Irish crop production – present and future challenges

NUFFIELD IRELAND

Farming Scholarships

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2. Executive summary

Arable farming in Ireland is facing a major challenge. Having experienced a period of sustained profitability in the 1980's, thanks in part to EU support, that same EU support in 2012 is no longer aiding Irish tillage farmers, it is now choking them. Exposure to world markets and the volatility it brings while tied to a historical rigid support system now means that tillage farmers in Ireland are very poorly placed to deal with volatility.

As high cost producers, our ex farm gate cost per tonne at ~ €170/t (€140/acre avg lease cost assumed) compared to €101/t in Argentina or €100/t in Ukraine (Rabobank 2013) leaves us at an immediate competitive disadvantage globally. In this situation, when the market turns bearish and drops, Irish producers will be the first to lose out as our cost base is too high. The vast majority of Irish grain producers fall into the leased land category, often with average land costs far in excess of €140/acre.

When our cost base is analysed inclusive of EU support, averaging €270/ha coupled with average Irish wheat yields at 8.6t/ha, this amounts to only €31/t of a return, leaving a net production base cost of approximately €140/t, still too high. Unfortunately, owing to the support systems ineffective structure, expansion focused farmers must more often than not farm without support to grow their business, leaving the most progressive and innovative of our farmers most at risk. Why are our most progressive tillage farmers being financially impeded? Is it sustainable to have operationally unprofitable farms here, all while the projected shift in EU support to the East of Europe nears?

A €140/t cost base is not sustainable and is largely a legacy of previous EU policy, however, possibly the most damaging EU policy change has been to ignore science led R&D and refuse to support the introduction of biotech crops. Hypocrisy at the highest level is being implemented where biotech crops are not permitted to be grown within the EU, all while EU ports offload biotech feed for EU animals on a daily basis. Biotech crops, where correctly legislated for, simply increase the pace of the now archaic, perfectly safe plant breeding process which is naturally occurring in the natural environment on a daily basis. Embracing technological advances over the past 50 years has resulted in 3 billion hectares of farmland (two South Americas) no longer being required to feed the global population, why are we now turning our back on science? Political abstinence on this topic can no longer be tolerated as the playing field is firmly tilted against EU producers. Biotech crops will eventually be widespread within the EU, why must we procrastinate while our competitors surge ahead?

Since 2005, there has been a huge influx of private investment and fund money into farming as the markets have realised the importance and the growth potential of farming. Unfortunately Ireland and the EU have seen little of this money as the political and legislative landscape in this region has developed a farming culture that returns too little for primary production, a point supported by the lack of outside investment in EU farms. This is indicative of the financial viability of EU farming, especially tillage, when analysed in a commercial manner.

The common agricultural policy has failed Irish tillage farmers and farmers in Ireland now face the prospect of dairy expansion, post 2015 quota removal, curtailing their business's and driving land costs to an unsustainable level for tillage farmers.

Tillage farming in Ireland has now reached a cross roads. Our cost base at present renders us poor competitors on a global scale. The EU support system ties up our most valuable commodity for

production, land, and the support is capitalised in land lease values ensuring that production on land without EU support is almost impossible. Irish tillage farmers need a rebuild of the production and support model, starting with the most basic areas.

Our variety trials system needs to measure varietal success in terms of €/t return. Our input trials need to be independently assessed to evaluate the highest cash yielding programmes, not t/ha. Tillage farms in Ireland must measure their success in terms of returns/ha or return/t rather than t/ha which takes no account of our cost base. GM crops need to be independently trialled to assess the potential environmental benefit to both the consumer and the farmer in using disease and herbicide resistant varieties in our high pressure environment. A key factor in achieving these goals will be engaging with our state and semi-state bodies, and relevant industry stakeholders to aid this transition to a margin based production system that encompasses all available technological, political and production based innovations and advances.

3. Background

Based in south Kilkenny, in the heart of the south east of Ireland, in partnership with my father, I grow root crops and combinable crops. Along with farming, I am a combinable crop agronomist and general Ag consultant through Hughes Agriculture and Farming Ltd and I am the majority partner in a land based adult education training company, Hughes Consultancy and Training Ltd.

Having completed a B.Sc. in Agriculture back in 2006, I travelled to the UK to complete an M.Sc. in Crop Protection and Agronomy, during which I also completed further agronomy qualifications in pesticide (BASIS) and fertiliser (FACTS) agronomy. Unfortunately for my father, who I farm in partnership with, upon finishing my masters in 2008, I returned to the farm with vigour to expand in all areas where possible. Cereal production increased 300%, carrot production increased 200%, and daffodil area increased 25%, all while moving headlong into the worst 3 years for weather and prices probably in the farms history, this while Ireland went broke.

Having got through that period, present day we grow approx 2,000 tonnes of retail pre-pack grade carrots for a local processor, 200 tonnes of daffodil bulbs for export to the UK and Holland, 6-7 million daffodil stems for export to JFK New York, O' Hare Chicago, Amsterdam, Warsaw and the UK all offered FOB to our wholesale customers in these areas. We also supply flowers to a number of domestic retailers such as Aldi and Marks and Spencer.

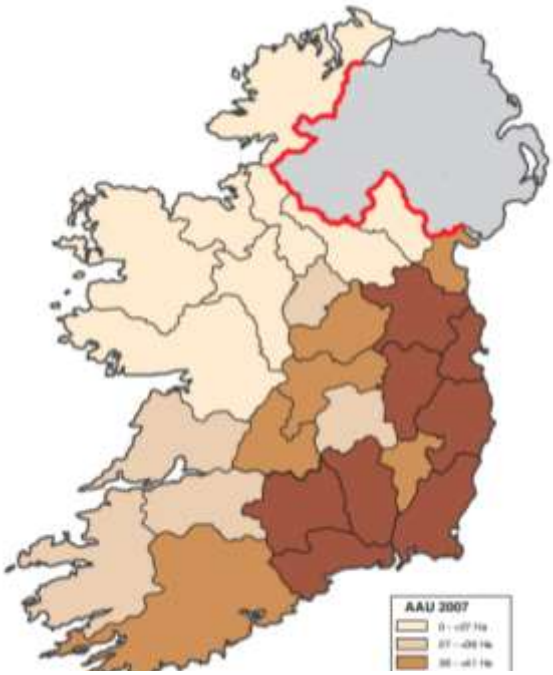
Hughes Consultancy and Training Ltd was setup in 2008 as an agricultural training company offering FETAC accredited programmes. In 2011, turnover of €500,000 was achieved as the company has expanded, employing 6 full time staff with over 80 associate trainers. This company was sold in 2012.

Since the beginning of my Nuffield study, along with offering agronomy services domestically, I have become involved in a number of projects outside Ireland. Visiting regions such as the Congo in Africa, through Hughes Agriculture and Farming Ltd I have been involved in the setup and evaluation of large scale crop production projects. Irregular media contributions and exam board duties for the Agriculture department in a local university are also run through Hughes Agriculture and Farming Ltd.

I am currently centrally involved in a large scale investment based arable project in Eastern Europe, buying, structuring and farming commodity crops on 17,000 acres.

4. Introduction

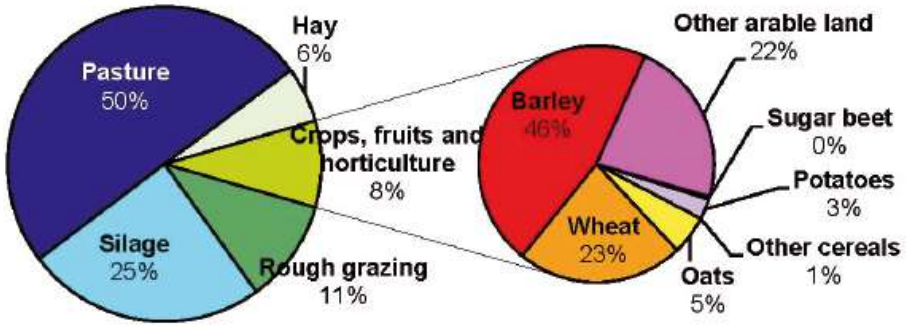
Average farm size in Ireland, at present is 34 hectares or 84 acres. Arable production is heavily reliant on land and as production has evolved, scale. Using anecdotal evidence and present market conditions, an arable farm size of a minimum of 200 acres returning €200/acre is required to give an income of €40,000pa before loan repayments, interest, depreciation and capital expenditure on machines is accounted for.



Average farm sizes in Ireland. CSO *Farm Structure Survey.* 2007

Arable farming in Ireland is most common in the south east region of the country where climate and soil type are most suitable. The farm structure diagram illustrates the impact arable farming in the south east has had on farm sizes where farm size averages are greater than 41 hectares. Many of these farms would be further aggregated together through lease and conacre (yearly rental) agreements to ensure adequate scale for production. Approximately 300,000ha of land is devoted to crops in Ireland producing approximately 2 million tonnes of cereals per year (CSO. *Production of selected crops.* 2007)

Output value of crop production in Ireland is 1.7 billion, 25% of the total agricultural output from crops and livestock production at 6.2 billion. Of the 300,000ha produced, the diagram below illustrates the breakdown of crop production in 2007.



Crop production breakdown 2007 (CSO. *Farm Structure Survey*. 2007)

Land access is one of the limiting factors of arable farming in Ireland. Payback periods of 75 years + make it unattractive for arable farmers to purchase land. Reliance on leased ground is currently the only method of expansion. Rental values at 1% of purchase cost may seem attractive in percentage terms, however, the inflated €37,000/ha value does much to make this seem inviting for prospective lessees. Lease prices of €400/ha, where margins for all but the top 10% of growers are already very low, represent a big risk in a market as volatile as the grain market. In a situation where prices fall, all but the growers who are farming over 50% inherited/owned land or are in the top 10% of growers are in a high risk situation in terms of profit and loss.

Yields in Ireland, using wheat as a base, are on a par with, if not the highest in the world at an average of 8.59t/ha. The market is predominantly feed grains for barley, oats and wheat with some 150,000t of malt, some seed crops and a portion of milling wheat. The table below demonstrates the yield comparison of Irish wheat with some of the market leaders worldwide in the wheat market.

Argentina	Australia	France	Germany	Ireland	United Kingdom	United States of America	Europe + (Total)
3.41t/ha	1.63t/ha	7.04t/ha	7.31t/ha	**8.59t/ha**	7.68t/ha	3.11t/ha	3.6t/ha

Comparison of wheat yields (FAO Agristat. *2011 Wheat Yields.* 2012)

Unfortunately, in achieving these yields, Irish production is heavily reliant on inputs such as artificial fertilisers and pesticides. Fertiliser costs of €296/ha (€120/acre), pesticide costs of €148/ha (€60/acre) and other costs such as seed, land lease, crop establishment and combining bring the total cost of production in Ireland to €1,517/ha (€614/acre). A gross return from wheat at €160/t producing 9.6t/ha is needed to just cover costs if straw is retained. With an average yield in Ireland of 8.59t/ha, this highlights the reliance Irish growers have on the single farm payment (SFP) and EU interventions to make up the difference. Unfortunately, our heavily input reliant production system puts us at greater risk than many of our counterparts worldwide who, while not having as big an output, have a far lower financial input to produce a crop. Volatility exasperates the risk in this situation.

Irish farmers receive on average €270/ha in EU support through the single farm payment. In return farmers are expected to maintain compliance with an increasing number of environmental measures while production efficiency is being sacrificed. Environmental and social policy dictates the current format of the EUs Common Agricultural Policy (CAP). The appetite for change is low in Ireland, however, crop producers and arable farmers in Ireland are paying a major price for their EU subsidy as land mobility is all but halted, false base lines have developed for land lease and purchase prices, average age profiles increase (55yrs old average in 2007), and exciting technology from around the world such as GM is not made available to us while GM is imported into the EU.

EU policy has become, as a result of EU subsidies, the single biggest factor impacting on the viability of crop production in Ireland. However, the question still remains as to what the true purpose of the EU subsidies really is, a farming policy or as many believe a misplaced social policy.

Arable farming in Ireland by numbers:

- 378,000ha cropped, 9% of the farmed area
- Average combinable crop output of 2.3 million tonnes per annum
- 51% of crops grown on leased/rented land
- Over 3 million tonnes of feed ingredients imported annually
- 30% of 51,500 jobs in food processing sector dependant on crops sector
- Grower numbers stable at 11,000, down from 100,000 in 1970's
- 23.4% of Irish soils deemed very suitable for crop production (appendix 1)

(Teagasc Tillage Stakeholder Consultative Group, 2012)

5. Objectives

Back in 2009, the outlook for arable farming in Ireland was bleak. Cereal prices were hovering around €100/t, 2008 and 2009 were extremely wet harvests causing yield and quality issues and credit was no longer freely available from the banks in Ireland, who were now broke.

Grain market volatility, a new phenomenon to Ireland where prices had been stable for 40 years, was a new entrant on the scene in 2008 with an extremely bullish cereal market, topping out at approximately €240/t for wheat off the combine, followed in 2009 by an equally bearish market which dropped back to just over €110/t off the combine. Volatility, we were told and can now verify, was here to stay.

With volatile grain markets, input costs, especially fertiliser, followed the grain price bull runs but was much slower to follow the equally aggressive and bearish drop in price. This unbalanced market was forcing us to become more reliant on our single farm payment, which was the EU average of €270/ha, to prop up the poor economics of growing a commodity in Ireland while being predominantly reliant on leased land for production. This reliance on lease ground put our business at great risk as we were immediately approximately €400/ha behind our neighbouring competitors who were producing on owned land and did not incur the cost of leasing ground.

Growing your arable farming business in Ireland is almost entirely based on leasing ground as land prices at €37,000/ha (2011) for good quality land, where a margin of €500/ha is achieved consistently, has a payback period of 75 years for capital only. Interest and bank charges almost wipe out any potential land capital gains over the purchase period. Land and the impact of market interventions from Brussels are two of the major limiting factors on arable expansion in Ireland.

These factors were the main drivers that prompted me to apply for a Nuffield Scholarship back in autumn 2009. The key questions I was asking myself was where did I want, and more importantly need to be as an arable farmer in Ireland, to build the business that would be financially sustainable and rewarding for the next 20 – 30 years.

The main objectives of the study tour were to:

- Identify macro agricultural production factors that would affect Ireland in the future
- Observe corporate and venture capitalist farming and identify aspects that can be incorporated into smaller scale production
- Study production practices around the world and seek to implement practices suitable to Ireland
- Evaluate GM production and its potential in the EU
- Identify new technology that will become the standard practice of the future
- Interview and meet inspirational agricultural leaders and business people and indentify why they have been successful

6. The study tour

Putting together a tour itinerary in the farm office in Kilkenny on a dark, wet January evening back in 2010, it was hard to imagine what would unfold.

Originally, in and out travel around the world encompassing South and North America, Asia, Australia and New Zealand, Germany, France and Russia was intended. However, it soon became apparent that, like the Irish banks in 2010, funds would be a limiting factor.

Refocusing on key areas, 7 states in the US Corn Belt, Argentina, Australia, New Zealand and the UK were all targeted when planning. Pricing ticket options, it was felt that once I got up and going, it was most cost effective to stay travelling as using Ireland as a base was far too expensive.

Prior to travelling, the areas targeted were categorised as to what I felt would be gained from visiting these areas:

- **UK (Wales & England):** New technology, predominantly arable agricultural industry, similar climate and environment, scale, diverse cropping portfolio and EU intervention impact.
- **USA (Illinois, Iowa, Minnesota, Wisconsin, Nebraska, Kansas & Missouri):** Corn production, food versus ethanol production, GM research and production, new technology, scale, similar seasons to Ireland and corporate farming.
- **Argentina:** Vast scale, major world grain producer, government impact, corporate and venture capitalist farming, major Irish farming business, potential for further increases in productivity, technology innovations and impact of outside investment.
- **Australia:** New technology, arable cooperation in deserted rural areas, diverse cropping portfolio, farm structure, impending GM introduction, innovation in agribusiness and business minded approach.
- **New Zealand:** Impact of dairy expansion on arable production, arable integration with the dairy industry, niche and premium crop production, similar landscape and industry makeup to Ireland, arable to dairy conversions and vice versa, and innovative agribusiness structures and approach.

Travelling for 14 weeks total, 12 of which were continuous, the study tour covered over 64,000km, 4 continents, 7 US states and 9 countries.

In addition to this tour, during the period of my Nuffield scholarship, I travelled to Republic of the Congo, Germany and extensively in Eastern Europe carrying our crop production related consultancy roles. In addition to my primary study tour, elements of this travel shaped the outcome of this study tour.

Study tour map and route

7. The EU

7.1 Intervention, regulation, subsidisation, suffocation

The Common Agricultural Policy, proposed after the signing of the treaty of Rome back in 1957, was initially devised to ensure farmers were offered a fair and consistent price for their produce, therefore allowing governments to offer affordable and consistently priced food to the masses.

In 1992, one of our own, Commissioner Ray Macsharry implemented the first reforms of note since 1957, introducing set-aside, forestation and stocking limits and early retirement. This was the first step down the road of moving from production based farming to subsidy farming in the EU. The result of the reforms was an overall average 29% reduction in support for cereal or arable farmers in the EU.

1999 saw the CAP split into two pillars, one rural development and the other production support. This was followed by the decoupling of subsidies in 2003 and the introduction of environmentally based cross compliance measures.

Strongly driven by socialist policy from Germany and France, the CAP has consistently since 1992 moved away from production focused support, incorporating increasing levels of environmental and rural development policies at the expense of commercial farming. Essentially CAP was becoming a social policy which traditional would have been handled by the department of environment and the department for welfare in member states while disguising itself as a farmer's policy. However, in the 1960's, we as farmers missed a real opportunity to advance agriculture in the EU with the unsuccessful Mansholt reforms failing to gain support.

In between the Treaty of Rome (1957) and the Macsharry reform (1992), Commissioner Sicco Mansholt tried and failed to implement reforms, which we can safely say now, would have been far more effective in putting agricultural production in the EU at the top of the global ladder.

The Mansholt plan observed and predicted many of the issues we currently face such as:

- Market imbalances (later addressed by the Macsharry reforms unsuccessfully)
- Poor standard of living for farmers in comparison to other industrial averages
- Benchmarking farmers against other industrial averages
- Unviable, small farm sizes hindering commercial efficiency
- Poor uptake of modern technology and biotechnology
- Land aggregation issues
- Early retirement
- Poor distribution of aid to inefficient and unviable farms

The Mansholt reforms are more relevant today than they were in the 1960's. EU tillage farmers have suffered a gradual but consistent decline in income over the last 20 years, especially so since the Macsharry reforms in 1992 followed by another blow in 2003 with decoupling. The CAP, marketed as a farming policy, supports inefficient farming, acting as a social welfare payment while locking up available land from commercially driven farmers. Technology such as GM, consistently passed by the WHO and EU scientific panels as being safe, is not available to EU farmers as politicians with no scientific reasoning vote against the use of GM, all while GM feedstuffs are imported into the EU on a daily basis.

Average farm incomes in Ireland continue to shrink relative to other industrial average's all while the burden of compliance consistently increases. How did farming, an industry that produces the single most important commodity/product for mankind (we don't need oil or cars to live), manage to trade ourselves so low down the ladder that we are now amongst the lowest industrial earners for the most important product?

Current (2011) proposed reforms of the CAP look to be travelling down a similar path to that already taken with further environmental measures being proposed and the use of the historical linking of payments being put forward for another round, all of which will drive farm incomes lower and decrease food security in the EU.

"Europe is on the verge of becoming a food museum. We well-fed consumers are blinded by romantic nostalgia for the traditional farming of the past. Because we have enough to eat, we can afford to indulge our aesthetic illusions." Unknown

7.2 New Zealand

While many in this part of the world, similar to a crutch, believe we will falter without subsidies, it has been proven to have been a revolutionary step to remove subsidies in New Zealand. Similar to Ireland in that it is an island with strong grass production ability close to major outlets such as Australia and Asia, New Zealand abolished subsidies overnight in 1984. Now closer to their customers with no government led boards dictating their output, New Zealand farmers have reshaped their industry with sheep production, a New Zealand icon; suffering a 41% decrease while dairy enjoyed a 74% increase in production. This market focused growth has been key to producing what customers actually want, not what governments think they want.

The New Zealand agricultural industry is now a vibrant place to be with new entrants, often from non farming backgrounds evident in all farms visited. Business structure and approach has also evolved for the non-intervened market place. A straw poll of any of the farms I visited while in New Zealand would say that removal of subsidies was the correct decision.

7.3 The price we pay for subsidies

As an EU farmer, I look enviously at our competitors around the world who operate in real market situations. As an arable farmer, land and access to land is the single biggest challenge we face.

Land lease prices in Ireland, without the influence of subsidies, should reflect the ability of the land to produce a margin for the farmer, simply that and no more. However, subsidies have caused the single farm payment to be capitalised into land prices, causing false base lines for lease and purchase prices.

Lease values track the true value of land far more accurately in Ireland, albeit with an increase due to the overall impact subsidies have. Taking this into account, it would be fair to assume a true lease value of €250/ha (€100/acre) for arable land when viewed on a potential operational return basis. Cash rental yields of 3% are an approximate standard lease value worldwide, and as €250/ha should represent 3% of the capital value, the real value of land should be closer to €8,333/ha (€3,372/ac). From this, we can interpret that lease values at €500/ha (€200/ac) are approx 50% higher than their real value and land purchase values at €29,652 (€12,000/ac) are 72% higher than their real value. While these figures don't allow for other factors such as the low risk of land ownership and

housing/development impact, they do highlight a major disparity between current and real land values, and more importantly, the effect EU aid is having on our land access in Ireland. In parts of Eastern Europe with similar yield potential, land purchase values are typically €2,500 - €5,000/ha (€1,000 - €2,000/acre) where the influx of EU money has not yet taken hold.

8. Corporate farming

Earlier we touched on some of the issues facing agriculture within the EU and Ireland where market intervention from the EU has led to an industry which is getting older, 40% over 55 in 2000 compared to 51% over 55 in 2010, and is slow to change with a current average farm size of 83 acres (32.7ha) only increasing by 1% since 2000. This paints a very poor picture when compared to the speed at which agriculture is progressing in other parts of the world.

Corporate and fund based agriculture is becoming increasingly common as farming is no longer seen as a quaint poetic industry but an industry with real growth potential and solid economic factors that are weighing heavily in its favour. Often demonised as being corporate monsters, corporate farms around the world are simply, well structured, organised units, which have clear entry, progression and succession pathways. Many of the farms visited had family members sitting in all of the key governance positions within the group but were keen to add clarity and structure to their farms.

8.1 Structure

While there are some very big corporate farms, the majority of the corporately structured farms visited were almost entirely run by family members, except for some of the board positions which allowed the family members to gain some outside perspective on their business. North America, Australia and New Zealand were the biggest advocates of this structure and many commented on the ease of running a business in this manner where each member had a very clearly defined role within the organisation, and had a clear progression, succession and exit path to follow.

Conversely, in Ireland the predominant structure is as a sole trader which is very difficult to operate with more than one member involved and inhibits that natural flow of people through the business. One doesn't have to look far in Ireland to find a farm where a 55 year old son still has no assets and the farm strategy is still being decided by a parent that is in essentially in retirement.

Limited liability companies are becoming increasingly popular in Ireland, especially with the more profitable farms for tax management purposes, however, there are many forms of non binding structures that farms visited were employing other than the obvious corporate structures. Strategy or non-binding advisory boards were one method which is popular in Australia.

Strategy boards generally sit once per quarter with a number of outside, paid board members making up the board along with the family members. The success of these boards is based on an necessity for the farm to very clearly analyse its figures and data four times a year and sit down and discuss the path the farm is on with outside experts. The non-family board members are often made up of non-competitor successful farmers, accountant, bank officials (useful method of involving the bank in informed decision making) and other parties that would have a beneficial view. The success of these boards is based on the quality of the outside board members and the quality of the data presented at the meetings.

8.2 Fund based farming

While in Australia, New Zealand and North America, many of the corporate farms are filled with family members. In areas such as South America where crop production has higher growth potential, many funds and investors have become involved to profit on the improving economics of producing crops.

One such investor is George Soros who has pumped over 0.5 billion dollars in Adecoagro, a New York Stock Exchange listed South American farming company. Soros is the second most successful self made investor in the world, behind the sage of Omaha, Warren Buffet. Soros is known as "The Man Who Broke the Bank of England" because of his US$1 billion in investment profits during the 1992 Black Wednesday UK currency crisis when he shorted the pound. Soros's presence in agriculture is indicative of the potential of the industry and the simple economics that population is increasing, diets are becoming less efficient and require more grain based foods and we cannot make more land are the drivers behind Soros and many other investors becoming involved in agriculture.

Adecoagro currently farms over 610,000 acres in Argentina, Brazil and Uruguay with EBTIDA of over 150 million dollars in 2011. Farming business such as Adeco section their business with land ownership, transformation and sale being a key section. Land ownership is the key component of a successful investment based farming company. One drawback of public listing in the case of companies such as Adeco is the markets immaturity in relation to farming companies and its inability to accurately value the assets and the business. This is improving every day as farming becomes more at home on public markets.

Closer to home, an Irish led consortium demonstrated the potential of this method of farming, buying, transforming and selling 30,000 acres of farmland in Argentina. Shares originally bought at a $1 were sold for approx $1.50 after 5 years, all during an intense global financial meltdown. When this farm was visited in Argentina, it was clear to see why the farm was as sought after as it was, crop husbandry, structures, systems and protocols were all exemplary.

Looking at the explosion of interest in farming around the world, you would question why we haven't seen such investment in farming here in the EU. A fund manager with over 500 million at his disposal explained to me while in Argentina, "EU Ag is over regulated, with environmental and scheme compliance costs too high relative to returns for it to be investable", a statement which further related back to the impact EU policy is having on agriculture within the EU.

This stagnation of EU agriculture is one of the main drivers behind our poor ability to attract the best people. Outside the EU, farm managers and operators were predominantly highly qualified MBA or degree level grads who saw a bright future in their industry.

A picture was beginning to be painted of EU farmers being kept on a drip for the sole purpose of providing cheap food to the masses.

9. Our low cost competitors

A key desired outcome from this study was an understanding of what Irelands competitors were doing and how it would impact on Ireland. However, with 300,000 hectares of arable land in production, Ireland is merely a drop in the ocean when compared to single farms in Brazil that cover over 350,000 hectares. As such, Ireland is heavily reliant on other countries to incur weather related issues in order to achieve a good margin on cereals.

We highlighted earlier in the introduction Ireland's position as one of the highest yielding wheat regions in the world, however, we pay a very high cost for that yield with input heavy systems that burn a lot of diesel. A carryover of mentality from the pre Macsharry reform era in the EU when yield at all costs was key, EU production is still heavily yield and not margin based. This obsession with high yields at any cost has placed us as one of the highest cost producers in the world.

Irish grain production has been predominantly focused on producing commodity type feed grains that are in direct competition with world commodity markets and GM grain. The cost base of Irish growers renders them poor competitors in global markets and thus one would question the logic of growing global commodity grains in one of the highest cost grain producing regions in the world, albeit with excellent yields but very poor returns as a result of the cost base.

At present, the EU CAP is making up some of the difference for EU grain producers, subsidising wheat production in the EU on average by €30/t to keep farmers in place, however, the drastic difference in production costs is a major concern in the long term. How much longer can Irish producers hope that others misfortune will continue to keep the price of grain high? And when it does come down, the highest cost producers will be the first to feel the pain.

It would seem a more prudent approach would be to identify our strengths such as our ability to grow a wide variety of crops to offset non-commodity grains that are being imported from places like China and the Balkan region.

Another option is for grain producers to divest a portion of their area away from grain to specialty crops such as vegetables, hemps for oils and fibre and other similar crops.

Ireland has an extremely suitable growing climate, therefore it would seem logical to grow premium return crops where the impact of high land and input costs are not as significant. High value, low volume seems a simple logic given our production parameters in Ireland.

In terms of grain production, systems for production need analysis and production systems such as no-till seem a logical fit in combinable crop production systems.

9.1 How can we compete?

One of the most obvious areas that our competitors around the world are lowering their costs is the use of genetically modified crops. As the focus within the EU has moved from food production and food security to environmental measures, research has been the main casualty. The GM dilemma within the EU has been fuelled by political abdication in fear of upsetting the vocal minority. GM will be discussed in greater detail later in the report.

One of the other main tools used to lower the cost of production in regions like Argentina is no-till. No-till is an establishment technique where no cultivation and very minimal soil disturbance takes place when planting the crop. Removing the need for costly passes of ploughs, cultivators, rollers and drills, no-till simply places the seed in the ground.

Trialled in the UK, our nearest yard stick to measure off, no-till has gained only a small market share of the area being drilled in the UK. Many would argue that no-till is not suited to the climate in Ireland in the UK, however, one of the main issues is not the climate but how the system is implemented. Farmers in the past that have trialled no till have not embraced the concept fully and tried to implement no-till in a conventional way. No-till involves a complete change of mindset.

One farmer visited in Lincolnshire, Tony Reynolds, has fully embraced the concept. In his own words "you can't cross a canyon in two small steps". Tony went from a plough based system on soils ranging from clay to peat straight into no-till. After yield had dipped to 7.5t/ha (3t/ac) in years 2 and 3 of the system, Tony stuck with the system and is now back to 10t/ha. This yield is achieved at a fraction of the cost. The table below highlights Tony's establishment costs from when he was ploughing to his current no-till establishment costs. At 10% of his previous cost, no-till has been very successful for Tony in reducing his production cost/t. Tony has also seen his diesel costs reduced from 96l/ha down to 46l/ha, a 50% reduction.

Process	**Traditional**	**No-Till**	**Auto-Cast**
Sub-soil 1/3	15	0	0
Plough	55	0	0
Disc	30	0	0
Spring Tine	20	0	0
Power Harrow	35	0	0
Drill	24	22	0
Roll x2	28	0	0
TOTAL	**£207/ha**	**£22/ha**	**£0 /ha**

Crop establishment method cost per hectare comparison for Tony Reynolds

The change in system saw Tony have to address a number of new challenges, each of which needed a new way of thinking to overcome. Crops on the farm are combined using a stripper header, leaving the straw standing. This has been a major success but has resulted in fields *"not looking right"* as commented on by visitors. This change in attitude from yield and over the hedge farming to sustainable, margin farming has worked well in Lincolnshire but requires less shiny kit and more time monitoring the crops.

34th continuous wheat crop, no-till established after a stripper header combine in Lincolnshire

No till is widely used in Australia also where Nuffield Scholar Dave Brownhill implements the system. Using no till Dave explained that profit at farm level is the only real driver of sustainability and in the case of no till, "the less you do, the better it gets". In Australia, no till is a key component of moisture retention and moisture management but conversely, in the UK Tony Reynolds benefits from no till soils ability to disperse excess water due to improved structure and organic matter levels.

9.2 Grower led R&D – AMPS (Aus)

Currently within the EU we are in a position where agricultural research and development is all but extinct. Research and development is the only way of driving efficiency and finding practical, science based solutions to the major questions being asked of our food chain and its ability to feed an ever growing population.

Fed up with waiting for others to find the solutions, a group of farmers from the Liverpool plains in Australia decided to take the bull by the horns and put together their own research initiative with a commercial edge. AMPs commercial was setup as a company, not a co-op, with each grower as a shareholder and with its primary function as an input supply business initially. The margin returned to the shareholders from the inputs business is then put solely towards research and development of the grower shareholders concerns.

The company started with 32 shares at $5,000 each, $160,000 seed capital. In 2011, AMPs turned over $25,000,000 after expanding into grain marketing and export, purchasing silos and adding further grower shareholders. “While the margin isn’t massive it still allows for a strong R&D programme”, Dave Brownhill, one of the founding partners, explained. A key reason for the success of AMPs is the can do attitude of the staff, highlighting the importance of having the right people with the right attitude on board.

AMPs is an exemplary model of grower led co-operation to solve common problems using a can do attitude. While Australian farmers tend to interact better with each other as they are more isolated and appreciate each other more, arable farmers in Ireland are becoming a rare species also with the current dairy surge swallowing up land, initiatives like AMPs in an EU devoid of R&D could possibly be a solution for adding value to arable farmers produce and solving issues such as the yield plateau being observed in crops with far in excess yield potential.

10. Biotechnology

Biotechnology research in the EU has slowed to a standstill at the expense of our farmer's competitive edge. Recent attempts in Ireland and the UK to launch GM trials have been hampered by the vocal minority green movement which is unwilling to allow science to dictate the fate of GM but rather here say and sound bites.

10.1 Monsanto effect

Having spent a day in the Monsanto world headquarters in St Louis, Missouri, the potential of GM and the pace at which it is progressing was striking. After attempted to ram GM down the EU's throat in the 90's and after a couple of high profile incidents in the UK, Monsanto have adopted a new tack with regard to winning public approval.

Seeing the potential of drought tolerant corn to swallow a large area of what was traditionally wheat dry land in the States, the American Wheat Growers Association has recently approached Monsanto with a view to dusting down roundup ready (RR) wheat and trying to win over the public to put it into production. However, unlike the last time, Monsanto have said to the wheat growers, "yeah we'll give it to you, but you have to get the public onside" as Steve Joehl, director of wheat industry affairs explained to me. Already dominating the maize corn and soya markets, Monsanto have lost their appetite to get publicly hammered again.

Monsanto, as a result of their history, have a mixed effect on the GM debate. They are the leading GM pioneers. However, they also have a chequered past with public relations. In South America, numerous indigenous seed houses have developed over the last number of years and are proving to be real competitors for the big boys such as Monsanto, Pioneer, Dow and Basf. Somewhat of a sore point with Monsanto is the way in which they perceive soybean royalties were flouted in South America and as the soybean was not hybrid, the local producers could save their own seed. This royalty issue is the main reason for hybrid seed, to prevent home saving.

GM seed prices are obviously higher than conventional but the key element is the consistency that GM brings to yield and crop performance. Herbicide tolerance is a benefit but the consistency in corn is key. Crops such as cotton, which had become almost extinct in Australia are now back in the rotation with the introduction of RR and bollworm resistant cotton plants. This has revolutionised cotton production.

The list of traits and pipeline traits is exhaustive, ranging from yield to drought to herbicide tolerant to insect resistance.

10.2 Kansas State – an alternative approach

Not too far from St Louis in Kansas, Kansas State University are taking a slightly different approach to GM wheat development. With the largest seed bank of wild wheat cultivars in the world on campus, the K-State guys are essentially looking backwards to go forward.

Using within species gene transfers, the K-State research team are using wild wheat plants to find genes with characteristics such as disease resistance and herbicide tolerance which they can transfer into commercial wheat cultivars.

As an independent body, I was keen to get the opinion of the K-State researchers as to whether GM was safe, John Fuellers explained that “within species plant to plant GM is simply speeding up conventional plant breeding, crossing a fish with wheat is when there is potential for trouble”. John also went on to explain how he felt Ireland and Western Europe stood to gain the most from GM as we are heavily reliant on inputs, “using traits such as septoria resistance and fertiliser use efficiency, you guys would benefit hugely from GM”.

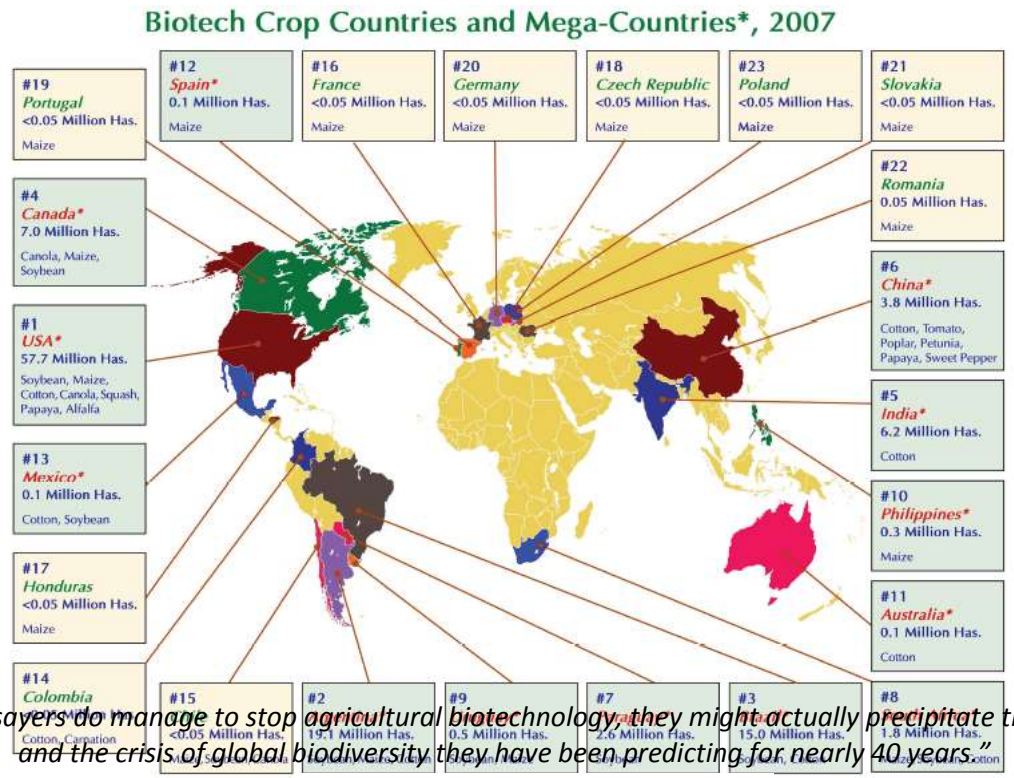
10.3 The EU and GM

There is currently over 200,000 hectares of GM corn grown in Europe, using corn borer resistant genes predominantly. GM soya meal is imported into the EU on a daily basis. Foodstuffs containing GM are flooding across EU borders every day. EU farmers must grow conventional wheat. The playing field is not level.

Current research (2012) attempts in Ireland, for GM potatoes, and the UK, for GM wheat are being hammered by the green movement and while the argument may stand that this is the will of the people, the major issue is the lack of education the public has received on GM and the vocal nature of a minority movement.

As a result of the very public failure to launch GM in Europe in the past, Monsanto and the rest of the GM industry has charged ahead with developing alternative markets. Steve Joehl explained to me, “if you guys want it at this stage, you are going to have to really pay for it”. At the time of going to print, Australia was on the verge of launching GM wheat onto the market. North and South America already produced GM corn and wheat, along with China entering the market. The world around the EU is moving on.

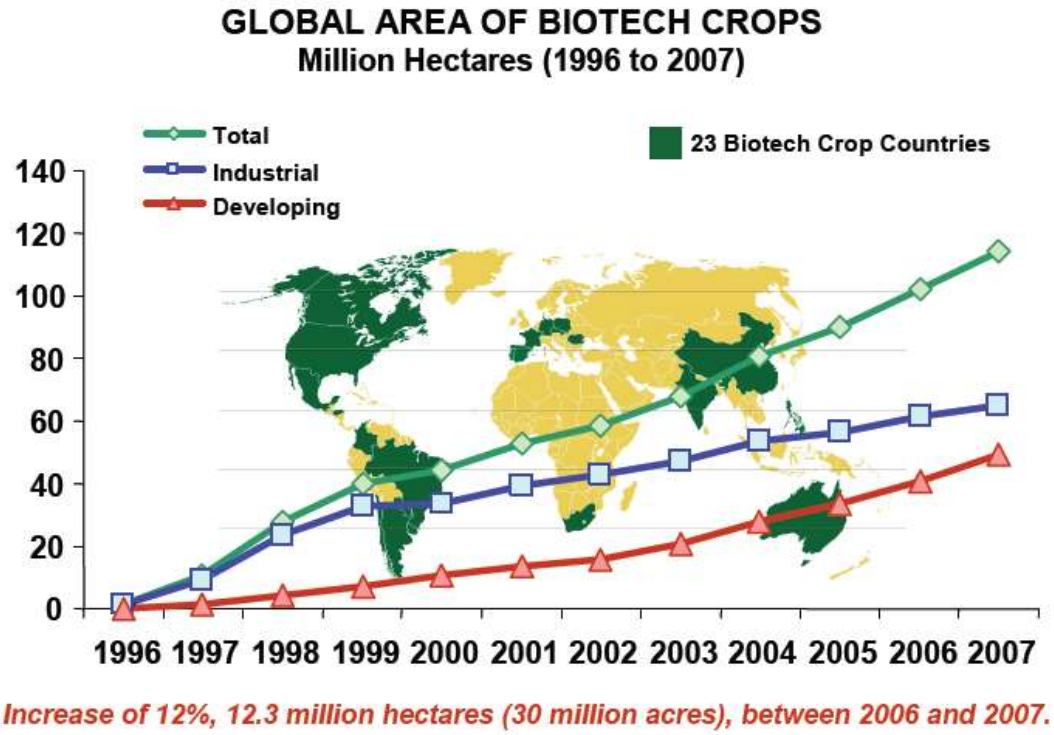
The map below illustrates the scale at which GM is evolving. Take note of the GM production in the EU but also the regions such as Australia that have small amounts of GM now but are looking to vastly increase that area.



"If the naysayers do manage to stop agricultural biotechnology, they might actually precipitate the famines and the crisis of global biodiversity they have been predicting for nearly 40 years."

Norman Borlaug

World GM/Biotech adoption map



World biotech adoption trends

Restructuring of the CAP towards a greener system with no major emphasis on commercial food production is putting EU farmers at a distinct disadvantage to their competitors around the world. Agriculture is the cornerstone of many economies and has real potential to vastly increase sovereign wealth in countries like Ireland through exports. GM among other exciting and necessary technologies

will enter the EU in time, therefore why are we standing back allowing the competition to get a substantial head start?

10.4 Basf vs. the EU

After Monsanto's ill fated attempt to bring GM wheat into the EU, more recently Basf took on the mantle and attempted to bring GM potatoes in Europe. With strong European roots and a product that was thought to be an easier sell to the public, in January 2012 Basf made the decision to move its plant science headquarters out of the EU from Germany and move to Carolina in the USA, the most recent indictment of the EU's inability to move with the times. The loss of such a progressive plant science company is a poor reflection on both our national and EU politician's as they stand idly by, afraid to voice an opinion and support innovation.

Basf had intended to launch the Amflora blight resistant potato that would have vastly reduced the amount of chemicals applied to potatoes. Pesticides and insecticides have been proven without scientific doubt to be harmful to humans at high concentrations while GM has been consistently passed as safe by the WHO and EU scientific panels, yet it is GM that is feared most. Argentinean farmers spend zero on fungicides and insecticides on corn while comparatively we in Ireland spend €160/ha on chemicals as a result of having to control a wide variety of pests and diseases.

10.5 Finding science - The anti-GM protestor's journey from anti to advocate

In his former life, Mark Lynas was a prominent UK based anti-GM protester, helping to start the anti-GM movement there back in the 1990's. Now a prominent environmentalist and author of science based publications, Lynas is now a strong advocate of GM. So what prompted the change?

A previous staunch anti GM protestor, through his work as a climatologist Lynas began to research the scientific research behind GM and myth by myth began to see the weakness in the argument against GM. Citing the anti movement as being rife with hypocrisies and members whose backgrounds permit them to spend as much time blocking science, Lynas is unequivocal in his support for GM.

Assumptions of an anti-GM protestor, an extract from Lynas's Oxford Farming Conference paper which he delivered in January 2013:

"What really threw me were some of the comments underneath my final anti-GM Guardian article. In particular one critic said to me: so you're opposed to GM on the basis that it is marketed by big corporations. Are you also opposed to the wheel because it is marketed by the big auto companies? So I did some reading. And I discovered that one by one my cherished beliefs about GM turned out to be little more than green urban myths.

- I'd assumed that it would increase the use of chemicals. It turned out that pest-resistant cotton and maize needed less insecticide.
- I'd assumed that GM benefited only the big companies. It turned out that billions of dollars of benefits were accruing to farmers needing fewer inputs.
- I'd assumed that Terminator Technology was robbing farmers of the right to save seed. It turned out that hybrids did that long ago, and that Terminator never happened.

- I'd assumed that no-one wanted GM. Actually what happened was that Bt cotton was pirated into India and roundup ready soya into Brazil because farmers were so eager to use them.
- I'd assumed that GM was dangerous. It turned out that it was safer and more precise than conventional breeding using mutagenesis for example; GM just moves a couple of genes, whereas conventional breeding mucks about with the entire genome in a trial and error way.
- But what about mixing genes between unrelated species? The fish and the tomato? Turns out viruses do that all the time, as do plants and insects and even us – it's called gene flow.

Last year Greenpeace destroyed a GM wheat crop in Australia, for all the traditional reasons, which I am very familiar with having done it myself. This was publicly funded research carried out by the Commonwealth Scientific Research institute, but no matter. They were against it because it was GM and unnatural.

What few people have since heard is that one of the other trials being undertaken, which Greenpeace activists with their strimmers luckily did not manage to destroy, accidentally found a wheat yield increase of an extraordinary 30%. Just think. This knowledge might never have been produced at all, if Greenpeace had succeeded in destroying this innovation. As the president of the NFU Peter Kendall recently suggested, this is analogous to burning books in a library before anyone has been able to read them.

Lynas went on to conclude, "The GM debate is over. It is finished. We no longer need to discuss whether or not it is safe – over a decade and a half with three trillion GM meals eaten there has never been a single substantiated case of harm. You are more likely to get hit by an asteroid than to get hurt by GM food. More to the point, people have died from choosing organic, but no-one has died from eating GM.

Just as I did 10 years ago, Greenpeace and the Soil Association claim to be guided by consensus science, as on climate change. Yet on GM there is a rock-solid scientific consensus, backed by the American Association for the Advancement of Science, the Royal Society, health institutes and national science academies around the world. Yet this inconvenient truth is ignored because it conflicts with their ideology.

So my message to the anti-GM lobby, from the ranks of the British aristocrats and celebrity chefs to the US foodies to the peasant groups of India is this. You are entitled to your views. But you must know by now that they are not supported by science. We are coming to a crunch point, and for the sake of both people and the planet, now is the time for you to get out of the way and let the rest of us get on with feeding the world sustainably."


C'EST SANS DANGER
Concernant les OGM, on n'a pas encore assez de recul...
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11. Precision farming

Precision farming, once only an option for large scale producers, is becoming more widely available and gradually moving from niche into mainstream as more and more growers begin to realise the benefits. Arable farming, by it machine reliant nature, has been the fastest adopter of precision farming technology. Recent work by East German company Agricon has highlighted a break even area of approximately 300 acres for economic use of precision technology, as scale increases from this point, the rate of return on the investment in this technology increases as overhead cost is diluted.

Some of the common precision farming methods being used are auto-steer, combine telematics (remote monitoring of the combine), variable rate fertiliser application and mapping. Auto-steer technology, while not widely in use in Ireland at present, is becoming more widespread as growers begin to realise the benefit of having 100% pass to pass accuracy when carrying out spraying, cultivating, seeding and combining. This accuracy ensures inputs such as diesel, chemicals, fertiliser and seed are not wasted while speeding up combining. Driver fatigue and machine management have also greatly improved as a result.

Combine telematics, pioneered by Claas, is no longer a new technology but its popularity is growing consistently as growers begin to realise the benefits of monitoring their combines performance during harvest. Telematics works via remote monitoring of the combine with outputs such as diesel usage, path recording, downtime, throughput, yield monitoring, moisture monitoring and service information all analysed and presented in mapped or easy to read formats.

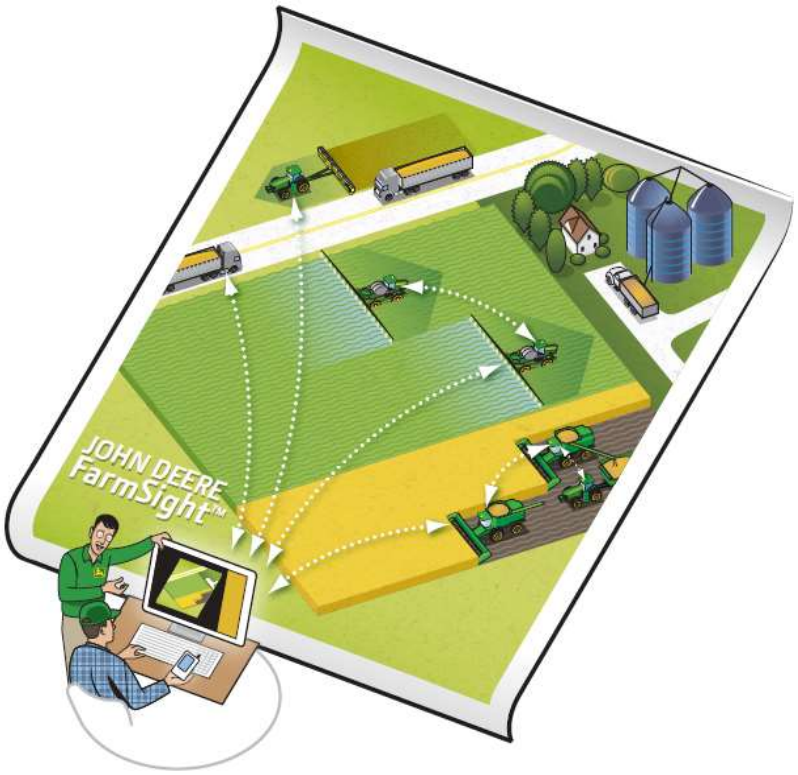
Telematics is more recently being used to monitor the performance of machines such as tractors, farm jeeps, loaders etc as a means to optimise whole fleet performance on farm. This detailed analysis not only acts as a mapped machine tracker service but allows farmers to be very accurate in their calculations of production costs as the telematics relays all information such as the machine movement history, fuel usage, downtime and many more useful functions.

Variable rate application has been for a long time popular in the UK but has failed to gather momentum in Ireland due to the perceived lack of scale to justify this technology. Variable rate application was traditionally confined to fertiliser application but more recently has been trialled to good effect across a number of other functions such as variable rate seeding, fungicides and most impressively growth regulating in cereals. Plant growth regulator (PGR) use relates directly to canopy density, thus using a cab mounted Yara N sensor, which measures crop biomass, linked into the sprayer allows for variable rate application of PGR's, increase the rate on lush areas and decreasing for lighter crops. Work by German firm Agricon has shown up €97/ha of an increase in margin where variable rate PGR's were used in conjunction with variable rate fertilisers. This was achieved while eliminating lodging and producing a uniform crop, a combine drivers dream.

11.1 Precision farming integration and advances

For a number of years, companies have been busy producing individually functioning precision farming tools. In more recent times, integration of these systems into one, easy to use product has been the goal with companies like John Deere and smaller companies offering fully integrated, one stop precision farming packages to farmers.

John Deere Farm Sight, a blue sky thinking model from John Deere, has taken variable rate fertiliser and seeding, their harvest lab software, auto-steer, machine sync and all of the other lesser precision tools and rolled them all into one, easy to use package. The benefit of this integration is the absence of data input duplication, the grower only needs to enter his data once to get a whole range of outputs and analysis results.



Machine sync, a new product from John Deere, allows one machine to control another and is indicative of the move to fully autonomous tractors. This has two immediate uses, one for cultivation as the cultivating machine can be set to mimic the drilling tractor, allowing an operator to set his cultivator operating 3-4 passes ahead of him and then control that tractor from the drilling tractor cab. Also, for chaser bin filling, a difficult task with a 30t bin, the combine takes over the operation of the chaser bin, allowing the combine driver with better vision to shunt forward or drop back the chaser bin via joystick control. A simple thing but it allows drivers to fill bins fuller without risking spillage.

German firm Agricon, mentioned previously, are one of a number of smaller companies that have developed precision farming integration packages. Using EMC texture and nutrient mapping, Yara N sensor biomass mapping and yield mapping at harvest, Agricon have developed variable rate fertiliser and PGR application systems that combine with whole fleet telematics (including the farmers car!)

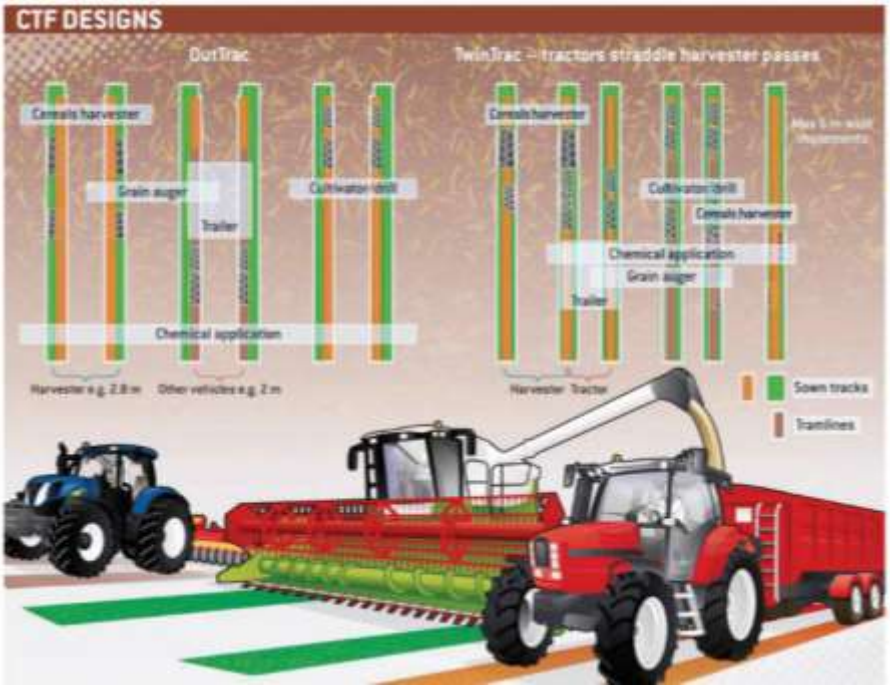
that allows for complete analysis of every aspect of a farmers operation from individual machine fuel usage, yield potential of specific areas through to machine use efficiency.

The rate of advance in technology is such at present that we as farmers cannot adopt or change quick enough to make use of the technology. Full autonomous tractors are available but the lack of demand prohibits the supply and cost. The use of sensing technology for cereals is another advance that will come more into main stream. Carrying a sensing boom that detects weeds using photo sensors, the need for nitrogen using biomass sensors, aphid pheromone sensors for aphid populations and fungi detecting sensors for disease will over time lead to constant variable rate application across all the disciplines in crop production, implementing technologically driven integrated crop management. This technology is available and field tested as accurate, however, we cannot move quick enough to adopt or demand. Farmers move is gradual steps, not big jumps when it comes to technology, owing to our generally conservative nature.

11.2 Controlled traffic farming

One farming practice than makes use of many precision tools is controlled traffic farming (CTF). Observed in Australia predominantly, CTF is based on real time kinetics (RTK) guidance of machines down the same tracks/tramlines, year on year, as a means of reducing compaction and lifting yield.

This is achieved by running a fleet than is wheeling's and implement width compatible. For example, using a 12m seeder, a 12m cultivator, a 36/24m sprayer, a 36/24m fertiliser spreader and a 12m combine, all on the same wheel width, it is possible to reduce machine compaction effect by limiting them to the same tramlines year on year using +/-2cm accuracy RTK. The diagram below highlights the two options commonly used; out trac is the most popular and effective of the two. As a result, CTF only compacts only 18% of a field compared to 140% with conventional, leading to yield increases in the region of 18% couple with fuel decreases. Scale is an issue and changeover to CTF is costly when spread over a small area.



RTK, once reliant on in field base station setups in order to triangulate or proof the actual position of a machine as the earth spins, is no longer as cumbersome as it once was, now widely available through sim cards, using telephone masts as their reference point on earth to triangulate. Kelly's of Borris in Ireland have just developed Ireland first dealer led initiative offering RTK guidance across the South East of Ireland via sim card.

12. Conclusion and recommendations

12.1 Conclusion

Having completed my Nuffield study tour, it is now apparent to me that many aspects of my original objectives are directly negatively affected by the EU. Two of my main themes, our competitive edge and GM have been bludgeoned by EU policy.

With the move away from production/commercial farming policy towards environmental/extensive farming policy, EU crop production is slipping into backwater that is allowing our competitors to pass us by; all the while our competitiveness is being eroded as our competitors embrace new technology and become more efficient. With CAP reform currently on the agenda, at present we face into potentially another ten years of referenced or historically based payments in Ireland. This system has shown itself to favour only the smaller, part time extensive farmers who are essentially blocking the progress of the more progressive and often younger farmers.

EU farmers receive on average €270/ha of support from the EU, and I as a recipient am grateful for this support, but only as a means to compete. The removal of, or better targeting, of subsidies at elements such as exports (which is the only way to increase sovereign wealth), would free up the land market in Ireland, breathing life into the sector. Recent research by the Farmers Journal highlighted a 1% aggregation over 10 years of Irish farmland, put simply every 10 years the average Irish farm will add 1/3 of a hectare (0.84ac) to his holding, slow evolution!

Irish tillage farmers produce they highest average wheat yields in the world at 8.6t/ha, however, this comes at a price, €115/t which is €72/t more expensive than Argentina. When EU support at €270/ha is factored in this moves Irish grain to within €41/t. However, this €41/t spread is only available to farmer growing on land where subsidies are available and in the case of most progressive expansion focused farmer, this greatly hinders their attempts to expand or puts them at greater risk where they do expand without EU support. This is not sustainable and with the expected shift in subsidisation to Eastern Europe along with further greening of the current subsidy package available, Irish tillage farmers are being pushed into a very exposed position all while have one of the highest production costs bases in the world.

The focus on commodity grain production is the wrong route for Irish growers to take, high value, premium crop production is the only logical approach for growers to take in our high yielding but costly growing environment. Speciality grains, vegetables and non-food crops all need careful consideration as these would seem a better fit in the modern grain market.

When observing our low costs competitors, more often than not I was also observing a corporately structured farming business, focused purely on return on capital in an emotionless manner. Corporate structuring does not mean the removal of family; it simply means organising and structuring family members roles within a business, allowing for ease of entry, progression, succession and exit from the business.

At a greater scale on the corporate ladder, many corporate farms observed were investment based, often through private equity or hedge fund structures. These business's and the capital they attract highlighted the change in attitude from the markets towards farming. Since 2005 the number of

farming business's that have been publicly listed has exploded while the level of private equity investment in farming has been staggering.

One of the key tools driving the profitability and the consistency of the returns to these corporate fund based farms is biotech or GM cropping. We in Europe simply cannot stand idly by as our competitors push ahead. GM, where within species crossing is implemented in a well legislated environment, is simply speeding up traditional plant breeding by an exponential rate. Why are we anti evolution within the EU? GM floods into the EU on a daily basis yet we must fight with our hands tied behind our back. EU policy must support commercial agriculture through science and R&D based decision making, not short term vote garnering political rhetoric.

Working hand in hand throughout the world with GM is no till production, a system that has the ability to stand a crop for £22/ha compare with £207/ha in the UK, all while incurring only a short term yield penalty for drastic long term gains. This establishment method will work in Ireland, however attempting to establish no till crops with a conventional attitude is similar to trying to milk a bull.

The technology to accompany the advances in other sectors, driven by precision farming, would lead one to believe that arable in Ireland is leading into a golden age. However, Irish farmers face this period without the ability to adopt the tools required for sustainability. The CAP structured as is inhibits expansion and growth. The only real road to sustainability is profitability. A stagnated tillage sector will not be in a position to raise capital for investment in new technology and expansion and this in turn will hamper the long term prospects in the face of increased competition from the dairy sector which is gearing up for a life post quota and restrictions. GM is a key tool is the delivery of consistent returns.

On a personal note, the Nuffield experience for me threw up many emotions. Possibly the most consistent of those emotions was frustration and often embarrassment at what we have allowed our industry to become. Our competitors around the globe see us as stuck in the past, a talking shop for politicians and lobbyists, and sadly I would agree. The tillage industry in Ireland has excellent people, a natural competitive advantage through our high yielding climate, and excellent proximity to the major world markets in North Africa, North America and Europe, however the policy makers within the EU have failed to see the benefit of a strong, world leading agricultural industry. With CAP change coming around the corner, policy makers have a real opportunity to positively influence food security within the EU and the sustainability of an industry that has, and always will be, the cornerstone of a strong society. Let's hope they value the source of their food.

12.2 Recommendations

As a result of my study tour and research, a number of recommendations that I feel would benefit arable farmers in Ireland have become apparent. They are listed in order of importance as I see them:

1. Refocus the CAP on commercial agriculture
2. Support GM trials and introduction
3. Removal of historical area based subsidy payments
4. Support research of low cost crop production systems such as no-till farming conducted by non-government agencies through CAP or modulated SFP funds
5. Increase tax incentives for medium to long term land lease, encouraging a gradual move from year to year “conacre” based system
6. Target subsidy payments at succession, new entrants and early retirement support
7. Target agricultural production with export potential through CAP. This is the only way to increase sovereign wealth.
8. Conduct major long-term trial plot and field based research into no-till crop production using true no-till techniques and equipment
9. Encourage growers to move away from commodity grain production and to grow premium grains, premium high return crops and alternative tillage crops that don’t compete with global low-cost grain commodities.
10. Conduct long term margin trials of different production systems such as no-till, min-till, strip-till and conventional tillage using accurate practices for each discipline, not one shoe fits all regarding timing of each operation and technique.
11. Promote margin based farming as opposed to yield based, the legacy of coupled payment
12. Support arable farming discussion groups and reward groups who move the model on for greater levels of cooperation and integration.
13. Corporate farming structures to be encouraged by government and semi-government extension bodies

13. Acknowledgements

Taking on a Nuffield scholarship is a big undertaking, one that would not have been possible were it not for the understanding on my partners in business and family. However, first and foremost I would like to thank the Irish Farmers Journal and the Irish Farmers Association who through Nuffield Ireland sponsored me, specifically Pat Smith in the IFA and Matt Dempsey of the IFJ. Thank you and I would like to wish Matt all the best on retirement from the Farmers Journal.

Within Nuffield, I would like to thank secretary Matt Ryan for his extraordinary patience and resolve in coaxing me to finish my report. Matt has played a huge role in Nuffield since he joined and again, I would like to wish him all the best on his new ventures outside Nuffield when he steps down, he will be sadly missed.

I would like to thank my fellow 2010 scholar, Kevin Kilcline, Bill O' Keeffe (Cork), Bill O' Keeffe (KK) and Kevin Nolan. A special group that made the experience what it was, except for karaoke singing in Washington which left a scar.

Travelling with me for large parts of my study tour, I would also like to thank my soon to be wife Valerie. Having sat through countless in depth, long and unwavering conversations about every aspect of crop production, I realised I had better ask her to marry me before she got bored of them. I can happily say we will be married in July 2013.

Finally, I would like to thank my parents whose support on the farm allowed me to properly experience Nuffield. Starting at 5am back in Ireland to harvest carrots while I was enjoying 35 degrees C in South America can't have been easy, thank you.

14. Appendices

14.1 Appendix 1: Tour picture book

Tony Reynolds beside his crop of auto-cast oilseed rape in Lincolnshire, UK. One of the best crops of OSR observed.

UK Nuffield Rhys Williams's outdoor rotary parlour in Wales where he milks 1,200 cows daily.

shire, UK.

Being put to work following the combine from the chaser bin in Iowa. USA.

ubbles with
esota, USA.

About to be given a dressing down from a Monsanto security member for taking photos. Monsanto World HQ, St Louis, Missouri.

With my then girlfriend, now fiancé and soon to be wife, Valerie, beside the corn pit on the trading floor of the Chicago Board of Trade (CBOT), Chicago, USA.

Poker straight GM corn rows with busting ears in the middle of the corn belt, Iowa, USA.

Moving a pivot irrigator from winter to spring crops, maximising irrigator use, on Aussie scholar Dave Brownhills farm in NSW, Australia.

Performance review meeting Aussie style over a few beers on Australian Nuffield Dave Brownhills farm on the Liverpool Plains, NSW, Australia.

ury plains, **Farm** Rotary dairy parlour on the Canterbury Plains in New
http:, Zealand.

14.2 Appendix 2: Mark Lynas – Lecture to Oxford

I want to start with some apologies. For the record, here and upfront, I apologise for having spent several years ripping up GM crops. I am also sorry that I helped to start the anti-GM movement back in the mid 1990s, and that I thereby assisted in demonising an important technological option which can be used to benefit the environment.

As an environmentalist, and someone who believes that everyone in this world has a right to a healthy and nutritious diet of their choosing, I could not have chosen a more counterproductive path. I now regret it completely.

So I guess you'll be wondering – what happened between 1995 and now that made me not only change my mind but come here and admit it? Well, the answer is fairly simple: I discovered science, and in the process I hope I became a better environmentalist.

When I first heard about Monsanto's GM soya I knew exactly what I thought. Here was a big American corporation with a nasty track record, putting something new and experimental into our food without telling us. Mixing genes between species seemed to be about as unnatural as you can get – here was humankind acquiring too much technological power; something was bound to go horribly wrong. These genes would spread like some kind of living pollution.

It was the stuff of nightmares.

These fears spread like wildfire, and within a few years GM was essentially banned in Europe, and our worries were exported by NGOs like Greenpeace and Friends of the Earth to Africa, India and the rest of Asia, where GM is still banned today. This was the most successful campaign I have ever been involved with.

This was also explicitly an anti-science movement. We employed a lot of imagery about scientists in their labs cackling demonically as they tinkered with the very building blocks of life. Hence the Frankenstein food tag – this absolutely was about deep-seated fears of scientific powers being used secretly for unnatural ends. What we didn't realise at the time was that the real Frankenstein's monster was not GM technology, but our reaction against it.

For me this anti-science environmentalism became increasingly inconsistent with my proscience environmentalism with regard to climate change. I published my first book on global warming in 2004, and I was determined to make it scientifically credible rather than just a collection of anecdotes.

So I had to back up the story of my trip to Alaska with satellite data on sea ice, and I had to justify my pictures of disappearing glaciers in the Andes with long-term records of mass balance of mountain

glaciers. That meant I had to learn how to read scientific papers, understand basic statistics and become literate in very different fields from oceanography to paleoclimate, none of which my degree in politics and modern history helped me with a great deal.

I found myself arguing constantly with people who I considered to be incorrigibly antiscience, because they wouldn't listen to the climatologists and denied the scientific reality of climate change. So I lectured them about the value of peer-review, about the importance of scientific consensus and how the only facts that mattered were the ones published in the most distinguished scholarly journals.My second climate book, Six Degrees, was so sciency that it even won the Royal Society science books prize, and climate scientists I had become friendly with would joke that I knew more about the subject than them. And yet, incredibly, at this time in 2008 I was still penning screeds in the Guardian attacking the science of GM – even though I had done no academic research on the topic, and had a pretty limited personal understanding. I don't think I'd ever read a peer-reviewed paper on biotechnology or plant science even at this late stage.

Obviously this contradiction was untenable. What really threw me were some of the comments underneath my final anti-GM Guardian article. In particular one critic said to me: so you're opposed to GM on the basis that it is marketed by big corporations. Are you also opposed to the wheel because it is marketed by the big auto companies?

So I did some reading. And I discovered that one by one my cherished beliefs about GM turned out to be little more than green urban myths.

I'd assumed that it would increase the use of chemicals. It turned out that pest-resistant cotton and maize needed less insecticide.

I'd assumed that GM benefited only the big companies. It turned out that billions of dollars of benefits were accruing to farmers needing fewer inputs.

I'd assumed that Terminator Technology was robbing farmers of the right to save seed. It turned out that hybrids did that long ago, and that Terminator never happened.

I'd assumed that no-one wanted GM. Actually what happened was that Bt cotton was pirated into India and roundup ready soya into Brazil because farmers were so eager to use them.

I'd assumed that GM was dangerous. It turned out that it was safer and more precise than conventional breeding using mutagenesis for example; GM just moves a couple of genes, whereas conventional breeding mucks about with the entire genome in a trial and error way.

But what about mixing genes between unrelated species? The fish and the tomato? Turns out viruses do that all the time, as do plants and insects and even us – it's called gene flow.

But this was still only the beginning. So in my third book The God Species I junked all the environmentalist orthodoxy at the outset and tried to look at the bigger picture on a planetary scale.

And this is the challenge that faces us today: we are going to have to feed 9.5 billion hopefully much less poor people by 2050 on about the same land area as we use today, using limited fertiliser, water and pesticides and in the context of a rapidly-changing climate.

Let's unpack this a bit. I know in a previous year's lecture in this conference there was the topic of population growth. This area too is beset by myths. People think that high rates of fertility in the developing world are the big issue – in other words, poor people are having too many children, and we therefore need either family planning or even something drastic like mass one-child policies.

The reality is that global average fertility is down to about 2.5 – and if you consider that natural replacement is 2.2, this figure is not much above that. So where is the massive population growth coming from? It is coming because of declining infant mortality – more of today's youngsters are growing up to have their own children rather than dying of preventable diseases in early childhood.

The rapid decline in infant mortality rates is one of the best news stories of our decade and the heartland of this great success story is sub-Saharan Africa. It's not that there are legions more children being born – in fact, in the words of Hans Rosling, we are already at 'peak child'. That is, about 2 billion children are alive today, and there will never be more than that because of declining fertility.

But so many more of these 2 billion children will survive into adulthood today to have their own children. They are the parents of the young adults of 2050. That's the source of the 9.5 billion population projection for 2050. You don't have to have lost a child, God forbid, or even be a parent, to know that declining infant mortality is a good thing.

So how much food will all these people need? According to the latest projections, published last year in the Proceedings of the National Academy of Sciences, we are looking at a global demand increase of well over 100% by mid-century. This is almost entirely down to GDP growth, especially in developing countries.

In other words, we need to produce more food not just to keep up with population but because poverty is gradually being eradicated, along with the widespread malnutrition that still today means close to 800 million people go to bed hungry each night. And I would challenge anyone in a rich country to say that this GDP growth in poor countries is a bad thing.

But as a result of this growth we have very serious environmental challenges to tackle. Land conversion is a large source of greenhouse gases, and perhaps the greatest source of biodiversity loss. This is another reason why intensification is essential – we have to grow more on limited land in order to save the rainforests and remaining natural habitats from the plough.

We also have to deal with limited water – not just depleting aquifers but also droughts that are expected to strike with increasing intensity in the agricultural heartlands of continents thanks to climate change. If we take more water from rivers we accelerate biodiversity loss in these fragile habitats.

We also need to better manage nitrogen use: artificial fertiliser is essential to feed humanity, but its inefficient use means dead zones in the Gulf of Mexico and many coastal areas around the world, as well as eutrophication in fresh water ecosystems.

It is not enough to sit back and hope that technological innovation will solve our problems.

We have to be much more activist and strategic than that. We have to ensure that technological innovation moves much more rapidly, and in the right direction for those who most need it.

In a sense we've been here before. When Paul Ehrlich published the Population Bomb in 1968, he wrote: "The battle to feed all of humanity is over. In the 1970s hundreds of millions of people will starve to death in spite of any crash programs embarked upon now." The advice was explicit – in basket-case countries like India, people might as well starve sooner rather than later, and therefore food aid to them should be eliminated to reduce population growth.

It was not pre-ordained that Ehrlich would be wrong. In fact, if everyone had heeded his advice hundreds of millions of people might well have died needlessly. But in the event, malnutrition was cut dramatically, and India became food self-sufficient, thanks to Norman Borlaug and his Green Revolution. It is important to recall that Borlaug was equally as worried about population growth as Ehrlich. He just thought it was worth trying to do something about it. He was a pragmatist because he believed in doing what was possible, but he was also an idealist because he believed that people everywhere deserved to have enough to eat.

So what did Norman Borlaug do? He turned to science and technology. Humans are a toolmaking species – from clothes to ploughs, technology is primarily what distinguishes us from other apes. And much of this work was focused on the genome of major domesticated crops – if wheat, for example,

could be shorter and put more effort into seed-making rather than stalks, then yields would improve and grain loss due to lodging would be minimised.

Before Borlaug died in 2009 he spent many years campaigning against those who for political and ideological reasons oppose modern innovation in agriculture. To quote: “If the naysayers do manage to stop agricultural biotechnology, they might actually precipitate the famines and the crisis of global biodiversity they have been predicting for nearly 40 years.”

And, thanks to supposedly environmental campaigns spread from affluent countries, we are perilously close to this position now. Biotechnology has not been stopped, but it has been made prohibitively expensive to all but the very biggest corporations.

It now costs tens of millions to get a crop through the regulatory systems in different countries. In fact the latest figures I’ve just seen from CropLife suggest it costs $139 million to move from discovering a new crop trait to full commercialisation, so open-source or public sector biotech really does not stand a chance.

There is a depressing irony here that the anti-biotech campaigners complain about GM crops only being marketed by big corporations when this is a situation they have done more than anyone to help bring about.

In the EU the system is at a standstill, and many GM crops have been waiting a decade or more for approval but are permanently held up by the twisted domestic politics of antibiotech countries like France and Austria. Around the whole world the regulatory delay has increased to more than 5 and a half years now, from 3.7 years back in 2002. The bureaucratic burden is getting worse.

France, remember, long refused to accept the potato because it was an American import.

As one commentator put it recently, Europe is on the verge of becoming a food museum. We well-fed consumers are blinded by romantic nostalgia for the traditional farming of the past.

Because we have enough to eat, we can afford to indulge our aesthetic illusions.

But at the same time the growth of yields worldwide has stagnated for many major food crops, as research published only last month by Jonathan Foley and others in the journal

Nature Communications showed. If we don’t get yield growth back on track we are indeed going to have trouble keeping up with population growth and resulting demand, and prices will rise as well as more land being converted from nature to agriculture.

To quote Norman Borlaug again: “I now say that the world has the technology — either available or well advanced in the research pipeline — to feed on a sustainable basis a population of 10 billion people. The more pertinent question today is whether farmers and ranchers will be permitted to use this new technology? While the affluent nations can certainly afford to adopt ultra low-risk positions, and pay more for food produced by the so called ‘organic’ methods, the one billion chronically undernourished people of the low income, food-deficit nations cannot.”As Borlaug was saying, perhaps the most pernicious myth of all is that organic production is better, either for people or the environment. The idea that it is healthier has been repeatedly disproved in the scientific literature. We also know from many studies that organic is much less productive, with up to 40-50% lower yields in terms of land area. The Soil Association went to great lengths in a recent report on feeding the world with organic not to mention this productivity gap.

Nor did it mention that overall, if you take into account land displacement effects; organic is also likely worse for biodiversity. Instead they talk about an ideal world where people in the west eat less meat and fewer calories overall so that people in developing countries can have more. This is simplistic nonsense.

If you think about it, the organic movement is at its heart a rejectionist one. It doesn't accept many modern technologies on principle. Like the Amish in Pennsylvania, who froze their technology with the horse and cart in 1850, the organic movement essentially freezes its technology in somewhere around 1950, and for no better reason.

It doesn't even apply this idea consistently however. I was reading in a recent Soil Association magazine that it is OK to blast weeds with flamethrowers or fry them with electric currents, but benign herbicides like glyphosate are still a no-no because they are 'artificial chemicals'. In reality there is no reason at all why avoiding chemicals should be better for the environment – quite the opposite in fact. Recent research by Jesse Ausubel and colleagues at Rockefeller University looked at how much extra farmland Indian farmers would have had to cultivate today using the technologies of 1961 to get today's overall yield. The answer is 65 million hectares, an area the size of France.

In China, maize farmers spared 120 million hectares, an area twice the size of France, thanks to modern technologies getting higher yields. On a global scale, between 1961 and 2010 the area farmed grew by only 12%, whilst kilocalories per person rose from 2200 to 2800. So even with three billion more people, everyone still had more to eat thanks to a production increase of 300% in the same period.

So how much land worldwide was spared in the process thanks to these dramatic yield improvements, for which chemical inputs played a crucial role? The answer is 3 billion hectares, or the equivalent of two South Americas. There would have been no Amazon rainforest left today without this improvement in yields. Nor would there be any tigers in India or orang utans in Indonesia. That is why I don't know why so many of those opposing the use of technology in agriculture call themselves environmentalists.

So where does this opposition come from? There seems to be a widespread assumption that modern technology equals more risk. Actually there are many very natural and organic ways to face illness and early death, as the debacle with Germany's organic bean sprouts proved in 2011. This was a public health catastrophe, with the same number of deaths and injuries as were caused by Chernobyl, because E.-coli probably from animal manure infected organic beansprout seeds imported from Egypt. In total 53 people died and 3,500 suffered serious kidney failure. And why were these consumers choosing organic? Because they thought it was safer and healthier, and they were more scared of entirely trivial risks from highly-regulated chemical pesticides and fertilisers.If you look at the situation without prejudice, much of the debate, both in terms of antibiotech and organic, is simply based on the naturalistic fallacy – the belief that natural is good, and artificial is bad. This is a fallacy because there are plenty of entirely natural poisons and ways to die, as the relatives of those who died from E.-coli poisoning would tell you.

For organic, the naturalistic fallacy is elevated into the central guiding principle for an entire movement. This is irrational and we owe it to the Earth and to our children to do better.

This is not to say that organic farming has nothing to offer – there are many good techniques which have been developed, such as intercropping and companion planting, which can be environmentally very effective, even it they do tend to be highly labour intensive. Principles of agro-ecology such as recycling nutrients and promoting on-farm diversity should also be taken more seriously everywhere. But organic is in the way of progress when it refuses to allow innovation. Again using GM as the most obvious example, many third-generation GM crops allow us not to use environmentally-damaging chemicals because the genome of the crop in question has been altered so the plant can protect itself from pests. Why is that not organic?

Organic is also in the way when it is used to take away choice from others. One of the commonest arguments against GM is that organic farmers will be 'contaminated' with GM pollen, and therefore no-one should be allowed to use it. So the rights of a well-heeled minority, which come down ultimately to a consumer preference based on aesthetics, trump the rights of everyone else to use improved crops which would benefit the environment.

I am all for a world of diversity, but that means one farming system cannot claim to have a monopoly of virtue and aim at excluding all other options. Why can't we have peaceful coexistence? This is particularly the case when it shackles us to old technologies which have higher inherent risks than the new.

It seems like almost everyone has to pay homage to 'organic' and to question this orthodoxy is unthinkable. Well I am here to question it today.

The biggest risk of all is that we do not take advantage of all sorts of opportunities for innovation because of what is in reality little more than blind prejudice. Let me give you two examples, both regrettably involving Greenpeace.

Last year Greenpeace destroyed a GM wheat crop in Australia, for all the traditional reasons, which I am very familiar with having done it myself. This was publicly funded research carried out by the Commonwealth Scientific Research institute, but no matter. They were against it because it was GM and unnatural.

What few people have since heard is that one of the other trials being undertaken, which

Greenpeace activists with their strimmers luckily did not manage to destroy, accidentally found a wheat yield increase of an extraordinary 30%. Just think. This knowledge might never have been produced at all, if Greenpeace had succeeded in destroying this innovation. As the president of the NFU Peter Kendall recently suggested, this is analogous to burning books in a library before anyone has been able to read them.

The second example comes from China, where Greenpeace managed to trigger a national media panic by claiming that two dozen children had been used as human guinea pigs in a trial of GM golden rice. They gave no consideration to the fact that this rice is healthier, and could save thousands of children from vitamin A deficiency-related blindness and death each year. What happened was that the three Chinese scientists named in the Greenpeace press release were publicly hounded and have since lost their jobs, and in an autocratic country like China they are at serious personal risk. Internationally because of over-regulation golden rice has already been on the shelf for over a decade, and thanks to the activities of groups like Greenpeace it may never become available to vitamin-deficient poor people.

This to my mind is immoral and inhumane, depriving the needy of something that would help them and their children because of the aesthetic preferences of rich people far away who are in no danger from Vitamin A shortage. Greenpeace is a $100-million a year multinational, and as such it has moral responsibilities just like any other large company.

The fact that golden rice was developed in the public sector and for public benefit cuts no ice with the antis. Take Rothamsted Research, whose director Maurice Moloney is speaking tomorrow. Last year Rothamsted began a trial of aphid-resistant GM wheat which would need no pesticides to combat this serious pest.

Because it is GM the antis were determined to destroy it. They failed because of the courage of Professor John Pickett and his team, who took to YouTube and the media to tell the important story of why their research mattered and why it should not be trashed. They gathered thousands of

signatures on a petition when the antis could only manage a couple of hundred, and the attempted destruction was a damp squib.

One intruder did manage to scale the fence, however, who turned out to be the perfect stereotypical anti-GM protestor – an old Etonian aristocrat whose colourful past makes our Oxford local Marquess of Blandford look like the model of responsible citizenry.

This high-born activist scattered organic wheat seeds around the trial site in what was presumably a symbolic statement of naturalness. Professor Pickett's team tell me they had a very low-tech solution to getting rid of it – they went round with a cordless portable hoover to clear it up.

This year, as well as repeating the wheat trial, Rothamsted is working on an omega 3 oilseed that could replace wild fish in food for farmed salmon. So this could help reduce overfishing by allowing land-based feed stocks to be used in aquaculture. Yes it's GM, so expect the antis to oppose this one too, despite the obvious potential environmental benefits in terms of marine biodiversity.

I don't know about you, but I've had enough. So my conclusion here today is very clear: the GM debate is over. It is finished. We no longer need to discuss whether or not it is safe –over a decade and a half with three trillion GM meals eaten there has never been a single substantiated case of harm. You are more likely to get hit by an asteroid than to get hurt by GM food. More to the point, people have died from choosing organic, but no-one has died from eating GM.

Just as I did 10 years ago, Greenpeace and the Soil Association claim to be guided by consensus science, as on climate change. Yet on GM there is a rock-solid scientific consensus, backed by the American Association for the Advancement of Science, the Royal Society, health institutes and national science academies around the world. Yet this inconvenient truth is ignored because it conflicts with their ideology.

One final example is the sad story of the GM blight-resistant potato. This was being developed by both the Sainsbury Lab and Teagasc, a publicly-funded institute in Ireland –but the Irish Green Party, whose leader often attends this very conference, was so opposed that they even took out a court case against it. This is despite the fact that the blight-resistant potato would save farmers from doing 15 fungicide sprays per season, that pollen transfer is not an issue because potatoes are clonally propagated and that the offending gene came from a wild relative of the potato.

There would have been a nice historical resonance to having a blight-resistant potato developed in Ireland, given the million or more who died due to the potato famine in the mid 19thcentury. It would have been a wonderful thing for Ireland to be the country that defeated blight. But thanks to the Irish Green Party, this is not to be.

And unfortunately the antis now have the bureaucrats on their side. Wales and Scotland are officially GM free, taking medieval superstition as a strategic imperative for devolved governments supposedly guided by science.

It is unfortunately much the same in much of Africa and Asia. India has rejected Bt brinjal, even though it would reduce insecticide applications in the field, and residues on the fruit.

The government in India is increasingly in thrall to backward-looking ideologues like Vandana Shiva, who idealise pre-industrial village agriculture despite the historical fact that it was an age of repeated famines and structural insecurity.

In Africa, 'no GM' is still the motto for many governments. Kenya for example has actually banned GM foods because of the supposed "health risks" despite the fact that they could help reduce the malnutrition that is still rampant in the country – and malnutrition is by the way a proven health risk, with no further evidence needed. In Kenya if you develop a GM crop which has better nutrition or a higher yield to help poorer farmers then you will go to jail for 10 years.

Thus desperately-needed agricultural innovation is being strangled by a suffocating avalanche of regulations which are not based on any rational scientific assessment of risk.

The risk today is not that anyone will be harmed by GM food, but that millions will be harmed by not having enough food, because a vocal minority of people in rich countries want their meals to be what they consider natural.

I hope now things are changing. The wonderful Bill and Melinda Gates foundation recently gave $10 million to the John Innes Centre to begin efforts to integrate nitrogen fixing capabilities into major food crops, starting with maize. Yes, Greenpeace, this will be GM. Get over it. If we are going to reduce the global-scale problem of nitrogen pollution then having major crop plants fixing their own nitrogen is a worthy goal.

I know it is politically incorrect to say all this, but we need a a major dose of both international myth-busting and de-regulation. The plant scientists I know hold their heads in their hands when I talk about this with them because governments and so many people have got their sense of risk so utterly wrong, and are foreclosing a vitally necessary technology.

Norman Borlaug is dead now, but I think we honour his memory and his vision when we refuse to give in to politically correct orthodoxies when we know they are incorrect. The stakes are high. If we continue to get this wrong, the life prospects of billions of people will be harmed. So I challenge all of you today to question your beliefs in this area and to see whether they stand up to rational examination. Always ask for evidence, as the campaigning group Sense

About Science advises, and make sure you go beyond the self-referential reports of campaigning NGOs .But most important of all, farmers should be free to choose what kind of technologies they want to adopt. If you think the old ways are the best, that's fine. You have that right.

What you don't have the right to do is to stand in the way of others who hope and strive for ways of doing things differently, and hopefully better. Farmers who understand the pressures of a growing population and a warming world. Who understand that yields per hectare are the most important environmental metric. And who understand that technology never stops developing, and that even the fridge and the humble potato were new and scary once.

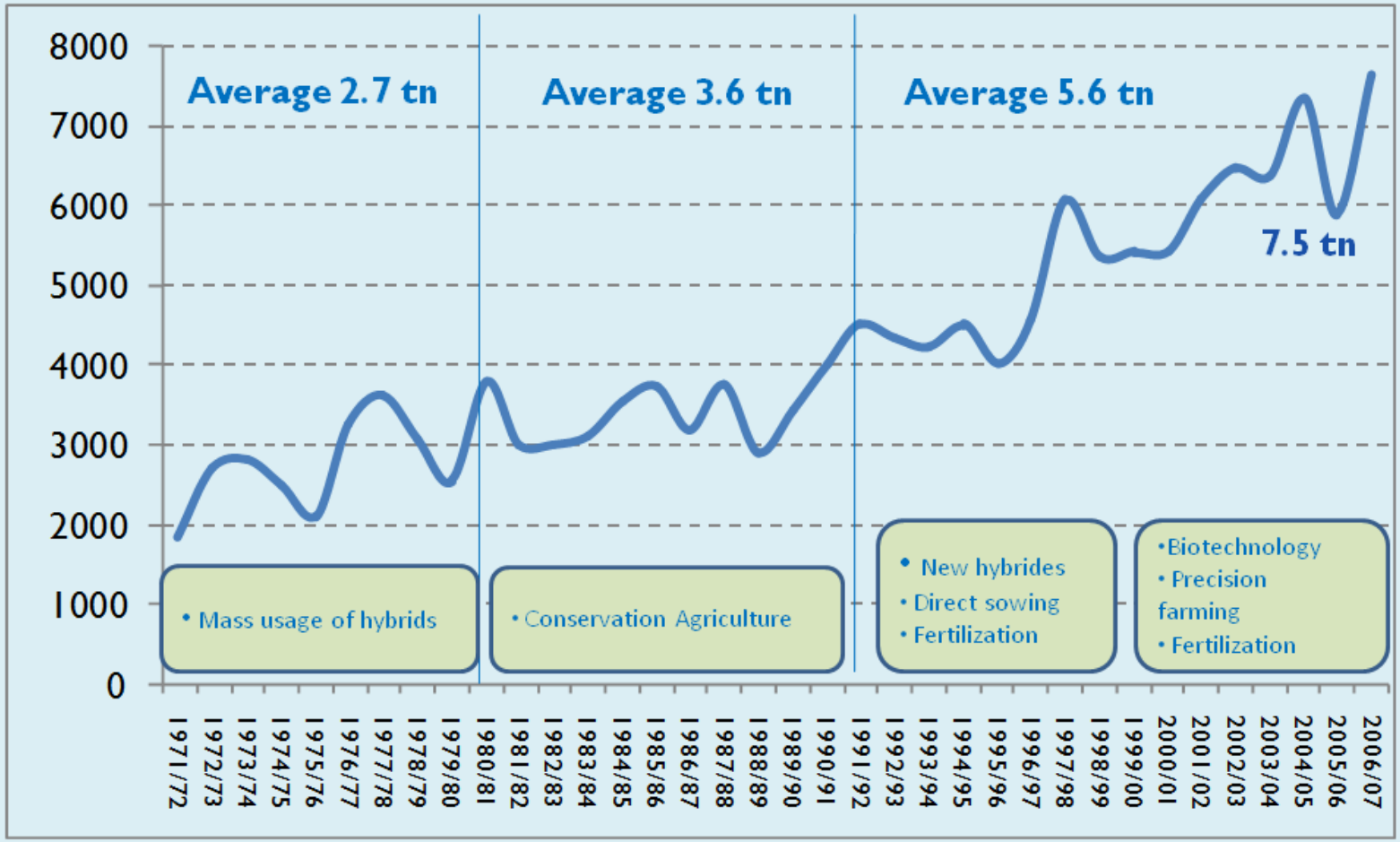
So my message to the anti-GM lobby, from the ranks of the British aristocrats and celebrity chefs to the US foodies to the peasant groups of India is this. You are entitled to your views.

But you must know by now that they are not supported by science. We are coming to a crunch point, and for the sake of both people and the planet, now is the time for you to get out of the way and let the rest of us get on with feeding the world sustainably.

Thank you.

14.3 Appendix 3: Impact of new technologies on corn yield in Argentina

IMPACT OF NEW TECHNOLOGIES ON CORN YIELD



Source: SAGPyA

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