SCHOLARSHIP REPORT

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David Cattanach

Address: P.O. Box 37, Darlington Point, N.S.W. 2706
Phone: 0429 696 854
Fax: 02 69684111
Email: david5@iinet.net.au

CLIMATE CHANGE
GREENHOUSE
&
AGRICULTURE

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CONTENTS

Executive Summary

Greenhouse Gases

These are a group of gases in the atmosphere that have the ability and potential to cause the surface of the Earth to warm. Their effect is much the same as that of a greenhouse and this where they take their name from. Of this group of gases three gases namely carbon dioxide, methane and nitrous oxide are the main ones contributing about ninety four percent of all the greenhouse gases released through mans activities. These are naturally occurring compounds and not man made but rather are accelerated through human intervention and released to the atmosphere. All greenhouse gases have been rated for their relative global warming potential (GWP) and are expressed as carbon dioxide equivalents (CO_2e). Carbon dioxide was assigned the arbitrary value of one, methane 21 and nitrous oxide 310. These gases envelope the planet acting like a one way mirror allowing solar energy to pass through unhindered to the planet's surface but reflecting back the infra red radiation emitted from the Earth's surface thus interrupting or blocking the planet's normal cooling cycle and so the surface steadily gets warmer. It is interesting to note that although there is still a group of people that don't believe that the planet is getting warmer no one is questioning the ability of these gases to cause global warming and no one is questioning the increased concentrations of these gases in the atmosphere. Therefore the only debate is at what level of concentration of these gases will global warming occur!

The major source of these gases is from the mining and use of fossil fuels, coal, crude oil and natural gas. Agriculture is itself a significant contributor in its own right however the majority of our emissions are the result of biological activity without which we would not be able to produce high quality food. From livestock the main sources are methane, a by-product of enteric fermentation, as part of ruminant animal digestive process and in intensive operations effluent and nitrous oxide from urine. For cropping systems the largest area is nitrous oxide from nitrogenous fertilisers and carbon dioxide from loss of soil organic carbon.

Climate Change

The Earth's average surface temperature is rising, particularly the surface temperature of the oceans which inturn is causing a change in our weather patterns. For the mid latitudes this generally means dryer conditions, warmer temperatures and increased water deficit during the crop growing season. The only areas that may benefit are in the far north of the northern hemisphere but as they do not have the transport infrastructure to take advantage of the more favourable conditions. As a result this potential is unlikely to be realised. Most of Australia's agricultural regions will have some serious problems within 20 years not only due to dryer conditions but also due to increased average temperatures during the grain fill period of most crops. The predictions for south eastern Australia by 2030 are that we will be on average about two Celsius degrees warmer, maximums up by about half a Celsius degree and minimums up by about four Celsius degrees, with a reduction of about sixteen percent in the winter/spring rainfall.

Opportunities

The biggest opportunity for agriculture will be in the energy sector. Ethanol will be the main one in the next few years, giving us a new alternative market for our grains and as crude oil prices rise then vegetable oils will become an economic option for diesel fuel.

Research

Research needs can be split into two categories.

i) Reduction of emission

a. Timing and application of nitrogenous fertilisers to improve nitrogen use efficiency and reduce nitrous oxide emissions
b. Identify limitations on soil organic carbon levels with the aim of increasing soil organic carbon
c. Reducing methane emissions from livestock
d. Reducing nitrogen content in animal urine and so reduce nitrous oxide emissions from livestock

ii) Adaptation

a. Increased water stress tolerance in crops and pastures
b. Reduce the effect of warmer temperatures during grain fill period on yields
c. New stone and pome fruit varieties that don't require a winter chill for bud burst
d. Alternative methods of achieving uniform bud burst in years where there is not enough winter chill for this to occur naturally

We urgently need an international standard emissions inventory that can be applied at farm level. Internationally recognised inventory's are available for other industries so why not agriculture?

GREENHOUSE GASES

What are they?

They are a group of gases that have the capability of causing the average surface temperature of the planet to rise. Three of these gases namely Carbon Dioxide (CO_2) , Methane (CH_4) and Nitrous Oxide (N_2O) make up about ninety four percent of all the greenhouse gases released by man and as such make these three a very important group. These gases have been rated for their global warming potential (GWP) as shown in the table below.

Gas	Symbol	GWP	Lifespan
Carbon Dioxide	CO_2	1	120 years
Methane	CH_4	21	12 years
Nitrous Oxide	N_2O	310	120 years

The Global Warming Potential of a greenhouse gas is often expressed as Carbon Dioxide Equivalents (CO_2e) and for audits and emissions reporting forms all gases are converted to their relative Carbon Dioxide equivalents, eg one tonne of Nitrous Oxide would be recorded as 310 tonnes CO_2equivalents.

How do they affect our climate?

They effectively form a blanket around the planet and operate like a one way mirror letting solar radiation in, which warms the surface, however they reflect back the infrared radiation from the planets surface thus interrupting and blocking the natural cooling cycle of the planet. Perhaps a better understanding may be found in the diagram fig 1 on page 6. It is interesting to note that while there is still a group of people with in society that believe that global warming and climate change is not happening no one has disputed the global warming potential of these gases or the increase in their relative concentration levels so I can only assume that the debate is not over the potential for man's activities to cause global warming but at what point it happens.

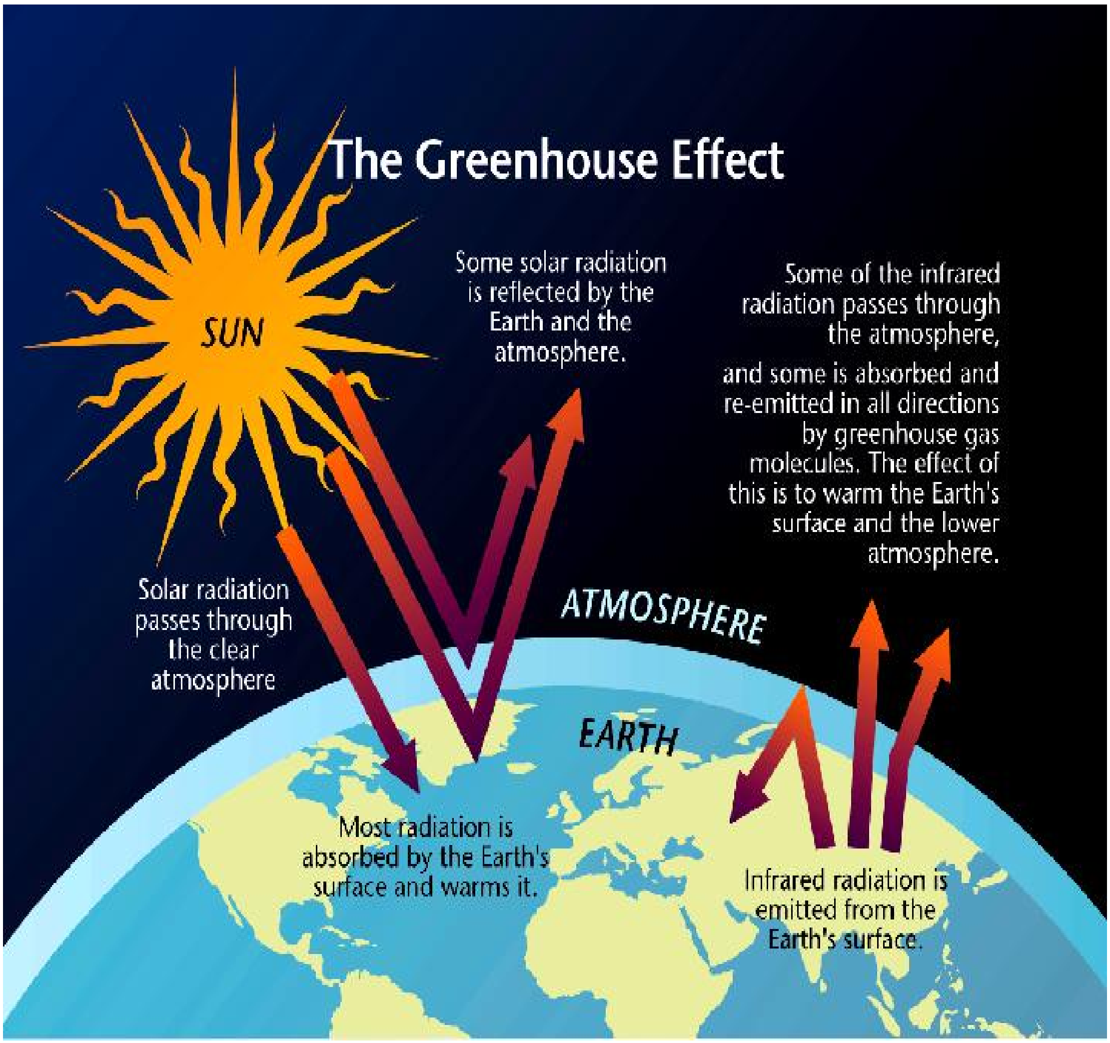

Fig 1 (Dr C. Rice)

It is important to understand that a certain level or concentration of these gases is actually necessary to maintain our climate and prevent the planet from freezing, which in turn would mean an end to all life as we know it. From the graph fig 2 on page 7 you can see that we have had a stable level of these gases in the atmosphere up until the late 1800's and after the so called industrial revolution the concentrations of these gases began to rise. Since the mid 1900's they have risen at an exponential rate.

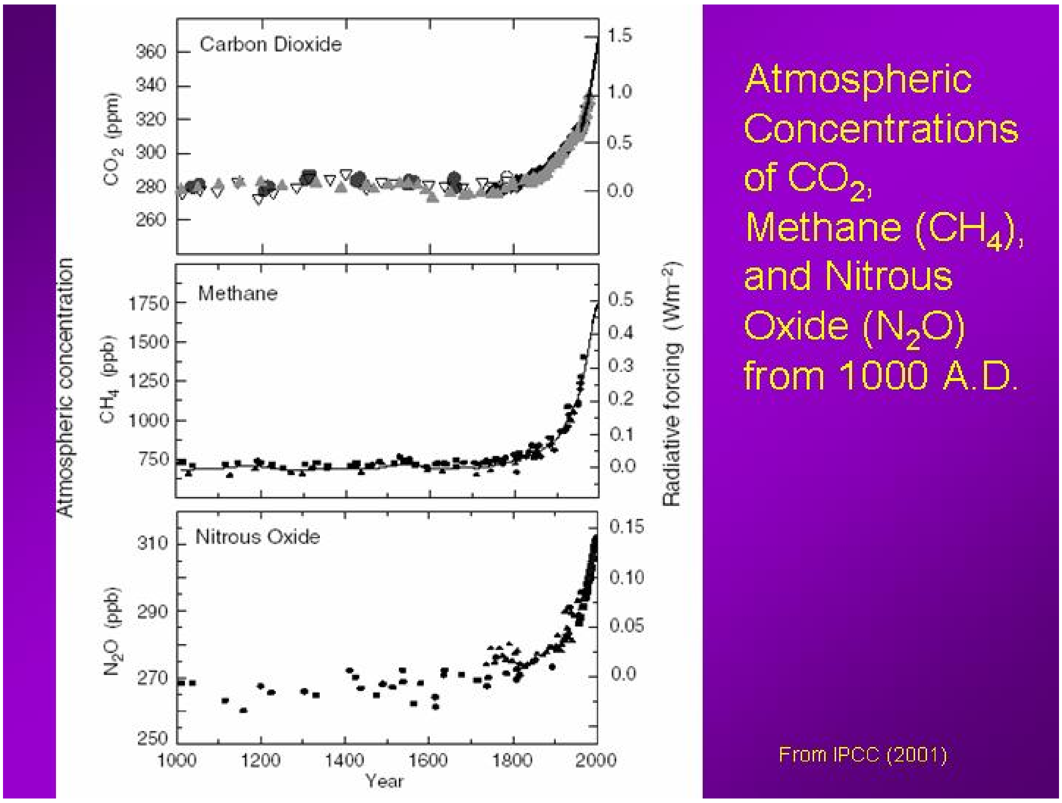

fig 2 (Dr C. Rice)

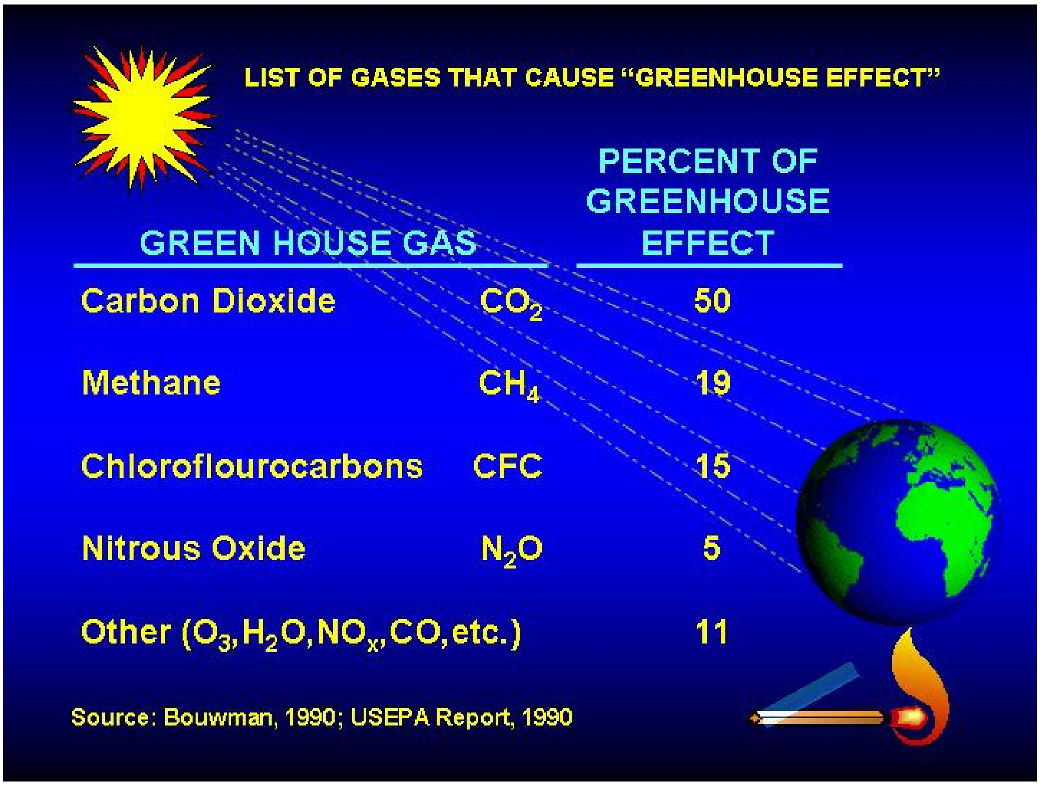

fig 3 (Dr D. Reicosky)

Where do these gases come from?

Broadly speaking they have two main sources:

The Natural Environment.

There is a continual release of carbon dioxide, methane and nitrous oxide from the natural environment. Prior to the industrial revolution in the late 1800's these emissions have been in balance with the relative life of these gases in the atmosphere and as such the relative concentrations of these gases have remained stable giving us a very stable and perhaps mild climate. All three gases are released from soils naturally, as a result of biological activity in the soil, however the rate of release is dependant on soil temperature and moisture. Although trees are generally considered to absorb carbon dioxide, they in fact absorb carbon dioxide during the day as part of their photosynthesis process but release carbon dioxide at night as a by product of respiration. Their rate of photosynthesis is related to the availability of moisture and their rate of respiration is directly rated to temperature. The significance of this was perhaps best demonstrated in Europe in the 2003 drought with warmer dryer conditions these forests became a net source of carbon dioxide due to increased respiration at night with higher temperatures and the reduced photosynthesis during the day due to moisture stress. This at the very least raises some questions as to the ability of trees to offset man induced emissions over the longer term. With the climate change predictions being that the Earth will be a warmer dryer place, this is scenario that we can expect to be repeated over and over again.

Although there is more carbon in the top ten centimetres of the earths surface than in all the plants and animals above it we can also expect to see significant releases of greenhouse gases from soils as the temperature rises. A team of scientists re tested all the soil on a line across England and compared them to results of tests done twenty five years ago and found that the carbon content of these soils had dropped and was most probably caused by increased biological activity in these soils as a consequence of the soil temperatures rising.

In the far north of the Northern Hemisphere the permafrost is starting to thaw. When the permafrost thaws it becomes a lake, not arable land and due to the anaerobic conditions, the plant matter that was growing on the surface then decomposes on the bottom of the lake releasing large quantities of methane. Not only are the by-products of mans activities releasing large quantities of greenhouse gases but our impact on the natural environment is causing it to accelerate its contribution to the problem as well.

Mans Activities

Mans contribution to the increase in greenhouse gas concentrations in the atmosphere comes largely from the mining and use of fossil fuels. Stationary energy is the largest single contributor mainly due to coal fired power stations to feed our unsatisfiable demand for electricity. This is by far the single largest group both for Australia and world wide. Although a number of ideas are being considered at present to reduce emissions from coal fired power stations they come at an enormous cost both in the capital equipment required and in running costs, which would probably double the cost of electricity. In most developed countries transport is another high contributor, however in Australia agriculture is the second largest industry group at around twenty percent of our total national emissions. It needs to be clearly understood that the majority of agricultural emissions are a result of good biological activity that without which we would not have any agricultural production. Any unrealistic regulation on agriculture would result in the community losing its access to the premium, quality and affordable, fresh foods in our super markets that we take for granted as a God given right. It has also been calculated that every person on the planet, man, woman and child, is responsible for eleven kilograms of carbon dioxide per day, so next time some one wants to pass the buck to the livestock sector perhaps they should look at themselves and the contribution being made by large urban centres. Some small changes in lifestyle in urban Australia would significantly reduce Australia's total greenhouse emissions.

Agriculture:

Livestock:

Currently there are no viable ways to reduce livestock emissions particularly with respect to broad acre production. Some trials have been carried out using tannins in their drinking water in an attempt to reduce nitrous oxide emissions but the results to date have been at best inconclusive. It has been suggested that with the addition of tannins to their drinking water that there would be a reduction in the level of nitrogen in the urine. Tests to date have shown a reduction in the nitrogen content of the urine of about twenty percent; however this did not translate in a reduction in nitrous oxide emissions. In general a well fed animal consumes more nitrogen than it can use and there is some debate as to where this nitrogen has gone if it is not in the urine. Some say that it has gone out in the faeces while others say it has remained in the body, and as yet a full nitrogen budget has not been done. It may also be possible that the tannin has acted as a masking agent and the nitrogen is still in the urine but not being picked up by the standard tests. A full nitrogen budget is essential to determine if this line of research is worth following.

Methane is a by-product of the digestive process and to date no viable method of reducing this source of emissions has been found, with the exception that perhaps a well managed diet may reduce these emissions in relation to production. This is an option quite obviously only available to intensive production systems.

For intensive production systems, ie piggeries, feedlots and dairies, where a critical mass can be obtained, then putting effluent through anaerobic digesters to collect the methane and then use it as an energy source to generate electricity would offset emissions from that business and, as energy costs rise would become an additional income stream.

Cropping Systems

Nitrogen

This is the one area where we could make significant gains or savings very quickly. Nitrous Oxide is the main greenhouse gas in this area and with limited short term research and trial work we would have some new best management practices that would not only significantly reduce our emissions but would also reduce our costs. Currently the Intergovernmental Panel for Climate Change (I.P.C.C.) uses a default value for nitrous oxide emissions as 1.25 % of half of the nitrogen applied as being lost as nitrous oxide and 1.5% of the other half of the nitrogen applied being lost as nitrous oxide through indirect losses from such things as ammonium volatilisation which in the real world is not the case. To their credit they have picked a mid range figure in the absence of good data sets and not the top end. The graph on page 13 fig 5 courtesy of the fertiliser industry shows nitrous oxide emissions relative to water filled pore space of the soil, but does not take into account timing of application, crop type, stage of growth and the soil biota that may be present at any particular site. The Intergovernmental Panel on Climate Change refers to this graph in choosing its default value for nitrous oxide emissions yet in my view this graph is of no value in trying to understand the losses or in developing a new " best management practice" to reduce our emissions. However realistically in relation to the nitrogen cycle we have relatively small emissions in the nitrification part and much larger emissions in the denitrification part of the nitrogen cycle. From this point alone it is reasonable to assume that if there is only enough nitrogen available to meet the plants needs then there will be no nitrogen left to go through the denitrification cycle thus causing a significant reduction in nitrous oxide emissions. Emissions in the nitrification cycle are bellow 1% and typically between 0.5% and 0.8 %, where as in the denitrification cycle it could be as high as 5%. Any nitrogen that goes into the denitrification cycle, is nitrogen that we have paid for and lost. There is a very real financial incentive to improve our use efficiency and reduce our nitrogen bill. Yet despite the cost and value of nitrogen, most if not all the nitrogen work has focussed on if we add more during the growing season do we get an economic response, but we have not looked at what value we get from existing applications, particularly pre plant applications. . The key or keys to achieving an increase in nitrogen use efficiency and a reduction in nitrous oxide emissions are rate, timing and to a lesser degree method of application. I believe the graph below offers a better insight and explanation into how we may achieve an increase in nitrogen use efficiency, a reduction in nitrous oxide emissions and at a very minimum maintain yield and quality.

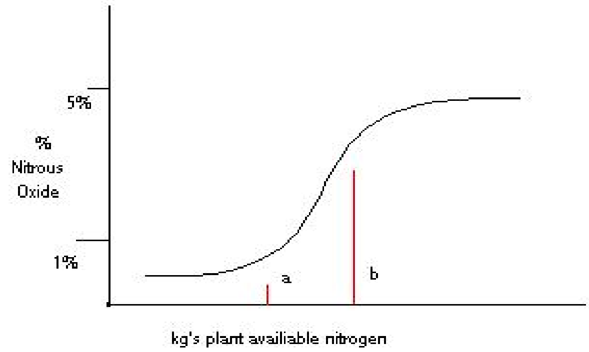

fig 4 (W. Hohenstein)

From the graph above it can be seen that there are very low nitrous oxide emissions from any nitrogen applied and is available to the plant up to the rate marked as "a". Point "a" is the amount of nitrogen that the plant can take up for a given growth stage and allowing for any other limiting factors. Any additional nitrogen is surplus to the plants requirements and is lost from the cropping system through denitrification. During the denitrification process there are several stages which in turn result in additional nitrous oxide emissions. Point "b" is most likely the rate that we generally apply using current recommended best management practices. A large proportion of pre plant nitrogen would undoubtedly go through to the denitrification process and I am quite convinced that we are too quick to blame a shortage of nitrogen when we see a crop pale in colour rather than looking for the real problem. The crop may well be short of nitrogen but is the problem a shortage of nitrogen or is something else blocking or preventing the uptake of nitrogen. A good example may be top dressing a wheat crop with urea because of a perceived nitrogen deficiency due to waterlogged conditions. How much of this nitrogen will actually end up in the plant? A much better result may be achieved by using a much lower rate of nitrogen but applied as a foliar application.

There is no doubt that by paying more attention to the rate, timing, placement and method of application we could significantly increase our nitrogen use efficiency and reduce our emissions at the same time. Unfortunately there is currently very little information available to encourage us to change the current recommended best management practices for nitrogen management.

Currently the international fertiliser industry is saying that the use of nitrification inhibitors are not cost effective, the cost of these inhibitors is far greater than the value of the nitrogen saved. We also need to make sure that the greenhouse emissions from the manufacture of these inhibitors are not greater than the reduction in emissions from the field that they were applied to. It is an essential outcome that there is a net reduction in total emissions and not just a shifting of the point source of these emissions.

Nitrogen Emissions vs Soil Moisture

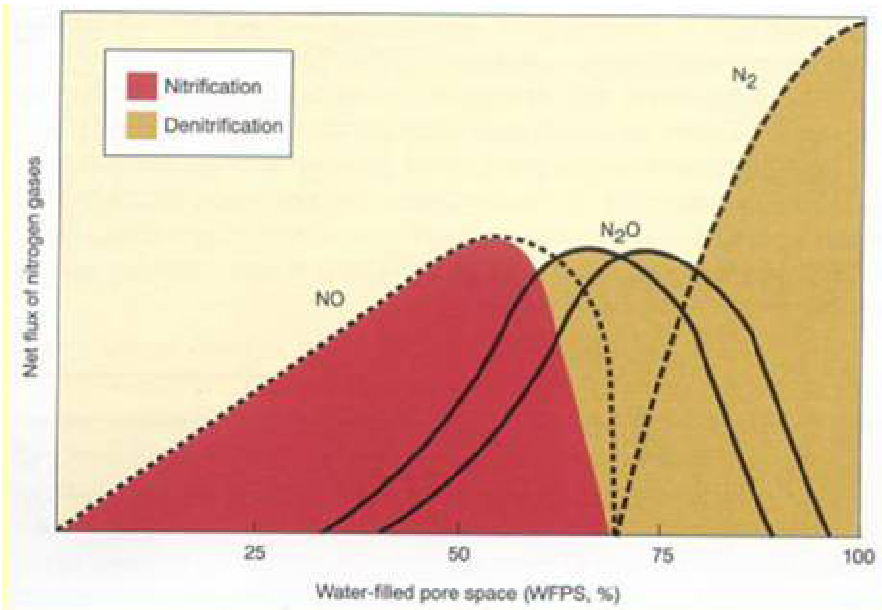

Fig 5 (Fertiliser Industry Federation of Australia)

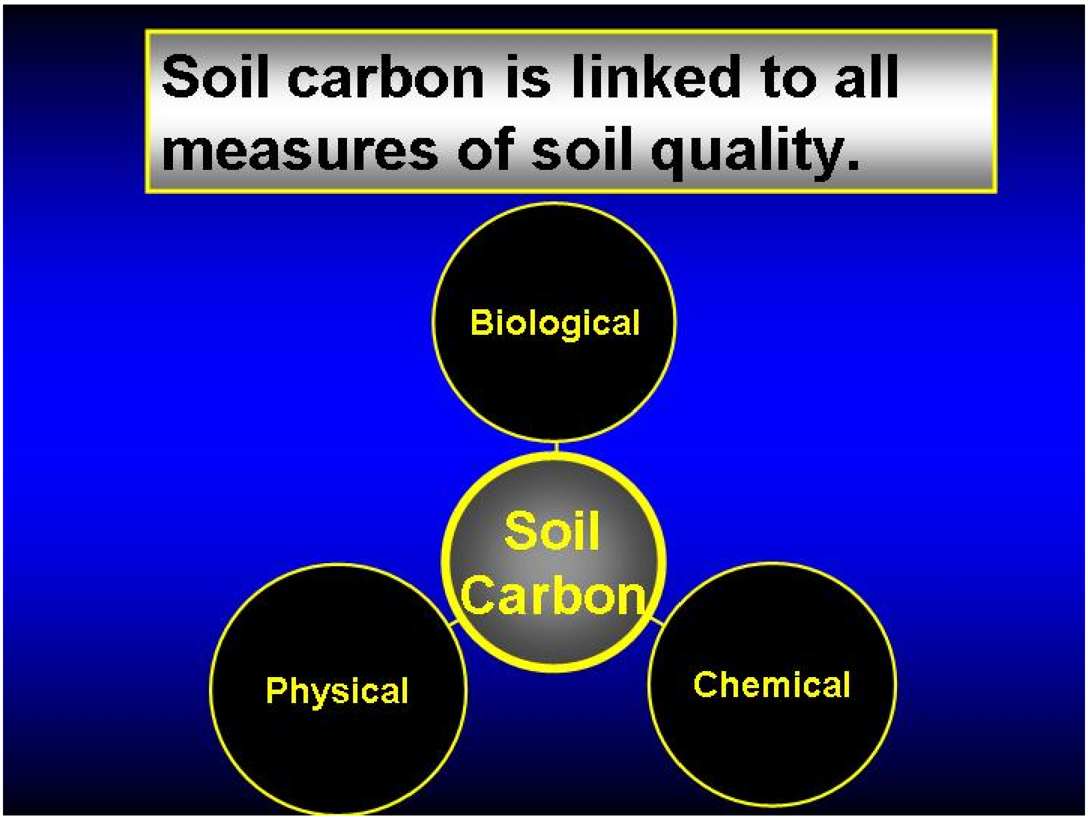

Fig 6 (Dr D. Reicosky)

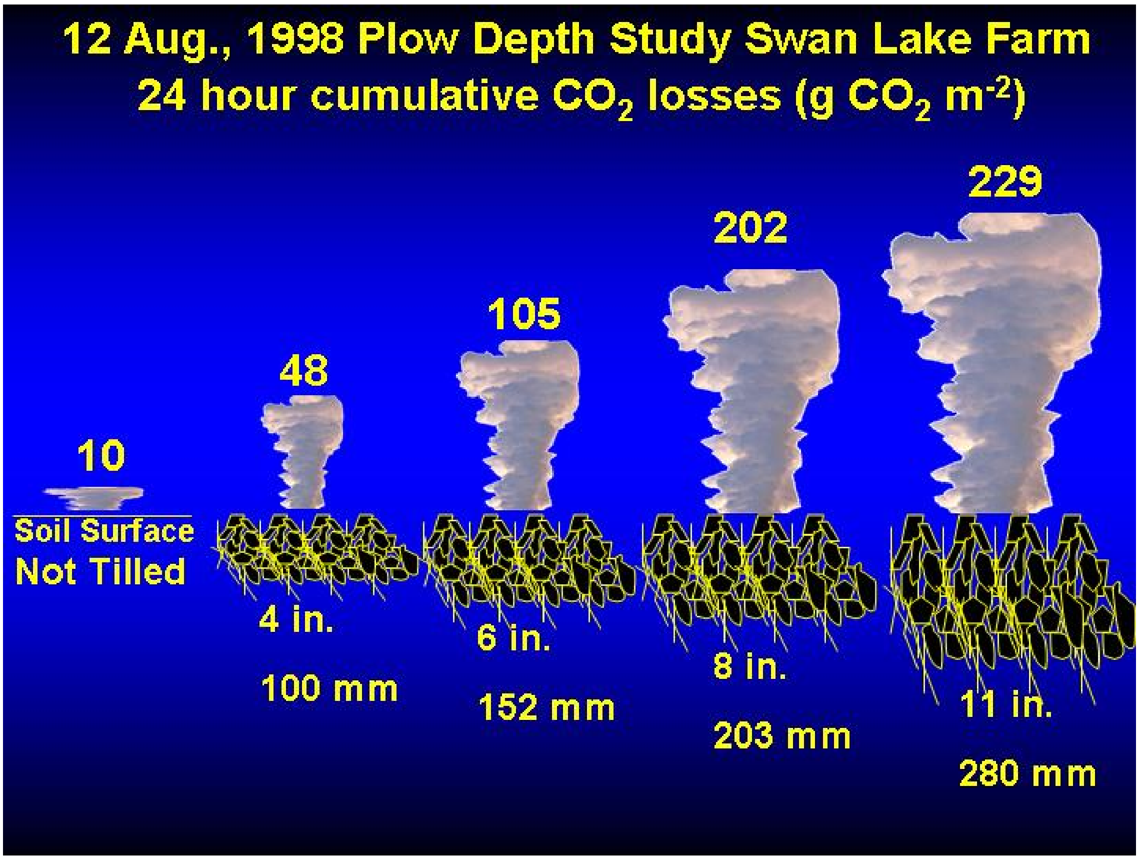

fig 7 (Dr D. Reicosky)

Carbon

Traditionally we are told that cultivating or disturbing the soil releases a very large proportion of the carbon as carbon dioxide from the oxidation of the carbon stored in the soil. Although there is a lot of work around showing a reduction in the level of soil carbon in agricultural soils around the world and work by people like Dr Don Reicosky from the USDA agricultural research service showing a direct relationship between the volume of soil disturbed and the amount of carbon dioxide released, they can not tell me how much of that carbon dioxide was from oxidation of organic carbon and how much was bubbles of carbon dioxide trapped in the soil and slowly working its way out. Figure 7 on page 14 is a graphical representation of the amount of carbon dioxide, as measured, that was released from different tillage methods.

However there are three other main causes for soil carbon loss that have been largely ignored to date:

Fallow.

Today we are being told by researchers that we must have something growing in the paddock to maintain soil carbon levels. If we use zero till management and chemical fallow techniques it could be at the expense of the deeper carbon. The shallow carbon is also the most vulnerable to loss.

Plant Biomass

Most native plants especially in the drier more arid areas have a large below ground biomass and relatively small above ground biomass and so have been replaced with improved pastures and crops that have a large above ground biomass and a small below ground biomass. This shifting of the plant biomass from below ground to above ground reduces the potential amount of carbon being put back into the soil.

Carbon: Nitrogen Ratio

A lot is made about the carbon, nitrogen ratio however this only half the story. A paper was published in the 1950's showing a direct relationship between carbon : nitrogen : phosphorous : sulphur, yet despite Australian soils being generally low in all four nutrients very little if anything is ever said about phosphorous and sulphur and their importance in building soil carbon levels. The C : N : P : S ratio in humus which is a very stable and important form of organic carbon is 10000 : 833 : 200 : 143. If we are going to increase or even just maintain our current levels of soil carbon then we need to pay more attention to phosphorous and particularly sulphur than we currently do. Quite clearly when we incorporate stubble in the soil we need to apply more than just nitrogen to help with the breakdown if we want to get the maximum benefit from the potential carbon that is present in the stubble. If any one of nitrogen, phosphorous or sulphur are limiting then other carbon compounds will be formed, some of which are easily leached and as such we lose the benefit of what we were trying to achieve in the first place.

Increased soil organic carbon levels leads to improved soil structure, increased water holding capacity, reduced tillage costs with less soil resistance.

To make our soils a viable long term carbon sink we need to eliminate unnecessary or ineffective tillage operations, where possible aim for a double cropping option, reduce or eliminate fallow and improve soil fertility particularly with respect to phosphorous and sulphur.

Climate Change

What is climate change

Climate Change may best be described as either an upward or downward trend in average temperatures and or rainfall over the longer term. Such changes are more noticeable in Europe and North America where the climate is more stable and predictable than in countries like Australia where we seem to oscillate between extremes from one year to the next. In defining climate change we need to keep in mind that we will still have wet and dry years and hot and cold years, and most importantly an increase in extreme weather events at both ends of the scale with less so called average or good years in the middle.

The Planet is getting warmer

Global Warming seems to be a news item every week or so now, but what do they mean by global warming. Basically they are saying that the average surface temperature of the planet is rising, not that the maximum temperatures are rising. In fact according to the computer simulations done to date the main shift in temperatures is expected to be a rise in the minimum temperatures. For south eastern Australia by the year 2030 the average temperatures are predicted to be approximately two Celsius degrees higher than at present. However when we break this down we see a rise of about four Celsius degrees in the minimums and a rise of only about half a Celsius degree in the maximums. This rise in minimum temperatures rather than in the maximums is extremely important for both society and agriculture in determining how we are going to adapt to a changing climate.

These are only predictions but what evidence in the real world is there that the planet is getting warmer?

- Corn is now being grown in Northern Ireland where if you took today’s varieties and management systems back twenty years you would still not be able to grow corn because it was too cold.
- Eight of the ten hottest years on record for Europe have occurred in the last decade.
- The spring thaw in the Rocky Mountains in south west Canada is occurring three weeks earlier than it did fifty years ago.

- Permafrost country in Alaska is starting to thaw and a couple of communities are looking at moving their whole village.
- The Arctic icecap has reduced significantly in recent times as shown by photo fig 8 on page 18
- Most of the world's glaciers are retreating at an unprecedented rate.

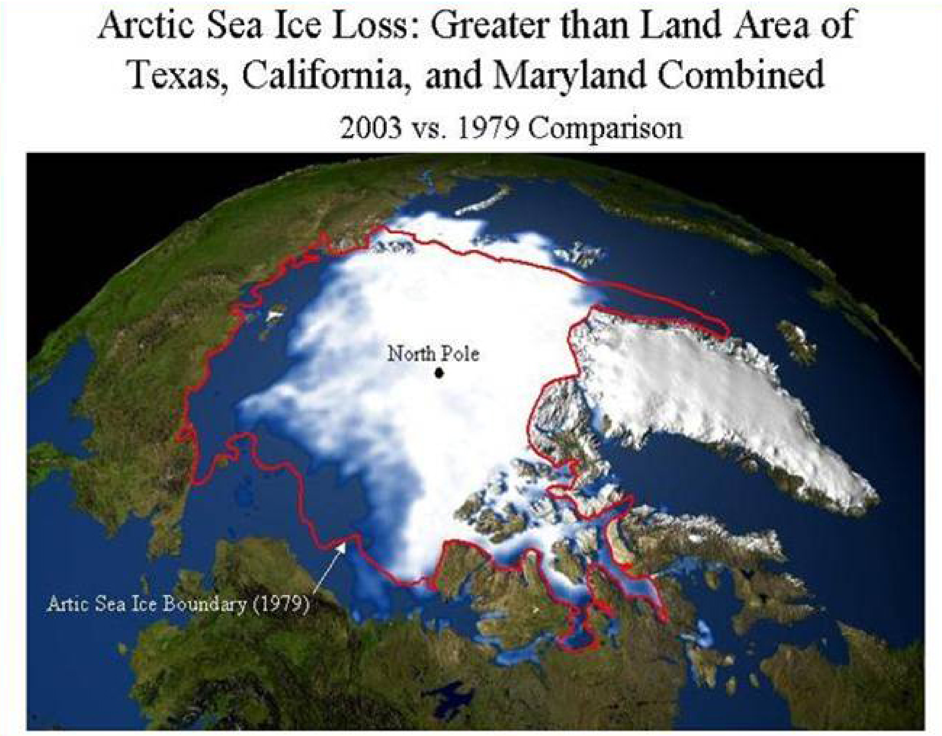

fig 8 (Dr C. Rice)

What about Rainfall?

As a general rule we are seeing and will continue to see a significant reduction in total rainfall in both the northern and southern hemispheres in what is referred to as the mid latitudes. This is the region between thirty and sixty degrees and includes the main agricultural production areas of the world. With this reduction in rainfall coupled with warmer temperatures, most regions will have an increase in water deficit during the growing season and despite a potentially longer season in northern U.S., Canada and parts of Europe it is highly unlikely that higher yield potential will be realised. Although it is difficult to say what technology may be available in ten years time, the greatest impact on production levels and markets will be from international politics rather than as a result of climate change itself. The price of crude oil will have a greater impact on prices and production levels over the next ten years than possibly any other single event. More information on this area in the "Opportunities for Agriculture" section.

Australia

At this point in time it appears that Australia will generally be drier with the only exceptions being in the far north of the tropics where there are very few people and agricultural production is almost non existent.

For the most part in the Murray-Darling basin by about 2030 we are looking at a rise in average temperatures of about two Celsius degrees. This rise in average temperatures appears to translate into a rise in the maximums of about half a Celsius degree and a rise of about four Celsius degrees in the minimums. As far as rainfall is concerned the predictions are for a reduction of about sixteen percent in the winter and spring rainfall and possibly a ten percent increase in the summer rainfall.

Impacts

Global

On a global scale the effect and indeed the impact of a warming of the Earth's surface will have a much greater and more noticeable effect in the northern hemisphere. To better understand this we need to look at the effect on sea surface temperatures first and then the flow on effect to weather patterns and then the land area.

The single most important area is an ocean current known as the Gulf Stream or Elevator which is a section of the ocean circulation current that runs from the Gulf of Mexico along the eastern United States seaboard then across the Atlantic Ocean past Ireland (this is why they can grow corn in Northern Ireland) and finishes near Greenland. A diagram of the ocean circulation current is on page 21 fig 9. As this current reaches Greenland the water cools, its density increases, this water is then heavier than the surrounding water and sinks, thus it is believed at present that this is the engine room that drives the global ocean current.

However with the warming of the ocean from global warming and the rapidly increasing sea surface temperature in the Gulf of Mexico the temperature of this stream is now much higher than it traditionally has been which in turn is causing the melting of the Greenland ice sheet and increased rainfall in Russia, which then finds its way down the rivers and into the ocean meeting up with the Gulf Stream and the fresh water from the melting of the Greenland ice sheet. The significance of this is that fresh water has a lower density than that of sea water and its believed that with the mixing of these two sources of fresh water and the saline water of the Gulf stream that the combined density will not be heavy enough for the Gulf stream current to sink, the engine that drives the ocean current is then switched off. It is now believed that this circulation could stop very quickly perhaps within a ten year time frame from when it starts slowing down. The bad news is that some of the latest work suggests that it may already have slowed by thirty percent but I believe this is yet to be verified. This current has stopped flowing many times before and restarted again, however the impact of this event will be enormous across Europe. The net effect of this current stopping is predicted that Europe will go into winter and stay there for a long time, may be as long as a hundred years. Europe will be hungry for both food and energy and this should be an advantage to Australian agriculture. This Global circulation current does not appear to have any great direct impact on the climate in Australia. However as the ocean is the major carbon sink on the planet, with the stopping of this current then the ability of the ocean to absorb carbon dioxide will be significantly reduced and so the rate at which carbon dioxide concentration in the atmosphere is increasing will be accelerated. This further accelerated increase in atmospheric concentration of carbon dioxide will cause the oceans to become warmer (the warmer the water the less carbon dioxide that it can absorb) and potentially cause the oceans to laminate much the same as happens in our dams now thus preventing the carbon enriched water from cycling down to the deep ocean. With increased levels of carbon dioxide in the ocean water , the pH of the water will drop and at present no one knows what effect this will have on the micro-organism that are the start of the food chain. Generally speaking most micro-organisms live in a very narrow pH range. Although at present we are looking only at relatively small changes in average temperatures in Australia in fifty or so years time these shifts in temperature could be much larger and happen at an accelerated rate.

Another area in the ocean we should watch closely is the Gulf of Mexico. Hurricanes form over warm water when a pool of air is heated and rises and so draws in air from surrounding areas. The warmer the water, the faster the air warms and rises, as happened in the Gulf of Mexico in 2005 with both Hurricanes Katrina and Rita. These two hurricanes were both notable for the fact that they gained an enormous amount of intensity while in the Gulf. As sea surface temperatures rise in the gulf we can expect to see an increase in both the number and intensity of these hurricanes. As the United States relies heavily on the Gulf of Mexico for its natural gas and to a lesser degree oil, any damage to its platforms or disruption to supply from hurricanes will send the oil price up. This inturn will have a significant impact on our economy.

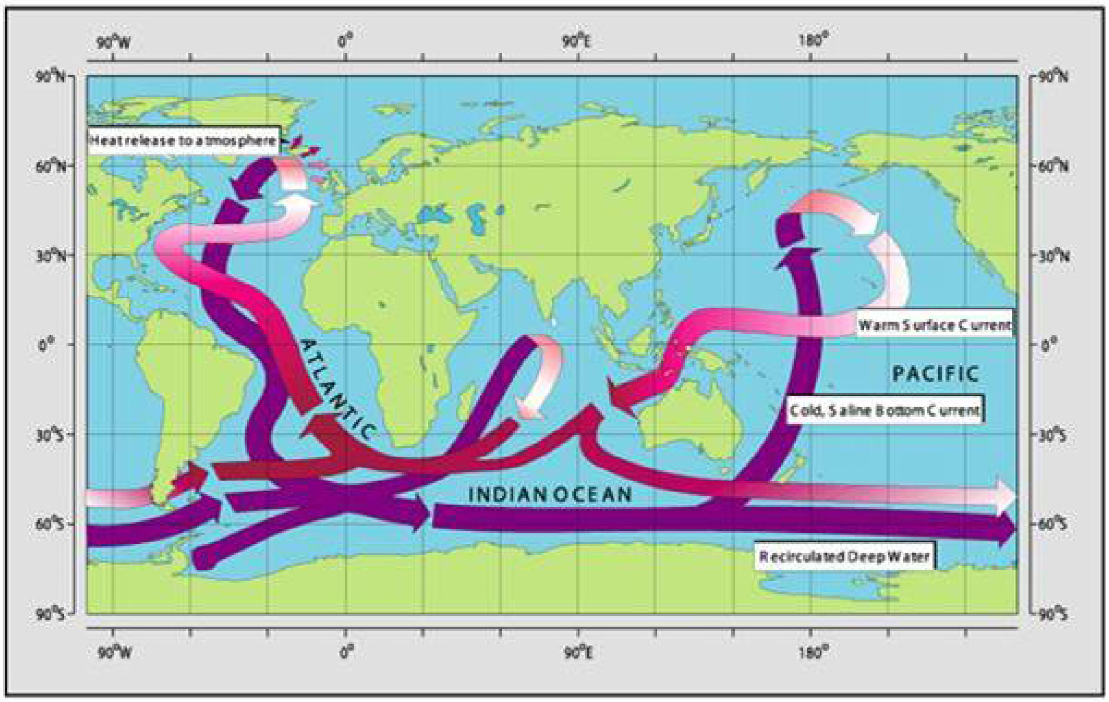

Fig 9 The above diagram shows the main ocean circulation currents.

Australia

Society

Although it may well be argued that with increased temperatures we will see an increase in the number of deaths from heat stress, this may be offset with a greater proportion of the population either having their own air conditioning or at least access to air conditioned premises in hot weather. However the down side is that additional air conditioning means extra power generation and an increase in greenhouse gas emissions, a vicious circle accelerating the rate of climate change.

Perhaps a much larger problem will be water or more importantly the availability of safe fresh water for urban centres. During the last drought all of our major and regional population centres in south eastern Australia were suffering from severe water shortages and as a society we appear to have learnt nothing from this experience. Currently there appears to be no long term plan to address the issue of water availability and supply for urban areas with the problems of the recent past being passed off as "it was a drought, no rain means water restrictions" yet we know that with the current climate change predictions, this situation will occur again and again more often and compounded by the fact that the population in these centres is growing. The current preferred option of all Australian Governments of taking water from agriculture to supply our growing cities and regional centres is not a long term option and is indeed destined to fail. Work is urgently needed to define how much water is needed by communities, the environment and agriculture, when it is needed and why. The current ad hock system of water management is wasting water, a luxury that the driest inhabited continent on Earth can no longer afford, and indeed some releases of water for environmental flows have proven to be the greatest examples of environmental mismanagement yet seen. Only when we understand the needs of all stake holders can we move forward and potentially meet a number of objectives with one parcel of water and reduce the wastage from environmental flows that are achieving nothing and in some cases have done considerable damage.

Environment

Higher average temperatures, lower rainfall and increased carbon dioxide levels in the atmosphere will all individually have a significant impact on the environment. Warmer temperatures will see a southern migration of insects, diseases and plants in the southern hemisphere and a northern migration in the northern hemisphere. With generally lower rainfall plants that have a lower water requirement will become more dominant and with a shift in rainfall patterns will favour some fungal and bacterial pathogens more than others. The effect of carbon dioxide fertilisation on plants varies enormously between species and so it is difficult to determine without a lot of research which will benefit the most and which will have limited or no beneficial effect. In short it is very difficult to determine what effect climate change will have on a particular region except to say that we will see a significant change in both the make up of that biodiversity and the dominant species.

Agriculture

Livestock

With warmer temperatures there will be increased heat stress on animals, however the main economic impact of this may well be offset by a significant reduction in cold stress. By far the largest impact is going to be from parasites, eg the “tick line“ will move steadily south along with a range of diseases.

Pasture production particularly in the dryer inland areas will be reduced resulting in lower stocking rates which inturn will have the greatest economic impact on the viability of many properties.

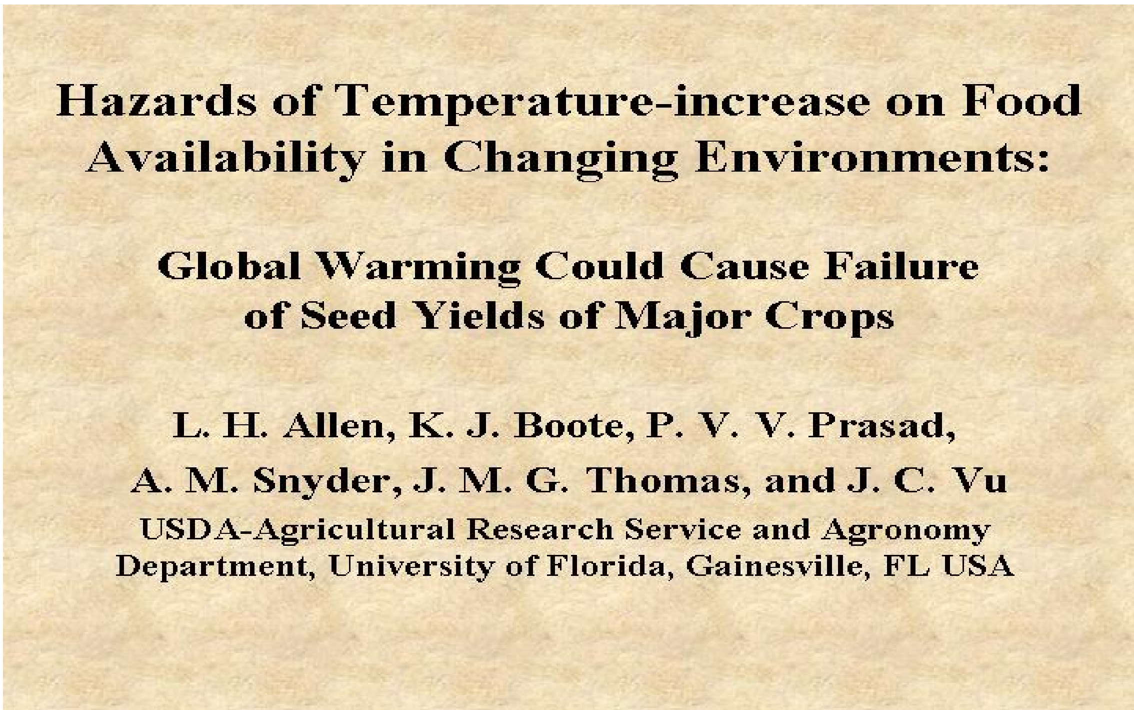

Fig 10

Cropping systems

There has been to date a lot of talk about how agricultural production will benefit from carbon dioxide fertilisation. Agricultural production in Australia is currently limited by water deficit during the growing season and by relatively high temperatures during the grain fill period. While carbon dioxide fertilisation may offset some of the impacts of reduced rainfall it has no impact on the effect of raised temperatures during the grain fill period. Dr Leon Allen from the USDA agricultural research service in Florida USA found that by doubling the carbon dioxide concentration he did not get a positive yield response with increased temperatures as shown on page 24 fig 11. If we are going to be both warmer and dryer, then carbon dioxide fertilisation will in its self not maintain our production. With warmer weather, particularly with the minimum temperatures rising, we will see a southern migration of insects, diseases and weeds in our cropping systems. This may require a change in current recommended “best management practices” and requires an urgent review of “integrated pest management” strategies to ensure that we are prepared and equipped to handle an outbreak of a pest or disease that was not normally an issue in a particular area.

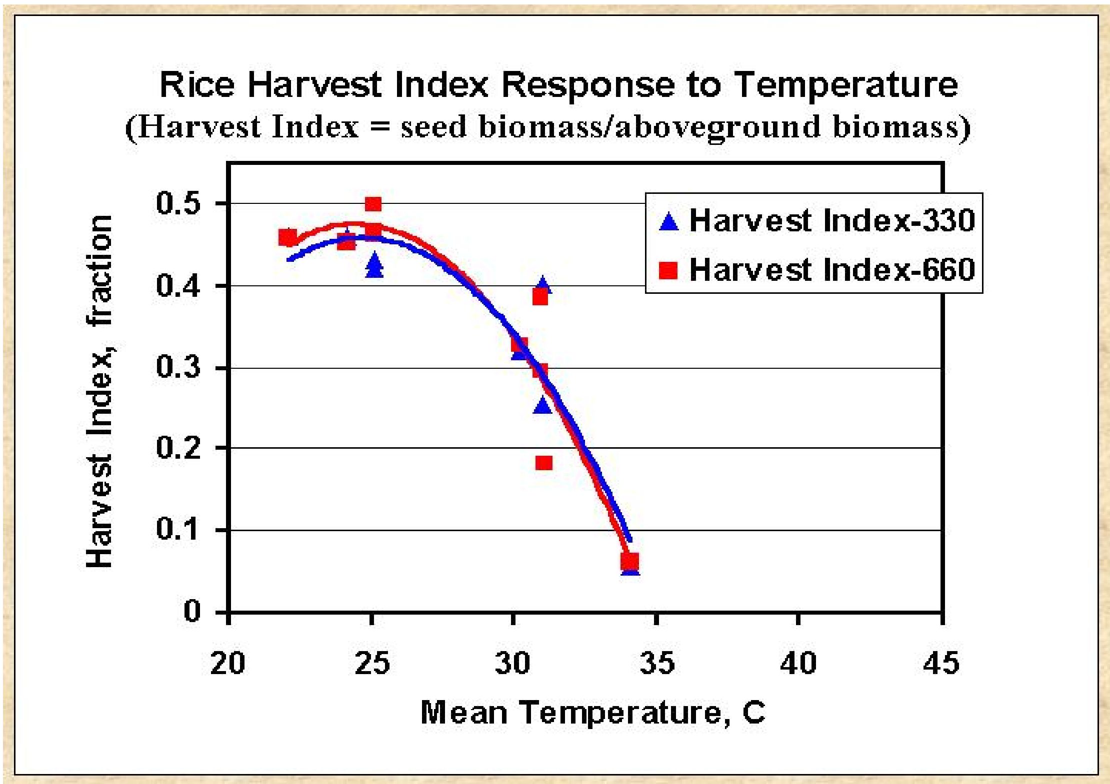

Fig 11 Blue line atmospheric CO_2 at 330 ppm and Red line 660 ppm (L. Allen)

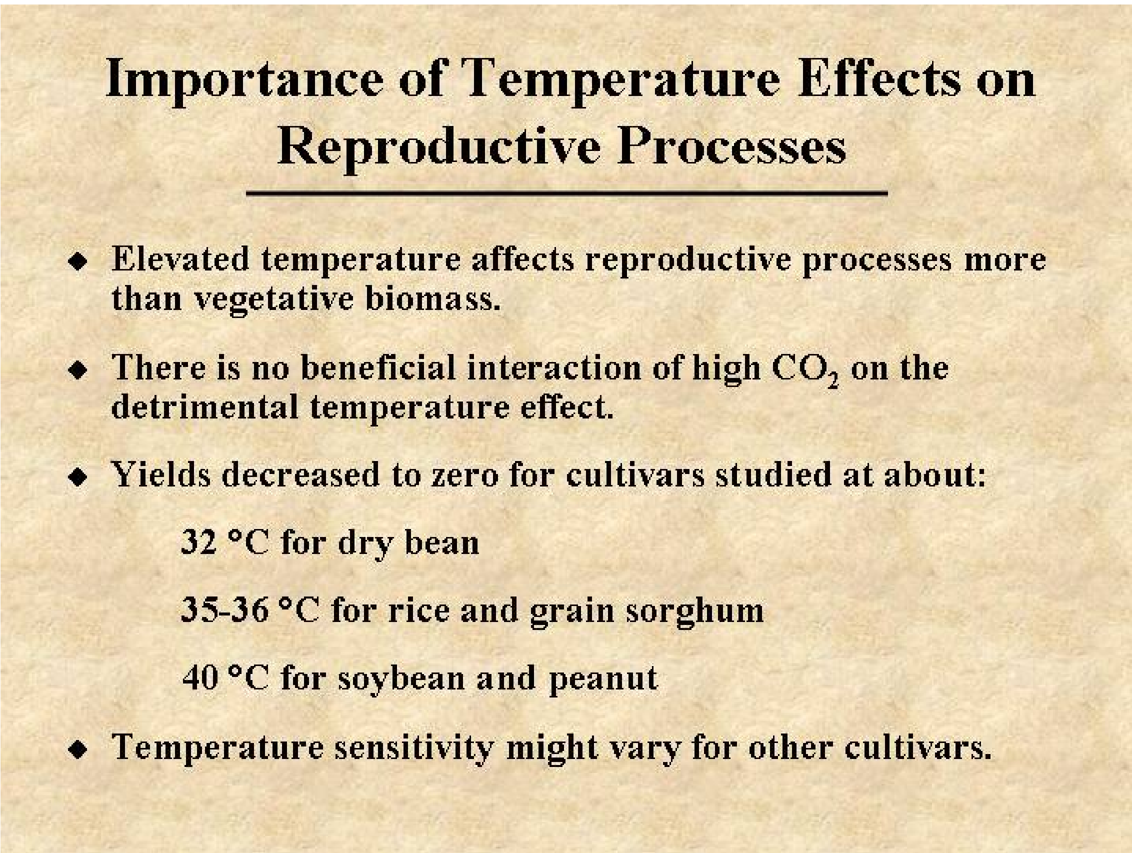

fig 12 courtesy L.H. Allen

Opportunities

Carbon Trading

This is an area where there has been a lot of talk on how this will be a windfall for agriculture. In reality I see very little money for us in it under current trading rules. In the United States farmers are getting around US$1-50 per acre to use minimum till systems but can only register a small portion of their program, typically about ten percent for the next five years, this is not a good income stream for agriculture but rather a cheap licence to pollute for power companies while at the same time giving a warm fuzzy feeling to their share holders. Currently in the United States they are only considering carbon, however the research community is moving towards a full accounting system, ie accounting for methane and nitrous oxide as well as carbon dioxide and under this approach agriculture are net emitters. With this in mind we can expect to see their carbon trading rules change significantly in the next few years. Under the Intergovernmental Panel for Climate Change (IPCC) rules for carbon trading, companies can only purchase carbon credits from companies in countries that have ratified the "Kyoto Protocol". This rule will no doubt be changed as power companies in Europe don't like paying thirty four euro per tonne of carbon when U.S. companies are only paying US$3-00 per tonne, the Europeans are going to push for a rule change so as to have access to cheaper carbon credits. It is interesting to note that the Canadian Government has set the maximum value of carbon credits in Canada at $17 Canadian per tonne again reducing the incentive for Canadian companies to reduce their emissions and limiting the income stream that may have been available to some farmers. **If you should decide to go down the carbon trading / storage track make sure you sign up a lease agreement preferably on an annual basis and not a perpetual arrangement** as with this type of contract if you lose carbon at some time in the future for what ever reason you will have to purchase credits to offset these loses and you can guarantee they will have a much higher value in a few years time.

Carbon trading – not much money in it, full of pitfalls, approach with great caution.

Energy, Bio Fuels, Diesel

Bio diesel or B2 as it is known in the United States is normal diesel containing two percent soy bean oil. If all diesel fuel in the United States was mandated to be B2 then this would use the equivalent of twenty percent of the United States soy bean crop. Due to particulate pollution in the United States it is already mandated that gasoline or petrol contain a minimum of ten percent ethanol at certain times of the year and so possibly the same will happen with diesel fuel in the near future. This year all diesel engines must now meet what is referred to as tier three emissions levels, which is a limit on the amount of particulates and NO_x gases that an engine can emit. This is being done to reduce the visible pollution across America and in 2011 tier four regulations come into effect. I was told by one engine manufacturer that if all diesel fuel was B2 it would make their job of meeting these standards a lot easier. As crude oil prices rise, vegetable oils as an additive to diesel fuel will become a more affordable option. It has been worked out that if all diesel fuel in the United States was B2 it would consume twenty percent of the U S soy bean crop. That is a lot of beans out of the world market.

Ethanol

This is without question the largest opportunity for agriculture. Currently in the United States it is mandated by law at certain times of the year that all gasoline must contain a minimum of ten percent ethanol. As crude oil prices rise ethanol becomes an economically viable fuel option and we are now at a point in time where we now have a second buyer for our grain that is prepared to pay for it. With present technology the cheapest ethanol is produced from corn starch and probably from other grains with a high starch content. In Brazil they are producing ethanol from sugar but this is only an economically viable option with high subsidies. Despite the rise in crude oil prices the European Union is winding back its sugar production, an action I am sure they would not be taking if producing ethanol from sugar was a viable option. The three big car manufacturers in the United States, namely General Motors, Chrysler and Ford all have on the market now vehicles that can run on any ethanol blend of up to eighty five percent ethanol (E85), these vehicles are referred to as “flex fuel vehicles”. Virtually all motor vehicles designed to run on unleaded fuel and manufactured after 1990 in the world will run safely on fuel containing ten percent ethanol. It is interesting to note that the President of the United States has said that within thirty years the United States should go from being thirty percent self sufficient in energy to about seventy five percent self sufficient. Drilling more oil wells is not an option as the country is a pin cushion now, so what option do they have?

Hydrogen fuel cells – high energy cost to produce the hydrogen and the technology still very much in its infancy.

CNG – Compressed natural gas, although the U.S. has plenty of natural gas reserves, as do we, there is a very high energy cost in compressing the gas and considerable logistical problems associated with installing and carrying heavy pressure vessels for your fuel or energy source on a car, truck, tractor etc.

LNG – Liquefied natural gas, probably the only viable fossil fuel alternative to gasoline with current technology.

Bio Fuels – currently the most viable option to fossil fuel. All current internal combustion engines will run on bio fuel without modification and no lifestyle change is required to be made by the motoring public or fuel user. The energy market is an enormous market and as crude oil prices rise the demand for bio fuels will increase and I believe will quickly exceed supply, nothing like competition between food and energy sectors to push up prices.

Conclusion

I have no doubt that climate change is not only inevitable but is happening now and that we are going to see a significant shift in climate patterns around the world in our lifetime. This shift in climate will result in the extinction of a lot of species across the globe, however I do not see it as in anyway a doomsday scenario for mankind. We have a proven track record of being able to adapt to a wide range of environments and indeed the ability to modify the local environment to suit our requirements and comfort zone. Perhaps my greatest concern at present is not climate change but rather our present attitude and approach in that after funding research that shows that the planet is getting warmer and so our weather patterns or climate is changing we seem to prefer to say our researchers have got it wrong in preference to funding the research that would allow us to adapt almost seamlessly with a minimum impact on our lifestyles, standard of living and both national and international economies. Are we going to continue with our head in the sand on this issue and take the attitude of "we will cross that bridge when we get to it"? This approach can only lead to the dislocation of a very large number of people from northern Europe and northern North America and potentially create enormous stress on the world economy as well as the economies of many countries.

When the Gulf Stream current stops we will see Europe and North America go into winter and stay there for many, many years resulting in no agricultural production in those regions and so the world's population will be relying on the tropics and selected areas in the Southern Hemisphere to be the world's food producers. Despite the fact that current temperatures during grain fill in the majority of these areas is a major limiting factor in production there are no projects running at present to raise this temperature threshold and yet all the research at present says that all these regions are going to get warmer further reducing our maximum potential yield. As it takes a minimum of eleven years to develop a new variety and a project like this would take at least fifteen years I believe we can not afford the luxury of waiting for major production failures around the world before we start. The benefits and needs of such a program are there now even without climate change.

From a Greenhouse Gas view point agriculture is at a serious disadvantage to all other industries. Currently we only have limited data sets on what our emissions are and very little if any information on what actual effect different management options may have on our emissions. For agriculture to move forward and produce a genuine net reduction in emissions, peak industry groups must become pro active on this issue, inform the consuming public of what research is currently being undertaken and at the same time lobby for more funds for this area of research to be made available preferably from government funds as the beneficiaries of this research would be society, the environment and agriculture.

Although I found that there is very little that can be done at farm level today to reduce agricultural emissions or for long term adaptation strategies to address and reduce the impact of climate change, I believe there is a lot that can be done at an industry level.

Research

The following areas need to be addressed urgently and should be seen as a high priority:

i) management options to increase soil organic carbon
ii) new best management practises for improved nitrogen use efficiency
iii) review of integrated pest management strategies and chemical registrations allowing for southern migration of insects, weeds and diseases
iv) new crop varieties that can handle higher temperatures during grain fill
v) methods to break dormancy in stone and pome fruits uniformly in years where there is not enough winter chill for this to happen naturally
vi) the impact of reduced winter chill on all crops both annual and perennial
vii) an international standard greenhouse gas inventory recording form that allows for different emission factors for different regions and management systems
viii) a location where any business that has taken actions to reduce their emissions may register these reductions and use these reductions as part or all of the reductions that a business in the future may be forced to make under government legislation. A business that makes reductions today may be unfairly penalised in the future for doing the work ahead of time if these reduction can not be counted as a credit.

References:

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Dr C. W. Rice	Kansas State Uni	Manhattan, Kansas	U.S.A.
Pioneer Seeds	Des Moines	Iowa	U.S.A.
John Deere	Waterloo	Iowa	U.S.A.
Dr Tom Wigley	N.C.A.R.	Boulder, Colorado	U.S.A.
7th International CO_2 Conference		Boulder, Colorado	U.S.A.
BIOCAP Foundation	Workshop	Calgary	Canada
Dr Susan Wood	BIOCAP	Kingston, Ontario	Canada
William Hohenstein	Global Change	Washington, DC	U.S.A.
Heather Ball	Railroad Commission	Austin, Texas	U.S.A.
Dr Mark Liebig	USDA ars	Mandan, North Dakota	U.S.A.
Dennis Harding	Iowa Farm Bureau	West Des Moines, Iowa	U.S.A.
Dr Benjamin Ellert	Ag Canada	Lethbridge, Alberta	Canada
Dr Karen Beauchemin	Ag Canada	Lethbridge, Alberta	Canada
Dr Reynald Lemke	Ag Canada	Swift Current, Saskatchewan	Canada
Dr Fernando Selles	Ag Canada	Swift Current, Saskatchewan	Canada
Dr Herb Cutforth	Ag Canada	Swift Current, Saskatchewan	Canada
Dr Leon Allen Jr	USDA ars	University of Florida	U.S.A.
Dr Francis Larney	Ag Canada	Lethbridge, Alberta	Canada
Dr Ardel Halvorson	USDA ars	Fort Collins, Colorado	U.S.A.
Dr Scott Kronberg	USDA ars	Mandan, North Dakota	U.S.A.
Mick Miller	General Manager Red Trail Energy	North Dakota	U.S.A.
Dr Jeffrey Mitchell	UCDavis	California	U.S.A.
Monsanto	St Louis	Missouri	U.S.A
Dr Johan Dormaar	Ag Canada	Lethbridge, Alberta	Canada
Dr Tim McAllister	Ag Canada	Lethbridge, Alberta	Canada
Dr Stephen Del Grosso	USDA ars	Fort Collins, Colorado	U.S.A.
Dr Linda Mearns	NCAR	Boulder, Colorado	U.S.A.
Dr Richard Eckard	Uni Melbourne	Melbourne, Victoria	Australia
Dr Mick Meyer	CSIRO	Melbourne, Victoria	Australia
Dr Bryson Bates	CSIRO	Canberra, A.C.T.	Australia
Clive Kirkby	CSIRO	Canberra, A.C.T.	Australia