A Nuffield Farming Scholarships Trust

Report

Award sponsored by

Royal Welsh Agricultural Society

Pasture Utilisation - Yield from the Field

Gareth Davies

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A Nuffield (UK) Farming Scholarships Trust Report

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

Title	**Pasture Utilisation – Yield from the Field**
Scholar	Gareth Davies
Sponsor	Royal Welsh Agricultural Society
Objectives of study tour	To look at the key factors of growing quality grass, and management techniques to best utilise it
Countries visited	Ireland Texas USA New Zealand
Key findings	Soil fertility and soil carbon levels are vital Rotational grazing works Cost of production is king An open mind is essential

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Disclaimer

The opinions I have expressed are my own and not necessarily those of the Nufield Farming Scholarships Trust, nor of my sponsor, nor of any other sponsoring body.

1. Personal introduction

My name is Gareth Davies and I live in the Swansea Valley in South Wales with my lovely wife Alison and our two children, Hannah and Dewi. I was born and brought up on a small mixed hill farm where my parents still live.

At this point I am supposed to impress everybody with a massive list of academic successes, but unfortunately I am unable to do so because I left school at sixteen with only a few O Levels to my name. I like to think this was due to a lack of effort rather than a lack of ability, which is probably an even greater indictment. Having said this I did really enjoy my school days at Cwmtawe Comprehensive (well actually I enjoyed the rugby more than the real lessons) and it is interesting that I am now a governor of the school and I have also returned to the school to promote careers in agriculture to the children.

When I left school I went straight home to work on the farm with my parents and brother. At this time we were producer retailers selling all our milk on our own milk round. In addition to the dairy cows we had a few suckler cows, a small herd of sheep and our four legged waste disposal units (pigs) in the woods.

Away from the farm I was always a very keen sportsman playing all sorts of sports, golf, snooker, cricket, darts, table tennis and squash but, by a distance, my number one passion was rugby. When my rugby career ended I became a coach and spent five years coaching a couple of local teams, before having to give up through work and family commitments.

Up until this point my life had been dominated by farming and rugby, but at the age of twenty eight all of this came to an abrupt end as a result of a serious farming accident when I had my leg crushed by a bale of silage. I was fortunate to keep my leg but pretty much all that I knew and loved had been taken away overnight. However with tremendous support from my family, especially Alison and my parents, I started to build a career which has culminated in a Nuffield Farming Scholarship and the creation of my own little company.

What this major change in personal circumstances did was allow me to travel and visit farms all over the country, and this just confirmed what I had always believed – agriculture is a fantastic industry.

2. The reason for choosing my topic

Grass is great, grow it, eat it and grow some more – "Simples"

When I left my hands-on farming career and started working in the wider agricultural industry, I spent a lot of time visiting farms all over the country. I became intrigued and somewhat baffled by the way the majority of the farms I visited seemed to overlook or blatantly disregard grass as a quality feed and had instead, in many cases, replaced it with other allegedly higher quality feeds.

I found this notion of grass not being a quality feed very interesting, because I deal and speak with farmers who regularly sample their grass and it remains at over 11.5 ME (metabolisable energy) all season. Now I know that if you have to go and buy a feed of that quality it would set you back a few bob; not only that, but as a farmer you have very little if any control over the cost of that feed. At least with grass you have an element of control especially when it comes to the quality.

The other thing that has happened as a result of this lack of focus on grazed grass is that farming systems have significantly altered. The diets of many dairy cows are now built upon home grown forages and bought-in feed. A large proportion of beef animals are finished indoors, again on forage and bought-in feed. Many lambs are now finished outdoors with the use of creep feeds. I am not saying these systems are wrong; but what I *am* saying is that quality grazed grass *could* (and in my opinion *should*) replace some of that more expensive feed during the grass growing season.

Another very obvious observation is that these changes in farming systems have added a lot of cost to farmers' businesses that weren't there previously. Again, this isn't necessarily a bad thing so long as those extra costs don't have a negative impact on profitability or significantly increase the cost of production – but are farmers sure that they don't?

Having seen all this with my own eyes, and in order to assist me in my crusade to get the value of quality grazed grass back to the forefront of UK livestock farmers' minds, I wanted to look into how I could increase my own knowledge of the subject. It is, after all, potentially a farmer's cheapest source of quality feed.

I will always be very grateful to the Nuffield Farming Scholarships Trust, and my sponsor The Royal Welsh Agricultural Society, for giving me the opportunity to travel to study my topic. I hope that the knowledge gained will, by giving me a platform from which to perform, help me in my attempt to promote grassland management in the UK.

It's all about – "YIELD FROM THE FIELD"

3. Destinations - and reasons for them

Deciding on destinations to visit was an interesting dilemma because I didn't just want to visit only the obvious countries, but I wanted to ensure that I got the answers I was looking for. I didn't want to visit loads of countries and not get the in-depth detail I was seeking.

So, after much deliberation, I ended up going to two obvious countries:

Ireland and New Zealand

and one far less obvious region for the study of my subject:

Texas, USA

I will explain why I chose these particular countries.

Ireland

I already spend a fair bit of time in Ireland, so I was very aware of the amount of research that takes place there especially in the area of low cost meat and milk production centred on pasture based systems. On my study tour I visited various farmers but spent most of my time looking at the beef trials run by the Grange, the sheep trials at Athenry, the dairy trials at Moorepark and the soil research at Johnstown Castle. **I visited in April/May and September 2012.**

New Zealand

It probably wouldn't be credible to study a grassland topic without visiting New Zealand. Here I spent some of my time with Ag Research Palmerston North, Lincoln University Research Farm and Ballantae Hill Country Research farm. However I spent just as much time visiting private beef and sheep farms, assessing both their methods of low cost meat production and their mentality**. I visited NZ in October/November, 2012.**

Texas

I went to Texas because I was intrigued by their grass fed beef production. Like many others I couldn't quite understand how this was achieved in a state like Texas which isn't renowned for its pasture based systems. I also wanted to visit the A+M University to look at the research being carried out into grass varieties, soil fertility and soil erosion.

I visited Texas in August 2012 which for a Celt who has been bred to withstand the Welsh weather was quite a shock; the first six days of my visit the temperature was over forty degrees C!!!

4. Below the ground

4a. Chapter summary

I discovered an amazing fact very early on in my studies, and that was the realisation that there is actually only one type of farmer: a SOIL FARMER. I was given a quotation from a farmer who had probably taken it from somebody else, and it really brought this message home. He said "*The whole of civilisation has been built upon six inches of soil and some rain".*

This is so true because it doesn't matter what type of farming you are practising, everything can be directly traced back to soil. So this chapter is going to concentrate on the importance of soil fertility, the importance of the soil's inhabitants and the key role of soil organic matter. Unfortunately today too many farmers see soil as the place where plants just hang out awaiting their next fix from above.

In short, soil organic matter is crucial and should be looked after and increased. In-depth soil testing is key to understanding what is excessive or deficient, thus enabling you to re-balance your soil. Regular visual assessments of the soil should also be carried out and recorded. If you get your soil fertility correct you can then work *with* nature rather than trying to manipulate it artificially.

4b. Soil organic carbon (SOC)

Organic carbon is right at the top of the criteria for soil fertility and health. As a result of microbial decomposition activity it supplies plants with many essential nutrients including Nitrogen. So the greater the amount of SOC the greater the number and diversity of soil inhabitants it can support. It is this *life beneath the surface* that shapes the whole soil structure, the soil's natural ability to suppress disease and its ability to buffer harmful and toxic substances.

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I have already mentioned the fact that SOC supplies N to the plants. This is because soil organic matter is 5% N and this is stored in the SOC. Without wishing to state the obvious, the higher the percentage of soil organic matter in the soil, the larger the amount of N that is stored within that soil. Most soils range from 1% to 5% organic matter so, to give an example, soil with 2% organic matter will release around 80kgs of N/Ha/yr.

The other very important role of SOC is in the retention of water/moisture within the soil. A 1% increase can allow the soil to hold an extra 144,000 litres per hectare, and it is as a result of this that people in very arid climates have had great success when they have put a concerted effort into building up organic matter in their soils. I saw this first hand in Texas when I was visiting some of the grass-fed-beef producers. None of them used conventional fertilisers, but there was a huge focus, almost bordering on obsession, with soil fertility and building organic matter. Yet these producers all had plenty of green vegetation to feed their stock whilst their neighbours had very little.

The importance of soil organic matter has also been evident in NZ this season (2012) with reports stating that the soils with higher organic matter were slower to be affected in the beginning of the drought period and faster to respond coming out of the drought.

The reason that SOC has a major impact on water retention is because of its role in feeding the microbial population within the soil.

The reason that SOC has a major impact on water retention is because of its role in feeding the microbial population within the soil. These microbes produce a sticky resin which has a binding effect on the soil particles. This then allows them to form stable aggregates thus creating a good soil structure enabling root penetration and water retention.

The items that make up SOC - which are partly decomposed organic matter, living microbial biomass, humus and charcoal - are all badly affected by excessive applications of N unless it is spread with a separate feed source such as a form of humus, i.e. soluble humic granules. This is because it allows the microbes to meet their N requirements, meaning they continue mineralising soil carbon unnecessarily, thereby reducing the SOC pool with no benefit to the plant. Also the application of N encourages shoot growth and this upsets the ideal ratio of root to shoot of 1:1. When you consider that roots contribute six times the amount of carbon that shoots do it makes sense to try to balance things up. A field growing 12T/DM/Yr could contribute 150kgs of carbon to the soil.

Methods to improve your SOC include:

- removing obvious barriers like compaction or waterlogging
- making sure your soil indices are correct
- applying well composted manures
- whenever possible using minimum tillage as opposed to ploughing (in trials in the USA they have been able to double the level of organic matter in the soil in ten years by avoiding the plough)
- considering a green manure crop
- using rotational or controlled grazing (I will explain this in a later chapter).

4c. Microbes

Life below the surface is not that different to life above in as much that it needs air, water and food. In an ideal scenario this would consist of 25% air, 25% water, 45% mineral and 5% organic matter. In such a scenario the bacteria can thrive and become an army of positive workers, working as hard for you below the surface as they possibly can. However if there is an imbalance in their deep dark environment, some turn into evil pathogenic microbes and start attacking your crops. I saw work in NZ which is trying to identify which of these microbes has this dark sinister side to their character!!

The bacteria and fungi play a critical role in the decomposition and biochemical changes within the soil. They provide N and S for the plants and play a key role in fixing atmospheric N and making it plant available.

It is the food chain within the soil and more importantly the C:N ratio of the soil inhabitants that makes all this happen, because once the microbes eat more than their basic needs the excess gets excreted. The clever bit is the fact that what they eat in the first place is non-plant available, yet by

the time it works its way through the microbes' plumbing it *becomes* plant available. To speed this up further the bacteria get eaten by various micro-arthropods with a higher C:N ratio which in turn get eaten by earthworms that have an even higher C:N ratio.

It is because of the essential role of the C:N ratio that N applications need to be monitored; because if these bugs get exposed to large amounts of N they either die or they have to mineralise loads of carbon to stay alive. This creates three problems:

- firstly you are creating even more N in the soil which the plants won't use because you have already given them all they can handle, which means it will probably leach away
- secondly you are depleting your SOC for no benefit
- and thirdly, if you are killing large numbers of microbes, they won't be able to work for you within the soil, so your soil fertility will drop and your reliance on feeding from above will increase.

All this action takes place in the root system called the rhizosphere, an area which is saturated with micro-organisms. The plant roots exude sugars and minerals and the battalion of bugs sets upon them and in turn feeds the plant. In such an environment with everything working properly these beneficial microbes will totally out-compete the pathogens, creating healthy plants and keeping weeds in check.

Mother Nature is incredible because each of these plants exudes feeds designed to attract the specific beneficial microbes that are best suited to its own root system. They exude an awful lot of feed because over 30% of the photosynthetic sugar is exuded through the root system. It is interesting to remember that for every naturally occurring organic material there are microbes capable of decomposing it.

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4d. Worms

Worms deserve a category all of their own. There are three main types of worms and they have extremely fancy sounding Latin names, which I can neither spell nor pronounce!! So I call them **surface worms, shallow worms and deep worms**!!

As a result of their feeding, burrowing, digesting and excreting activities worms have an impact on the physical, chemical and biological properties of the soil. They are a very good visual indicator of the soil's health and condition, because their proliferation is linked to soil properties and management practices.

Now I might sound a bit sad but I like digging holes in a field and, amongst other things, counting the worm population. Less than 10 worms per spade full is poor, more than 30 per spade full is great, and the most I have seen so far is 42.

As expected, **surface worms** work on the plant litter and dung on the surface. The **shallow worms** ingest and mix the soil in the top 200-300mm of soil and the **deep worms** pull down plant litter and other organic matter and mix them in the depths. All this activity increases the top soil and SOC.

The casts of worms contain 5 times the N, 3-7 times the P, 11 times the K and 3 times as

much Mg as the surrounding uningested soil, so they are like your own little fertiliser factory in the soil. But it doesn't end there. When they die they are actually 12% N themselves, so if you have 25 worms in a spade full of earth you can have 20 kgs/N/ha after they die. In fertile soils worms can deposit around 20T/Ha/Yr of castings.

Worms also act as natural aerators and conditioners of the soil, improving its porosity and structure and its ability to retain water. They also promote pasture growth by secreting plant growth hormones along their burrows. This allows the development of dense, deep roots along these nutrient rich channels. These same channels also help reduce compaction.

Worms also promote N fixing organisms in the soil, by increasing the population, activity and diversity of the soil microbes which play an important part in decomposing the organic matter into humus. They like soils that are high in calcium, so excess salt and ammonia fertilisers can reduce worm numbers.

Don't forget that, in a healthy soil, the weight of all the fungi, bacteria, arthropods, worms etc. below the ground should be equal to the animal liveweight above the ground.

4e. Humus

Humus is decomposed organic matter that bears little or no relation to its original state and it plays a significant role within the soil. It is very rich in **Humic, Fulvic** and **Ulmic** acid which basically aids nutrient availability, soil structure and plant growth via hormones, vitamins and enzymes. Humus acts as the reservoir for nutrients, holding 90% of the N, over 50% of the S (sulphur) and up to 80% of the P, allowing a percentage of this to become plant available throughout the season. It also has the single biggest impact on the soil's ability to hold nutrients and water and can also help buffer the soil against changes in PH.

Another role of humus is to help regulate the soil temperature. This happens in two ways: firstly by being very dark in colour it absorbs more heat from the sun and retains it, and secondly by supporting large amounts of soil life, which in turn give off body heat which warms up the surrounding soil. Don't forget that, in a healthy soil, the weight of all the fungi, bacteria, arthropods, worms etc. *below* the ground should be equal to the animal liveweight *above* the ground.

4f. Compaction

This is basically an increase in the soil density, which in turn solidifies the soil and reduces the pore space. There is then is a reduced capacity for air and water movement and infiltration within the soil. With this comes increased run off, poor root growth, and a reduction in the microbial life due to a lack of oxygen. Compacted soils are quite often low in organic matter.

Before hitching up to some fancy expensive machine to sort out your compaction problem, attach yourself to an inexpensive spade and dig a few holes. Identify how deep the issue is before you waste your time and money carrying out a procedure which might make *you* feel better but achieves nothing. Identify the problem and use the correct implement/procedure to rectify it.

I was shocked in NZ to find that little Jersey crossbreds had actually compacted a field three times as much as 5 passes of a 3 ton

vibrating roller. Every time the field was grazed the grass in a fenced-off area was cut and then given the roller treatment, yet this failed to replicate the same level of compaction that the cows had created.

It isn't just heavy machines that cause compaction!!!

4g. Elements

I have put a table near the end of my report listing the elements and the role that they play within the soil. (See Appendix 1 on page 30)

4h. Cation exchange capacity (CEC)

CEC is a measure of the soil's ability to hold cations. It is basically an indication of the soil's ability to store nutrients for the plants and soil inhabitants. It ranges from 1 for extremely thin sandy soils to over 30 for heavy clay/peat type soils.

I have heard a lot of talk about ratios of Ca/Mg and N/S - amongst a myriad of others - but I am very cautious about this because the ratio could be perfect but the numbers can be miles off. For instance 1:10 is mathematically the same ratio as 10:100 but is massively different in reality.

What I will say is that it is possible to raise the CEC by applying organic matter to the soil and increasing the soil microbial activity.

4i. Soil tests

If you are soil sampling you should have a full *soil sample carried out.*

I am a firm believer in soil testing and maintain that every farm should have a soil testing policy just as it would have a reseeding policy. What I also believe is that if you are soil sampling you should have a *full* soil sample carried out. There are many different elements in the soil, each with their own specific purpose - why would you not test them all?

If you were going to bake a cake that had 13 ingredients, you wouldn't try to make do with only the 4 main ingredients would you? It is the pinch of salt or the dash of cinnamon that makes the difference; the soil needs the same detailed attention as your baking.

Also, if you are going to be applying expensive fertiliser, you need to be confident that the soil is in the best shape possible to give you the optimum return for your investment.

5. Above the ground

5a. Chapter summary

What goes on above the ground is generally more familiar to farmers, purely because it is visible. You can't see a thriving worm population but you *can* see if you have thistles in a field. What I found on my travels was that picking the correct crops and varieties of crop for the environment in which they are meant to grow, plus the aspirations of the farmer, is quite fundamental. As an example, in Ireland I visited a farm that was trialling some tetraploid grasses. They had been sown on some fairly wet ground and it was without doubt a disaster, whereas I saw the same variety on some dry land and it was some of the most productive pasture on the farm.

Another thing that caught my eye was the way that a lot of the beef and sheep farms I visited automatically used mixed species swards, with great results.

There is a mass of information available about particular grass seeds and what circumstances they are best suited for. I am not going to focus on that because it is very specific to individual circumstances. What I *am* going to concentrate on is the potential impact of non-grass forages such as legumes, and also look at weeds, reseeding and brassicas.

5b. Weeds

As a result of my travels I now look at weeds in a wholly different light. Before my study tour my attitude would have been broadly similar to that of most other people: I have weeds so I spray them - then I no longer have weeds!!

Now this approach does undoubtedly sort out lots of weed problems, but are we missing something? In Texas I met a fascinating lady who told me that all weeds should grow with a big red flag attached to them, shouting out to us that there is something wrong below the surface. She meant that, as we know from my previous chapter, if the soil is working properly the weeds struggle to compete. Lots of weeds thrive in low-PH soil that is also low in calcium but high in potassium.

- **Thistles** often indicate low Ca and PH but high K and S levels.
- **Docks** like soils with a high K:P ratio along with high N + K, but with low Ca and P. Interestingly their leaves are high in Mg, P + K so they aren't all bad news.
- **Buttercups** thrive in compacted poorly aerated soils with a low humus content.
- **Daisies** like low PH, compacted soils.
- **Nettles** like good moist soil with a high N content, which is why they often grow around where feeders have been.

So you can see just from these examples you can start to build up a picture of what is going on *below* the surface by looking at what undesirables are growing *above* the surface. Controlling weeds in the short term is an issue. Sometimes hard grazing and regular mowing can check them enough for the grass to out-compete them, but generally people spray them and I would suggest a herbicide as opposed to a fungicide or insecticide. However, remember how a herbicide works. It secretes a compound into the soil which activates the pathogenic organisms which kill the plant root system. If too much of a product is used there can be a residual effect

in the soil from this spray when you plant your next crop. It was because of this that a farmer I visited in NZ was adding humic acid to the spray and was getting good results whilst using half the recommended dose, with no visible effect on the next crop.

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If you can, spot-spraying early on is preferable to spraying whole fields for obvious reasons, but the best long term solution is to get everything below the ground working in your favour. As I indicated above, very few weeds grow in soils that are in A1 grass growing condition.

5c. Alternative forages

White Clover.This is a popular part of most farmers' reseed mixtures. It has one of the highest digestibility values of any grassland species, and thrives under low nitrogen fertiliser inputs. Applications of over 100kgs of N are seriously detrimental to white clover, but why would you apply more than this to a white clover sward when the clover itself can fix 100kgs + of nitrogen/Ha? It does this via a process called biological nitrogen fixation. This is achieved by the activity of bacteria in the clover nodules, which convert inert nitrogen gas from the atmosphere into plant available nitrogen in the soil, and also by the action of worms dragging dead stolons beneath the ground where they release their store of nitrogen. To enable the bacteria to perform this task they must have sufficient quantities of molybdenum and iron.

During my visit to Solohead research farm in Ireland I was very interested to see that in one of the trials they had been able to carry a stocking rate of 2.2 cows per hectare, using only 72 units of nitrogen and actually produced 1.5 times the national average of milk solids.

In another trial they had one area that was grass only and another that was a grass and clover mixture. Each area was given 60kgs of nitrogen. The grass-only fields grew 6.9T of dry matter whilst the grass-clover mixture grew 10.7T of dry matter. Interestingly there was another area that had received 230kgs of nitrogen and, despite that, it only grew 11.3T of dry matter.

As a rule of thumb white clover can fix around 50kgs of nitrogen per 10% of ground cover. It likes to grow in fertile soils that have a decent capacity to withhold moisture, is fairly shallow rooting and doesn't grow well in low PH soils.

A point to note when choosing white clover: if you intend to graze it with sheep I would advise small leafed clover. Sheep graze so tightly to the ground they have a tendency to pull out the roots of medium and large leaf clovers as there is more stem to tug at, whereas the small leaf clover grows very close to the ground and sheep tend to eat the leaf only.

Red Clover. This is very different from white clover. It is generally only a 2-4 year crop, has very deep roots and grows far taller than white clover. It has the ability to fix double the amount of nitrogen that white clover does, anywhere between 200-300kgs/Ha. A lot of people who grow red clover tend to cut it a couple of times and then graze it thereafter. Caution needs to be used when grazing, firstly because of the risk of bloat and secondly because of the high levels of oestrogen within the red clover. On the bloat

front don't introduce stock that are hungry, and to lessen the risk sow the red clover as part of a mixed sward; it seems to work very well with high sugar grasses. On the oestrogen front don't graze red clover leys six weeks prior to or six weeks post mating.

Red clover is a very good green manure.

In EBLEX trials lambs on red clover swards finished faster, heavier and with a better killing out percentage.

Lucerne. During my visit to NZ I was very impressed with lucerne. It was widely used to finish lambs as part of a mixed sward, it has a very deep tap root and again fixes large amounts of nitrogen, around 250kgs/Ha, it grows well in soils with a PH anywhere between 6-8, but in its establishment phase it requires trace elements in the soil. On the farms I visited they were able to grow anywhere from 10T/DM/Ha to 17T/DM/Ha.

Lincoln University was also stressing the benefits of keeping lucerne in the diet once you had introduced it, because every time lambs came off it or went back onto it there was a blip in growth.

If lucerne is sown as a monoculture you have to supplement with sodium as there is no sodium in the plant. Lincoln University was also stressing the benefits of keeping lucerne in the diet once you had introduced it, because every time lambs came off it or went back onto it there was a blip in growth.

The main trial I witnessed at Lincoln involved grazing ewes and twins on mixed lucerne and grass swards. It was stocked at 10 ewes and 20 lambs per Ha and 300g/day live weight gain - or 6kgs/Ha/Day - was currently being achieved. The lucerne was planted along with deep rooting tall growing grasses like cocksfoot. In order that the grass didn't smother out the lucerne, the latter was planted first with the grass seed added a few weeks later. The re-growth time for lucerne is 10 days and an ideal rotation length is no shorter than 35 days. The plant grows from the crown so you can graze it down as tight as you want; the only issue is that nearly all the nutritional value is in the leaf and not the stalk.

Sanfoin. This was another legume that I came across and the farmer was very enthusiastic about it, not only because it was good at fixing nitrogen but also because of some of its other properties: it was good for honey bees, it is supposed to disrupt the life cycle of parasitic worms and the farmer claimed that if sanfoin was more than 20% of the sward it would prevent bloat.

I am not entirely sure about all of these claims but the gentleman in question was so convinced and enthusiastic about it, I nearly bought some off him to bring back home with me!!!

Cow Peas. This is a legume I came across at the A+M Beeville Research Centre in Texas. It is very heat and drought tolerant, you can have early and late varieties which make it very versatile, and it can mature in 60 days. I am not sure if it is available in the UK but it was certainly interesting.

Chicory. This is something I am an advocate of, partly because of its anthelmintic properties which help reduce internal parasites, and partly because of its deep tap root which helps with water, air filtration and soil structure.

It is also implanted in my brain because of a very memorable moment when an Irishman

lambasted me - when I dared to criticise chicory for its lack of persistency - for my "above ground thinking". He was very quick to demonstrate that even if it only lasts for three years in the sward its effect below the ground continues for much longer. He dug a hole and showed me how the root channels of the chicory allowed the grass plant roots to move in and grow far deeper than they would have otherwise. He pointed out that it also allowed easy movement for worms.

Having said all that he did agree that chicory didn't thrive under a set stocking system, but did well under a rotational grazing system, and provides the animals with minerals including copper and zinc.

Plantain. This is a mineral-rich grazing herb that is high in protein. It contains quite high levels of calcium, magnesium, phosphorous, sodium, zinc, copper and cobalt, and the animal's ability to retain copper, sodium and magnesium is higher when on plantain than when on grass. It was interesting to hear farmers claim that the plantain was often the first plant that animals grazed.

Plantain has a deep fibrous root system which puts a lot of tools in its tool box, and is particularly good at performing well in lower fertility soils. It also responds well to nitrogen.

5d. Brassicas

I am going to talk in general about brassicas because I have seen so many different kinds on my travels. If I wrote about them all I would be here for another 18 months!!

Most people use them as a break crop during their reseeding regime, planting them in some of the poorer performing paddocks, grazing them through the autumn/winter and reseeding to grass in the following spring.

Their feed value is very good with dry matters of 12-18%, ME of 10-13 and D (digestibility) values in excess of 75. They are very high in calcium so care needs to be taken regarding late pregnancy stock. They are very low in minerals and trace elements so supplementation is advised. It is not advisable to graze young cattle below about 200kgs because their rumen isn't sufficiently developed, and it is probably wise to avoid grazing with old ewes unless you have a good sheep dentist handy.

It is also worth spending time planning your grazing of the field, and also having an un-ploughed area or adjoining field to allow animals to loaf on solid ground. Graze the stock down a hill if possible, which will enable any run-off to be caught by the crop and not disappear somewhere it shouldn't. It may also be an idea to graze towards a road for visual reasons. Consider placing round bales of hay or silage in the crop as it is being grown so that the animals' ration was then available to them without further work on your part. This could also avoid having to drive tractors through stubble ground in the winter, which creates a mess and drags muck onto the road.

As a result of the intensive nature of grazing brassicas it is a good way of increasing nutrient levels in the soil, and is generally a fairly low cost option for out-wintering animals. I have found, speaking to a number of organic farmers, that establishing and growing a good crop of brassicas is quite tricky, and the opinion of the few farmers I spoke to was that it was probably a marginal crop to grow under an organic regime.

5e. Reseeding

This is a topic that I have been intrigued by, because again there is no straightforward answer to the frequent query of: how often

should I reseed? What I have decided is that there should be some key on-farm questions which, if answered will then guide you to hopefully a sensible answer.

Some people say that you should reseed 10% of the farm every year, which could well be correct for lots of farms, but I was recently on a farm where the bottom 10% of the paddocks were growing over 11T of dry matter; is he really going to get a big jump in performance from reseeding? On the other hand I am currently dealing with a farmer who took over a new farm a few years ago that had been set stocked for years with very little reseeding. He is slowly reseeding the farm and the reseeded paddocks are growing double the amount of the permanent paddocks.

Again the driving factor for reseeding is poor performance, so first you need to identify the poorer performing paddocks. Then, before you go racing into the field with shiny machines, take some time to get a spade and go and dig some holes and check compaction and soil structure. Send off some soil samples to see if the paddock is performing badly as a result of low PH or calcium, sulphur, phosphorous etc. Basically identify why the paddock is under-performing and then correct it. It may well be that it is purely an old, worn-out sward and it badly needs reseeding, but check the soil first and then you will know that your proposed course of action is the correct one.

It is obviously the ideal time to add fertility into the soil, whether that be organic manures or topping up the soil minerals, so make sure you use the opportunity to get the maximum benefit. Lots of farmers are like council roadmen, they reseed and then very quickly apply some manure, then they get the sub-soil machine out, then decide they need to drain the far corner. It is like laying a lovely new tarmac road and then a week later digging it up to alter the water main. So, whilst reseeding, get all other required work carried out.

One thing I am an advocate of is: where possible use minimum tillage as opposed to ploughing. In A+M university they have been carrying out trials and in ten years they have been able to double the organic matter in the soil just by moving to minimum tillage.

Every time you stick a plough in the ground the birds appear from nowhere and they gorge themselves on your priceless worms.

Also when you plough you break into the soil organic matter and this allows the evaporation of some of the nitrogen into the atmosphere. We know how environmentally bad that is and how valuable the nitrogen in the soil is, so ploughing should be avoided if possible. Also another negative aspect of ploughing is the sheer number of worms that get taken from the field. Every time you stick a plough in the ground the birds appear from nowhere and they gorge themselves on your priceless worms. Finally if you have shallow topsoil you want to keep it at the top not bury it six inches below the surface.

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6. Practical grassland management

6a. Chapter summary

The one message that came shining through like a beacon during my studies is that rotational grazing works; it works both above the surface and below the surface. In this chapter I am going to outline the general fundamental rules of rotational grazing, and also highlight different management techniques for the different sectors, namely beef, sheep and dairy.

6b. Understand the plant

Before you can manage grass you have to understand how it grows. I will try to make the process understandable and simple, although it is in fact far more complicated than this; but so long as farmers understand the basics that is all they need to know to make it happen.

The first thing you need to understand is that the ryegrass plant only ever has three live leaves. As the fourth leaf appears the first one starts dying, which means you are then beginning to waste grass and lower the quality of your grass. The next thing to understand is how it grows. Once you have eaten off the grass it then uses up its store of sugars to push up the first leaf. This process is visible to the eye within 48 hours, so in an ideal world animals should not have access to the same patch of grass any longer than 48 hours: for once this first leaf has appeared the sugar store has been severely depleted, and the plant relies on the first leaf to act as a solar panel for photosynthesis to grow the second and third leaf, as well as for replenishing the sugar levels in readiness for the next cycle. Also on a dry matter basis around 75-80% of the total dry matter of a three leaf plant is in the second and third leaf.

6c. Rotational grazing

When you consider that last sentence you can begin to understand why rotational grazing works. You graze the plant down to golf ball height, and then rest it and allow it to grow back to its prime three leaf stage before grazing it off again. This allows the plant to grow to its potential and allows it to go through its full natural cycle of growth and replenishment. When you compare this to a set stocking system, here you have the first leaf appear all full of lovely sugars, then the stock come along like children in a sweet shop and immediately eat it. Now this is problematical for the plant because once that leaf has been eaten, the sugar store has been almost emptied and there is only a tiny little bit of green shoot left to act as your solar panel to fuel your regrowth. You are also only allowing the plant to offer you a tiny amount of its dry matter potential, because with set stocking you never see the second leaf, let alone the third.

In my experience once farmers start rotational grazing they are amazed at just how much quality grass they can actually grow.

Another massive benefit of rotational grazing is the impact it can have on soil fertility. When grass grows you have a sort of mirror effect happening, for as the grass grows above the ground so the roots also grow below the ground, and once you graze the grass above the surface a similar proportion of the roots

die off below the surface. This root death provides a veritable feast for all of the soil inhabitants and a proportion of it gets turned into soil carbon. There is six times as much carbon in grass roots as there is in surface plant litter. Again under set stocking this root mass never gets to grow, so the amount of root die-back is minimal and there is less product for the soil inhabitants to work on, and subsequently less soil carbon produced.

.... as the grass grows above the ground so the roots also grow below the ground, and once you graze the grass above the surface a similar proportion of the roots die off below the surface.

The ability of rotational grazing to build soil fertility was highlighted in full 3D HD super colour vision in Texas. I visited two farms on the same day that were only a few miles apart. One of them was, as I had expected in Texas, almost desert-like and the other was covered in a lovely blanket of green vegetation. The first farm basically ranched the cattle just leaving them to roam over a huge area, whereas the second farm restricted their grazing area and moved them every few days. What was interesting was that not that long ago this second farm apparently looked like its neighbour, but after a number of years controlling the grazing and, more importantly, concentrating the nutrient loading, the soil is now far more fertile with greater numbers of worms and the ability to hold onto whatever rains come along.

6d. Residuals

The residual is the amount of grass you leave in the paddock after grazing; this is one of the single most important aspects of rotational grazing. It is the residual that determines the quality of the next grazing. If you leave a paddock with too much grass in it (more than 2 inches, whereas the ideal is 1.5) this grass will still be there at the next grazing providing a low quality, low digestibility feed that the cows will probably refuse to eat. This then means that in the grazing after that there is even more of this low digestibility feed.

This is the main reason that lots of farmers have lost faith in the ability of grass to provide a top quality feed, but it is nothing to do with the grass itself, it is all to do with the *management* of the grass. There are many farmers in the UK who have grass from March to October that never drops below 11.5ME and they can grow 12T to the hectare and utilise 10T of that. At £250T of dry matter that is £2,500 per hectare of feed grown.

6e. Grazing pressure

The main reason that lots of farmers struggle with grass quality is because of a lack of grazing pressure. It is the grazing pressure that allows you to get good residuals to maintain quality in the pasture. Think of it like Christmas dinner; you sit down with a big plate of food and you eat all your favourite food first and then at the end if you aren't completely full you consider eating the sprouts!!! Animals are no different. If you give them a large area to graze they eat all the nicest grass first and then leave the grass that isn't quite as tasty, knowing you will give them some more nice grass shortly. So it is vital that you restrict the area they have available so they always eat the "sprouts".

6f. Paddock residency

As stated earlier, in an ideal world you shouldn't let animals have access to the same

area of ground for more than 48 hours, because after this re-growth will be compromised. It is also a key to help avoid sward damage because once stock are moved it allows a rest period for the ground, enabling it to recover.

6g. Grass measuring

This is an area that in the UK is woefully overlooked.

If you don't know what you have got how can you possibly make best use of it? If you can reduce your purchased feed by 1kg/cow/day or carry 5 more sheep on the same area just by measuring your grass regularly, why would you ignore it?

6h. Dairy management

Dairy farmers have one big advantage over the other livestock sectors when it comes to grassland management, purely because they are, by default, moving their cows twice a day which allows rotational grazing to be managed more effectively. But it isn't all good news because as a result of all this movement, it is essential that dairy farmers have very good infrastructure: specifically tracks, troughs, paddocks and multiple entrances. You will not be able to graze successfully in poor weather or on the shoulders of the season if you haven't got good infrastructure. This infrastructure allows you to carry on grazing when otherwise you would have the cows housed. In fact this is where a lot of the cost savings are made, so money spent on infrastructure should be seen as an investment and not a cost.

The number one factor in feeding a dairy cow is ensuring that every feed that is part of the diet is a quality feed, and that includes the grass element.

When managed well with a major focus on measuring, residuals and residency grass has the potential to be as high if not higher quality feed than the other feeds in the diet, but can be fed at a fraction of the cost. Research at Moorepark in Ireland has shown that on a quality adjusted dry matter basis the ratio of cost between grass, conserved forage and concentrates is 1:2.5:4. So you can feed 4kgs of grass for the same cost as 1 kg of concentrate. Now before people start getting excited and hot under the collar, I am not against feeding forage and concentrates, all I am saying is: don't feed them at the expense of quality grass. Why would you choose to replace a cheap feed source with a more expensive one? Utilise the cheap food first and then top stock up with the more expensive feed.

The other misconception is that if you want to do a good job of grazing you have to go down the so-called "NZ route". This is of course nonsense. I know numerous farms ranging from 3,500 litres milking once a day, to farms averaging 8,500 litres milking Holsteins, that all do a great job of grassland management and utilising their pasture.

> *It is the mind-set of the farmer that makes it happen, not the production system.*

It is the mind-set of the farmer that makes it happen, not the production system. Put a plan in place to allow early turnout, don't be afraid to graze the silage ground, get your heifers out grazing grass as soon as practical, plan your grazing in late summer to allow you to graze late into the autumn: all of these things can be done and can make a significant impact on costs, but they can only happen if there is a desire to do so.

When you do graze the cows make sure it is high quality; turn them into fields when the

grass is about 5-6 inches (12cm) high and graze it down to about 1.5 inches (3.5cm). Allow the fields to recover until they are back to their pre-grazing height and then graze them again. It is important to do your measuring because you need to know what quantity of dry matter cows are eating out in the field, to enable you to adjust the diet back at the yard.

> My study has confirmed my long-held belief that quality grass can and should play a significant role in almost any dairy production system.

6i. Beef systems

One of the driving forces for me doing my study was to look at grassland management for beef and sheep farms. As a result of my experience with dairy farms I was always confused as to why rotational grazing isn't widespread within these sectors too, especially when historically beef cattle and sheep spend far more of their time in a field than dairy cows do.

It has been no surprise to me that the various farms I visited on my travels that were using rotational grazing were getting good results, but the systems employed differed widely.

In Texas the grass fed beef farms were rotationally grazing, but they were on average using 90-day rotations, so the fields were only grazed four times in a year. As a result their stocking rate was low but the grazing pressure was high on the individual paddocks. However because of the climate and the soils, they didn't want to get tight residuals. They were happy to only graze 65% of the grass and leave the rest behind or trample it into the ground. This reduced the effect of wind erosion, it protected the soil from the baking sun and the trampled grass enabled the build-up of organic matter in the soil which subsequently assisted the moisture retention within the soil. The low stocking rate wasn't too much of an issue as a result of the sheer size of the farms and the premium price obtained for grass fed beef.

It was interesting that 10% of Texans won't buy feedlot beef due to their dislike of the use of hormone implants, and at the moment the grass fed beef producers and the organic producers can only supply 3% of the market. This means there is a 7% share of the Texan beef market waiting for suitable product. When you consider that this market is for frozen meat why couldn't UK farmers supply grass fed beef and organic beef to Texas?

The extreme opposite of this was the Techno Cell beef systems that I saw in NZ. This is a system of finishing beef cattle by grazing them in very small areas for two days at a time. I went to see one of the longest serving practitioners of this system who was finishing Friesian bulls 1,300ft above sea level on a quite exposed hill near Canterbury. The whole system was set up with electric wires and water troughs. There were no gates anywhere; with a quad fitted with an alkathene pipe below it, you could just drive over the electric fences.

In mid-late autumn (around May in NZ), the cattle had entered this Cell system at about 20 months of age and for the first three months they were purely eating a maintenance ration of grass due to there being very little grass growth. But in the spring when the grass growth took off there was massive compensatory growth, resulting in a regular peak of over 2kgs of weight gain per day. The cattle would stay in the Cell system until finished in mid-summer (Dec/Jan). During their entire time in the Techno Cell system the cattle were

comfortably averaging 1kg per day of growth, purely on quality grazed grass.

One thing I must highlight about this farm is that only part of it was set up for this Techno grazing, the rest of the farm was being grazed in large blocks by Friesian bulls. These other bulls also finished at the same time as the bulls in the Techno system, and achieved very similar weight gain and conformation as the bulls in the Techno system, but the big difference was in numbers finished. On the Techno system stocking was at 3 bulls/Ha; in the large paddocks stocking was only at 1 bull/Ha. So three times as much beef was produced per Ha under the Techno system.

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By far and away the most common grazing approach that I saw working well in the beef sector was what I dubbed the "four day" system. The farmers worked out how large an area was needed per day for their cattle. They then worked out how large an area was needed for four days, and set up seven of these four day paddocks, and just moved the cattle to a fresh paddock every four days creating a 28 day rotation. On the best performing farms grass was being measured every week and stock numbers adjusted to suit the growth. The four day paddocks were also split in half with a wire to stick to the 48 hour rule.

This was a simple grazing system that lots of UK beef farmers could adopt and improve the performance from both grass and cattle. It is also good for stockmanship, because every 2 or 4 days you are physically moving the cattle and you can see any problems far better than whizzing past on the quad every couple of days. One farmer mentioned to me that he always made a note of the last six cattle through a gateway, as they were the ones most likely to have problems!!

In trials in Ireland comparisons were made between one lot of calves that were weaned in November and kept inside until they were finished the following summer, and a second lot that were wintered inside, let out for 100 days in the early Spring on top quality grass before being re-housed in June and finished inside thereafter. In this trial the first group of cattle just about broke even, but the second group of cattle made a profit, and this profit could be directly linked to the weight that was gained during the 100 days at grass. To ensure this sort of finishing quality on grass, target grazing at 5 inches and graze down to 1.5 inches. This would mean cattle were grazing highly nutritional grass with very little stem

6j. Sheep systems

This was the sector that was definitely the most interesting to look at because there seemed to be a Northern Hemisphere/Southern Hemisphere divide in the mentality. Up here in Wales the industry is quite accepting of the need to use creep feed to finish lambs, and it has become a widespread practice. Down under it is considered that resorting to creep feed is an admission of failure.

What was interesting was that in Ireland, UK and particularly in NZ there are sheep farmers doing a very good job of rotational grazing of sheep, but in the UK and Ireland there aren't many of them. The sheep systems I saw were broadly similar to the four day system I spoke about with the beef sector. The main difference is the height at which you start and finish grazing, with sheep target grazing at about 3-4 inches and grazing down to about 1.25 inches.

In NZ I saw a few farms where daily live weight gains of 300g were being obtained by lambs purely from grass whilst still on the ewe, and similar results were expected once they were weaned; but lots of the farms were targeting selling 45% of the lambs straight off the ewe. It was interesting the way they had a switch of focus between lambs and ewes. Once the lambs were weaned they were given priority when it came to grass quality to enable them to be finished as quickly as possible; but when it came to late summer the priority was switched to the ewes to ensure they were hitting the correct body weights and BCS to ensure a successful tupping season, and the lambs became of secondary importance.

What was noticeable on the NZ farms and on a few Irish farms was the stocking rates, and this all fits in with my earlier section about grazing pressure, residuals and allowing re-growth. It was common to be stocked at 10 ewes per Ha which would mean that a 100 acre farm would carry around 400 ewes. This sounds an awful lot, but if they were 70kg ewes demand would only be about 14kgs/DM/Day. Lots of farms in the UK could grow that for 9 months of the year, but only under a rotational grazing system.

Sheep farmers need to look at the possible benefits of rotational grazing and believe in the value of grass. On one sheep farm I deal with, the grass in April was over 20% protein and 11.5ME. You would struggle to buy that in a bag, and if you did it would be considerably more expensive than your grass. One important thing to remember is that, whatever your system, you need to graze grass to grow grass, but you need to rest the grass to grow more grass.

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7. Cost of production

Along with focussing on what goes on below the ground, the importance of cost of production (COP) was the other absolutely crystal clear message that came back to me, time after time, from all the best farmers I visited. It didn't matter if they were dairy, beef or sheep men, they all knew what their COP was.

In essence every farm is a manufacturing business. Whether it is meat, milk, cereals or whatever, farmers produce a product to sell on to someone else. If you were starting up a manufacturing business making teddy bears, and you knew that in the past five years the price for teddy bears was £5, you would need to make sure you could produce them for less than £5 to survive. You can only do this if you have a complete understanding of your COP.

Research from many countries has proved that your COP explains over 70% of your profitability, so why do so few farmers seem to actually know their true COP? Farmers will quickly tell you how much milk they have sold or how many lambs they have marketed, but not enough of them know what it has actually cost them to achieve it.

Research from many countries has proved that your COP explains over 70% of your profitability, so why do so few farmers seem to actually know their true COP?

Are you better off selling lambs for £70 with a COP of £50, or are you better selling them at £50 with a COP of £20? One of them is better for bragging rights at the pub, the other is better for paying for the *drinks* at the pub.

Making better use of your grass can help lower your COP, every kg of other feed that you can replace with quality grazed grass can save you money. If moving from set stocking to rotational grazing allows you to grow more grass, it can help your COP. If your infrastructure and management allows you to lengthen your grazing season it, too, can help lower your COP.

Obviously turning all your animals out on to quality grass is not going to make all your issues and problems disappear, but it can play a significant role in creating a more robust business for the future.

"It isn't turnover, it's left over".

7a. Benchmarking

A key element in knowing your COP and driving your business forward is benchmarking, I know there are a lot of farmers in the UK who *do* make use of benchmarking, but it's probably a relatively small percentage overall.

Knowing how much your purchased feed cost amounts to per kg of live weight sold; knowing what your vet bill is per Ha; knowing what your labour cost is per Ha; knowing your contractor costs per Ha …… you can go on for ever, but the top farmers that I have met know these figures because they need to know the answers to be profitable.

I visited one farm in NZ who was able to tell me how many cents profit he had made per kg of dry matter fed. It is farmers like these whom we are competing against, not the next door neighbour. Farmers need to become far more professional and business minded in their approach if they want to compete in a global market in the future.

7b. Discussion groups

I am a big fan of discussion groups. They are the ideal vehicle for benchmarking and identifying best practice. Every time you go to a meeting you will learn something that will make your business better. It may be something physical that you need to change within your farming system, or it may just be a different way of thinking about something. It doesn't matter but if you hadn't gone to the meeting that change would not have taken place.

Also, farming being in most instances a solitary profession, you can sometimes come up with a fantastic idea that is going to transform your business, but if you are part of a discussion group you can first explain this fantastic idea to the group and they could be absolutely in awe of your genius; or, someone might say *"I tried that two years ago and it didn't work*". Either way it doesn't matter, if you get the first response you feel great and you will have helped the other group members, if it is the second response they have probably saved you a lot of time and possibly a lot of money.

The keys to a successful discussion group are the need to be open, the need for honesty, a good facilitator and variety. Don't just go wandering around your own farms, go and visit other good farmers. Don't restrict visits to agriculture; identify a successful local business and go and see them, find out why they are so good at what they do and what makes them tick. First and foremost you are running a business; it just happens to be a farming business – learn from other industries.

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8. General observations

I wanted to write a short chapter on some of the observations I made during my travels which aren't directly related to my topic.

It was very interesting to see that wherever you went there were environmental issues - NVZ, soil erosion, water quality and availability, methane emissions, sprays etc. In a strange way it was almost comforting, because when you are caught up in the goings-on in your own business and your own country, it is easy to think that we are the only people with all these issues when, in actual fact, we are no worse off than lots of other countries, and better than some.

Lack of succession planning is a big threat to our industry but it is a silent threat.

Another major issue is succession planning. Lack of succession planning is a big threat to our industry but it is a silent threat. It creates huge tension within farming families and it is something that can have a devastating impact on some farming businesses. There are professional people available to help deal with these issues before they become a major problem. I would advise anybody with children to sit down with them and a professional, and sort out all the issues when the children are in their early twenties, if not before.

Quite often a major obstacle to development is the father or even grandfather not handing over the reins to the next generation until the latter are in their late forties or fifties, by which time their drive and enthusiasm has been all but extinguished. Heirs need to take over while they have the energy and fire in their belly to drive the business forward.

Something that was also very noticeable on my trips was the political effect of farming. I have always said that in this country farming will forever be in the political background because of its lack of votes. We live in a country where a political party could lose every single agricultural vote and still win the election by a landslide, and it was interesting to see that it was the same story in Texas. This was further highlighted by the fact that the only person or organisation that didn't reply to my initial contact regarding a possible meeting concerning my Nuffield study was DEFRA. Unfortunately we live in a country of political indifference towards agriculture.

You then contrast this with the situation in NZ and Ireland where no party would get anywhere near the halls of power without the agricultural vote, and it is very different. Their politicians seem to be falling over themselves to help the agricultural industries, and to be seen as good allies. In stark contrast to the UK, I was given a great reception by David Carter and his team at the parliament building in Wellington.

Also, when I was in Ireland I was talking to a friend who told me that at the last general election the prospective parliamentary candidate had gone to speak to his local YFC. I doubt if UK politicians would even know the YFC existed.

It is because of this political situation that the UK farming industry needs to do more to connect with the public, rather than seeing it as a necessary evil. As soon as there is some sort of scandal or crisis we immediately want the public on side because, on our own, farmers are too small a voice, and in general the public in such situations is very supportive. But as soon as the problem is

solved the charm offensive stops and we are back to normal.

What do farmers do for the rest of the year to connect with non-farming people? Whether we like it or not we need the public as much as they need us. We also need new blood into the industry, and this is another reason to make our industry accessible and appealing as a potential career for bright young students.

Agriculture is a fantastic industry, and the UK is a fantastic place to be a farmer – spread the word.

The one thing that was a constant with all the best farmers I visited was their management. I am convinced that any form of farming can be a success provided the management is effective.

Success isn't about systems, it is about people and management.

Success isn't about systems, it is about people and management.

9. Conclusions from my study tour

1. Soil fertility is fundamental to growing crops successfully and sustainably
2. Rotational grazing works
3. Cost of production is the key to profitability
4. Knowledge transfer is vital for the industry
5. Quality management and forward planning are essential to success

10. Recommendations

1. All farmers, whether they are livestock or arable farmers, should investigate their soils on a regular basis. There should be a regimented comprehensive soil sampling and visual assessment protocol on every farm. I would recommend soil testing the lowest yielding fields on the farm, or a minimum of 10% of the fields annually. I would also suggest doing visual assessments on at least 20% of the fields annually.

2. If you graze animals you should do so on a rotational basis. This will allow the plant to regenerate to offer maximum dry matter. It will help build up carbon in the soil, it concentrates nutrient loading and it will enable you to grow more grass.

3. Every farm is a manufacturing business, it manufactures food for sale. If manufacturers are to compete in a global industry they have to be competitive and profitable. The single biggest factor in profitability is Cost of Production. How can any farm start to be competitive or profitable if it doesn't know its cost of production?

4. The sharing of knowledge within the industry is vital, especially the intergenerational knowledge transfer. This can be accelerated by the setting up, or joining of, a discussion group. This aspect has been clearly identified in Ireland where farmers are actively encouraged by government bodies to join discussion groups. Whilst in these groups the most progressive farmers have an extensive benchmarking system, to enable them to become more efficient and to identify best practice.

5. The most successful farms I have visited all have clearly defined goals and targets that all family members or staff are party to. They have five and ten year goals to focus their operations, but they also have lifestyle goals and most importantly a succession plan. I see the battle of the generations as a major obstacle to future success in the UK farming industry. There are professionals out there who specialise in this area; seek them out and use them. Staff management is also a skill that most farmers need to concentrate on. It doesn't come naturally, so again go and seek out people to help you. I would strongly suggest looking outside the agricultural sector.

11. The experience

I have to admit that, even having gained all the experience and knowledge that I have documented, the true highlight and my abiding memory of the whole Nuffield experience has been of the incredible people I have met and the sheer privilege that it has been to meet them.

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It started in the Netherlands on the CSC and the first of these memorable people was Herman Snijders, the Minister for Economic Affairs, Agriculture and Innovation. He was a fantastic speaker and the proof of that was the fact he gave a thoroughly captivating entertaining speech about CAP reform!!

The next on my list was Robin Baan the owner of Koppert Cress. This man had a mind as sharp as the sharpest pin you could ever find, and he completely understood marketing and the need to connect with customers. But what he was also very good at was surrounding himself with fantastic staff. He also made the claim that somewhere in the world there would be a drought and disease tolerant wheat, you just needed to find it!!!

Next on my list was a speech given by Angus Davison, an awe inspiring speech that I am sure will live for a long time with those who heard it.

It was then off to Texas where I met Dr Russell Jessup. He was a fantastic lad, so passionate and enthusiastic, who didn't mind going the extra mile for his students, as well as being more than happy to challenge conventional thinking, but another remarkable man.

Next I had the absolute privilege of spending a day at the farm of Ben and Alysha Godfrey with Dr Jessup. This was a fantastic day. The Godfreys had a herd of grass fed Jerseys milked once a day, they had a farm shop selling cheese, yoghurt, milk, cream, butter, honey and a whole host of other things, they had aquaponics growing seedlings for local nurseries, they had hydroponics growing grass for his cows, and in amongst all this forward thinking, cutting edge technology, were their horse drawn implements and two Percheron horses used for all their field work! It was a mind blowing mix of ancient and modern.

Steve Fergusson was next up and the funny thing was I only went there because I had taken a wrong turn!!! But what a wrong turn, this man had a normal ranch but his sideline was breeding rodeo bulls. I had a fascinating insight into the world of rodeos and breeding psychotic bulls!!

Off now to NZ and a man called Dr Alec Mackay of Agresearch in Palmerston North. He had one of the most laterally thinking minds I think I have ever come across. He would look at things from a completely different angle and didn't worry if he stirred up a hornets' nest. I would like to think that my time with him has made me a little broader minded.

Then there was the guru of trees, Dennis Hocking. Dennis was a fantastic gentleman who terrified me with his intellect, but it was

his passion for trees and his willingness to challenge the current methods and thought processes that really inspired me. Awesome!!

I also met Harry Weir, the founder of the Techno grazing system for beef cattle. He was an incredibly clever, practical man seemingly able to make anything he wanted. Again it was the sheer passion and absolute belief in what he was doing that really shone through and impressed me.

Finally I spent some time with Russell Snodgrass. He was the person I had been waiting to meet. He had a lot of the pieces I was missing in my personal jigsaw, and he had the ability to dissect what was going on and come up with practical solutions he had every confidence in.

My thought processes have been influenced by all of these experiences and more – **Thank you.**

12. Post Nuffield

I am certainly not the first Scholar, and I would be amazed if I were the last Scholar, who has used the whole experience of Nuffield to launch their own business. Since returning from my travels I have started up my own grazing advisory business, to try to influence as many farmers as possible in the benefits of grazing. With the cost of feed, fuel and fertiliser, and with ever more volatile global feed markets, I felt that this is probably as good a time as any for me to set up my own company, and try to help people regain an element of control over their cost of production.

Already I see the benefits of having had a Nuffield Farming Scholarship, because a lot of external organisations know the standards set by the NFST and it immediately gives them confidence that, in me, they aren't dealing with a complete numpty. I genuinely feel that the knowledge and confidence gained doing my Nuffield Farming Scholarship is going to make a big difference to my business

Gareth Davies

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13. Thanks

I would like to thank all the following for their time, support, help and knowledge over the past eighteen months. I apologise in advance for those whom I have omitted. But firstly I must thank my wife Alison, daughter Hannah and son Dewi, for all their support throughout my study, as well as my mother, father, brother, sister, mother-in-law and Mick.

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I would like to dedicate this report to two people who had a big influence on me and my career:

David Roberts and Laura Gravell, each sadly missed but not forgotten

14. Executive summary

I make no apologies for being an unashamed grazing enthusiast, and it was this enthusiasm and a sense of frustration that prompted me to undertake a Nuffield Farming Scholarship. The frustration I had was that I was absolutely convinced that grazed grass can be a feed of great quality, and that in much of the UK we can grow large quantities of it. So why do so few farmers focus on and actually make best use of it?

To gather evidence to test my viewpoint on the potential of quality grass, I visited a couple of the obvious countries – Ireland and New Zealand, and the not so obvious Texas. I went to Texas to look at the work that A+M University were doing on plant varieties and soil fertility, and also to visit some of the "Grass Fed Beef" producers, as I was intrigued to see how this in action in this hot, arid State.

On my travels probably the three most important messages were soil fertility, rotational grazing and cost of production. The cost of production has without doubt the biggest impact on profitability, yet so few farmers have a true grasp of their actual cost of production.

However the sub topic that made the biggest impact on me was that of soil fertility and the vital role that it plays in growing quality crops. Too many farmers nowadays seem to regard the soil as somewhere the plants hang around in, waiting for their next "fix" of feed from above, yet I saw many farmers growing excellent crops using little or no artificial feeds. They concentrated on improving everything *below* the surface. This often started with a full soil analysis to see what was actually going on, and then where possible adding natural products to re-balance the soil.

Monitoring the life *in* the soil was also a key aspect of success as low soil life meant poorer soils and poorer crops. I went to one farmer who only used a little Nitrogen in the spring and I counted 40 worms in a spade full of earth; and he grew 17T/DM/Ha.

The other take home message was that rotational grazing works. It helps build soil carbon, it allows the plant time to grow large quantities of DM, allows greater control and is generally able to carry higher stocking rates.

Quality grazed grass has a key role on all UK livestock farms – **GET GRAZING!!!**

15. Appendix 1 : Elements and their role

Element	Role
PH	Regulates the availability of nutrients to the plant, has major impact on bacteria and fungal activity. 6.2 -6.8 is ideal*
Boron	Seed development, production of sugar and carbohydrates, nutrient usage and regulates other nutrients
Calcium	Essential for cell formation, cell strength, regulates PH, helps transport nutrients in the cells, stimulates microbial activity
Copper	Reproductive growth, aids root metabolism, helps utilise proteins
Iron	Needed for chlorophyll and photosynthesis, required for respiration and by N fixing bacteria
Magnesium	Essential for photosynthesis, sugar and protein production, and energy release
Manganese	Involved in the breakdown of carbohydrates and the metabolism of N
Molybdenum	Needed for effective usage of N especially with legumes as they cannot fix N without it
Nitrogen	Vital for growth, part of all living cells, helps form protein, key ingredient for photosynthesis. Very leachable.
Phosphorus	Vital for photosynthesis, rapid root and shoot growth, transfers solar energy into chemical energy
Potassium	Second only to N in quantity absorbed by plants, helps build protein and sugar. Strong stalks, hardiness and resistance
Sodium	This has a role in the production of sugars in the plant, and palatability
Sulphur	Production of quality protein, root growth and seed formation, needed for N fixing root nodule bacteria
Zinc	Transformation of carbohydrates, helps regulate the consumption of sugar, part of enzyme system that regulates plant growth