A *New* Agricultural Testament

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1. A *New* Agricultural Testament

Thank you and welcome to the launch of The BHU Future Farming Centre and this lecture 'A New Agricultural Testament'

This lecture is something of a hydra, it is part science, part philosophy, part politics, part history lesson, and part acknowledgement of a few of the giants on whose shoulders we all stand. Its aim is to paint a picture of agriculture in the widest sense and context possible, and look at a few key issues, as a means to explain and explore the ideas that underpin the Future Farming Centre and therefore what needs to be done, to ensure the future prosperity of agriculture, and therefore society as a whole. This is a big and audacious aim, so, as this is one lecture, not a whole degree, I will not be able to delve into detailed arguments, only touch on a few topics, some controversial, leaving you to fill in the gaps. To that end it is also clearly meant to be a stimulus to further discussion and debate, not the final word.

Also a quick clarification: I will use the terms agriculture, farming, farms and farmers in the broad meaning i.e., they include all the primary industries e.g., horticulture, forestry etc. but for the sake of brevity I will use agriculture and farming as proxies.

2. Agriculture at a crossroads

The last century has been one of great turmoil for agriculture, and human civilisation as a whole. The dominant form of agriculture during this time, called industrial agriculture, as it attempts to mimic the production line processes of the industrial revolution, is now increasingly being called into question. The most substantial of this recent criticism came from the 'International Assessment of Agricultural Knowledge, Science and Technology for Development', the closest thing agriculture has to the Intergovernmental Panel on Climate Change (IPCC). The conclusion of the Ag-assessment was that "Farming is at a crossroads" and that "business as usual is not an option": farming can not continue down the industrial path, it has to turn to the 'alternative' paradigms such as agro-ecology and organic agriculture.

This is not, however, some ivory tower dialectic: despite the astonishing changes that science and technology have made to human society, civilisation is still as utterly dependent on agriculture as at any other time in history and there is little indication of the sun setting on agriculture any time soon. It is therefore as far as you can get from an academic argument, it is one of the most important and practical problems facing us today.

It is also not a new argument: the debate has been engaged since the earliest days of industrial agriculture, fiercely at first, then meekly during the middle of the last century, especially post the second world war, but more recently with renewed vigour, as wider society starts to comprehend that industrial agriculture's chickens are coming home to roost.

I now want to highlight two early protagonists of this debate.

3. An Agricultural Testament

71 years ago, Sir Albert Howard published 'An Agricultural Testament' from which this lectures title is taken. Testament is one of the key foundation stones upon which the global organic movement has

been built. Most of the book is an argument, built on a lifetime of practical farming and agricultural science experience, that the reductionist 'NPK' approach to crop nutrition, which was based on Liebig's discovery that plants take up nutrients as soluble minerals not organic matter, was fundamentally flawed, and that a different path should be taken, namely of treating soil as a biological entity not just a container to hold minerals for plants. Basing this lectures title on An Agricultural Testament is an acknowledgement of Howard's immense wisdom and vision despite the contrary mainstream view, and that most of the concerns he raised are still critical contemporary issues.

4. Farmers of Forty Centuries

Exactly one hundred years ago Professor Franklin King's "Farmers of Forty Centuries" subtitled "permanent agriculture in China, Korea and Japan" was posthumously published. This work is also widely considered a classic in alternative agricultures, which is interesting as King was part of his day's establishment.

FoFC first introduced the concept of 'permanent agriculture' to a wide audience and it is from this work that the Future Farming Centre has taken the term, and the concept, of permanent agriculture, and made it, its foundation. It is the issue of permanence in agriculture that this lecture primarily addresses. Unfortunately, little of Prof. Kings wisdom has made it to the mainstream, either, and it is becoming increasingly urgent that his and Howards ideas become more widely understood.

Permanent agriculture is a complex topic so I am going to take handful of examples to explain what I mean. First, however, It will also require a bit of context.

5. Permanence

'Permanent', along with the related, and now rather muddied, word 'sustainable' are terms relating to time. Without stating the time period in consideration they are pretty meaningless. So in good philosophical tradition, I'd better define my terms. To give a feeling for how I consider permanence in the context of agriculture, I'm going to give you a very, very brief history of time.

6. A very brief history of time

The universe, and time with, it began 13.7 billion years ago and about 9 billion years later, our solar system formed, making the earth 4.5 billion years old.
Life appeared on earth very pretty much as soon as the place had cooled enough for liquid water to exist, around 3.5 billion years ago. However, for about 85% of the life of life, life was pretty simple, or to be exact singular: for 3 billion years the microbes had the planet to themselves. Then about half a billion / 500 million years ago, multicellular life burst onto the scene in the evolutionary creative orgy of the Cambrian explosion.
It took evolution 498 million years from the start of multicellular life, or 2.4 million years before present, for the first members of our genus *Homo* to appear. From there it took 2.2 Myrs to create the first Homo sapiens but it was only 50,000 years ago that fully behaviourally modern humans appeared.
Even though those first fully modern humans had all the cognitive equipment to create agriculture, that did not happen for another 40,000 years / 10,000 years BP. Agriculture, therefore, is truly a new kid on the block.
However, if agriculture as a whole is a new invention for *H. sapiens*, then, industrial agriculture - modern farming, is a real flash in the pan, being barely 100 years old. Even the modern way of thinking that started in the Enlightenment, of which science is a key foundation, and which is essential for the creation of industrial agriculture, is only a couple of hundred years old.
Even with the rapid speed of progress with which we are currently living, it is difficult to comprehend this exponential acceleration of the processes that have lead to our current situation. The world we find around us, which we consider to be normal, is very far from normal at all, it is the most abnormal situation that has ever existed in the entire history of everything we know. The experiences we collect during our day to day lives, and 'common sense' are unreliable guides to understanding the present and

future. The best tools we have are the lenses of science and reason, bestowed on us by the Enlightenment. It can be argued that we are standing at the early dawn of a new epoch in human history, which can be divided into our species birth, appearance of cognitively modern humans, the advent of agriculture & civilisation, and the enlightenment. The enlightenment as changed humanity in ways that were previously impossible and inconceivable, yet we as a species and society are still struggling to understand its effects. We gaze into a future where the past is a very poor guide indeed. This is a truly grand perspective, and while it is essential to understand just how abnormal agriculture and especially industrial agriculture are, it is rather too grand for the job of defining permanent agriculture.

7. The duration of farming

The time span I believe we need to think of, is that of our existence as a species. We, Homo sapiens are 200,000 years old. The average life of a species is about a 1,000,000 years. If H. sapiens, survives for this average duration, even though we as a species are anything but average, then we have another 800,000 years to plan for, i.e. four times longer than we have already existed, and 80 times the duration of agriculture.

As Niels Bohr pointed out, making predications is hard, especially about the future. Predicting 800,000 years into the future is nonsense: we may have achieved faster than light travel and colonised multiple galaxies, we may still be stuck on planet earth, or we may no longer exist at all.

So while 800,000 years is a bold figure to demonstrate the magnitude of the issue, it is however, so far in the future that it is beyond fiction. It is also a length of time that most people are completely unable to comprehend, let alone intuitively. We need a time scale that indicates the issues we face without being so big, as to be meaningless.

For this I suggest one millennium, i.e. 1,000 years.

8. Dirt: The erosion of civilisations

The concept of a millennium as the fundamental unit of permanence in agriculture is taken from Prof. David Montgomery's book 'Dirt: The Erosion of Civilizations'. His thesis is that most human civilisations have a maximum duration of about 1,000 years as this is how long it takes them to destroy their soils, and as Wendell Berry pointed out, "what we do to the land, we do to ourselves".

Montgomery is not the only person to point out that human civilisations have a habit of destroying their foundations: Plato, said as much in 400 B.C. and it is a key thesis of Prof. Tim Flannery's 'The Future Eaters'. Put simply, nearly every human civilisation from the very first to the present, destroyed itself, by destroying its soil. This is why 'Farmers of Forty Centuries' or to use our new timescale, four millennia, is such an important message: these are the only farmers that are part of civilisations, in the whole history of civilisation, than have achieved permanence. Everyone else, including ourselves, has stuffed it up.

I therefore suggest that agriculture needs a foundational ethic.

9. The first ethic of agriculture

"The primary task of agriculture is good husbandry of the soil, such that soil 'quality' / 'health' is maintained or improved at timescales of millennia"

There have only been ten millennia since the start of agriculture, there are another 800 to go if the lifespan of H. sapiens, is anywhere near average. If we, as a species don't get this right, now that we are farming practically all of the farmable areas on the planet, we are sealing our own fate.

To fully understand this issue, we need to understand some first order explanations of how agriculture and the planet works.

10. The earth machine

Looking through the lens of the most fundamental of laws, those of thermodynamics, the earth is a giant entropy 'excreting machine'. It uses the energy flowing from the sun across the earth and out to interstellar space, to 'export' entropy to the universe. This allows it to create low entropy, i.e., complex, things such as life. This process is the foundation of the concept that James Lovelock named Gaia.

11. Matter cycles

The complex things the earth machine makes by excreting entropy, are made from matter i.e., the chemical elements of which the planet, and the rest of the universe, is formed. The key concept here is that energy flows, but matter cycles, and cycles and cycles.

Scientists have a habit of creating complex jargon, partly due to that human need to maintain oneself with the 'in-crowd' but also because we are pedants for accuracy. One of those terms is biogeochemistry - which is the science of the chemical, physical, geological, and biological processes that govern the composition of the natural environment. The chemistry of biology and geology. I suspect that most people would think that the chemistry of biology and geology have nothing in common. Nothing could be further from the truth. As Lovelock pointed out, the geology and biology of the planet are part and parcel of the same system. Therefore understanding the biogeochemical cycles is essential for understanding the planet.

So, what has biogeochemistry got to do with farming? Farms are microcosms of the planet as a whole. They use sunlight to power photosynthesis which creates complexity from the chemical elements by excreting entropy to the universe, exactly the same as the planet as whole. That is why we can not understand farms until we understand how the 'earth machine' works.

It also gives us the fundamental measure to tell us if our farming systems are permanent or not, because if they are not working with the earths systems, they are working against them, and sooner or later, they will break, because, as Lynn Margulis pointed out "Gaia is a tough bitch“ she is much tougher than humanity and we will loose any battle we try to wage on her.

12. Industrial ag / green revolution

Keeping in mind the picture I have just painted, I now want to turn to the fundamental technologies that power industrial agriculture, and one of its key philosophies, the green revolution, to see how they fair against the yardsticks of a millenia and working with the biogeochemical cycles, and therefore to act as a contrast with permanent agriculture.

The technologies that power industrial agriculture are: fertilisers, particularly nitrogen, pesticides, irrigation and breeding.

I want to focus on the most important of these: fertilisers and pesticides.

13. The elements of life

First fertilisers. Once again we need to think beyond our day-to-day understanding of 'fertilisers'.

Of the 94 naturally occurring elements, only 24 are used by life, and most of those are only used in small quantities: life is mostly carbon, hydrogen and oxygen, for example, they make up 96 odd percent of plants. It is therefore very fortunate that these three elements cycle via the atmosphere, as this means they are freely available so we don't have to apply them to crops as fertilisers - which is why they are not commonly thought of as fertilisers at all. All the other elements, except for nitrogen, are lithospheric nutrients, i.e., they don't occur in gaseous forms so they can't cycle via the atmosphere, they can only cycle as solids, via the rocks of the earth.

If the elements of life were a pack of cards, carbon, oxygen and hydrogen would be the royal cards while the lithospheric nutrients would be the numbered cards, and nitrogen would be the joker.

14. Nitrogen the joker

Nitrogen is the joker of the biogeochemicals, because it is an atmospheric nutrient, indeed uniquely the main planetary store is the atmosphere, but, most life can not make use of atmospheric di-nitrogen, it can only use reactive nitrogen where di-nitrogen is combined with hydrogen.

15. Nitrogenase

Turning di-nitrogen into reactive nitrogen is very, very hard, due to the laws of thermodynamics and quantum mechanics. There are only a couple of handfuls of mostly primitive, single-celled, organisms that can do this and they all use essentially the same enzyme - nitrogenase, which means that just about all of life on earth depends on this one molecule. Even evolution, with all its power and 3.5 billion years to play with, has only found one solution to this problem, which is pretty scary.

16. Haber-Bosch nitrogen

However, one hundred and two years ago, Fritz Haber discovered a practical, economical, non-biological, means of fixing di-nitrogen, and with the help of Carl Bosch industrialised the process. No other practical and economic means of synthesising reactive nitrogen have been discovered in the intervening century, and not for want of trying.

The Haber-Bosch process is considered to be one of the most important achievements of the 20th Century, with some arguing it has had far greater impact than Hitler, Gandhi, and Einstein, (see http://www.idsia.ch/~juergen/haberbosch.html). However, synthetic N has turned out to be something of a double edged sword, which is why I describe it as one of humanities greatest follies.

Synthetic nitrogen is one of the key foundations of industrial agriculture and the green revolution, because, in most agricultural systems N is the limiting nutrient. The main aim of the green revolution and industrial agriculture has been the production of more food, by increasing yields, with the aim of feeding a growing world population and therefore avoiding Malthusian starvation. There is little argument that it has achieved its general aim, but there is a growing realisation that the unintended consequences are a bigger problem than the solution.

17. Thomas Malthus

The first, and rather politically unpalatable, issue is that it is impossible to unendingly increase food supply to match unconstrained demand. Fundamentally Malthus was, without doubt, correct; living things will multiply up to the limit of their food supply and then their population will crash.

Despite disbelief of this idea, especially in mainstream economics; biological and ecological scientists see its effect everyday, from cultures in Petri-dishes, to large scale ecosystems. It is also one of the key tasks of a livestock farmer to manage their stock numbers within the Malthusian limits of what their farm can produce, and if there are too many animals, remove the excess, not buy more land for the extra stock. The flow of energy from the sun is from the bottom-up, i.e., from plants, up through the food chain, not down from humans to plants. This is not a vague political concept, it is very hard physics, and as Scotty often said to Kirk, “you canny break the laws of physics, Captain!”

So the effect of using Haber-Bosch nitrogen (HBN), was not only to feed the current population, it also allowed the population to increase beyond what it could of done without HBN. Today is the day the UN has estimated the worlds population has reached seven billion. This is difficult territory, but some estimates calculate that there are an extra 3.5 billion people on the planet today due to HBN, i.e., half the worlds population only exist because of HBN, i.e., it has not solved the problem at all it has only made it bigger.

Fundamentally the argument that we need to increase food supply to match a particular population is a classic example of the logical error of the cart in front of the horse. If humanity considers itself to be in for the long haul, i.e., for millennia, not decades, then the way forward is to manage agriculture so as to ensure its permanence and then to manage the human population to match agricultural output. All the technical solutions to solving world hunger by increasing food supply are all fundamentally flawed: if they succeeded they would in fact make the problem worse.

18. Nitrogen - made from thin air?

Returning to the problems with nitrogen. It is not just that Haber-Bosch nitrogen has doubled the number of people on earth, there are a host of other problems with synthetic N.

Nitrogen fertilisers are made from 'oil' i.e., fossil fuel, mostly natural gas. This supplies both the considerable energy needed and hydrogen to make reactive N. The N itself comes from the air for free. However, about 1.5% of global energy supply and about 6% of global natural gas supply are used in the Haber-Bosch process to make reactive N, most of which is used to make N fertiliser. It is no surprise then that the price of nitrogen fertilisers moves in lock step with oil, because they are both metaphorically and literally made from 'oil'.

As peak oil is now widely taken as a given, this is a clear problem for the production and use of nitrogen fertilisers as the price can only go up and supply down. If we apply our permanent agriculture yardstick of a millennium to the idea of making N fertiliser from fossil fuels, then it comes up pretty short - one century so far, and its looking pretty unlikely that it's going to last for another one, let alone another nine centuries.

19. The nitrogen deluge

The next problem is that nitrogen fertiliser does not stay put in farmers fields, it has spread across the whole globe producing a cascade of side effects. The European Nitrogen Assessment, published this year, is nearest thing to Nitrogen's IPCC. It lays out our best current understanding of nitrogen and its side effects, including, I quote "human health, ecosystem health, biodiversity and climate", i.e., pretty much everything. A few examples of these effects are eutrophication of water, both fresh, and salty e.g., oceanic dead zones, greenhouse forcing from nitrous oxide, and acid rain.

This is the big reason why I think of nitrogen as the 'joker' it has a multitude of different chemical forms, having different properties - nutrient and pollutant, greenhouse gas and non-greenhouse gas, enemy and friend. All these problems are effects of humanities short-circuiting of the biogeochemistry of nitrogen, in the hubristic belief that we know what we are doing.

I suggest that we need a new relationship with nitrogen based on a realisation, that it is a joker, a double edged sword, and that treating it with precaution rather than hubris, is probably the wiser thing to do.

20. The lithospheric nutrients

I now will touch on the lithospheric nutrients. These are nutrients such as phosphorus, potassium, magnesium, etc., that are commonly considered to be 'fertilisers' in agriculture. Again, they are lithospheric nutrients, because on earth they don't have a gaseous form, so they can only cycle via the rocks of the earth, i.e., the lithosphere, not the atmosphere. This puts a pretty serious time constraint on the speed of the cycles, because while the rocks of the earth move, as we have recently been reminded in Canterbury, they only move by appreciable amounts in timescales of tens of millions of years, i.e. time scales much bigger than our estimation of H. sapiens life span of 0.8 million years.

Using phosphorus as a proxy for all the lithospheric nutrients, from the perspective of agriculture, its cycle can be divided in to two parts, the soil cycle, and the litho/hydrosphere cycle. The cycle in soil can be pretty fast, as phosphorus is taken up by plants, which then die and return the phosphorus to the soil. The litho/hydro cycle involves phosphorus that enters streams and rivers, where it is then transported to the seas and oceans. There, it settles out as sediment, which then turn into rock, which is uplifted by plate tectonics above sea level, where it can then be eroded to release the phosphorus back to the soil. Clearly this cycle is rather slower than the soil cycle.

The problem we currently have is we are short-circuiting the cycling of the lithospheric biogeochemicals, by transferring them from the soil to the sea at unprecedented rates. This is both directly, e.g., by runoff and leaching from land, especially farmland, but also by another of humanities most successful follies, the water closet.

The WC was invented to solve a number of communicable disease problems, and on that front it has been very successful. However, people, such as King and Howard, have been pointing out, that it had the significant downside of transferring nutrients from the soil to the sea, on what in human timescales is effectively a one-way trip.

21. Fossil fertilisers

That is why the current system of agricultural fertilisation is fundamentally flawed. It is based on mining fossil nutrients, first in the form of guano and currently in the form of rocks, such as rock phosphate, which were laid down in shallow seas 10s to 100s of millions of years ago. This means that they will have a peak in supply, just like oil. Trying to predict peak phosphorus, peak potassium, etc., is difficult, but current ballpark figures for phosphorus is 70 years and potassium 400 years. Seventy and especially 400 years sound like a long time, but, based on our yardstick of a millennium, 70 years is a flash in the pan and 400 does not even get us half way.

Worse however, our short-circuiting of the lithospheric biogeochemical cycles is a fundamentally different problem to our short circuiting the atmospheric biogeochemical cycles of carbon and nitrogen. Unlike the changes to the atmospheric cycles, which from a scientific viewpoint can be pretty easily reversed, due to the rapid cycling time, it just needs the political determination and money. The same is not true of the lithospheric cycles, once these elements are lost to the bottom of the ocean we have no conceivable practical way to get them back, in anywhere near the same amounts that we are putting them in. As numerous highly qualified people have stressed, there are NO economic substitutes for the chemical elements in agriculture, period. Once we run out, we have run out, end of story. Once agriculture runs out of nutrients, it grinds to a halt. If you think climate change is a big problem, then humanities short-circuiting of the biogeochemical cycles of the lithospheric elements, is of a completely different magnitude and type.

22. What's the solution?

So, what’s the solution? Well humanity has known about the solution for a very long time.

Prof King showed that the answer has been fully understood by farmers in the east for at least four millenia, probably more. In today's parlance, the solution is that we must ensure all the lithospheric biogeochemicals removed from soil are recycled back to the soil within human time scales, i.e. years, and done in such a fashion that maintains, or better, improves the biological functioning of the soil. Scientifically this is about as simple as things get, but at a practical and political level, it is very hard indeed. Trying to get across to the general public and politicians that Haber-Bosch nitrogen and the WC are a curse on our civilisation has to date, proved impossible.

I am now going to leave fertilisers and look at that the problematic technology of pesticides. I’m using pesticides in the broad meaning which includes herbicides, fungicides, insecticides etc. I’ll start with a couple of quotes from key players from my speciality of weed science.

23. There is no cavalry

Dr Anne Thompson, is Head of Development and Registration at Dow AgroSciences. She was speaking at the ‘The Future of Weed Research’ workshop held in the UK in 2008, with a mandate from the agri-chemical industry. Said she had a message to pass onto farmers, as they did not seem to understand the situation. Her message was very simple:

“Please tell the farmers there is no cavalry coming over the hill.”

She was equally transparent that the agrichemical industry is in the business of making money, not making pesticides, and that unless a pesticide is profitable, which almost certainly meant a tie-up between transgenetic (GE) crops and propriety pesticides, then farmers should assume there would be no new pesticides.

To reinforce just how big a deal is, this was the horses mouth of the agrichemical industry saying the agrichemical game is over.

24. The post herbicide era

Dr Jon Marshal, is the editor of the world's leading weed science journal, 'Weed Research'. In his landmark editorial to celebrate half a century of the journals publication, he introduced the concept of a post-herbicide era. Weed science, and its journals, have been almost entirely dedicated to herbicide science not weed science, for their whole existence. For the editor of a journal that been dominated by herbicides to say on such a important occasion, that he can see a time when there are no herbicides at all, is jaw dropping.

However, the message is the same for all the pesticides, and it is being spoken by an increasing number farmers and scientists. What's more we may well already be past peak pesticides, in terms of the number of chemicals available and/or the amounts being used. So, what is causing this increasingly rapid change?

25. A pincer movement

Pesticides are caught, to use their own militaristic terminology, in a pincer movement.

First: they are being rendered ineffective by Darwin's law of evolution.

Second, The lack of new chemistry is not for want of trying: the whole business model of the agrichemical industry was dependent on the discovery of new chemistry. New chemistry is simply not there to be found.

Third and final, societies are re-evaluating the cost : benefit analysis of pesticides, and increasingly viewing the costs as outweighing the benefits.

The issues of evolved resistance and lack of new chemistry are mostly the results of the laws of nature, so we can study them and understand why we are unlikely to see current trends reverse. The issue of societal acceptance is not fundamentally due to laws of nature, it is down to ethics, so it is impossible to predict, and it can do a U turn as circumstances change. However, that will be of limited use if there are few effective pesticides left to re-legalise.

So, using our millenium measure, how do pesticides stack up? In round figures, the widespread use of pesticides started in the 1940s, so we have had about 70 years of extensive use. If we have already passed peak pesticides, their effective lifespan at a guestimate will be similar, so a total duration of, say, 150 years, which is 850 years short of being permanent. We had therefore better find alternatives that are truly permanent solutions to pest management. What are these?

26. The integrated management framework

My perspective of looking at this issue, is through the well established framework of integrated pest management, where physical, chemical, biological and ecological techniques are all brought to bear on the pest problem in a whole-of-system approach. From this perspective, chemical pesticides, are only one of three management techniques, i.e., there are still plenty of options left. The problem is that research on non-chemical techniques effectively stopped with the advent of chemical pesticides, i.e., there has been a 70 odd year research hiatus, which means that the amount of knowledge is comparably much, much, less than chemicals.

What's more, few non-chemical techniques are as easy to use as agrichemicals - many only work as part of an integrated solution and require system level changes, e.g., from monocultures to rotations and polycultures, which will require significant changes to industrial agricultural practices, which, ipso facto, means such farming systems are no longer industrial, they are ecological.

27. Bio-Protection

Fortunately, despite the lack of research over much of the last century, great progress is now being made, for example the Bio-Protection Research Centre, HQ'ed here at Lincoln University, is conducting world-leading research in this area.

28. The post-industrial agriculture era

To conclude this part of the lecture, I have shown how the two key technologies that underpin industrial agriculture, mineral fertilisers and pesticides, are unsustainable, i.e., they have very limited durations compared with the lifespan of agriculture, plus they have multiple side effects, some which now threaten humanity.

Globally there is a realisation that agriculture has to change from the yield maximisation ethic of industrial agriculture, to wider objectives such as provision of ecosystem services. In many places, including NZ, it is already changing. Industrial agriculture can be viewed as 100 year long experiment that is now increasingly considered to have failed. I suggest that we have already passed peak industrial agriculture sometime in the last twenty years. So, what is the alternative going to look like? Well, if you strip industrial agriculture of its ethic of yield maximisation require it to use recycled soil nutrients and non-chemical pest management, what do you have? Organic agriculture!

29. Ethics, science and agriculture

Having looked at some of the problems of industrial agriculture I now want to turn to ethics and its relationship with science and agriculture.

I consider this to be a utterly vital area of knowledge, but it is one that practically never gets an airing, even within the rarefied atmosphere of universities. I therefore need to spend a little time explaining the basics so we are not talking at cross purposes.

First up, for our purposes, ethics and morals are interchangeable as terms, even though moral philosophers have more precise meanings as per this slide. For our needs morals and ethics are the things that tell us if something is good or bad, right or wrong.

Firstly, I am not just talking about current and obvious moral issues, such as: is it ethical to keep chickens in cages. I am talking about the moral codes and values that underpin our ethical world-views as societies, e.g., slavery is wrong. Unlike the current moral dilemmas which are consciously debated, moral codes mostly operate at a sub-conscious levels, i.e., while there is a lot of debate about whether keeping chickens in cages is right or wrong, there is no discussion that slavery is wrong, it is taken as a given. The problem with these foundational ethics is that they are mostly subconscious so we often do not realise that they are moral or ethical decisions at all, they are just 'how things are' and therefore often mistakenly considered to be 'how things have always been, and always will be'.

The issue with such foundational ethics is when they start to change, confusion is often the result. I consider it a particular problem when these changing morals get mistaken as scientific concepts. The issue is trying to find a rubric for spotting the difference. This is mine…

30. It is unscientific not to use slaves on farms

It is unscientific not to use slaves on farms, their use increases yields and profits.

I hope that the modern absurdity of this statement make the intellectual slight of hand that was used jump out. The use of slaves is clearly an ethical issue not a scientific one. However, if we were living 300 years ago at the height of the slave trade, were modern science around, it could be used to work out how to maximise the output of slaves, and what would happen if you stopped using them, but it could only be utterly silent on whether using slaves was right or wrong.

This is an example of what I mean by confusing science and ethics. The way to use this as a rubric is to change the term 'slaves' for some other term, for example, tillage, pesticides, nitrogen fertilisers, the internal combustion engine, or GE. Philosophically, these are just as valid concepts to put into this statement as slaves. They are also real world examples, in that there are real farming systems deliberately operating without one or more of them.

31. Francis Bacon

At this point it is really critical to understand the incompatibility and relationship between science and ethics.

Theoretically just about everything in the universe is amenable to the scientific method. Practically we have lots of problems, e.g., physicists dream of particle accelerators the size of the milky way, but at a theoretical level just about everything can be studied by science, except, matters of right and wrong, good and bad, i.e., what is ethical and moral. This is not news, Francis Bacon who established the inductive methodologies for scientific inquiry, clearly said that ethics forever lay outside of science. There are many others since his time that have elaborated further, e.g.,

32. Impossibility, the limit of science and the science of limits

For example, John Barrow in he book, "Impossibility, the limit of science and the science of limits".

To distil, what is a complex issue, it is simply impossible to answer an ethical or moral question using the scientific method. For example, it is impossible to design an experiment to determine if slavery is right or wrong, just as it is impossible to design an experiment that shows that maximising yields is right or wrong. The problem is that it is fully within the ability of the scientific method, to design an experiment to determine how to maximise yields. This, I believe, is at the heart of much of the philosophical confusion in agriculture. We have confused a moral aim, i.e., that maximising yields is good and now consider it to be scientific.

33. REACH regulation

So, let us look at this issue from the perspective of a current conscious ethical debate, that of pesticides.

Europe is at present re-evaluating all 'chemicals' under the REACH regulation. This regulation is built on the ethical foundation of the precautionary principle, as opposed to risk assessment, i.e., chemicals need to be shown to be safe, rather than there being no evidence of their harm, put logically, absence of evidence is not evidence of absence. This has resulted in many agri-chemicals being banned, their use restricted or being removed by their manufacturers. Many agricultural scientists have been up in arms about the removal of these pesticides, based on a rational along the lines that the chemicals were created by science, are scientifically proven to be effective and there are no alternatives, so therefore to remove them is un-scientific. The other side of this debate is summed up by Professor Vyvyan Howard who said…

34. Professor Vyvyan Howard

"What I find most absurd is the claim that the EU proposals are not based on science. Whole teams of national and European scientific experts are involved. Where a specific pesticide is classified as being carcinogenic it's because there is substantive scientific evidence linking that substance with cancer"

So we have a situation where two groups of scientists are publically claiming their position is scientific and the other un-scientific. The problem here is not science, the problem is ethics. The two groups have quite different, and mostly un-articulated, moral frameworks, and it is these frameworks that are being disputed, but mistakenly on the scientific not the ethical battle ground.

Both positions can be viewed as an example of 'scientism' i.e., to claim the authority of science, where it is not valid.

35. Scientism and organic agriculture

Scientism has been common in regard to organic agriculture, which was often presented as being un-scientific in the 70s and 80s, and a few people still hold this view today, for example, Sir Paul Callaghan. This is nonsense. Organic agriculture uses science all the time: there are a whole swag of scientists around the world using science to study and help organics meet its ethical objectives, they even have an international society - ISOFAR, the International Society of Organic Agriculture Research.

The real conflict here is that industrial agriculture has an ethic of yield and/or profit maximisation while organic and other ecological agricultures have ethics of permanence, respect for Gaia, humans and other animals, etc., However the ethic of industrial agriculture has become for many people 'scientific' and thus garnered with a type of authority which it not due. Science can be used by both systems to meet their moral objectives, as science is blind to ethics, but, it can not decide which ethical system is right or wrong. That is the turf of philosophers not scientists.

However, despite being blind, science can inform ethical decisions.

36. Ethics consistent with reality

Using the slavery example again. While science can not decide if slavery is right or wrong, it can inform the debate, for example it can show that enslaved races have the same mental lives, thoughts, and feelings as those of the slave keepers. Had this 'scientific fact' been around at the time of the slavery it would have been powerful ammunition to undermine one of the key moral arguments in favour of slavery, i.e., that slaves are sub-human so it's OK to enslave them.

Science can therefore be used to determine if the arguments used to support an ethical position are consistent with reality. Again, that's not to say the ethic is wrong, just at odds with reality. However, having an ethic that is at sufficient odds with reality becomes a problem when the actions that result from an ethical system, conflict with the aims of the system. For example, an ethic that food supply must be increased to match current and forecast populations, when increasing the food supply without population control will result in the population expanding further, so requiring further increases in food production, ad infinitum.

If humanity, as a civilisation that now spans the entire globe, wants to be in for the long haul, I suggest that it is essential that its ethics and thus politics are consistent with reality. As humanity is still 100% dependent on agriculture, then ipso facto, agriculture also has to have an ethic that is consistent with reality. However, as I have explained, industrial agriculture is not consistent with reality over the long term, so it will not be able to provide humanity with food in the long term. We therefore have a miss-match. The solution is to change the way we do agriculture to one of permanence. That is what underpins the Future Farming Centre, a determination to create an agricultural system that can persist for as long as humanity wishes to continue .

37. What is agricultural science

I now want to take look at agricultural science and extension.

First I had better be clear what I mean by agricultural science. Somewhat tautologically, I take it to be science that is primarily undertaken to influence agriculture and/or farmers. I feel the need to state, what should be obvious, as there appears to be increasing amounts of agricultural science that is of no relevance to farming. To use an example from an agricultural science seminar in Ireland, when the presenter was questioned as to the use of his research for farmers, replied, “what has it got to do with them?”

I was also fortunate, while in Ireland, to attend one of the pan-European conferences titled “Towards Future Challenges of Agricultural Research in Europe” held to deliberate on the current state and future direction of agricultural science. There was an unambiguous feeling that something was rotten in the state of Demark. Not only were the presentations by the invited speakers pretty critical of the current agricultural science system, the sentiment from the audience was at times brutal.

38. Towards Future Challenges of Agricultural Research in Europe

One audience member pointed out that the scientific understanding of mastitis control is a line on a graph going from bottom left to top right: the control of mastitis on farms was a line going from top left to bottom right. He nearly got a standing ovation. A another person simply said that “agricultural science is broken” and practically brought the house down.

This sentiment is not confined to Europe, across the world, there appears to be a growing realisation that agricultural science is increasingly not fit for purpose.

39. Why agricultural science is different I

To understand some of the problems with agricultural science, it is essential to understand how and why agricultural science is different from practically every other scientific discipline.

Farmers as implementers

The first, and most important difference is that the primary users and implementers of agricultural science, are not scientists or even highly trained professionals, e.g., doctors, but mostly people with low levels of education. NZ is an exception in the high level of training among its farmers, but most still ‘only’ have a bachelors degree, not a post graduate research qualification. The scientific literature, which for most sciences, is the best way to get your research out to end users, is almost useless in agricultural science, because the people who need to know about and implement research, will almost certainly never read a single research paper in their entire lives.

Ag-science is a social science

Agricultural science is as much a ‘soft’ social science as a ‘hard’ science of physics and chemistry.

In the bad old days in the middle of the last century, when scientists as a whole were viewed as objective diviners of truth, advisory systems, were pretty linear, i.e. designed to carry information from scientists to farmers who were expected to do as they were told. It is now clear that this model does not work, we need to use the soft sciences of sociology and psychology to design research systems so that farmers and scientists can work collaboratively to ensure that the science is relevant and farmers will implement successful results, i.e., farmers and scientists need to be on the same level.

40. Why agricultural science is different II

This also means that agricultural scientists not only need to be experts in the science of agriculture, they also need to have a deep knowledge of real world agricultural practices. One of the key reasons agricultural science fails to be taken up by farmers, is the research is of no relevance to them because the scientist did not understand their farming systems. The blame here has to squarely lie with the scientist.

Like farmers, scientists are people, and they have value systems, morals, ethics and therefore politics. For the physicist and chemist their ethics, whether they vote right or left, has no effect on their science. However, once you start to move into the biological and especially the ecological and social arenas, a scientists world view has to have an influence on their science, often considerable, and often unconscious. Deciding to use yield as a measurement in an experiment is not objective, it is laden with a myriad ethical judgements. Measuring the amount of yield should be objective, e.g., a numerical value determined by a machine, but the values that created the decision to measure yield, mean that the results and their interpretation are not, and never can be 'objective'. That is why every agricultural experiment, and therefore all of agricultural science is a political act.

However, I suspect that some agricultural scientists view their discipline as being closer to that of physics and chemistry i.e. they are external to their study system. In comparison sociologists acknowledge they are a part of the thing they are studying and that their world view influences how and what they research. It is perhaps time for agricultural scientists to learn from their social science colleagues and clearly state the ethical and philosophical positions that underpin and inform their research.

41. The Future Farming Centre I

Having touched on a few issues of agricultural science I will now highlight how they inform the way the FFC aims to operate.

First, the FFC will wear its morals and ethics on its sleeve, not under a bushel.

It will be dedicated to science for agriculture and farmers. That does not just mean research that farmers want, but also research they may not want to hear. It also does not only mean short term, production focused research. What is missing in much of current agricultural science in my view, is the big idea, long term, blue sky, whole-of-system ideas and research programs, for example, the development of no-till farming.

A strongly participatory extension system will be at the core of the FFC, to ground and inform the science, especially research aimed at solving practical farming problems, and also to ensure researchers understand real-world farming. I don't believe it is possible have an agricultural science system that does not have extension at its core, i.e. extension workers and scientists as part of the same team and sharing the same tea room. Separate advisory systems, even those in the 'building next door' are part of the old linear 'scientist know best' days, though that is still far better than the complete lack of extension systems in many developed countries.

The primary output of science at the FFC will be to farmers, with communication to scientists in second, but vital, place. This dissemination of knowledge to farmers needs to be both new science and more importantly the collation and synthesis of whole areas of existing knowledge. This is essential because the location of knowledge in industrial and permanent agricultures are quite different. This is best illustrated by pesticides: they are not only bottled chemicals, but bottled knowledge. However, for many non-chemical pest management tools there are few proprietary products or bottled knowledge: you can not put a rotation in a can, only in a brain. Therefore, permanent agriculture represents a shift in the location of knowledge from specialists, such as biochemists, to farmers. The problem is this requires farmers to learn a lot more. The advantage, as Prof. Gerry Boyle, the Director of Teagasc in Ireland, pointed out, is that such knowledge does not wear out, it can be used indefinitely at no marginal cost, which is in complete contrast to the proprietary knowledge and ongoing cost of pesticides.

42. The Future Farming Centre II

In terms of the range of science the FFC will undertake it will be broad in scope. Many traditional research approaches have been within production types, e.g., vegetables or dairy. Permanent and ecological agricultures often require more mixed farming and holistic approaches and they often have strong linkages between the different farm systems, so it is essential that science can also work across production types and take a whole-of-farm system based view of the situation.

Thinking holistically is great, but, often the devil is in the details, and I believe that more detailed and rigorous approaches are needed such as life cycle analysis, while understanding the limits of models and not considering them to be reality, only a guestimation.

All roads lead to the soil, and as I have outlined, it is vital that the good husbandry of the soil is always considered when undertaking research, and I also want to make it a key extension activity. As an example of this there is a growing interest among farmers, including mainstream farmers, about different approaches to soil management than the typical 'NPK and lime' approach, e.g., use of 'biological' fertilisers, the base cation saturation ratio or Albrecht approach, the soil food web etc. Some are backed by science, some lack scientific validation but may be valid, but worse some are contrary to scientific knowledge. Plus this area is beset by different ethics / objectives for soil management i.e., soil health vs yield. This is an area that clearly needs some good long term comparative experiments and thoughtful extension to tease apart the ethics from the science. It is also an area I believe farmers need truly independent advice so they do not end up buying into fruitloopery.

Research into management of nitrogen, particularly by increasing the use of nitrogen fixing species, in cropping situations, e.g., as polycultures, intercrops, cover crops etc., needs significant attention. It also probably needs some big blue sky ideas and integrated research to make such systems work in real world farming, and some solid life cycle assessment to make sure the extra nitrogen is not playing jokes on us.

43. The Future Farming Centre III

Linked to that is min-till. No-till is dependent on glyphosate and a very small number of other broad-spectrum systemic herbicides, that are facing significant resistance issues. We need a plan B for no till for when chemical ploughing starts to fail.

While the impacts of tillage on soil are complex and arguments fly about its relative impact on soil health compared with other issues, tillage still uses a lot of energy, so on that front alone we should be looking for new ways to minimise the amount of tillage while keeping in mind the practicalities of farming. This is especially important as more weed management moves from herbicides to physical methods such as hoeing. Again this is potentially a big can of worms, so system level thinking and analysis are going to be critical.

Most of these ideas are big, and longer term, but even though the FFC is also based on some pretty big ideas, it will also be tackling the kinds of specific issues that keep farmers up at night. For example:

I have already concluded lab tests of insect mesh covers for tomato potato psyllid (TPP, Bactericera cockerelli) management which have found them to a 100% barrier with an additional apparent disguising effect indicating they could be very effective in the field, so field experiments are in the pipeline.

Mainstream farmers are already running into resistance issues with anthelmintics, so I'm pleased to say that the FFC is a partner in a non-chemical parasite management trial with Robin McAnulty and colleagues from Lincoln Uni using their Targeted Selective Treatment (TST) system with bioactive forages. We hope to expand on this work.

44. The Future Farming Centre IV

The FFC is conducting a desk study on non-chemical management of phytophthora on avocados to identify existing effective methods and where new research is needed.

Another desk study is looking at the issues surrounding the potential to ferment, rather than compost domestic kitchen organic waste before returning it to the land, to help close the biogeochemical cycles, while checking for unintended effects e.g., non-CO2 greenhouse gas emissions.

There are also a lot of big and small ideas to work on in my speciality of non-chemical weed management, from better understanding of the biology and ecology of problem weeds to find their weak points, to some serious engineering in the form of intrarow soil heating to eliminate the weed seed bank in the crop row. Non-chemical weed management as a whole discipline is almost unknown among farmers, so again, this is another area that is in desperate need of extension, indeed I've a proposal for a comprehensive e-book waiting for funding if any funders brought their cheque books.

Therefore, there is clearly no shortage of work to be done.

45. The Future Farming Centre V

So, while science and extension will be the main work of the FFC, it also aspires to higher academic and intellectual goals.

The FFC will also promote the philosophy and history of agriculture and agricultural science. The history and philosophy of science (HPS) is a well established discipline, but I suspect the history and philosophy of agriculture is a new concept to many people. However, as this lecture shows, failing to understand the history and wider issues of agriculture and agricultural science, such as ethics and philosophy, can result in considerable confusion.

I also want the FFC to maintain independence from commercial and business interests as much as possible, so that it can truly offer impartial advice to farmers. Globally, organisations that used to be non-commercial have increasingly commercialised the intellectual property that they had previously given away for free, to make up for funding shortfalls. However that has often come at a loss of impartiality, both at the level of the individual, and the organisation. Farmers are finding it increasingly difficult to find impartial advice and I want to ensure the FFC is as free as of such biases as possible, and where they exist, to clearly declare such conflicts of interest.

I also see a role for the FFC as a critic and conscience of agriculture. The role of critic and conscience is normally associated with universities and in many cases it was a role that has often been hard fought for. However, as research has shown, this role has significantly declined, with academics increasingly being reluctant to speak their minds. Clearly, being an academic does not automatically make you right, but, the freedom to think hard and deep and/or conduct independent research and then freely voice ones conclusions, is a cornerstone of the enlightenment and democracies. This lecture is an example of the critic and conscience role, in that I have covered topics that may be politically and commercially unpalatable, based on my conviction that they are important and correct. Agriculture is far too important to just be left to market forces and political winds. Science, philosophy and ethics have an utterly vital roll to play as well.

46. Conclusion

So, to conclude.
Academics, have a reputation of banging on a lot, often making a mountain out of a molehill. Farmers in comparison, especially kiwi farmers, are known for being a tad more prosaic. I therefore want to give the last word to farmers.
There is a farming proverb, that sums up somewhat more succinctly, the concept of permanence in agriculture. We are increasingly overdue to start heeding its message.

Live, like you'll die tomorrow;
Farm, like you'll live forever.

Thank you very much.