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LOOKING FOR OPPORTUNITY AND AVOIDING OBVIOUS POTHOLES: SOME FUTURE INFLUENCES ON AGRICULTURE TO 2050

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ABSTRACT

In a rapidly globalising world nothing is ever certain. However with a strategic focus of one or two human generations (25-50 years) there are a number of long term drivers or influences which cannot be ignored. Australian society may change its orientation radically. The demand for traded agricultural goods could increase by several orders of magnitude and this will produce tensions in water availability for traditional industries. The long term issues relating to landscape degradation will be resolved or not resolved, and this will determine whether we can take advantage of export opportunities or not. Surrounding all of these issues will be the imponderable of cheap petroleum supplies and whether we are successful in meeting our climate change obligations. While many of these issues can be seen as problems and purveyors of doom, they can also present many opportunities to the strategic thinker and the maker of long term plans. If massive tree plantings are required to repair inland hydrology they may also be a source of income when trading in fixed (or sequestered) carbon becomes part of management of the greenhouse problem. The production of liquid transportation fuels from the same biomass resource will become a source of competitive advantage for regional areas and a source of employment opportunities. Many of these issues are open to robust forms of qualitative and quantitative analysis. Complete trust in perfect markets and level playing fields is no longer obligatory for strategic and long term planning.

Key words: futures, water tensions, energy, international trade, scenarios

INTRODUCTION

In any attempt at future gazing it is important to describe societal context in which a nation or and industry might be immersed, and the trends and the technical issues which surround the operations of that nation or industry. This paper will take an opportunistic journey through a number of future related issues that might impact on the broad acre farming industries of Australia. It has the following structure:

- Three scenarios for a future Australia
- Future trade demand
- Future water tensions
- Implications of landscape change
- Future petroleum supplies

SCENARIOS

In his forthcoming book *Australian Futures*, Doug Cocks (Cocks, 1998) has developed a number of actively managed scenarios which could take Australia into radically different modes of management and social and political belief systems. Cocks has developed three different scenarios, Conservative Development, Economic Growth and Post Materialism. Extracts from a synopsis of the book describing the scenarios are presented below.

The three scenarios are built around three core beliefs about how a society seeking high quality of life for all should respond to four over-arching hazards of our late 20th century society: an inappropriate rate of economic growth (too low? too high?); increasing environmental degradation; increasing social injustice; and declining sociality (social health) mirrored by rising sociopathy (social decay).

Conservative development

The first of these core beliefs, underpinning a Conservative development strategy, is as follows:

Environmental degradation and social injustice are important impediments to high quality of life which will only be ameliorated if they are managed directly within the context of a more hierarchical, reconstructed form of social organisation. Nonetheless, it is desirable, and should be possible, to do this and simultaneously reach and maintain a high rate of economic growth. Sociopathy is a collateral problem rather than a priority problem.

The strategy proposed for implementing this philosophy centres on achieving full employment, this being the best way to address both social injustice and social decay. A Jobs and Incomes Program will be funded by a major tax reform program. Environmental degradation will be addressed by an Environment Management Program which will have a significant 'green jobs' component. Environmental damage is strongly related to energy consumption and to the quantities of raw materials entering the economy as inputs and leaving the economy as pollutants. Regulatory, fiscal and market-based measures will be used to stabilise net materials-use and energy use as rapidly as possible and to cap the rate at which land is converted from low-intensity to high-intensity uses. Other priority components of this strategy are industry support programs, trade management programs and population stabilisation.

Economic growth

The second of these core beliefs, underpinning an Economic growth strategy, is as follows:

While it is true that environmental degradation and social injustice are important impediments to achieving high quality of life, these hazards will be ameliorated without resorting to any serious collective intervention if we move towards a more individualistic form of social organisation focused on the feasible objective of reaching and maintaining a high rate of economic growth. Sociopathy is not a priority problem.

The two-pronged strategy proposed for implementing this philosophy is to selectively remove significant barriers to profit-making by entrepreneurs (eg environmental regulations) while focusing a small (by today's standards) government sector on the task of providing business with cost-saving infrastructure such as transport and communications and with productive human capital in the form of a technically educated workforce. Other priority components of this strategy are: population growth; extended property rights; a flexible labour market; and free trade.

Post Materialism

The third of these core beliefs, underpinning a Post-materialism strategy, is as follows:

Environmental degradation, social injustice and sociopathy are all important impediments to high quality of life which will only be ameliorated if managed within the context of a more mutualistic form of social organisation. Economic growth is also a priority problem requiring management, but in the sense that it is too high rather than too low, with social and environmental costs exceeding the benefits.

The strategy proposed for implementing this philosophy focuses on transforming the economy, redistributing power in society and radically reforming the socialisation system, these being the starting points for ameliorating environmental degradation, social injustice and pervasive social decay.

The socialisation system, assisted by a formalisation of citizens' rights and responsibilities, will concentrate on producing responsible, collaborative and useful community members. Power redistribution will be sought through the widespread development of participatory, non-adversarial institutions and the devolution of State and Commonwealth powers to strong regional governments. A range of tools (eg comprehensive recycling, population stabilisation, decentralisation, import replacement, a cap on personal consumption) will be used to diversify and localise and 'green' the economy and the cities so as to conserve energy, materials and natural systems. Stabilising consumption will facilitate investment in social, human and institutional capital at the expense of 'output-increasing' capital.

While it would be surprising to see the Australian electorate vote for and persist with any of these strategies strictly as described, it would be most surprising to see the Post-Materialism strategy adopted.

It implies a greater change from reigning values and ideas than the other two scenarios. Adopting an Economic Growth strategy or a Conservative Development strategy would be less surprising in the sense that these strategies simulate positions towards the ends of the range of conventional wisdom in first world countries

These three scenarios are feasible options for Australian futures. Each attempts to positively deal with the core values which might drive any future society. Australia could change radically over the next two human generations in response to society's interest or concern about economic fundamentals, environmental quality or social health. Each scenario aims to maximise its core values, while minimising negative effects on other values. Interpretations which classify such scenarios as the 'high, medium and low roads to success' make the mistake of interpreting only one axis of progress. Nevertheless each of the scenarios is open to its own particular form of failure and dysfunction. The Conservative Development scenario may be gridlocked by bureaucracy in decision making, the economy may stall and its core value 'environment quality' may not improve (Cocks, 1998). The Economic Growth scenario may find its core value of growth stalled by a number of external factors, environmental quality may be further threatened and social inequality may give an increasingly truculent and difficult workforce. The Post Materialism scenario may fail because there is not enough economic growth to maintain the basic functions of the economy causing widespread poverty and environmental decline.

The first futures insight from this paper is that Australia in two generations time could run under vastly different policy settings. Future agriculture under each scenario would have different strategic objectives. Some of these are described in the next section.

Land management issues that arise from each scenario

In a study for the Land and Water Resources Research and Development Corporation (LWRRDC, 1997) the implications of these scenarios in relation to a number of options of future trade demand were explored. The key linkage between each scenario and the implications for a farming sector depended on the extent to which farmers paid the full price for any environmental damage and the extent to which society was prepared to pay for the existence of environmental values. The implications for each scenario are shown in Table 1. Because of the different political, social and economic drivers, each scenario gives a different range of management issues. A family or corporate farmer could use these issues to think how well their business structure and their product mix is suited to each scenario. Any research bureau, whether orientated to public good or private gain, could equally think about the portfolio of their research efforts and how useful research outcomes might be under different scenarios. While the timespan to 2020 and 2050 seem to be a long time away especially when a business might be surviving from year to year, the long term processes which drive the health of Australia's water and soil quality operate on scales from 25 to 200 years. Likewise societies and institutions change slowly. If a farming enterprise is totally orientated to only one world view then it may not have the capacity to change when indications appear that Australia may be taking a different track.

Table 1. Issues that might evolve for agricultural production in an Australia under a conservative development, economic growth or post materialism scenario.

Scenario	Issues
Conservative development	How large are the environmental externalities in both a physical and a value sense.
	How much of potential world demand would be met and what product groups (eg livestock) would have their production base decreased
	How would government go about managing the environmental externalities of agricultural production.
Economic Growth	How to manage the decline in broadacre yields associated with shorter rotations in cropping and grazing.

	How to raise productivity across the broadacre industries to current 'best practice' levels
	How to incorporate the externalities associated with the more intensive use of land and water into private costs
	How to allocate water between competing productive activities.
Post materialism	The yield of current agricultural products when grown under fully sustainable conditions
	The potential for other products and new products to be grown, the technical feasibility and market feasibility thereof
	The sustainability of land when returned to an uncultivated state.

Possible trade demand by 2025

As a part of the study described above The Centre for International Economics (LWRRDC, 1997) conducted a number of simulation studies with their world wide trade models to explore the possible demand for Australian broad acre agricultural produce out to 2025 (Table 2). These analyses were undertaken using assumptions that operate within a somewhat muted version of the Economic Growth scenario ie these analyses are not integrated with the overall national scenarios. The driving forces behind the analyses relied on assumptions on population growth in our trading partners, the growth in per capita incomes in those countries and the extent to which they maintained improvements in technology, institutions and governance. Also included were assessments of the degree to which Australia could retain a quality and price advantage over its trading competitors in these markets. The analyses suggested that demand for Australian wheat, coarse grains, sugar and rice could double by 2025 and that demand for cotton and horticulture could increase by 4-5 times (Table 2). By contrast the demand for meat might increase by 30 to 60% and the demand for wool could even decrease.

Table 2. Possible total demand for Australian farming product resulting from analysis by The Centre for International Economics (LWRRDC, 1997)

Product Sector	Amount	Optimistic income	Best bet income	Pessimistic income	Average over 5 years to 1996
Wheat	Kt	29516	25247	21542	14677
Coarse Grains	Kt	13233	12968	12816	7630
Rice	Kt paddy	1933	1853	1838	943
Cotton	Kt lint	1650	1555	1200	363
Wool	Kt greasy	1150	1055	710	811
Beef & veal	Kt cwe	2682	2530	2385	1698
Sheep meat	Kt cwe	791	747	708	602
Sugar	Kt	9500	8600	7700	4173
Horticulture	Index of product	513	493	474	100

Some of the production levels have been attained in the last thirty years in the case of wheat (Fig. 1), but these have been attained in good rainfall years and when most normally available land was planted. If this production were to be maintained year after year then a much larger area would have to be ploughed and less would be available for pasture ley rotation or other crops. Alternatively more land would have to be brought into production, and while this is considered infeasible in the current environmental and political value set, the acceptance of an economic growth paradigm would possibly allow this to happen. In the case of cotton (Fig 2) this production increase would require a steady increase in both yield and area cropped from the present levels. Animal production increases were considered less feasible, although possible (Fig 3a and 3b). In the past, total sheep and cattle numbers have increased out of phase with each other as market opportunity and climate variability produced a number of conflicting drivers. If all the increases in crop demand in these projections were met, there may be a limitation in being able meet a consumer requirement for product quality and timeliness, since most high quality land would be assigned to cropping and most irrigation water taken by higher value crops.

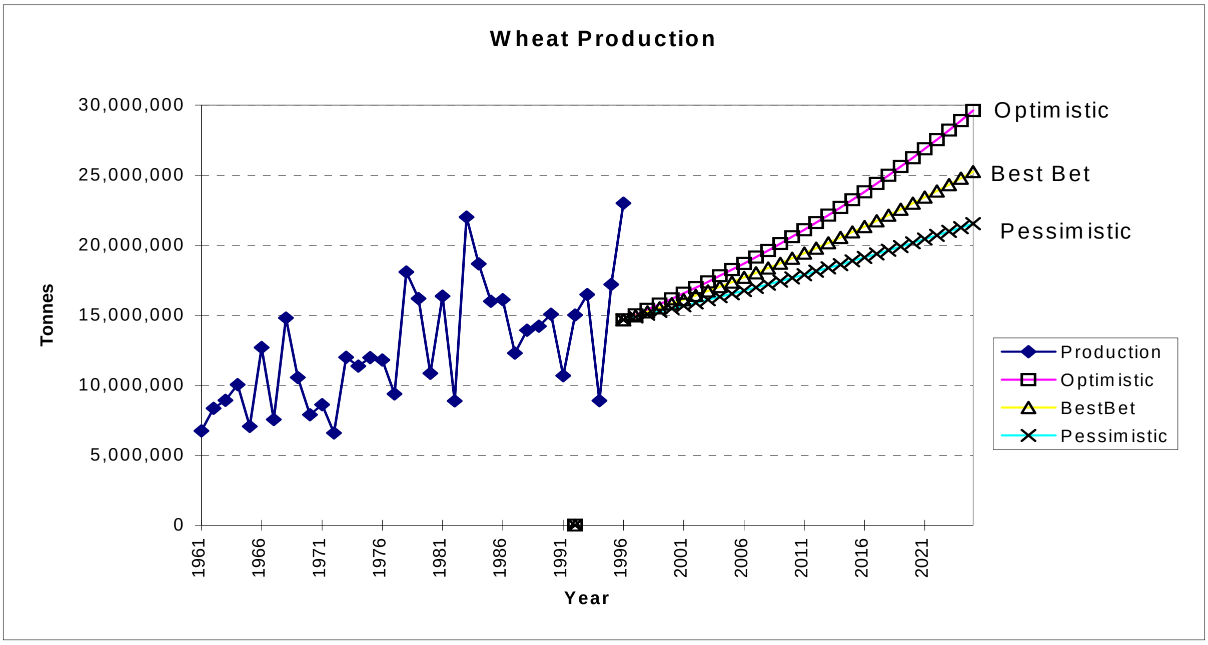


Fig 1. Historical wheat production in tonnes to 1996, and three scenarios to 2025.

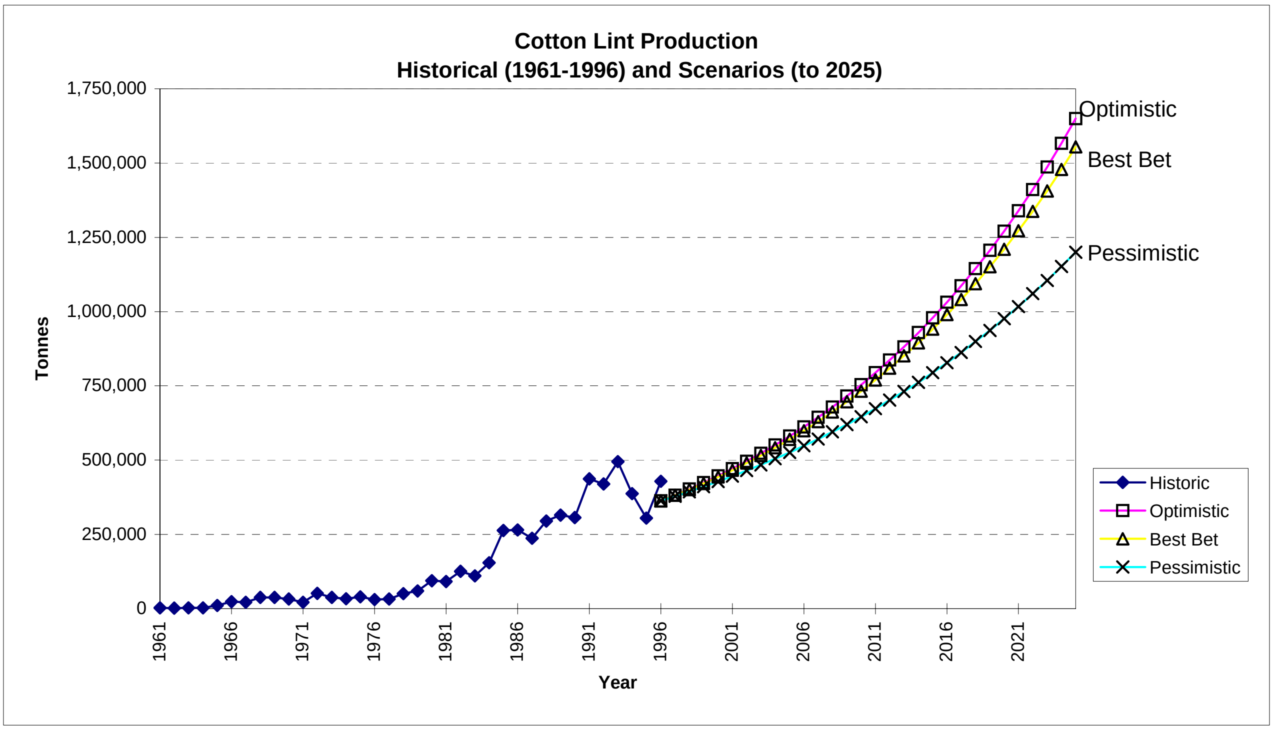
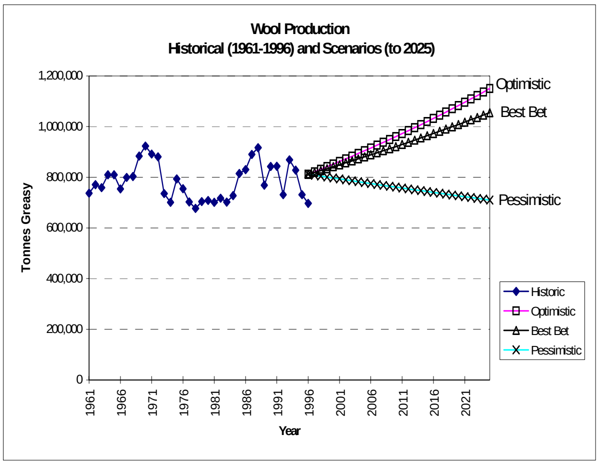


Fig 2. Historical cotton lint production in tonnes to 1996, and three scenarios to 2025.



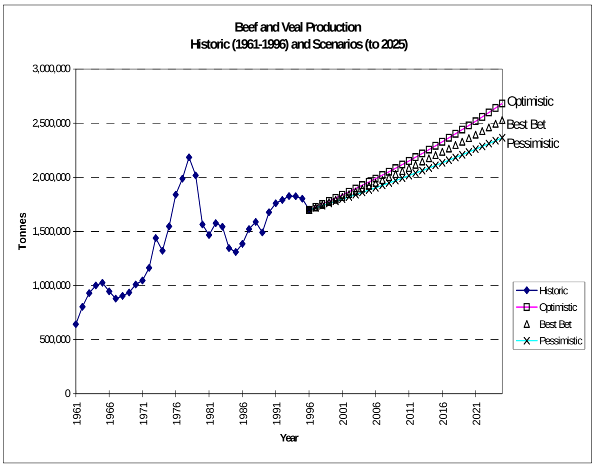


Fig 3a.. Historical wool production in tonnes to 1996, and three scenarios to 2025.

Fig 3b.. Historical beef and veal production in tonnes to 1996, and three scenarios to 2025.

There is little doubt that each of the individual commodity groups could achieve these production increases by themselves in isolation from the remainder of the farming system. The extent to which there would be sufficient land of suitable quality to do them all together is explored in Table 2. For each crop linear and log relationships were fitted to national yield per hectare data for the last 25 years and projected out to the year 2025. The linear relationship was interpreted to mean that historic trends would continue indefinitely into the future, while the log relationship suggested that limits due to resource constraints or technology plateaux could apply. Thus in the case of wheat under the optimistic trade scenario between 15 and 19 million hectares would be required to meet the demand for 29.5 million tonnes on a continuing basis. While the study did not relate the total demand for land to a detailed inventory of soils types in rainfall zones, the total production target was judged to be not limited by land resources. This is a somewhat limited statement but recognises that management practices and crop adaptation may continue to increase yield per hectare, that pasture areas may be cropped, and that more land may be developed in some areas. Within the scope of the study, water resources were considered to be a more critical production factor underpinning what are essentially economic predictions in a global marketplace. This is dealt with in the next section.

Table 2. Hectares of land needed under two projections of yield per hectare, needed to supply total production for each demand scenario in the year 2025. The 'linear' and 'log" options for crop yield were obtained by fitting a linear or log relationship to the average yield per hectare for the period 1961 to 1995 and extrapolating this through to 2025. This set positive and neutral bounds around future technological advances in cropping technology.

Crop	Extrapolation of historic yield per hectare to 2025	Optimistic Scenario	Best Bet Scenario	Pessimistic Scenario
Wheat	Linear (2.0)	14,760,000	12,623,000	10,771,000
	Log (1.55)	19,042,000	16,288,000	13,898,000
Coarse Grains	Linear (2.4)	5,513,000	5,403,000	5,340,000
	Log (1.7)	7,784,000	7,628,000	7,538,000
Raw Sugar	Linear (12.0)	792,000	717,000	642,000
	Log (11.6)	819,000	741,000	664,000
Paddy Rice	Linear (9.0)	215,000	206,000	204,000
	Log (7.5)	258,000	247,000	245,000
Cotton Lint	Linear (2.75)	600,000	565,000	436,000
	Log (1.6)	1,031,000	972,000	750,000

Possible water tensions

While the previous section noted that land area might be considered as not limiting for most production sectors, that is not the case for water. The most important aspect of water for irrigation is that it allows the production of the appropriate quality of product at the time required by the market and by the consumer. This is critical in a market place that is already national wide, and is rapidly becoming global.

The use of water for irrigation in most established agricultural areas is constrained by both management and the environment. Many rivers in the Murray Darling Basin have more than 50% of their annual flows diverted into irrigation and this is now recognised as having the potential to cause long term decline in the quality of the water resource in both the surface and underground systems (ABS, 1996).

As proper water pricing comes into play, market mechanisms will probably ensure that water is allocated to the most financially attractive sectors. Examples are given in Table 3 of the "water cost" of a kilogram weight of market product. It can bee seen that the animal products are an order of magnitude higher than the vegetable products. Thus in 'water" terms, a kilogram of beef should bring 25 times the dollar returns that a kilogram of rice brings to a grower. A kilogram of butter should bring 18 times the return of a kilogram or a litre of wine.

Table 3. Water demand for irrigated crops in south eastern Australia (after Meyer, 1997)

Crop	Yield per Hectare in kilograms	Irrigation Water per Hectare per Year in litres	Water per Kilogram of Market Product
Rice	9000 paddy rice 5850 white rice	12,000,000	2000 litres per kilogram of white rice
Wheat	5000 grain 3750 flour	5,000,000	1300 litres per kilogram of flour
Cotton	3000 with seed 1700 as lint	9,000,000	5300 litres per kilogram of cotton lint
Maize	13800	7,000,000	500 litres per kilogram of maize
Wine Grapes	9300	8,000,000	1000 litres per litre of wine
Dairy Pasture	830 butter fat	15,000,000	18,000 litres per kilogram of butter
Beef Pasture	300 steak	15,000,000	50,000 litres per kilogram of steak
Wool Pasture	88 clean wool	15,000,000	170,000 litres per kilogram of wool

In 1994 total area of irrigated land was 2,4 million hectares of which pastures were 136,000 ha, cereals 354,000 ha, vegetables 96,000 ha, fruits 144,000 ha, sugar 168,000 ha and other products 275,000 ha. The sources of this water was 46% from state run irrigation schemes, 31% from streams and farm dams and 16% from underground aquifers. On average, each hectare of irrigated land receives about 4,250,000 litres (4.25 megalitres) of irrigation water. If cotton is to expand to 600,000 or even 1,000,000 ha, then each hectare added to the current stock of cotton land will require the withdrawal of 2 "average" irrigated hectares from our currently exceeded irrigation potential. This will probably impact first on the sheep meat and the beef and veal sector. Their potential expansion will therefore be truncated because they are unable to supply quality product at the appropriate time. They may be able to expand low quality product on marginal land to meet the scenario objectives, but this will probably conflict with some assumptions of market attractiveness and return, which assume that a product, if produced, will be cleared somehow in the international marketplace.

Vintaging (or aging) of Australia's landscape infrastructure

One issue around long term sustainability is concerned with maintaining the quantity and quality of our soils, the infrastructure on which agriculture depends. This section describes an approach to looking at the possible long term implications of a decline in soil function for Australia's cropping areas. We take account of this in the *Australian Stocks and Flows Framework* (Robbert Associates, 1995) through attention to the history of agricultural land use, and by keeping track of arable land vintage, ie the cumulative effect of agricultural activity on the land since it was brought into cultivation. We have developed a soil function index which describes the combined effect on crop yield of acidity, dryland salinity, salinity due to irrigation, and soil structure. These four measures of declining soil quality are assumed to increase with cumulative duration of cropping - that is, the longer the history of cultivation and use, then the poorer its function, and the lower the resulting crop yields. Increasing inputs can help in the short term, but they are eventually overtaken by decline in soil function in the long term.

Our soil function index is undoubtedly crude, but it does take into account the essential concept for any long term analysis of agricultural productivity. It has been developed for the 58 statistical divisions (used by the Australian Bureau of Statistics) by assuming that the land was in good condition in 1850 (or when it was first brought into cultivation) and ascribing its current status (in terms of the four measures of soil quality) to the cumulative effects of cropping activity. During most of this period, of course, the effects of declining soil function have been masked by periodic additions to the area cultivated, the introduction of improved varieties of crops, and increased use of inputs such as fertiliser. As a result, overall production has increased. But it is not at all clear whether this growth can be sustained. In engineering terms it may mean that our agricultural systems have a design life. Our analysis has separated soil quality decline from the counteracting development and technological processes and examines the scope for these processes to maintain agricultural output in the future.

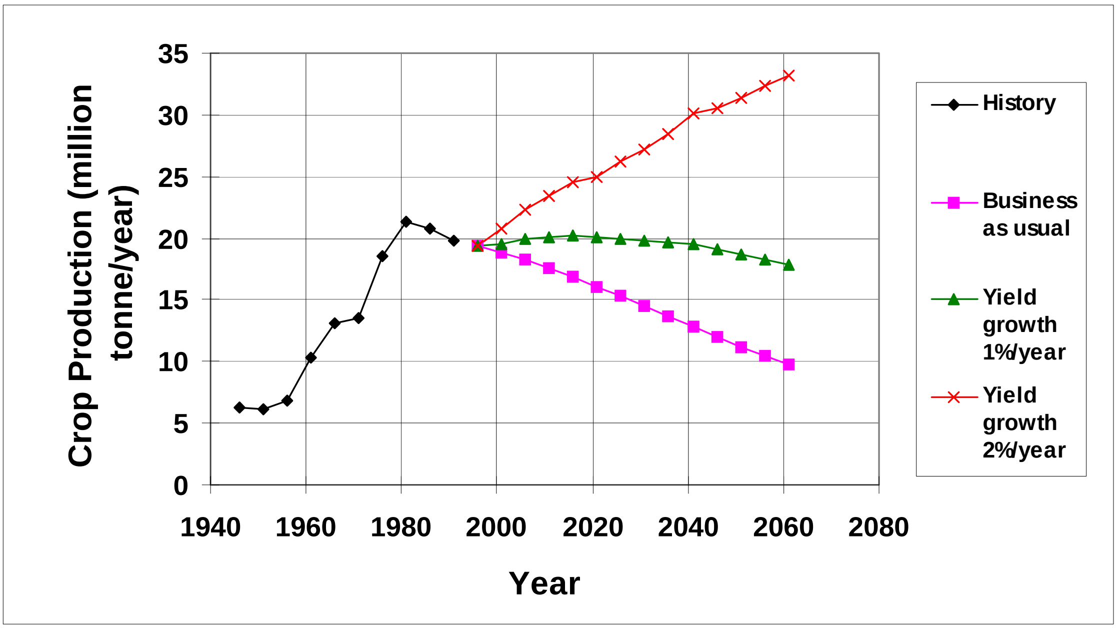


Fig 4. Testing options for Australia's future grain yields using a prototype version of the *Australian Stocks and Flows Framework.*

Simulation 1: Some implications of landscape vintaging for Australian grain production to 2050
The application of our vintaging concept is shown in Fig 4. The framework is calibrated on statistical data from the last 50 years (1945-1995) across the nation's main grain growing areas. The turnover in 1980 is caused by an advance to and then a retreat from a maximum area planted ie there was no sudden catastrophe. There is no new land brought into production after 1996. The *business as usual* scenario assumes a gradual loss of soil function due to the concept of vintaging. This is reflected in a gradual decline in total production from 20 to 10 million tonnes per annum over a 100 year period. This is an hypothesis of which might happen if we took no action to counter the loss in soil function, either due to our technical inability to reverse the landscape processes or a lack of price incentive to do so. To counter this decline we have presented two technological options based around the concept of genetic gain. This assumes that our plant breeders give us varieties which accommodate changing soil function and have increased disease resistance without a major change in arable farm management. Two options are presented around a 1% and 2% gain in yield per year. A 1% gain per year manages to maintain broadacre grain production around the current levels, while a 2% gain per year provides a pretty optimistic future.

There are many more technological options which can be tested such as more fertiliser and more soil refurbishment. The genetic gain one was initially chosen because it is a “clever country” option and theoretically could happen without adding additional physical flows. While it is obvious that forests must be replanted, lime must be applied and irrigation salinity must be drained, all of these activities will further increase physical flows and perhaps challenge other criteria within the national sustainability framework.

Over the last decade, the social innovations of Landcare, Total Catchment Management, A Billion Trees etc. suggest that the nation would be unwilling to allow a steady decline such as this to take place. However Mien (pers. comm) suggests that we are currently losing 30,000 ha per year due to dryland salinity and a 100 year time span would account for 3 million ha. New farming systems could also reverse this scenario of decline, but many of these landscape processes linked to the concept of vintaging are long lived and persistent, and may take 50-100 years or more to turn around. Making the transition into more sustainable cropping systems is difficult where arable land is limited and the climate variable. Two long term cropping experiments in the Wimmera (Hannah and Leary, 1995) and at Glen Innis (Norton et al., 1995) show that certain cropping rotations can maintain of crop yield or even double it. Within the experiment we present, mimicking the best features of these long term studies could remove large areas or arable land from cropping each year (into pasture ley) which would cause an initial decline in yield before improvement in soil function gave corresponding yield responses.

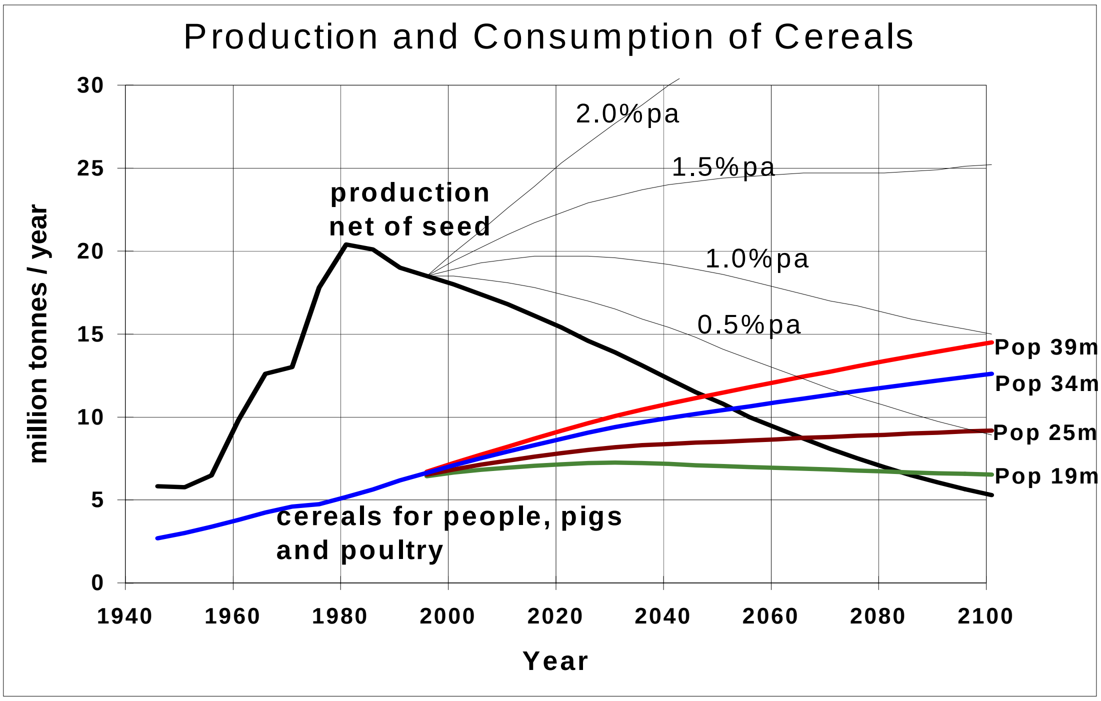


Fig 5. Possible tensions in home grown grain supply due to a loss in soil function and dietary demand from different human populations.

Simulation 2: Population growth and grain exports to 2050

In the second experiment we explored the implications of increasing human populations, future options for grain production and the possibility that future export volumes might be constrained (Fig. 5). A range of options for genetic gain in cereal production, from 0.5 to 2.0% per year is presented as in simulation 1 above. Also we present the demand for cereals by the Australian population growing at rates which lead to 19, 25, 34 and 39 million people in the year 2100. This experiment assumes that our dietary composition will remain much the same as it is now. Thus pigs, poultry and people are major consumers in the grain chain, and the demand for grain would increase further if we ate substantially more beef from feedlot cattle. Should agricultural research provide us with a regular production gain of 1% per annum, we appear to have few problems well into the future. At our highest population scenario of 39 million people in 2100, there is still enough grain to feed us. Also this ignores a century of potentially rapid innovation in front of us. Even in the worst case option of grain production declining with vintage and the highest population level, we have until approximately 2050 before demand equals supply. However well before the spectre of the food crises proposed by Malthus is upon us, our capacity to export grain or grain products may be gradually squeezed. There are many ways of coping with this possible squeeze. We could develop more arable land, invest substantially in our agricultural R&D capacity, reduce our consumption of grain fed meat animals and so on. Long term population policy is another obvious policy lever. If a 1% growth rate in grain production is technically feasible, given these simulation assumptions of ‘no new land’ and ‘declining soil function’, then lower target populations allow grain export (and other food commodities) to be maintained. In general produce twice the domestic requirement of total foodstuffs, but this may not always be so. However these responses represent one one set of options based on the past, rather than the future. This analytical approach does not seek to prophesise doom and passive inaction. Rather it seeks to help define our *physical options* well ahead of time. In this way we seek to inform market mechanisms so that they understand longer term horizons. Shorter term instruments such as markets and politics are appropriate for immediate management actions. The longer term approach gives a range of options which may help markets to be better informed and thus work more efficiently.

Risks and opportunities around petroleum resources and liquid fuels

While the direct use of electricity and petroleum products in agricultural production are less than 5% of the Australia’s total energy use, the effect of a declining supply of domestic petroleum resources must be borne in mind for any long term product or industry planning. The spaghetti like assemblage of graphs seen below come from the OzEcco embodied energy model of Australia’s physical economy developed by the CSIRO Resource Futures Program (Foran, et al., 1997). This is one approach to understanding some of the long term challenges that Australia might have to face. The physical transactions that underpin the monetary economy (such as agriculture, transport, electricity production etc.) are driven ahead in time by their requirement for, and their ability to access, joules of energy, rather than dollars.

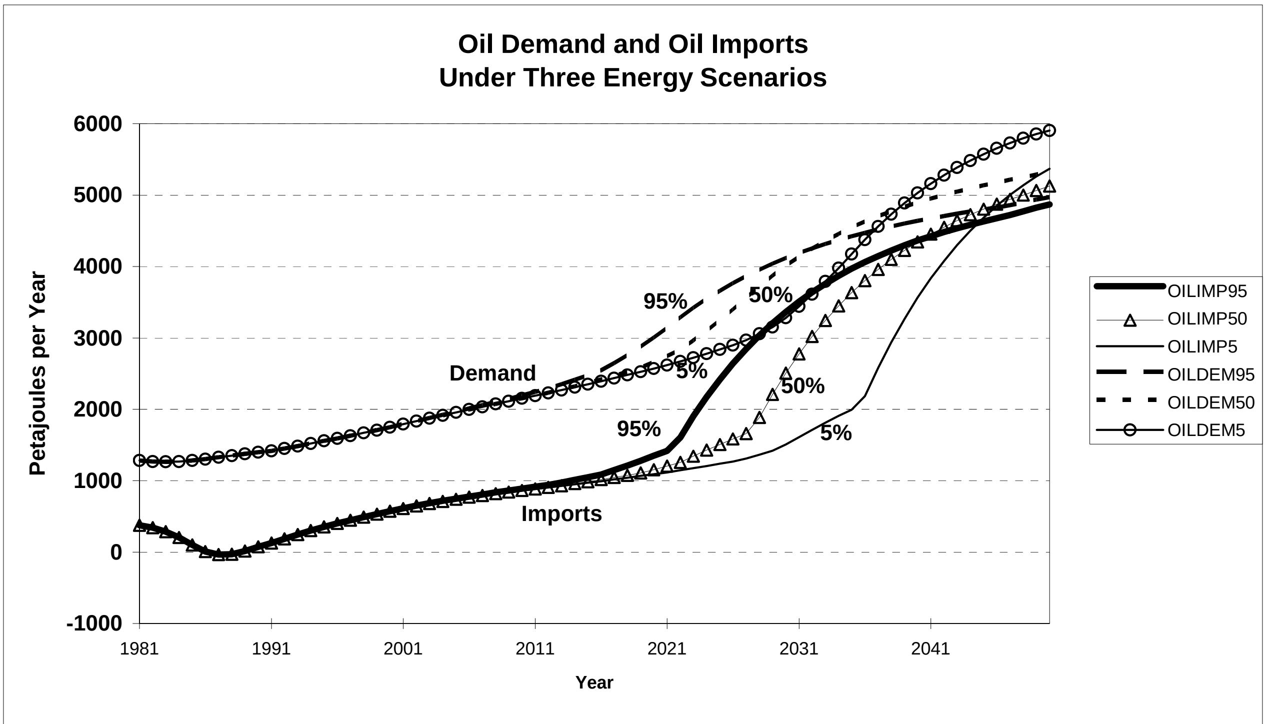


Fig 4. Simulated domestic demand and requirements for imports for oil and condensate out to 2050 under three scenarios of oil and gas discovery rates. Units are petajoules per year (Foran et al., 1997).

The top set of three graphs represent the possible total demand for petroleum products by the entire physical economy out to the year 2050. This depends on whether petroleum exploration finds the lower end (95% sure), the best bet (50% sure) or the higher end (5% sure) of all the oil and condensate that might be on the mainland and within the exclusive economic zone. The final demand at 2050 varies from 5000 to 6000 petajoules per year which is three to four times what we use now. The bottom set of graphs show the possible requirements for imports under the same (95% sure, 50% sure, 5% sure) sets of exploration possibilities. The key message is that there could be a very rapid increase in the requirement for petroleum imports from around 2020. Depending on the exploration success the uncertainty around this period extends from 2020 to 2035. This will challenge the technology behind most farming operations as we know them today.

A wide range of responses are potentially available. The first is to expect that we will find substitute products such as liquefied natural gas, oil from oil shale, or liquid fuels from the fermentation of biomass. The latter option should be examined in a regional context. The production of ethanol or methanol from the high-tech fermentation of specially grown biomass crops may offer agricultural regions the possibility of becoming self sufficient in liquid fuels at a regional level. The biomass may have to be harvested within 40-60 km of a large centralised plant which would be the equivalent of the local sugar mill. As well as a stimulus to local industry and employment opportunities, there are obvious greenhouse gas benefits because the production system offers the opportunity to recycle the same carbon rather than continually add to the carbon store in the atmosphere that comes from the use of fossil fuels. The production of ethanol or methanol from biomass fermentation is estimated to be more efficient in a process and thermodynamic sense than current approaches producing ethanol from grain or sugar cane. Processes now in the pilot stage can produce an energy output/input ratio of 5 for ethanol from biomass versus a ratio of 1 for ethanol from maize (Lynd et al., 1991)

A related issue to the production of liquid fuels is that of carbon fixing or carbon sequestration. The recent agreement on greenhouse gasses at the Kyoto will most probably allow the carbon fixed in plantation forestry to be used as an offset against carbon released by the combustion of fossils fuels. The protocols for international trading in carbon credits between countries and industries is being negotiated this year. Good forestry sites in higher rainfall country will grow timber at the rate of 20 to 30 cubic metres per year. Well managed plantations could then be used for timber, carbon fixing, biomass fuels or off-reserve conservation. The question of whether biomass fuels should be grown on high quality or marginal land is both a social and a political decision. It is however possible to propose regionally based systems where plantations are established on marginal lands for biodiversity and water discharge reasons, while biomass for liquid fuels is concentrated on higher quality lands. The three scenarios in the opening section give rationales on how this might work. The Economic Growth scenario would assume that high quality land is used for whatever landuse gives the highest economic returns. The Conservative Development scenario might suggest that reafforestation happens wherever it is needed for both water discharge and biodiversity habitat. The Post Materialism scenario may suggest that regional self sufficiency and low regional unemployment are key political goals. Woody biomass for liquid fuels and wood fuelled electricity generation my be important components of regional strategic planning in this latter scenario. In areas of comparative and competitive advantage, trade with other regions and with external markets is still feasible though not to the same extent as in the Economic Growth and Conservative Development scenarios.

Many technological innovations will become available before this rapid rise in petroleum imports becomes feasible or necessary. The future is never certain. However in planning your farming system or your product mix, three questions should always be asked (1) Is this system or product overly reliant on the use of petroleum products ? (2) Will this system be physically and financially resilient if the oil market becomes fragile around 2020 ? (3). Is there some long term advantage your region can gain from a long view on the possible depletion of domestic oil ? Do not be misled by the current low prices for domestic petroleum or the world market price for oil (Campbell and Laherrere, 1998), if you are hoping that your children's children will still be Australian farmers.

Conclusions

It is a foolish writer who attempts to predict the future with some certainty. There are however some long term drivers which every farming family and corporate farmer should think about in their strategic planning sessions. Five long term propositions have been placed before the conference. They are as follows:

- That Australian society could change radically from its present 'business as usual' or 'bumbling along to strategic mediocrity' ways.
- That the possible demand for Australia's traded products from agriculture could increase by as much as three times for some industries.

- That this demand has very large implications for the agricultural users of water and that there might be a significant re-allocation of water away from animal based production systems.
- That the continuing prospect for detrimental landscape changes will challenge agricultural technology and subsequent productivity in two generations from now.
- That the depletion of domestic petroleum reserves may cause a rapid rise in oil imports from about 2020 onwards.

There are perhaps no surprises in the above list to any farmer, trader or agricultural scientist. Perhaps the key point is that all these factors may be interacting with each other. Choosing a strategy for survival, or more importantly a strategy for thriving, is difficult but this challenge must be engaged. From the author's point of view, the most important challenges for long term sustainability are those that relate to decarbonisation and dematerialisation of modern industrial economies. Decarbonisation means that we may have to remove fossil carbon as much as possible from our production systems. Dematerialisation means that we may have to reduce as much as possible the material transformations and movements that underpin our every day lives. In a modern economy approximately 80 tonnes of material is moved per person per year excluding water. Perhaps Australian farming can lead the way by example in these core requirements for long term sustainability.

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