A Nuffield Farming Scholarships Trust Report

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BEMB R & E Trust

Improving bird welfare on free-range systems

Gordon Whiteford

July 2016

NUFFIELD UK

NUFFIELD FARMING SCHOLARSHIPS TRUST (UK)

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A Nuffield (UK) Farming Scholarships Trust Report

Date of report: July 2016

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

Title	**Improving bird welfare on free-range systems**
Scholar	Gordon Whiteford
Sponsor	The British Egg Marketing Board (BEMB) Research and Educational Trust
Objectives of Study Tour	• To determine the future direction of the free-range industry going forward. • How can we improve welfare given the trend for large free-range units and the challenges around our climate? • How to take my own farm forward at home
Countries Visited	The Netherlands, Germany, USA, Kenya, South Africa, Denmark
Messages	• More focus on a higher welfare barn egg with natural daylight. • Reconsider industry stance on beak trimming to protect our domestic market. • Security in diversity, building healthy resilient mixed farming systems. • Focus on biological farming and nurturing the soil. • Industry should consider stance on genetically modified soya and look towards other protein sources.

Contents

Table of figures

DISCLAIMER

The opinions expressed in this report are my own and not necessarily those of the Nuffield Farming Scholarships Trust, or of my sponsor, or of any other sponsoring body.

CONTACT DETAILS

Gordon Whiteford

Lower Mill of Tynet Farm
Clochan
Buckie
Moray
Scotland, UK
AB56 5HJ

Gordon@highlandeggs.co.uk

07919 443336

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
www.nuffieldscholar.org

1.0. Executive summary

The UK egg market has gone from 1% free-range in 1981 to approximately 50% today, as a result of a drive from the consumer to increase bird welfare, with battery style cages being banned across Europe in 2012. This rapid increase in free-range has seen the intensification of free-range units, whilst the British weather gets increasingly unpredictable.

The purpose of this report was to determine how welfare could be improved in free-range systems and determine the future direction of the industry. As a new entrant into the industry in 2005 and starting a farming career from scratch, I was also looking for direction for my own farm. I visited The Netherlands, Germany, Denmark, USA, Kenya and South Africa.

A visit to the Rondeel system in The Netherlands demonstrated how barn eggs could be the way forward for the industry, bringing the outdoors inside. Whilst barn eggs are predominantly misunderstood by the consumer in the UK, free-range and organic standards are very different across the globe. Aligning organic standards closer to Europe's would also improve welfare and make the organic sector more competitive.

The UK has an efficient laying industry especially in terms of labour; however this ultimately drives prices down and free-range eggs are becoming more of a commodity. Despite efficiencies in labour, other efficiencies may be lost due to economies of scale, which can see nutrients leaving the farm for no value. The real cost of cheap food is paid for through our health, the environment and animal welfare. The UK egg industry has benefited from the lion code of practice, which has protected our domestic market from imports. However, the UK risk falling behind our European neighbours in terms of beak trimming. Scandinavian countries such as Denmark pride themselves in good animal welfare and are successfully farming with birds with intact beaks.

The biggest improvement to free-range management would be to improve range management. This means improving the soil structure so rain infiltrates better: growing a living root and keeping residue on top is paramount. The soil is fundamentally the most important aspect of agriculture.

Farming systems need to be more diverse to be sustainable, with a move away from chemical agriculture and a bigger focus on biology including embracing biological controls. Biotechnology is a short term fix. There needs to be a bigger focus on supporting home grown protein and less on imported environmentally damaging monocultured crops such as soya.

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2.0. Introduction

I am a first generation farmer on the Fochabers Estate in Moray, Scotland. I am 35 years old and farm with my wife, June, and we have a three month old son, Alexander.

I was brought up on a dairy farm in Ayrshire until the age of ten when my father left the farming partnership to pursue a career as a Church of Scotland minister. This was a major culture shock, moving from country life to town life. In hindsight this was the best thing which could have happened as the alternative would have seen me working with my uncle and cousin, a recipe for disaster. Instead, this fuelled my ambition to be a farmer in my own right.

I studied for an HND in Agriculture at SAC Auchincruive and later for a post graduate Diploma in Farm Business, Organisation and Management at SAC Craibstone. I then spent three years working as Farm Coordinator on a mixed organic dairy farm and thought my future would be in farm management. However, with a burning ambition to be my own boss, in 2005 I saw the opportunity to go into organic egg production. I rented a 3Ha field at Ardersier and sourced 3000 layers to supply Glenrath Farms. The bank, at this time, was unsupportive as I had no security to my name. I pressed on and sought funding through The Prince's Scottish Youth Business Trust, local grants, hire purchase and even credit cards to finance the venture. In 2010 I started packing and distributing my own eggs due to the downturn in the organic market. I was then fortunate to gain a 52Ha farm tenancy in 2012 and in the same year was runner up for the Farmers Weekly Poultry Farmer of the Year award.

Figure 1: The author, Gordon Whiteford

3.0. Background to study

In 2005 I went into egg production as a route into farming rather than because of any particular aspiration to keep poultry. I did not have any experience of the poultry industry. This is a decision which I have never regretted, and one I believe could help others into farming as it offers good cash flow and profitability, and can be achieved on a relatively small area of ground.

That said, it has been a steep learning curve. My second flock of birds, which were not beak trimmed - in line with organic standards - had a bad cannibalism outbreak. As a consequence of this they had to be emergency beak trimmed. I can therefore fully understand the emotion behind farmers wishing to keep this practice. However, I do believe this unfortunate experience vastly improved my management thereafter.

Is free-range in actual fact higher welfare for the birds than a caged system, or have we brain washed the consumer into thinking free-range is the best?

My subject topic came about after being disillusioned by free-range, in a country with average annual rainfall from 600 to 1250 mm and with increasingly extreme weather patterns. Pictures of free-range often show lush green fields, but in winter - and even summer - heavy rain can quickly change this image, as the following photos display. This led me to ask the question: whether free-range is in actual fact higher welfare for the birds than a caged system, or have we brain washed the consumer into thinking free-range is the best? As one professor put it to me: "Free-range has the potential to be the highest welfare system". Hence my subject topic: "Improving bird welfare in free-range systems".

Figure 2: house 2, home farm, summer 2016

Figure 3 house 1, home farm, winter 2015

3.0 Where I went and why

I started my Nuffield Farming journey by going to The **Netherlands** in March 2015, where they have approximately 35 million laying hens, similar to the UK. The industry is focused on welfare as it exports a lot of eggs to Germany, and consequently carries out a lot of research. It is also home to several poultry equipment manufacturers such as Vencomatic, who were also behind the innovative Rondeel system.

In July 2015 I spent 3 weeks travelling across **The States**. Unfortunately at the same time the country was experiencing the worst outbreak of avian influenza in history. This was to change my visit plan as it would not be possible, for biosecurity reasons, to gain entry onto poultry farms. It did give me the opportunity to look at the soil, a topic which became more relevant to my study subject than at first appeared.

In January 2016 I travelled with fellow Nuffield Farming Scholar Andrew Howard to **Kenya** and **South Africa** for 3 weeks. Andrew's topic is looking at companion cropping, something which we are doing at home to grow more home grown protein. Initially we had the same contact in Kenya looking at biological controls. Many farms which we were to visit were mixed operations and so our combined knowledge of crops and livestock complemented each other on visits.

if I could improve just one area, what would make the biggest improvement to hen welfare for the industry? The answer to this would have to be range.

I then spent a week in **Denmark** in July 2016. Denmark has already banned beak trimming and is predominately a white egg market. They have in recent years seen a rapid increase in the demand for organic eggs, which accounts for over 25% of production. Scandinavian countries have traditionally focused on the environment and high welfare.

The scope of my subject topic is potentially huge, as there are many aspects which will affect welfare. This was in part deliberate as I didn't want to narrow down my subject. It did however make me ask the question: if I could improve just one area, what would make the biggest improvement to hen welfare for the industry? The answer to this would have to be range management - and this is the direction my research was to take me.

4.0. Farming welfare defined

The modern domesticated hen (*Gallus gallus domesticus*) is thought to be a descendant of the Asian Red Junglefowl, domesticated approximately 4-5000 years ago. This is relevant as modern hybrids still show natural instincts such as foraging, dustbathing and perching. In order for me to research improving welfare, it was important to first define its meaning. This of course has legislative consequences, which would be different across the globe.

4.1. WSPA

The World Society for the Protection of Animals outlines three states of animal welfare as the diagram below shows. Mental state is much more difficult to assess and traditional definitions of welfare are likely to be focused mainly on physical needs.

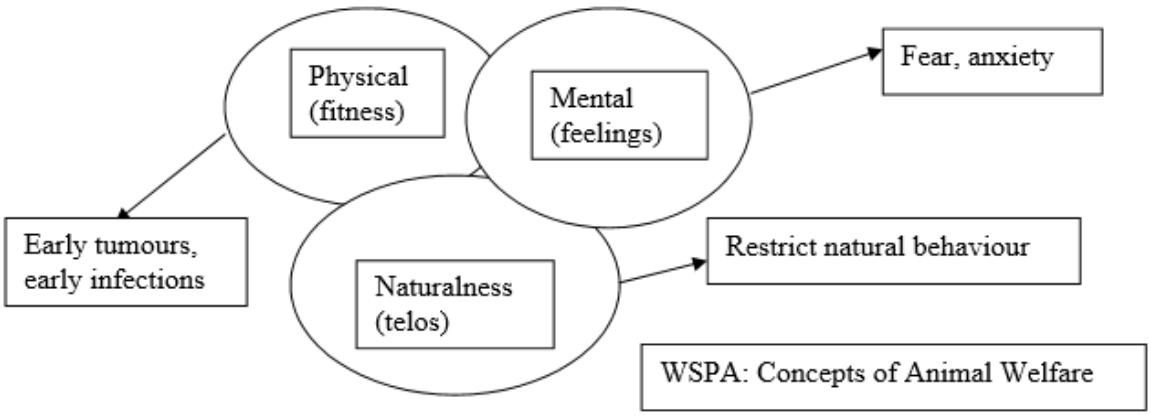

Figure 3: WSPA: concepts of animal welfare

4.2. Five Freedoms

The Five Freedoms from the Farm Animal Welfare Council (FAWC) are now internationally recognised as a method of assessing welfare parameters including physical and mental states. It is widely used in the industry from farm to slaughter.

1. **Freedom from Hunger and Thirst** - by ready access to fresh water and a diet to maintain full health and vigour.
2. **Freedom from Discomfort** - by providing an appropriate environment including shelter and a comfortable resting area.
3. **Freedom from Pain, Injury or Disease** - by prevention or rapid diagnosis and treatment.
4. **Freedom to Express Normal Behaviour** - by providing sufficient space, proper facilities and company of the animal's own kind.
5. **Freedom from Fear and Distress** - by ensuring conditions and treatment which avoid mental suffering.

4.3. Bristol University – Featherwel

Bristol University carried out a four-year study (Bristol Pecking Project) from 2008-12 into injurious pecking. This *"was a knowledge transfer study that investigated the protective effects of implementing evidence-based on-farm management strategies designed to reduce injurious pecking in non-cage laying hens*" (Bristol.ac.uk). The outcome of this for the industry was the FeatherWel guide to promote bird welfare (non-cage birds) in both rear and laying periods.

4.3.1. Injurious pecking

Injurious pecking (IP) is commonplace in free-range flocks and covers 4 types of pecking:

- Gentle feather pecking
- Severe feather pecking
- Cannibalistic pecking
- Vent pecking

4.4. AssureWel

AssureWel is collaborative project by Bristol University, RSPCA and the Soil Association. Its aim was to develop a practical welfare outcome assessment for use on farm alongside farm assurance schemes, covering laying hens, dairy cows, pigs, broilers, beef and sheep. It can be used to assess different farming systems and can be used by the producer as a self-assessment. The assessment for laying hens has 7 main criteria as follows:

1. Feather loss
2. Bird dirtiness
3. Beak trimming
4. Antagonistic behaviours
5. Flightiness
6. Birds needing further care
7. Mortality

(http://www.assurewel.org/)

It is designed to take 10-15 minutes and requires a visual inspection of 50 birds at random. A benchmarking tool has been created to compare scores with the rest of the industry.

4.5. Market

The egg market is segmented into four production methods and are coded 0 – 3

0 – Organic
1 – Free-range
2 – Barn
3 – Cage

The lower the number the higher the perceived welfare and subsequently the higher the premium the market returns.

4.5.1. Enriched cage

Battery cages were a popular method of intensifying egg production post war up until 1981 when it reached its peak. Free-range eggs at that time consisted of just 1% of the UK market. This method of production came under increasing pressure from animal rights activists as perceived cruelty, and eventually saw the European Union ban the use of conventional battery cages across member states on the 1st January 2012. Cages have now been superseded by the colony cage or enriched cage, which better meets the bird's welfare requirements. This method of production now makes up approximately 43% of production in the UK egg market. This is an industrial farming method and extremely efficient in terms of labour and feed consumption. Mortality is also expected to be lower as shown in the following chart for Lohmann Brown (courtesy of K Shaw).

Note that "LB" stands for Laying Bird.

Age	LB Colony	LB Alternative
70	4.8%	7.7%
80	5.8%	9.2%

4.5.2. Barn

Barn eggs are similar in production method to free-range, the only real difference being that the birds do not get access to the outside. This method of production applies to about 5.5% of hens in the UK and the customer mostly confuses it with battery eggs. It is a much more common system across Europe.

4.5.2.i. Rondeel System

The Rondeel housing (meaning round house) system is a revolutionary egg production facility in The Netherlands, producing eggs that are classified as barn eggs. The house is based on a central core area (Figure 4) housing 30,000 birds, non-beak-trimmed, in 5 flocks. The dark areas show the night quarters, similar to a standard poultry house. In between the night quarters are the day quarters where the birds can forage and dust bathe in natural daylight. There is then a wooded area around the perimeter which birds can have further access to for foraging.

The objective of this system was based on animal welfare and the environment, with a strong focus on corporate social responsibility. Eggs are marketed in a round box (Figure 5 on next page), fully

biodegradable and including 7 eggs, apparently one egg for each day of the week! Rondeel eggs were given three stars by a Dutch animal welfare organisation “Dierenbescherming”, which places a “Beter Leven” (better life) hallmark on various products by granting a one, two or three-star status. Rondeel eggs are the only non-organic product to gain 3 stars. Free range in contrast has only been given 2 stars mainly due to the practice of beak trimming. The organisation Compassion In World Farming (CIWW) has also endorsed this production method.

Figure 4: Rondeel House, The Netherlands

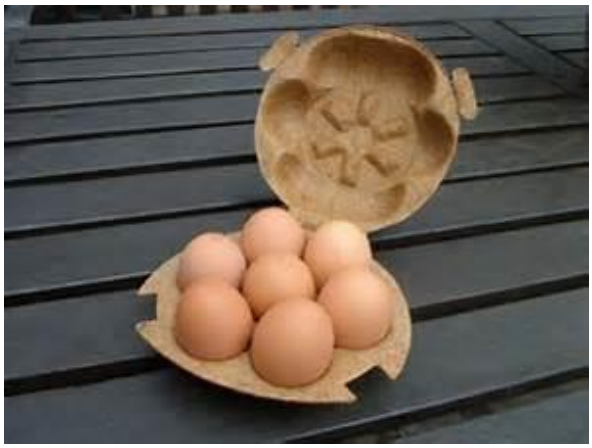

Figure 5: Rondeel egg box

4.5.3. Free-range

The UK is at the forefront when it comes to free-range egg production and the industry is well regulated, accounting for approximately 49% of the total UK egg production – a far higher percentage than in any other country. The maximum flock size is 16,000 birds, split into 4,000 bird colonies within the house. Birds are stocked inside at a maximum stocking density of 9 birds/m^2.

4.5.3.i. Happy Eggs

The Happy Egg company is a brand started by Noble Foods in the UK. In 2012, it was launched in the States and is managed there by David Wagstaff (pictured). The egg market is changing rapidly in the States; caged eggs (still mainly battery style) accounted for 95% of sales in 2012 but now stand at 82%, with free-range becoming increasingly popular. At the time of my visit Happy Egg in the States was a $20,000,000 brand supplying 6000 stores, anticipating in 2 years' time being worth $50,000,000.

Figure 6: David Wagstaff and me, San Francisco Happy Egg headquarters

Happy Egg base their free-range standards voluntarily on UK standards as they don't see American standards as being high enough. For example, the American Humane Association standards for free-range allow for 2 square foot (0.19m^2) per bird of outside range, compared to 5m^2 in the UK.

4.5.4. Organic

In the UK organic egg production accounts for 2.5% and hens must be free-range, in smaller flock sizes, no larger than 3000 birds per flock. Birds are stocked at 6 birds/m^2 and beak trimming is prohibited. This is in contrast to The States where organic hens can be kept in cages and fed organic feed. The idea is that they should be free of antibiotic/GM in feed, rather than any consideration for how the animals are housed.

4.6. Beak trimming

Beak trimming is a practice which removes the sharp point on the upper beak. It is generally carried out by an infra-red beam in the hatchery when the birds are a day old. The purpose is to avoid flocks starting injurious pecking or - worse - cannibalism. This is an emotive subject as officially the practice is classed as a mutilation. Denmark and Austria have already banned the practice, followed by Germany in 2016 and The Netherlands in 2018. Currently the UK government has rejected plans to ban the practice in the UK for the time being.

Figure 7: Bird with beak trimmed

Figure 8: Bird with intact beak

4.7. Denmark

This was the last country I visited, in July 2016. Denmark, much like other Scandinavian countries, has a big demand for organic food, with organic eggs accounting for over 25% of production. Beak-trimming has been banned here since 2014 and it is predominantly a white egg market, with 85% of production from white birds. Birds are not vaccinated against salmonella, but it is a requirement that all feed is heat-treated to 80 degrees.

4.7.1 Mikael Hald

Mikael works for Triova, a modern hatchery in Denmark selling day old Lohmann chicks. We visited an organic rearer and 2 organic laying units. In rear, organic birds must have access to outdoors from the age of 6-7 weeks in summer, and 11-12 in winter. Organic standards have notable differences to the UK. In the UK the permitted flock size is 3000 birds, additional flocks can't be added on to the same house unless a solid partition is in place between flocks: this means different air space and feeding/ drinking lines. In contrast, in Denmark much like other countries in Europe, additional flocks can be added on to the end of a house, utilising the same feeding lines, with hens merely partitioned off inside and outside the house. This dramatically improves efficiency. For example 30,000 organic birds can be put under one roof. It is also an organic standard that silage is fed to the hens daily to provide a fiber source. The two photos overleaf show an automated system and a self drive unit used to distribute silage onto the litter area of the house.

It is also an organic standard that silage is fed to the hens daily to provide a fiber source.

With the automated system you could have been excused for thinking you were walking into a dairy shed. Silage was loaded into what could be described as a typical feed mixer wagon; the elevator filled a transporter unit which then went around a monorail twice daily and dropped silage onto the litter area. Typically a barley/pea wholecrop finely chopped was used as the silage, or clover grass. Silage was fed at 10-15g/bird. This

was not a substitute for feed: a higher rate would have risked birds eating less hen feed and subsequently risking production problems.

Figure 9: automated silage system

Figure 10: self-drive silage system

4.7.2. Jan Volmar

Jan had 12,000 organic Lohmann Brown birds under one roof and was achieving 315-320 eggs per hen housed at 72 weeks. His shed was unique. There were no walls or popholes like a typical shed would have, and instead a curtain was rolled up. Inside the shed was another curtain which could be raised and the shed was naturally ventilated. It was also very bright. The current birds were 46 weeks old and not a feather out of place.

Figure 11: curtain on outside instead of wall and popholes

Figure 12: curtain splitting litter and slatted areas

Jan was very innovative and was involved with the university with several trials. He was one of three producers in Denmark who had a machine for de-hulling oats; the naked oats were then added to the feed at 25%, providing energy and the essential amino acids, methionine and lysine.

4.8. Discussion

It could be argued that free-range, with mortality figures of approximately 60% higher than colony cages, is an inferior welfare system. This, however, does not take into account mental state or naturalness. Free range has become dominant in the UK market to the point where it is losing its premium and becoming more of a commodity. Houses are erected on welfare standards which are dictated by legislation. 16,000 birds is the largest permitted flock size, but flocks are often multiplied up on the same farm, with 100,000 free-range birds on one farm now not uncommon.

The Rondeel system is hard to fault. It is an efficient system which appears to cater for all of the bird's requirements. This system of course is only barn eggs, although it is more like bringing the outdoors into a controlled environment - possibly the best of both worlds! (free-range and barn). It is often said that the consumer is always right and as such, requires and is willing to pay a premium for free-range eggs. To shift this mindset would require education. The Rondeel has done this: their farms are open to the public during daylight hours. It is a fully transparent system which doesn't hide behind biosecurity. The public area has a glass floor to enable viewing of egg collection (figure 13 below) and a tunnel (figure 14) takes you to eye level of the birds in the day quarters. It even displays the solar power currently being generated on the roof. You can also walk around the perimeter of the house to view the birds in the wooded area.

Figure 13: Rondeel house egg packing

Figure 14: Rondeel house visitors tunnel

This all comes at a cost and the Rondeel house is approximately three times the capital cost of a traditionally built house. Rondeel have successfully marketed their brand for a premium in order to cover this extra investment.

I believe the concepts of the Rondeel system should be brought to the UK, not necessarily as a round house. Verandas could be added to existing free-range houses to allow natural daylight. This could create a high welfare barn egg, better for the bird and better for the producer. Some predictions within the industry suggest colony cages will be phased out with many supermarkets planning to stop stocking caged eggs. Barn eggs would therefore be a potential substitute but the system is largely misunderstood. There is a risk that the intensification

Verandas could be added to existing free-range houses to allow natural daylight. This could create a high welfare barn egg, better for the bird and better for the producer

of free-range units could jeopardise the free-range sector as this comes under increased scrutiny. A high welfare barn egg could potentially improve welfare of birds both from intensive systems and where producers were struggling with free-range systems. It all comes down to the price the producer is paid and that comes down to marketing.

Whilst travelling in The Netherlands and speaking to egg producers, it became apparent how fortunate we are in the UK to have the Lion quality assurance scheme. This scheme is supported by all the major supermarkets and requires that the eggs have to be British. The Netherlands, being the world's largest exporter in value terms, has a laying flock similar in size to the UK. The Lion assurance scheme was described to me as being a brick wall preventing The Netherlands from exporting eggs to the UK.

it became apparent how fortunate we are in the UK to have the Lion quality assurance scheme.

That said, it is of concern that the UK stance on beak-trimming is lagging behind that of our European neighbours, and that could give them a competitive edge to penetrate our market.

I started my Scholarship off by questioning the intensity of free-range houses. Visiting Denmark put a different perspective on this. The Danes are very proud of their animal welfare standards and their organic production. The rules in Denmark around organic production are very different to those in the UK. At first glance they appear to be more relaxed allowing more birds per house, numbers being similar to free-range houses in the UK. However, the standards of the organic layer units I visited were excellent, with birds ranging well and in excellent condition with outstanding production figures. The units I was taken to were probably some of the best; however, I was told that organic mortality rates in Denmark were on a par with cages at around 4%, and much lower than those for barn or free-range. The increased number of birds per house makes organic production more competitive in Denmark; in all other areas I would say organic egg production in Denmark was stricter than in the UK. Pullets being 100% organic-reared and given outside access better prepares birds for the laying house, and adding forage to their diet is a good enrichment and stops birds pulling feathers instead. The ability to put more birds in a house makes enrichments such as silage feeding a viable option.

I was told that organic mortality rates in Denmark were on a par with cages at around 4%

5.0. Economies of scale

Poultry is an efficient industry with feed conversion ratios of 2.1:1. This compares to pigs 3.5:1 and ruminants 8:1. The introduction of cages allowed easier management, with small numbers of birds being protected and reducing feed consumption. Economies of scale comes with labour efficiency as cages can be stacked up, with flocks of up to a million birds or more achievable on one site. Cages may provide for the bird's physical needs of feed, water and shelter, but does very little for bird welfare. This intensification eventually saw the ban of battery style cages in Europe on the 1st January, 2012, on welfare grounds.

5.1. Mechanisation versus labour

In farming systems, variable costs (typically labour) can be reduced per unit of production by investing in fixed costs such as mechanisation. This can be seen in figure 16, graph 1 below. The breakeven point is higher and there is a potential risk from expenditure on specialist items; however, economies of scale would bring higher profits. Graph 2 would be typical of a small scale enterprise reliant on more labour but would not be as profitable if scaled up, especially if prices dropped or variable costs such as labour increased.

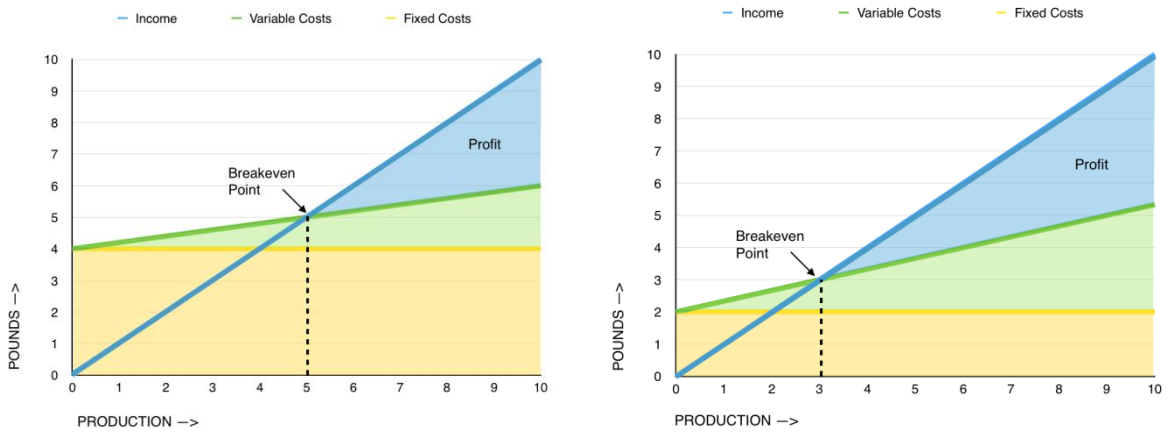

Figure 15: Graph 1 on left, graph 2 on right. (compiled by author from standard economic data)

5.1.1. Kenchic (Kenya)

After an eventful morning getting caught for speeding (the speed limit was changed on a section of road, good tactics by Kenyan police!) I met up with James Ogila and Francis Kariuki who managed two broiler breeder units for Kenchic. Kenchic is the largest broiler breeder farm in East Africa: as a company they produce 1 million chicks per week at their hatchery. The two farms we visited had 10 and 11 sheds of 8000 birds/shed. They housed grandparent stock for both Cobb for broilers and ISA for layers.

The biosecurity on these farms was excellent, double gated entry with questionnaire and you had to shower in and out. The sheds were spaced out and were very basic, open-sided with tin roof, no

mechanical ventilation, with a service area in the middle splitting the 8000 birds into two flocks. The birds were stocked at 4 birds/m^2. Labour in Kenya is cheap, so everything is done by hand. Each shed employed 4 staff, allowing 3 to always be on shift. Eggs were collected out of traditional nest boxes 6 times per day, feed was all in bags and either poured into feed pans or a hopper for chain feeding. The litter was turned over with a fork from one end of the shed to the other every day to keep it aired and friable. It was a low cost, high labour system, and a good contrast to the sort of fully automated system which would be enjoyed in the UK.

5.2. Commodity price trends

Agricultural commodity products fluctuate in price in the short term mainly due to supply and demand economics. For example, if poor weather causes a bad harvest, demand ultimately exceeds supply and causes market prices to increase. Over-production would have the opposite effect. Government policy, war and farm subsidies will also play a role in short term prices. In the long term, however, commodities generally decline in value (in real terms). This is mainly due to increases in mechanisation and production efficiency, ultimately pushing prices down. This is also known as the treadmill theory.

Wheat is a basic commodity which can be grown almost anywhere in the world and as such is a good base line indicator. Figure 16 below shows in real terms the value of wheat and corn from 1866 to 2008. The two world wars have a clear impact on prices; since then prices have declined. This can be seen better in figure 17 which shows a 60-year period from 1948 to 2008 where prices for wheat and corn have dropped on average by 2.3%/year (DANIEL A. SUMNER). A peak in the 70s is likely to have been caused by political issues around oil embargos at the time, as well as international shortages caused by poor harvests. This clearly shows the effect improving agricultural practices and mechanisation has on prices.

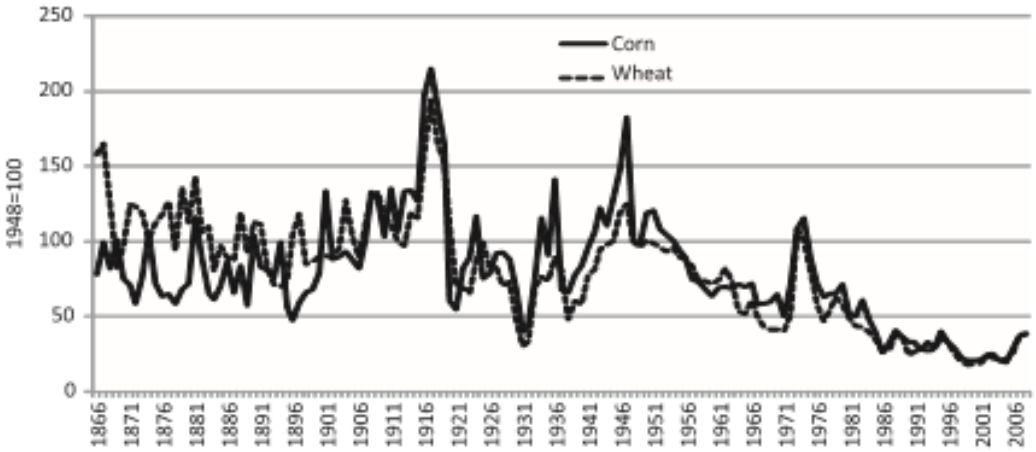

Figure 16: Index of real corn and wheat prices, 1866–2008 (DANIEL A. SUMNER)

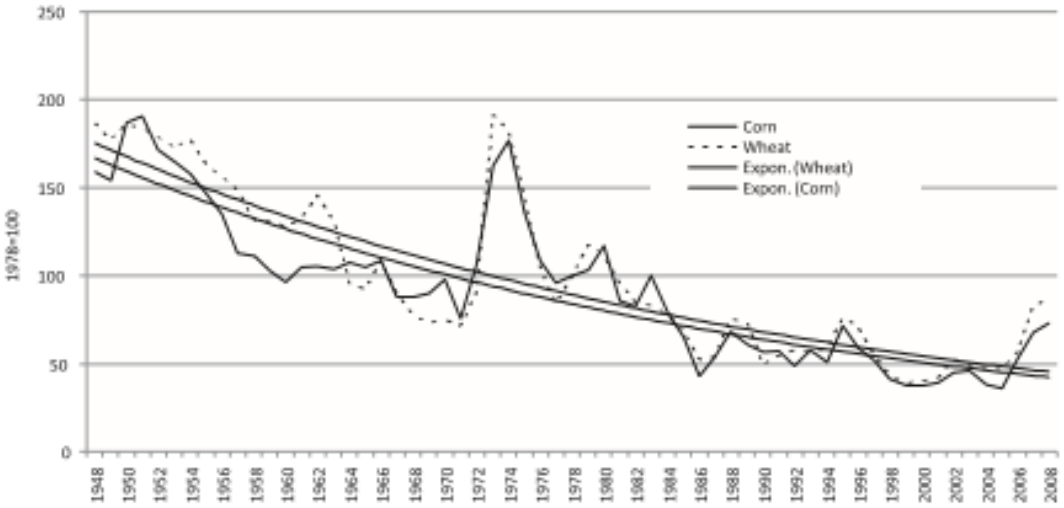

Figure 17: Index of real corn and wheat prices, 1948–2008 (DANIEL A. SUMNER)

5.3 Health care spending trends

The chart below says it all.

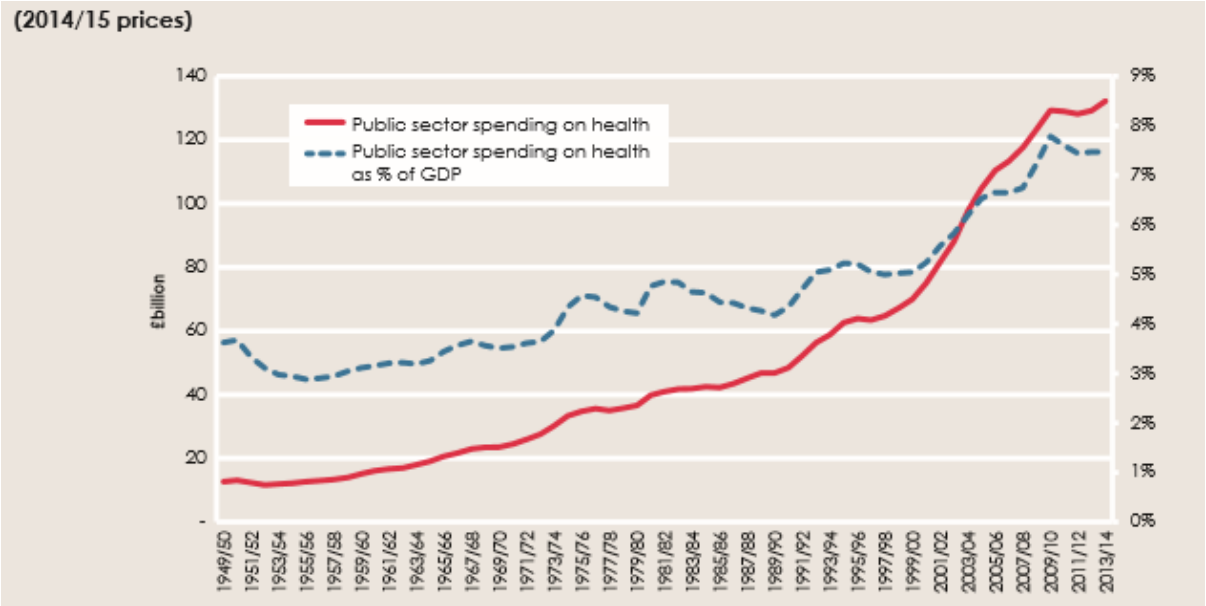

Figure 18: Public spending on health in the UK, in real terms and as a percentage of GDP

5.4 Nutrition

The nutritional density of food, in particular fruit and vegetables, has declined in the past 60 years. Figure 19 shows the percentage change of broccoli. There are likely to be several reasons for this. Organic enthusiasts often quote the intensification of agriculture and the decline in soil health as the primary reasons. However, yields over this period have increased three fold in some cases, which is likely to have a nutritional dilution effect.

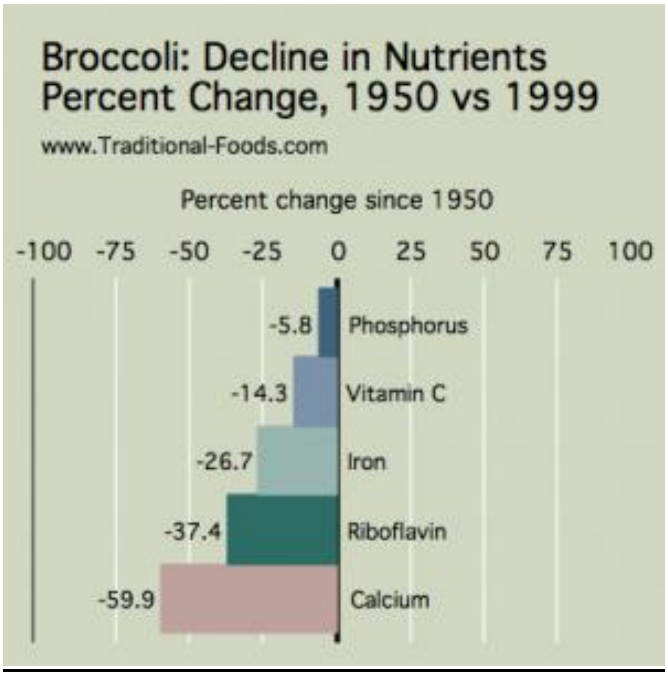

Figure 19: change in nutrient percentage of broccoli, 1950 vs 1999. (www.traditional-foods.com)

5.4.1. Rothamsted Research

Rothamsted Research in the UK has been running the world's longest wheat trials, called the Broadbalk Wheat Experiment. Starting in 1843, wheat has been grown continuously in the same plots for over 170 years, and the effects of yield comparing plots receiving farmyard manure with different fertiliser programmes have been looked at. This puts Rothamsted in a good position to test nutritional density using their archive figures alongside soil samples from the same periods. The minerals zinc, iron, copper and magnesium have decreased significantly in wheat since the 1960s. Minerals were shown to be stable from 1845-1960s. The outcome of these results was the introduction of semi-dwarf, high yielding cultivars.

5.5. Environmental costs

Farming methods inevitably affect the surrounding environment, whether beneficially or destructively. The plight of bees has been well documented in recent years, with colony collapse disorder affecting an estimated 30% of hives.

However, an estimated 99% of all living organisms are invertebrates (IUCN). The graph on the next page shows a global index of the decline of invertebrates of 45% in four decades.

See graph on next page

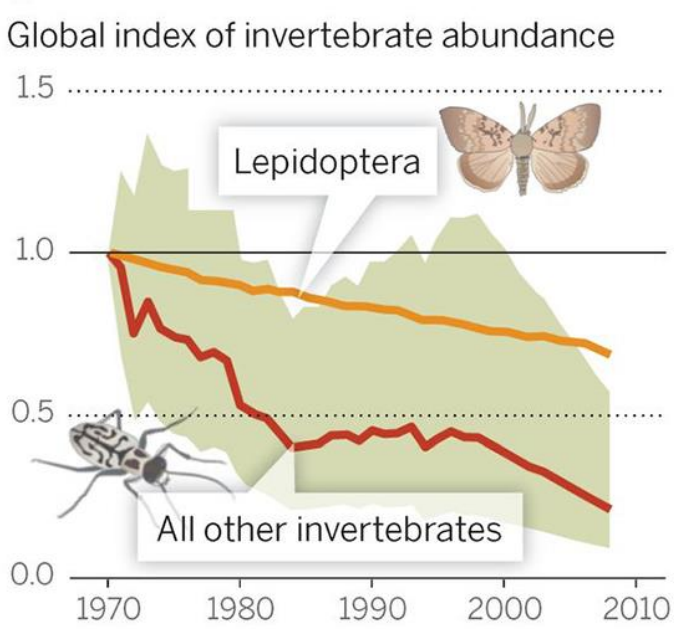

Figure 20: global index of invertebrate abundance, base year 1970 (CHRISTIAN SCHWÄGERL)

5.6. Discussion

Economies of scale often dictate profitability in a farming system. This generally means working to the limits of legislative requirements i.e. maximising flock sizes and stocking rates. Labour is often the single biggest cost, and can be unreliable so adopting mechanisation maximises output/unit. The drive to reduce costs inevitably reduces market prices in the long run "the race to the bottom". Is there such a thing as cheap food? Or does society pay the price through our health and environmental costs, and through our livestock's welfare? One way of mitigating this is by adding value. Organic and free-range are more labour intensive and this demands a premium which offsets the extra cost of production.

I believe that with economies of scale, despite a huge benefit in labour efficiency, there is a loss of other efficiencies. An example of this would be hen manure. This can be a real asset to arable farmers as it improves soil structure and is abundant in nutrients including calcium. However, intensive poultry units rarely take advantage of this asset and often it is given away just to get it removed. It may travel several miles in the process in order to be utilised.

I believe that with economies of scale, despite a huge benefit in labour efficiency, there is a loss of other efficiencies

Health care spending may be a bit of a blunt instrument as I'm sure drug and alcohol-related illnesses are up, but nutrition also comes down to food choices and so this might in part show a change in society. However, cancer and many diseases including allergies and intolerances are all rising. The reasons are likely to be multifactorial; however, the decline in the nutritional density of our food and the loss of biodiversity in our environment is a worrying trend.

6.0. The soil

My Nuffield Farming journey started with the UK annual conference in 2014 in Kent. I was inspired by some of the 2013 Nuffield Farming Scholars talking about soil health and biological farming methods. (Incidentally, 2015 was the international year of the soil). This took my research in a different direction and at first it seemed irrelevant to my topic, albeit interesting to me as a farmer thirsty for knowledge. It was when I went to the States and my plans to look at poultry were hindered due to the seriousness of the Avian Influenza outbreak at the time, that I decided to follow up on some soil research. This took me to Dakota Lakes Research facility in South Dakota, where I was to meet Dwayne Beck, and the realisation of an important link with free-range management.

6.1. Dakota Lakes

Dakota Lakes research farm at Pierre in South Dakota is run by Dwayne Beck and has been in operation since 1990. The farm is half irrigated and half dryland and the management is a strong advocate of no-tillage. I visited Dakota Lakes at the same time as they were hosting a soil show, with the main speaker Ray Archuleta. He was described to me by Dwayne as being the "God" of soil health in the US. Ray is a conservation agronomist and teaches soil health throughout the country.

The day started with a rainfall simulator (Figure 21 on next page), with 5 different managed soils:

1. Perennial grass
2. Cover crop
3. Diverse no-till rotation
4. No-till rotation
5. Conventional tillage

If the soil is functioning properly (mineral and water cycle), the water infiltrates the soil and collects in the jar below. Alternatively, the water runs off and collects in the front jar. This demonstrates that reducing tillage, increasing rotation diversity, and having a living root in the soil improves soil health and allows it to function properly.

The second test was the Slake test (Figure 22 on next page). This is an aggregate stability measure. A lump of dried soil is taken and placed into water. If the soil shows good aggregate strength, it holds together as can be seen in the left cylinder. The soil in the right cylinder disintegrated as soon as it was submerged into the water.

See photos on next page

Figure 21: rainwater simulator

Figure 22: slake test

The next demonstration was out on the dryland pasture, where a water infiltration test was carried out on two sites 10 yards apart. The two sites looked the same: one was rotationally grazed and the other was continuously stocked. The infiltration test timed how long the equivalent of an inch of rain would penetrate the soil. The rotationally grazed site took 40 seconds, which compared to approximately 40 minutes on the other site!

6.2. Soil properties

Soil has three properties: chemical, physical and biological, which all interact and have to be in balance for a healthy soil.

6.2.1 Chemical

The conventional approach to farming is based on N-P-K and pH. However, crops additionally need at least 16 elements and will only perform to the level of whatever element is in least supply. Furthermore, an excess of one nutrient can lock up others.

Work carried out by Dr. William Albrecht in the 1950s recognised the importance of calcium in the soil and how this improved plant uptake of all other nutrients, hence producing more nutrient-dense food.

The soil contains cation (positive charge) and anion (negative charge) elements. The base saturation of soil should be 95% cations. The five major cations are:

- calcium
- sodium
- magnesium
- hydrogen
- potassium

Calcium, magnesium and potassium all interact with each other and should be in prescribed ratios to each other.

An excess of magnesium has a hardening effect on the soil whereas excess potassium can cause livestock health problems.

6.2.1.i. Gary Zimmer

I read Gary Zimmer's book "The Biological Farmer" after becoming interested in the soil, and subsequently visited him in Wisconsin where he farms. Gary farms over 1000 acres organically at Otter Creek farm with his son and daughter, growing wheat, maize and soya bean crops for their 150 Holstein cows and beef cattle. Gary first trained in dairy nutrition and then in the 80s set up Midwestern Bio-Ag with three partners. This company specialises in supplying sustainable agricultural inputs and biological farming consulting.

Gary believes good nutrition starts with the soil in order to produce quality crops to the benefit of both animal and, ultimately, human health. He describes calcium as the trucker of all minerals, with boron as the steering wheel. Calcium will not be taken up by the plant unless there is sufficient boron in the soil.

6.2.2. Physical

The soil is made up of solid, liquid and gaseous parts. The solid part contains approximately 5% organic matter and 45% minerals, which can be a mix of sand, silt and clay. Water and air make up the rest of the soil in equal quantities of around 25% each.

6.2.2.i Ray Archuleta

If Ray spoke about the principles of soil health, his main message would be to mimic nature and not try and control it. He describes tools such as pesticides, herbicides and fungicides and tillage as being chronic stresses to the soil and as such should be minimised. Instead we need to understand the principles of nature and then use the tools in context, as the following diagram (figure 23) describes. Figure 24 on next page is what Ray describes as Ecological Architecture.

Figure 23: Principles of soil health, Ray Archuleta

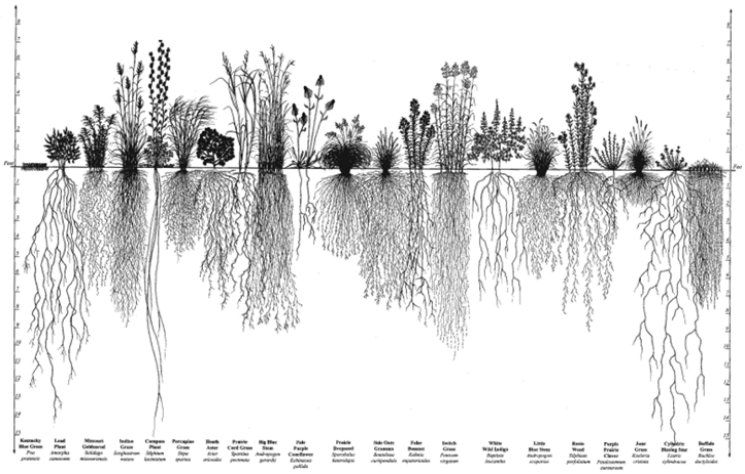

Figure 24: Ecological architecture. (Conservation Research Institute)

6.2.3 Biological

A healthy soil contains an estimated 1000kg/acre of livestock (Armitage) in the soil food web, building soil structure and recycling nutrients. This livestock need feed: the basis of this food is carbon (organic matter) in the soil and plants photosynthesising. A healthy soil and everything in balance reduces disease, pests and weed problems. This can be seen in the following example of the soil food web. Earthworms are the largest organism in the soil and a good indication of the health of the soil is that a square foot of healthy soil should contain between 20 and 25 earthworms. I carried out this simple test on my own farm with interesting results. In permanent pasture I could find 20 worms/foot but in fields which have been cropped intensively, very few if any.

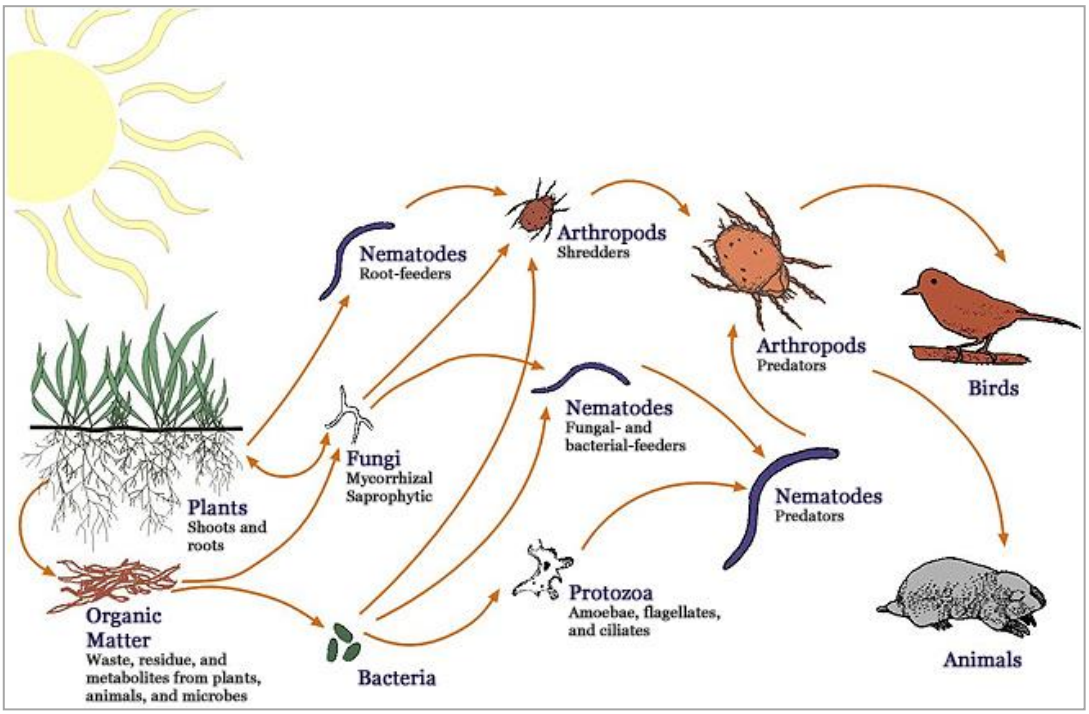

Figure 25: The soil food web, *www.lifeunderyourfeet.org*

6.2.3.i. Dr Jonathan Lundgren

Jonathan is an entomologist and an agro-ecologist who I met at the Soil Show, and later decided to go and visit him at his base in Brookings, South Dakota. At the time of my visit Jonathan worked as an USDA scientist, carrying out various trials from neonicotinoid pesticides to the effect cattle wormers have on biodiversity. He expressed concern about having the freedom to publish his research when it came up against chemical company's pursuit of product development. This led to him being suspended on the grounds of a travel related infraction. Since then Jonathan has resigned from the USDA and set up Blue Dasher Farm with the help of crowd funding, raising over $80,000. Blue Dasher Farm is a profit-based farm with the aim of carrying out research, education and demonstration on regenerative farming systems for both crops and livestock. The following are two quotes from Jonathan:

> *"A pest-centric approach to pest management ignores the fact that for every pest species, there are 1700 species of insects that are beneficial to humans and the environment. We ignore these beneficial species to our detriment"*

> *"The world is not facing a bee problem; it is a biodiversity problem. The bees are just the canary in the coal mine, and we are observing species losses in many other groups of plants and animals in addition to bees. But if we lose bees, we lose plants. If we lose plants, we lose people. Just that simple"*

Figure 26: Dr Jonathan Lundgren

6.2.3.ii. Real IPM – Kenya

Real IPM (Integrated Pest Management) was founded by Louise Labuschagne and Dr Henry Wainwright in 2003, based near Thika, Kenya. They produce predatory mites under licence from Syngenta Bioline and also produce bio-pesticides in their laboratories, employing over 200 staff. I first came across Louise when she addressed the Oxford Farming Conference in January 2015 and then met her at the Soil Association Symposium in November.

REAL Metarhizium 78 is one of their bio-pesticides; it is a naturally occurring fungus found in the soil. It is a contact biopesticide in which the Metarhizium fungus spores infect the host pest and proceeds to germinate, multiplying in the haemocoel of the insect thereby killing it. It can also be used in conjunction with chemical applications of pesticide and fungicide in synergy, reducing chemical use by 50%. It has been shown to kill the varroa mite in bee hives, with no harmful effects on the bees. In fact, bees can be used as a vector to apply the biopesticide to flowers. This method of biological control gives nature a helping hand and is used extensively in the fruit and flower industries as part of a prophylactic programme. It reduces the risk of resistance build-up in pests and protects non-target biodiversity. This product is highly likely to be effective in the use against poultry red mite. However, it has not been tested for this application.

The problem in the EU is that these products have not been registered and that requires huge investment running into six figures for each product. Each product would have to be added on to Annex 1 of The PIC Regulation before going through rigorous field trials. REAL IPM UK has been set up by farmers and growers to hopefully make these products available in the UK.

Figure 27: REAL Metarhizium, a biopesticide which could be used to control poultry red mite without building resistance

6.3. Discussion

My visit to Dakota Lakes really emphasised the importance of how the soil works. The biggest issue with free-range is the unpredictable weather. Hens tend to wear the pasture heavily around the house, making the soil bare. Heavy downpours of rain and constant rain makes soils water logged; this increases disease and parasite issues and also causes hens to enter the house with wet feet and subsequently causes litter to become capped. At Dakota Lakes they were irrigating crops, applying 2 inches of water in 9 minutes, and the soil soaked this up due to the good soil structure. Residue on the surface protected the soil and earthworm holes improved the rapid absorption of water.

The big take-home message was improving soil structure by keeping a living root and the soil covered all year round. I think I left the Soil Show with more questions than I went in with, but it has opened up my mind as to how we should be managing our range, and has created a few ideas to try at home. I discuss agro-forestry later in this report: this may be one way to keep a living root in the soil. Residue can be added to the surface in terms of straw or wood chips. I also plan to try some cover crop mixtures, perhaps fencing off strips at a time or some inexpensive grow-tunnels; this may also take excessive nutrients out of the soil.

It is often said that pasture around poultry houses can become "fowl sick". This may be a bigger problem in years to come as many new free-range sites become more mature. The areas around poultry houses are also likely to be high in potassium, from hen deposits. At home we have started analysing the soil in order to balance this out, applying gypsum or calcium sulphate to counteract the potassium.

Chemistry is just one science and biology is without question more important, yet seems to be a forgotten science.

I think farming has become over reliant on chemicals. Chemistry is just one science and biology is without question more important, yet seems to be a forgotten science. This is not to say I think the world should all convert to organic. In fact I'm not sure if organic farmers have really focused on biology either; they just cut out the chemicals and accept the consequences.

Nothing would grow without biology, and biology needs to be nurtured. Perhaps we listen to too many salesmen - and that includes agronomists and vets who are often influenced by chemical and drug companies.

The potential for biological controls is massive, yet regulation stands in the way and makes them unaffordable. Products like metarhizium are a naturally occurring fungus in the soil. Full eco-toxicological studies have been carried out on these products and they are proven to be safe to the environment, non-target organisms, and people.

7.0. Farming systems

It became apparent early on in my study tour that farming is on a par with how we view politics, i.e. left and right wing. The answer is normally somewhere in the middle. At one end of the farming spectrum is monoculture, biotechnology, chemical farming, antibiotics. At the other end is polyculture, organic, biodynamic and permiculture. The answer again is somewhere in the middle: the best description would be biological farming or biotic farming. Poultry by its nature is intensive and very much a monoculture. To change this would substantially increase cost especially in terms of labour.

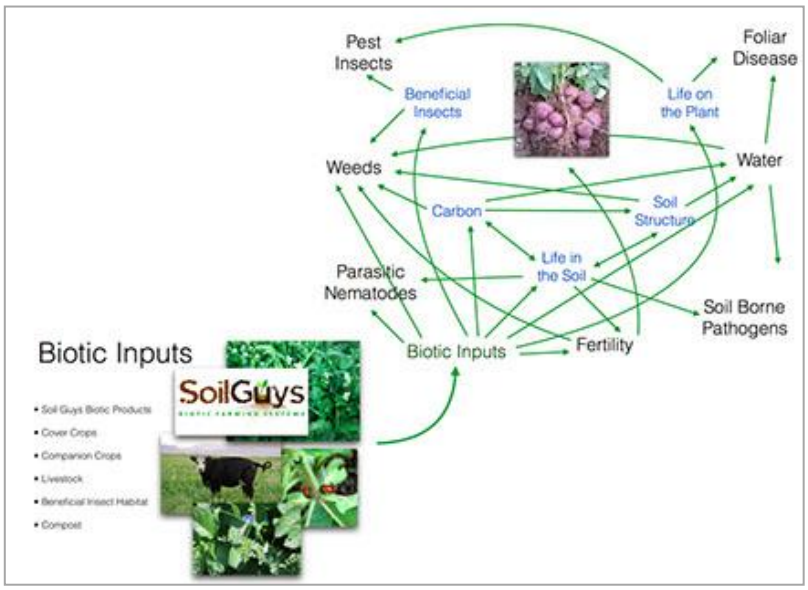

Figure 28: A pro-biotic approach promotes, enhances and nurtures life. The green arrows represent how biotic inputs support natural relationships in a farming system.

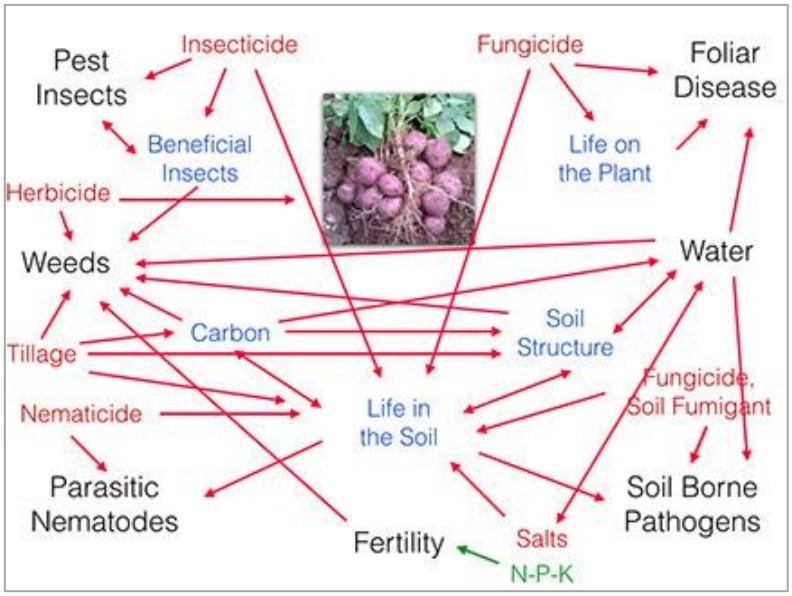

Figure 29: An anti-biotic approach prevents, inhibits and destroys life. The red arrows represent how "cides" and synthetic inputs disrupt natural relationships in a farming system

The diagrams above illustrate a Pro-biotic system versus an Anti-biotic system, *www.soilguys.com*

7.1. Holistic management

Holistic management is about building a farm system which mimics natural systems. This is based on the movement of wild herbivores such as bison. These animals would graze an area then move on, trampling grass back into the soil whilst leaving manure behind. This builds carbon in the soil and supports a whole new ecosystem.

7.1.1. Farmer Angus

Angus McIntosh is a biodynamic farmer in South Africa near Stellenbosch, although in his previous life he was working for Goldman Sachs as a stockbroker in London. The farm has four main income streams: eggs, beef, grapes and carbon credits. Angus practices holistic grazing where 260 head of Limousin cattle are mob grazed, moved twice daily on a 5-6 week rotation around the farm on an 18-species grass mixture. 4000 Amberlink hens are then moved daily in their "eggmobiles" a week behind the cattle. The hens were producing 318eggs/hen/housed at 84 weeks of age.

Figure 30: Angus's Limousin cattle being mob grazed

Figure 31: Angus's "egg mobiles"

Free choice minerals were offered to the cattle; 30% would be utilised by the cattle whilst the other 70% would return to the pasture through their manure. This would naturally correct any imbalances in the soil. Legume seeds were also mixed in to help regenerate pastures.

Figure 32: Angus's free choice cattle minerals

7.2. Diversity

7.2.1 Rockey Farms

Brendon Rockey is the third generation speciality potato grower in the San Luis Valley, Colorado, where he farms with his brother Shendon. The farm grows 250 acres of seed potatoes every year on their 500 acre farm! Yes! Just to clarify, that is a 2-year rotation. I was given this contact whilst in South Dakota and although it has nothing to do with poultry, it demonstrates how a typical intensive monoculture system could completely change.

It was around 20 years ago that Brendon's uncle first recognised that the farmers with the biggest potato nematode problem were the same ones applying the most fungicide. It was clear to him that this was a vicious cycle. It was then they decided to cut out all artificial fertiliser and chemical use and change to a biotic farming system. The only chemical used was sulphuric acid for burning the shaws down pre-harvest. I asked Brendon about going organic. His reaction was one you would expect from a conventional farmer, stating :

> *"Organic farmers can use pesticides, they are just organic-approved ones. They can be just as damaging to the soil, if not more so, than synthetic chemicals"*

The secret to Rockey Farms' success was down to adding diversity. In the second cropping year a 20-species cover crop was grown. This was then mob grazed by another farmer, bringing in an additional income source and further diversity. Half the cover crop would be grazed whilst the other half would be tramped in as a green manure. Flowering strips were grown to add further diversity and attract beneficial insects. At planting time a seed hopper on front of the potato planter sows peas, vetch and buckwheat at 10kg/acre as a companion crop. This not only adds diversity but creates a habitat within the crop which the beneficial insects like. The health of the farm was evident in the soil. Although it had only around 2% organic matter, this level was being maintained. Brendon recalls how the wheels of the pivot irrigators used to create big ruts and get stuck due to poor soil structure: figure 34 shows how small a footprint is left now. The farm uses 12 inches/acre of irrigation water on the potato crops, this compared to an average of 20 inches in the valley.

Figure 33: Brendon's healthy soil

Figure 34: Small imprint from irrigation wheels

Brendon says most of the farmers in the valley thought he was crazy, now they pay him for advice on how to change their system. This is evident from the numerous conservation awards he has won.

Figure 35: Brendon Rockey with one of his conservation awards

7.3 Intercropping

Intercropping or companion cropping is where 2 or more crops are grown at the same time on the same land area. This makes use of natural synergies between plants, adding diversity to the soil. This is something we are doing on my home farm. In 2015 spring wheat (60%) and peas (40%) were sown together as a companion crop. This crop was then taken through to harvest and stored in its mixed form, having yielded over 5ton/Ha with no inputs. The synergy of two crops mitigates any fungicide requirements, whilst peas are contributing nitrogen to the soil and the wheat helps hold the peas up. The improvement in the soil was evident with a 300-400% increase in the number of earthworms in one year. This crop was then added to the home mixed hen feed at 10% and the hens produced extremely well. Furthermore, it saved on purchased soya, contributing to the value of the wheat/pea mix so that it was worth £142/ton; this can be compared to a wheat price of around £100/ton.

7.3.1 Push-pull technology - ICIPE

The International Centre of Insect Physiology and Ecology (ICIPE) at Mbita Point in Kenya, in collaboration with Rothamsted Research centre in the UK, developed push-pull technology.

In Kenya and other African countries, the staple diet of the indigenous population is white maize. This is ground down and made into ugali - much like we would make porridge, but thicker. Farmers therefore try and grow maize every year, often on the same land. It often struggles to grow due to the stemborer moth and striga weed. This is a parasitic weed which wraps its roots around the crop's root system and starves it of nutrients; it is also a sign of degraded soil. The answer came from intercropping maize (or other cereal such as sorghum) with a perennial forage crop desmodium. The desmodium, which is also a legume, suppresses the striga weed whilst repelling the stemborer moth. Napier grass is then grown as a border crop and attracts the stemborer moth, hence the name push-

pull. Whilst a good crop of maize is grown, both the desmodium and napier grass can be harvested and fed to livestock.

Figure 36: maize intercr4opped with and without desmodium

Figure 37: crop devastated by striga weed (purple flower)

7.3.2 John Otiep

John is a farmer in Rongo, Kenya. Aged 60 he farms a total of 7 acres and sustains a household of 15, including his mother aged 96 and 10 children whom he will fund through school and university. He was identified as a poor farmer and as such benefited from a Heifer International dairy goat programme which put John in touch with ICIPE. He subsequently adopted push-pull technology and is now a farmer-teacher spreading the word and inviting farmers to his farm.

Figure 38: John with his wife and mother

The ability to grow fodder for cattle meant that John could keep a couple of goats and an Ayrshire cow, which bring in valuable income from milk sales at the local market, with the manure being returned to the land.

7.4. Agroforestry

I visited The Netherlands in June 2015 to meet Monique Bestman who researches agroforestry trials through the Lois Bolk Institute. Monique took me round 5 organic farms using different plantations for range. These varied from:

- Willow plantations, which could be cut for biomass
- Apple orchard
- Miscanthus, cut yearly, could be used for biomass or bedding
- Cherry orchard

Figure 39: hens ranging in an apple orchard, The Netherlands

Figure 40: hens in willow, The Netherlands

Planting trees has numerous benefits to the environment and has been encouraged with some egg brands. The benefit of trees in the range has been to improve welfare by creating a more natural environment for the hens. It encourages hens to range further from the house, using more of the available ground.

Research carried out by Bright and Joret on behalf of MacDonalds found ranges with trees reduced mortality and second quality eggs, hence improving both welfare and bringing direct economic benefits.

7.5 Discussion

The idea of keeping hens in small “egg mobiles” or “tractor chickens” may have lots of welfare benefits, with fresh ground on a regular basis. This can also spread fertility around a farm and reduce parasite pressure on other livestock. However, this is a labour intensive method and would only work in the UK if eggs could be sold direct to the consumer to maximise return. It could also be argued that

small flocks get less attention and therefore could lead to a detrimental effect on welfare. There are however concepts which can be learned. Adding other species to the farm mix adds diversity. A return to more mixed farming also has the economic benefits of "not putting all your eggs in one basket".

Nowhere in nature do we see bare soil or a monocrop. Intercropping/companion cropping allows plants to synergise and complement one another; it can also confuse pests. I believe that companion cropping holds huge potential in the UK as a way of growing more home grown protein. Take our own example of growing wheat/peas, yielding 5t/Ha, producing 850kg/Ha of protein, and then compare this to an average winter wheat crop of 8.4t/Ha. At 10% protein would produce 840kg/Ha. Furthermore, there were no chemical inputs into the companion crop and it improved the soil. Yield is only one indicator of performance: quality is fundamentally more important and may only be assessed through livestock health and performance.

Poultry will always predominantly be an intensive monoculture - even free-range poultry - but integrating it into a whole farm system is more sustainable. The trip across the States brought home the message about how soya and maize crops were grown. It was estimated that in the State of Iowa, 5-15 tons of topsoil were lost on every acre annually due to erosion. This came down to monocropping over vast areas, and the loss of diversity in the landscape was clear. I think in the UK we are lucky to still have a diverse landscape, although some areas are suffering from the lack of livestock. One way the poultry industry could vastly improve its environmental credentials would be to reduce its reliance on soya, which can be 20% of poultry feed. As farmers we encourage the consumer to buy British, yet we import vast quantities of feed to feed our livestock. Perhaps we could collaborate more with arable farmers and produce more home grown protein. A small exercise with my nutritionist demonstrated a soya-free diet could be achieved and, surprisingly to both of us, only cost an additional £5/ton. This hypothetical ration may have contained too high a level of rapemeal to be practical, but it does warrant further investigation. An area I haven't looked at is the reintroduction of bone meal or insect protein, which could be beneficial.

It was estimated that in the State of Iowa, 5-15 tons of topsoil were lost on every acre annually due to erosion.

One way the poultry industry could vastly improve its environmental credentials would be to reduce its reliance on soya

Biotechnology is a heavily contested subject, and before my Nuffield Farming Scholarship my view would have been relatively neutral. However, my view now, based on what I have seen, would be against this technology. Perhaps GM crops are not going to be detrimental to our health, it's more a moral issue over the ownership and whether it is actually beneficial in the long run. Having spoken to a scientist whose research findings have been blocked, and visiting Kenya to see subsistence farmers, I see no real need for it. GM crops are not a higher yielding alternative, they are a management tool. In many cases we are trying to grow a crop where the ground is degraded. The answer is to fix the soil. A healthy soil will have less disease, pest and weed pressures. One big issue for subsistence farmers is the inability to farm-save GM seed. These farmers rely on a self-sustaining system and often can't afford inputs. Push-pull technology achieves the same goals as GM, except the farmer owns the knowledge and doesn't require the inputs.

8.0. Conclusions

1. Barn eggs are a misunderstood production method and have the potential to improve welfare.
2. UK interpretation of organic standards puts it at a competitive disadvantage.
3. BEIC red lion quality assurance scheme protects our domestic market in the UK.
4. We risk falling behind our European neighbours in standards around beak trimming.
5. The UK egg industry is extremely efficient, especially in terms of labour. However, there is a risk that the industry is too monocultured, focused with a race-to-the-bottom mentality on price.
6. The soil is fundamentally the most important aspect in agriculture.
7. Diversity creates healthy farming systems.
8. Biology first, then chemistry.
9. Biotechnology is a short term fix.

9.0. Recommendations

1. More focus on a higher welfare barn egg introducing natural day light.
2. Organic standards need to be aligned with Europe to improve competitiveness and welfare.
3. Reconsider industry stance on beak trimming to protect our domestic market.
4. Security in diversity, building healthy resilient mixed farming systems with a focus on biological farming and nurturing the soil.
5. Industry should consider stance on Genetically Modified soya and look towards other protein sources.
6. Be more open and embrace the public.

10.0. After my Scholarship

I started my farming career going into the organic sector. This was because it offered a good return, and was therefore a business decision rather than any ethical reason behind organic farming. I would say this is true for many organic farmers. Throughout my Scholarship I have visited many organic farms, - not deliberately but purely incidental to where innovation was happening. There is no doubt in my mind that farmers need to embrace biology, both organic and conventional farmers.

How do I want to farm?

I want to reduce artificial fertiliser and chemical use and reduce tillage.

Do I want to do this with one hand tied behind my back and go organic?

My Scholarship has made me more aligned with the organic ethos, albeit this may not be perfect. Organic farming can no more feed the world than the high input chemical system is sustainable, but we need balance.

I have started converting our new farm to organic standards this year. I have purchased sheep and cattle as management tools and to add diversity. I have also purchased dairy heifers in the hope of establishing an organic dairy in the next 2 years. The plan is to build a diverse, self sufficient, healthy flexible system focusing on biology and building on soil health. The organic name isn't that important. This is how I want to farm, and of course there was still a business decision in there!

11. Acknowledgements

Firstly, I would like to take this opportunity to thank the Nuffield Farming Scholarship Trust for this opportunity and The British Egg Marketing Board Research and Education Trust for their kind generosity in sponsorship. Then, my wife June, for her continued support throughout, and bringing our son Alexander into this world.

Thank you to all the staff who kept the business running at home, in particular Kirsten and James for overseeing everything when I was on my travels.

Thanks to past and present Farming Scholars for the inspiration and new friendships made, and Andrew Howard for being a travel companion to South Africa and Kenya.

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Wil Armitage

Kenny Shaw

Joe Kirk

USA

Leah Zerbe

Garry Zimmer

Dr Dwayne Beck

Emily Yeiser

David Wagstaff

Dr Randy Anderson

Dr Jonathan Lundgren

Brendon Rockey

Aaroon Kinsman

Stephanie Zimmerman

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Craig Shultz

Ray Archuleta

Brett Adee

Kenya

Louise Labuschagne

Dr Henry Wainwright

Steven Humphreys

Dr Zeyaur Khan

John Otiep

Dennis Siroh

Caleb Omolo

Zacheus Mbuvi

James Ogila

Francis Kariuki

South Africa

Hendrix Smith

Willie Pretorious

Ian Veldsman

Janvos Landgoed

Piet Prinsloo

Sean Hensman

Angus McIntosh

Mark Muncer

Mark Williams

Denmark

Jørgen Nyberg Larsen

Jan Volmar

Mikael Hald

Torben Bredahl

Jørgen Nødgaard Hansen

Claus Kildegaard Handberg

Torben Jørgensen

Anders Bang

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