, The Essential Guide. SANTFA.

Beyond the Beginning, The Zero Till Evolution. Manitoba – North Dakota Zero Tillage Farmers Association.