

Limits to Development: Prospects for Australian Agriculture

Farrer Memorial Oration, 1992

This is a copy of the 1992 Farrer Memorial Oration, presented by Dr E F Henzell.

The Farrer Memorial Trust was established in 1911 to perpetuate the memory of William James Farrer and to encourage and inspire agricultural scientists. Initially it awarded scholarships for 'study or research in agricultural problems'. Later it included the delivery of an annual oration and the presentation of the Farrer Memorial Medal to a distinguished agricultural scientist for service rendered in the fields of research, education or administration.

For more information see the Trust website at

www.dpi.nsw.gov.au/farrer-memorial-trust

The document has been scanned from hard-copy archives held by NSW Department of Primary Industries and is provided for historical purposes only. It is not represented as current information.

Every effort has been made in the preparation of this copy to make the content accessible to the widest possible audience. However due to the limitations in the quality and format of some of the original documents, we recognise that the automatic text recognition may be inadequate in some cases and we apologise in advance for any inconvenience this may cause.

© State of New South Wales through NSW Department of Primary Industries 2008. You may copy, distribute and otherwise freely deal with this publication for any purpose, provided that you attribute NSW Department of Primary Industries as the owner.



LIMITS TO DEVELOPMENT:

PROSPECTS FOR AUSTRALIAN AGRICULTURE

THE FARRER ORATION 1992

E F HENZELL

I. INTRODUCTION

In the midst of today's confidence-shaking depression, many Australians look with nostalgia to William Farrer's time when we were one of the wealthiest peoples in the world (Blainey 1991). Now we have fallen below the OECD average and are becoming relatively worse off.

I decided to use the privilege of giving the Farrer Oration to re-examine the role of agriculture in the development of the Australian economy, and to assess what scope there is for further significant contributions by agriculture to national development. Furthermore, the nostalgia for a golden age now is often accompanied by an uneasy concern about the future sustainability (it is hard to avoid using this word) of Australian farming practices. People ask: What are the safe limits to agricultural development in Australia? So that must be taken into account also.

William Farrer, whose name and work we commemorate with this Oration, lived from 1845 to 1906. But his outstanding agricultural work did not begin really until he was in his early forties, when in 1886 he resigned from his job as surveyor in the NSW Lands Department to concentrate on his experiments with wheat (Russell 1949). His initial wheat crosses were made in 1889, the first year of the second century of Australia's European-type of agriculture. So one can truthfully say that the second century of Australian agriculture began with Farrer, and as I shall remind you presently, he then had a major influence on its development.

I must confess that I have been surprised by the outcome of my reading on the economic history of Australian agriculture. Most of the existing capacity for farm production was created not in the first century of development (the golden age), but in the second. Moreover, the greater part has been created since 1948, that is during the last forty years of the second century. Productive capacity has been assessed by the volume of production achieved in the 1970s or 1980s, but disregarding the very high peak sheep and cattle numbers of the 1970s, because those stocking rates are probably unsustainable with existing levels of pasture improvement.

Let me take you then briefly through the evidence that leads to my main conclusions: the first century is viewed too favourably in retrospect, because we were so exceptionally wealthy a hundred years ago, and insufficient credit has been given to the remarkable achievements of Australian agriculture since 1948; finally, there are no sound reasons why that success cannot be repeated in future.

II THE FIRST TWO CENTURIES OF AGRICULTURAL DEVELOPMENT

(a) First Fleet to William Farrer

The wealth of the Australian people in 1888, just under three million of them, had been created almost entirely by exports of gold and wool. Never since, not even during the wool boom of the 1950s, has Australia's ratio of exports to GDP reached the high level of the gold rush era (Figure 1).

Australia's agricultural base was remarkably narrow in 1888, and almost entirely pastoral. Sheep and cattle had spread out and multiplied remarkably rapidly after their introduction, so rapidly that within 50 years of the first settlement there was almost continuous pastoral occupation from Brisbane to Adelaide, as well as in the south-west of Western Australia. Within 100 years, sheep and cattle had spread almost to their current limits. There were more than 80M sheep in this country, and about 220 kt of wool were produced annually (Peel 1986). The meat and dairy industries, however, had only just begun to contribute significantly to exports in the 1880s, following the first profitable shipments of frozen meat and butter to the U.K. Previously, hides and canned or salted beef had been the only practicable forms of cattle exports (Davidson 1981).

The wheat industry had not been nearly so successful. It was not until Tasmania became a wheat exporter in 1810 that fears of famine diminished in the NSW Colony. Tasmania, which these days grows only one to two thousand hectares of wheat a year, was the leading wheat producing State (Colony) from 1820 to 1850 (Macindoe 1975). It was well suited climatically for growing the long-season English varieties then available. In fact, Australian wheatgrowing was largely confined to higher rainfall, cooler districts until Farrer's varieties became available.

Although Australia exported wheat in most years after 1870, two bad crops in a row still led to imports, as happened in 1889. In fact, imports were required occasionally up to 1915.

Australian farming in 1888 was not very sustainable, to use today's terminology. Wheat was then the major crop, apart from oats and maize grown chiefly to feed horses. Self-sufficiency in sugar was not to be achieved until the 1920s and in 1888 cotton was in the depths of one of its episodes of almost total disappearance from the Australian scene.

Archer Russell, in his biography of William Farrer (1949, p 12) listed the main problems of Australian wheatgrowing in Farrer's time as rust, bunt, soil exhaustion, weak milling quality, unscientific farming and unseasonable dry periods. Poorly adapted varieties must be added to that list. Farrer's paper to the Australasian Association for the Advancement of Science in 1898 had a section entitled "Reasons of the slow progress wheat-growing has made in this Colony", mainly about the poor adaptation to Australian conditions of the wheat varieties available up to that time (Farrer 1898, p133)..

To sum up, the situation of Australian agriculture at the end of the first century of European occupation was of almost total dependence on a single export commodity, wool, and of major problems with its principal field crop, wheat.

(b) William Farrer to the Bicentenary

While Australia's pastoral industries developed very substantially again during the second century, the most spectacular advances were in cropping. The area of crops grew almost ninefold (Yearbook 1991). Much of this increase in the total volume of Australian

agricultural production¹ during the second century occurred between 1948 and 1988. In fact, 60% of the productive capacity evident by the time of the Bicentenary was created after World War II. The proportion of export capacity developed over this period would have been, for most commodities, even larger.

The developmental pathways for different agricultural products between 1888 and 1988, in many cases, throw a good deal of light on their prospects for further development.

Wheat:— Farrer's varieties were to play a vital part in the transformation of Australian wheat-growing into a major export industry. He began under great difficulties. For the first two years he did not even have forceps with which to remove anthers from the normally self-pollinating wheat flowers (having removed the anthers, the plant breeder can then transfer pollen from another wheat plant and so make a cross). In 1889 and 1890 he had to make do by using hairpins with flattened points to remove the anthers (Farrer 1898).

While Farrer's primary objective was to breed for rust resistance (then a devastating disease in bad years), he put considerable store also on milling and baking quality and on drought resistance. The breeding was done in a field of not much more than a hectare in area, using the halves in alternate years, at Lambrigg. That property still exists, just beyond the southern 'front' of Canberra's suburban spread and across the Murrumbidgee River on the Brindabella or western bank.

The main centres for testing his crosses, however, were at Wagga, Cowra and Coolabah. Wagga and Cowra will not surprise anyone with a knowledge of wheatgrowing, but Coolabah lies between Nyngan and Bourke and has an average annual rainfall of no more than 400 mm. Farrer really was aiming to test the suitability of his wheats for the dry inland! For the same reason, Richard Soutters' wheatbreeding program in Queensland was, until 1935, based at the Roma State Farm (Skerman 1990), near my parents' home.

Farrer's early-maturing, rust-escaping, short-strawed wheats had a dramatic effect in extending the Australian wheatbelt, especially in New South Wales. That Colony became a wheat exporter after 1898 and its area under wheat increased fourfold between 1897 and 1915 (Wrigley 1981). The most widely grown of Farrer's varieties, Federation, was the leading variety for the whole continent from 1910 to 1925. Improved methods of cultivation, and mechanisation of harvesting and transport also played a major part in expanding the wheatgrowing area of Australia from 1.3M ha at the end of the first century to about 11M ha at the end of the second (Davidson 1981, ABARE 1991). The yield per hectare doubled over the same period.

Despite the importance of the growth that occurred earlier in the century, following Farrer's and other innovations, about 60% of the wheat-producing capacity that was evident at the end of the second century of Australia's agricultural history has been developed since the late 1940s.

Other Grains:— Barley growing expanded in an even more spectacular way than wheatgrowing between 1888 and 1988, and about 90% of the expansion in area occurred between 1948 and 1988. In contrast to the situation with wheat, plant breeding played little part in the development of the Australian barley industry until relatively recently (only two bred malting varieties had been released by 1950 – Sparrow and Doolette 1975). The Australian industry until the late 1960s was based predominantly on the variety Prior's Chevalier, a line of obscure geographic and genetic origin first recognized by growers and maltsters in South Australia.

¹ The ABS index of volume of Australian farm production (ABARE 1991) weights the quantities of different products by constant factors derived from price relativities in a base year. This helps to overcome the problem of, for example, a kg of wool being worth more than a kg of wheat.

Until the 1930s about half the Australian oat crop was cut for hay, mainly to feed horses. Surprisingly, when horses were replaced by tractors (the process began in the 1920s and horse cultivation had almost disappeared by 1948 – Davidson 1981) the area of oats actually increased somewhat, mainly thereafter as feed for sheep and cattle (Walken Brown 1975). Bred varieties played a significant part in the resilience of the oat industry. It was J T Pridham, for three years the assistant at Lambrigg, who did for oats what Farrer had done for wheat (Russell 1949).

A number of other dryland grain crops have developed substantially since 1948 (ABARE 1991). One is the lupin, a leguminous grain and rotation crop developed by a modern-day Farrer, John Gladstones. Prior to 1971–72 its use was too small to be recorded separately; in 1987–88 it had grown to one million hectares and \$95M of exports. Field peas, apparently the main leguminous grain crop of southern Australia in the days of horse-drawn agriculture, boomed in the 1980s with \$92M of exports in 1987–88. In the warmer parts of Australia, grain sorghum has been grown extensively in the last two decades of the Second Century, with exports of \$51M in 1987–88.

Sugarcane:— As with many of the grain crops, most of the development of the Australian sugarcane industry has occurred since 1888. Furthermore, about 75% of the productive capacity existing in 1988 has been developed post World War II. Sugarcane growing dates from the 1860s, though there were earlier crops (Bull & Glasziou 1979). By the end of the 1880s, about 16,000 ha were grown annually. That area was to expand about 20-fold during the second century, while the yield of sugar per hectare more than doubled.

Cotton:— As a result of a spectacularly successful phase of growth in northern NSW and southern Queensland since the early 1960s, of which agricultural research has been an essential component, cotton has come to rival sugar as Australia's second most valuable crop product. Before that the industry had a long history of ups and downs. The promise of cotton growing apparently played a major part in attracting settlers to south-east Queensland after the Colony was separated from NSW in 1859. There was a peak of production during the American Civil War (1861–65), another in the 1890s, and others in about 1911 and the early 1930s (Wadham & Wood 1950). The 1930s, however, achieved production levels only about 5% of those reached by 1988. Moreover, none of its previous Australian history gave any indication that the cotton crop could be worth a staggering gross value of \$US449M in 1987–88 and more since (ABARE 1991).

Irrigated Agriculture:— Although the Chaffeys began their schemes at Mildura and Renmark in 1887, the first major diversion structure built in Australia, the Goulburn Weir, was not completed until 1891 (Australian Encyclopedia 1988). Hence, Australia's irrigation agriculture has been created almost entirely since 1888. Again, most of the productive capacity has been developed since World War II; the area irrigated in the late 1930s was about 325 thousand hectares compared with 1.5 to 1.6 million in the 1970s and 1980s (Wadham and Wood 1950, Cribb 1991). At the end of the second century irrigated farming generated about 20% of Australian farm output, chiefly from horticulture, rice, dairy, cotton and sugar.

Dried vine fruit played a critically important role in the development of Australian irrigated horticulture. Production reached 72kt per year by the 1930s; in the 1980s it was about 82 k per year with exports worth more than \$60M in 1988 (ABARE 1991). More than two-thirds of Australia's winegrapes are grown under irrigation (Cribb 1991), a fact that is not often mentioned in polite company! Between the 1950s and the 1980s Australian winegrape production increased fourfold, one of our major successes.

Commercial ricegrowing commenced in the Murrumbidgee Irrigation area in 1924. Total production grew from an average 92 kt per year in the 1950s to 743 kt per year in the 1980s. Exports were worth \$123M in 1987–88 (ABARE 1991).

Crops that did not develop:— A number of cropping ventures in the second century did not succeed. Maize, the third most important graincrop in the world after wheat and rice, was relatively important in the first few decades of the NSW Colony and the area sown in Australia increased up to 1910–11. It has declined since, notwithstanding the efforts of some outstanding maize breeders.

Australian horticulture, with the exception of grapegrowing, has also been disappointing. Applegrowing, for example, was the first Australian fresh fruit industry to expand on a scale sufficient to enter export markets. The first refrigerated cargo was sent in 1887 (Woodham & Wood 1950). Exports grew steadily until the 1930s, fluctuated about that level until the 1960s, and have declined since to about one-third of what they were in the 1930s.

Another relative failure has been in tropical dryland and irrigated cropping in the far north and northwest of the continent. Since 1946 CSIRO has devoted about 500 professional scientist years of effort to crop and pasture research in that part of Australia without much commercial benefit so far.

Sheep and Wool:— The second century did not begin well for Australia's pastoral industries. The drought from 1895 to 1904 was perhaps the most severe yet experienced. By 1902 the sheep population had been approximately halved. Recovery took until 1910 and the increase in numbers was slow thereafter until the Second World War (Butlin 1962). Since then it has been very rapid at times, with the national flock peaking at 180M in 1970 and 174M in 1990 (ABARE 1991) compared with just over 80M in 1888 (Peel 1986) and 123M in 1941 (Yearbook 1991). The cut per head has also risen from about 2.4 kg of greasy wool in the 1880s to about 4.5 kg a hundred years later (Newton–Turner 1962, ABARE 1991).

Despite the glamour of wool at the end of the first century, at least 70% of the current woolgrowing capacity has been developed since, 40% of it since 1948. This increased capacity since 1948 must be attributed largely to pasture improvement in southern Australia, which began in the 1920s and peaked in the 1970s (Hutchinson 1992). Perhaps about half the grazing livestock in southern Australia are carried on sown pasture, the rest on native vegetation (now usually much altered from its state in 1788).

Beef Cattle:— During the second century, beef cattle numbers followed the same general trend as for sheep, but with an even slower increase from 1910 to World War II, and an even more rapid one since. Herd numbers increased from 9.3M to 22.0M over the century, by a factor of 2.4 (3.2 in the record year 1976), and annual beef and veal exports grew from less than 10kt to more than 800 kt (Wadham and Wood 1950, ABARE 1991). Between the 1950s and the 1980s, Australian meat production grew by 50%. Total exports of cattle and sheep meats in the 1980s were four and a half times those of 1947 and five times those of the late 1930s.

A good deal of the post-war increase in beef production occurred in Queensland, where meat production has expanded between two and threefold since the late 1940s, and at a rate slightly greater than the increase in cattle numbers (Clements and Gramshaw 1991). Pasture improvement in northern Australia began about 30 years later than in the south. Sown pastures probably carry 15% of the beef cattle in Queensland, but account for a somewhat larger proportion of output.

Dairying:— The number of dairy cows was not recorded separately before 1890 but there were probably about 1M in 1888. Development had begun to accelerate in the 1880s with the introduction of the cream separator and the first refrigerated exports of butter (Wadham & Wood 1950) and continued strongly through until the 1950s when cow numbers peaked at an average 3.2M. Exports of butter grew considerably up to World War II, but by 1987–88 Australia exported more cheese than butter (ABARE 1991). By the 1980s dairy cow numbers had decreased to an average 1.76M, but milk production did not decrease because of an even greater change in productivity per cow.

Total Grazing Livestock:— An estimate of the total carrying capacity of Australian grazing lands can be derived using factors of 15 for dairy cows and 8 for other cattle to calculate sheep equivalents (Davidson 1981). Thus, the stocking rates of Australian pastoral lands were approximately 170M sheep equivalents in 1888, 259M in 1951, 392 M in the record year of 1971, and 350M on average during the 1980s. Despite the great increase in cropping during the second century, stock carrying capacity has doubled.

To sum up, Australian agriculture has developed to a far greater extent in the second century than in the first. For five of the seven commodities listed in Table 1, which together accounted for 72% of the gross value of farm production in 1987–88 (ABS 1991), the greater part of the present-day capacity for volume of production has been created since the end of World War II. Even for wool, the star commodity of the 1800s, 40% of its development has occurred in the 40 years prior to the bicentenary. The recent performance of Australian dairying has been more modest; its main phase was, nevertheless, after 1888, not before.

Why then are Australians now not as wealthy as they were a century ago. The brief answer is that both wealth and trade have broadened considerably in composition since then (Table 2). No longer are exports of gold and wool, even of a broader range of minerals and agricultural products, sufficient for the greatest wealth. That requires also manufactured goods and services (not included in Table 2; their share of world trade has also grown rapidly). These are sectors in which Australia has generally performed poorly.

Despite that, Australia cannot afford to neglect the future possibilities for increased production and exports from its agriculture, an area in which its recent performance has been so outstanding. But do we have the resources to permit a further phase of expansion, similar say, to that from 1948 to 1988, and if the answer is yes, could it be done without unacceptable damage to the environment?

III FUTURE PROSPECTS

Before addressing questions of resources and sustainability, something needs to be said about profitability and markets. The emphasis so far in this paper has been largely on volumes of production and exports, not farm economics.

(a) *Economics and Markets*

The remarkable fact about the development of Australian agriculture since 1948 is that farmers' costs have risen in relation to prices throughout (Figure 2). In fact, world wheat prices, corrected for inflation, have declined since the middle of last century (Ruttan 1992). The same is probably true for wool; it certainly is for the period since World War II. Comparing the means for 1950s and 1980s, greasy wool prices increased by a factor of 2.8 and the CPI by a factor of 6.2 (ABARE 1991).

There is no certainty that the terms of trade for agriculture in Australia and overseas will continue to decline. By the first decade of the 21st century, almost all increases in world food production must come from increased output per hectare and the sources of productivity growth are not as apparent as they were a quarter century ago (Ruttan 1992). While population growth rates are expected to decline substantially in most countries during the first quarter of next century, the absolute increases in population size are likely to be large (Table 3), barring horrific diseases, wars or famines. Many countries will experience more than a doubling of food demand before the end of the second decade of next century (Ruttan 1992).

On the down side, Australian agriculture could suffer grievously if there were to be a marked increase in protectionist barriers around trading blocs from which it was excluded.

Roe & Pardy (1991) have contrasted the situation of agriculture in less-developed countries, where interventions in foreign trade and domestic markets have usually resulted in covert

taxation of agricultural export products, with that in advanced stages of economic development where the opposite is true. In the latter case, agriculture is a much smaller component of the total economy (instead of being 35–45% of GVP it may be only a tenth of that; Table 4 shows Australian data) and its demands for protection can be met at lower political cost. The result then is that the agricultural sector receives more protection than the industrial sector. Australian agriculture at present seems to be emerging from the 'hidden taxation' phase in the domestic economy, but is way short of the point where the country can afford to subsidize it.

It may seem insensitive to the people on the land now, many of whom are suffering great hardship in a depression that may rival in severity those of the 1890s and 1930s, to suggest that Australian agriculture is very likely to be able to continue developing without subsidy and despite all the possible future difficulties of economics and markets. Yet that is precisely what the record of the past two centuries, especially since 1948, indicates to be the most likely future scenario. So the key limiting factors probably are the availability of natural resources and their environmental sustainability.

(b) Natural Resources, Technology, and Sustainability

The prospects for the further development of agricultural production vary considerably between commodities.

Wheat:— There is very limited scope for expanding the area of wheat and other rainfed grain crops in southern Australia, unless new types of rotations can be developed that require less time under sown pasture. There is some scope for an increased area of these graincrops in the clay soil region of subtropical eastern Australia (Clermont to Tamworth) but again at the expense of pasture.

The major opportunity for increased grain production is in higher yields. In the medium- to high-rainfall parts of the current wheatbelt, soil limitations and varietal deficiencies (such as susceptibility to root diseases) generally limit wheat yields to no more than 30% of the potential determined by rainfall. It is certainly practicable to lift that percentage to about 50, using new and better technologies. Some very efficient farms on the dry margins of wheatgrowing are already able to achieve 70% of potential.

The historical trend of wheat yields in South Australia, the leading wheat producing State from 1850 to 1890, is shown in Figure 3. It is immediately obvious why Farrer was so concerned with soil management. He mentioned it specifically in a letter accepting a position with the then NSW Department of Mines and Agriculture in 1898. Unfortunately, he never had the time or resources to work to any extent on soil problems, nor on the testing of foreign grasses and forage plants, also mentioned in that letter (Russell 1949). But his varieties were a significant factor in the recovery of yield early this century, shown in Figure 3.

Though not yet of relatively large extent, erosion and dryland salinity are serious threats to the sustainability of Australian graingrowing.² They can be reduced by changing farming practices and introducing new technologies, and by a carefully planned reassignment of land use between trees, pastures and crops (Agriculture ESD Working Group 1991). Some districts in both the south-eastern and south-western parts of the wheatbelt have been

² Australia has a significant area of lightly degraded land, caused chiefly by overgrazing, but only a relatively small area of land in the moderate, strong and extreme classes of degradation. The World Resources Institute (1992) has estimated the area of human-induced soil degradation, 1945 to late 1980s as : light 749.0 (96.6); moderate 910.5 (3.9); strong 295.7 (1.9); and extreme 9.3 (0.4). Values are in millions of hectares, with those for Oceania (Australia predominantly) in parentheses. Oceania has about 13% of the world's lightly degraded land but only about 0.3% of the total in the other three classes.

overcleared (90% or more of the native vegetation removed).

Other Grain Crops:— The arguments about wheat apply equally to barley and oats. There is an urgent need for higher yields of barley, which have not improved significantly since the 1950s (Outlook 1992); malting quality also needs further attention. However, the greatest opportunity probably lies in grain legumes and oilseeds, with the outcome likely to be both substitution for cereals and expansion of the total cropped area. A new generation of William Farrers and John Gladstones is needed for this; some of them are already at work.

The future possibilities for rainfed grain crops can be summarized as follows: It would be possible to repeat the achievements of the last 40 years, mostly by better soil management but also from continued genetic gain and some expansion of area. But that assumes a continuation of the current level and effectiveness of R&D. There will have to be changes in land management and land use. For instance, the push to extend cropping inland has gone far enough, perhaps too far in some fragile environments. The other point about the grain industries is that Australia should be able to capture a larger proportion of the money made from food- and feedgrains beyond the farm gate, both here and overseas.

Sugarcane:— There is undoubtedly scope for substantial further growth of sugarcane production. The Sugar Industry Working Party (1990) estimated that land was available to sustain a 50% increase in canegrowing. Others' estimates have been lower, though the Canegrowers (1992) envision Queensland production reaching five million tonnes by the year 2000 (it was 3.4M in 1988). NSW is pursuing an expansion of up to 40% (Industry Commission 1992). The major cause for concern about the prospects for sugarcane is that sugar yield per hectare has plateaued or even declined slightly during the last 20 years (Canegrowers 1992).

The sugarcane industry faces some environmental concerns, arising chiefly from its significant use of agricultural chemicals, especially for control of soil-borne pests, and its proximity to the Great Barrier Reef. On the other hand, the current change from burned- to greencane harvesting offers real scope for innovation in soil management.

In summary, there are good prospects for a further expansion of sugarcane production by about 50%, and by even more if the problems of yield decline and sustainable soil management can be overcome by R&D.

Cotton:— The main constraint to the expansion of cottongrowing within its present area (the subtropics of northern NSW and southern Queensland) is the scarcity of additional irrigation water (Hamblin 1990). There is limited scope for southward extension, and much greater scope for northward extension but transport and infrastructure costs are a deterrent in the far north. Yield and quality of the Australian cotton crop are already high, though it may be possible to lift yield by another 30% (B. Hearn, personal communication).

Cottongrowing is one of the most intensive users of chemical pesticides amongst rural industries. Integrated Pest Management (IPM) techniques rescued the industry from the brink of disaster in the 1970s and there are good prospects for modern biology keeping the environmental and pest problems under control, provided R&D are sustained.

In summary, a repeat of the spectacular development of cottongrowing of the last 30 years is not impossible, but it is probably less likely than for other crops. The possibility of Australia capturing more value beyond the ginnery should be pursued.

Irrigated agriculture:— The scope here is not so much for extension of area, although only about 21% of Australia's usable surface water has been developed (Cribb 1991), as for a far more intensive use of the existing resource. About half the present irrigated area is in pasture, and an additional one fifth is used for cereal grains. There is great potential to increase the proportion used for horticulture, and it may be that horticulture is the only industry capable of covering the future infrastructural and environmental costs of irrigation

in southern Australia. It seems unlikely that the community will continue to carry as much of the cost of irrigated agriculture as it has in the past. There are also serious and steadily worsening problems of soil and water degradation to be dealt with, as well as problems with chemicals used for pest management on fresh fruits and vegetables.

In summary, there appears to be much greater scope for the future development of irrigated horticulture than occurred in the period 1948–1988. Irrigation also has a vital part to play in the future expansion of sugarcane– and cottongrowing. But Australian horticulture other than grapes needs to undergo a grower, technological and marketing revolution as profound as the one that transformed the cotton industry, if it (horticulture) is to realise its true potential.

Sheep and Wool:– There is virtually no scope for expanding on the 449M hectares of grazing land in Australia (Agriculture ESD Working Group 1991 and Figure 4). Furthermore, the condition of the 419M hectares of 'native' grazing land is such that it is very likely to be necessary to reduce its stocking rate somewhat in order to improve its condition (Table 5). In the arid zone that includes the need to control animal pests, particularly rabbits and kangaroos. There may have been about 600M rabbits in Australia before myxomatosis; now the numbers are back to 200–300M again (AAHL 1992). It has been estimated that 200M rabbits consume as much feed as 12.5M sheep (CSIRO 1990).

The really difficult issue to assess is the scope for expansion of sown pasture area and yield in southern Australia. In Victoria, the mostly intensively settled of the States (Lumb 1987), there are about 5.7M ha of sown pasture and 2.5M ha of unimproved grazing land, plus 3.5M ha of other land (not crop) on private holdings. How much scope is there to improve the 2.5M ha of hitherto unimproved grazing land, a question raised earlier and more widely by Davidson (1981). Equally, how much scope is there to lift the yield of the existing 26M ha of sown pasture in southern Australia? Can it be lifted by one to several percent per annum through effective R&D, as the yield of crops such as wheat can be (Evans 1980) and the productivity of the sheep themselves. By most accounts, the productivity of southern sown pastures has deteriorated with time, not increased. Furthermore, there is no reason to believe that the productivity of these sown pastures is any closer to the rainfall potential than it is for wheat.

In summary, production of sheep and wool is limited by feed supply and unless that can be raised expansion will be limited to the gains achievable from animal research. There may even be some temporary loss of sheep and wool production from the 'native' grazing lands of the arid zone as stocking rates are adjusted to be much more sustainable. The possibility of capturing more value from wool down the processing chain is certainly worth exploring.

Beef Cattle:– The observations made about 'native' grazing lands and sown pastures in southern Australia apply also to beef cattle production there. Another factor influencing future beef production is the decreasing dairy herd. During the 1960s, when cow numbers were higher, about a quarter of Australia's beef and veal was derived from animals born in dairy herds (Bailey and Durand 1986).

Undoubtedly, the scope for expanded beef production lies chiefly with pasture improvement in Queensland and with feedlots in the subtropics of northern NSW and southern Queensland. Currently there are about 3M ha of improved grass pastures in Queensland and 1.5M ha of legume–based pastures (Hutchinson 1992). The 'easily attainable' sown pasture potential is estimated to be 22M ha (Walker and Weston 1990), and there is growing interest in such development. Half of the beef producers who responded to the AMLRDC's North Australian Beef Producers Survey in 1990 had planted improved pastures during the previous two years (Clements and Gramshaw 1991).

Turnoff from feedlots accounted for 10% of the cattle slaughtered in Australia in 1990. The Australian feedlot industry predicts that within five years it will turn off 20–25% of all cattle slaughtered.

There are environmental problems to be solved in the Queensland beef industry. The stocking rates of 'native' grasslands during the 1970s were certainly excessive, and the beef cattle population has since fallen from 11 to 9M. There is the opportunity in Queensland to develop the 22M ha of sown pasture potential while retaining native vegetation on perhaps 50% of the terrain. It should be possible with the forewarning available from southern Australia to avoid its problems of erosion and dryland salinity. The environmental problems of feedlots can be serious, but Australia can draw on a substantial body of relevant experience from North America and Western Europe.

In summary, there are very good prospects for Australia being able to repeat the success of meat production since World War II (Table 1), at least for beef, and in an environmentally acceptable manner.

Dairying:- Although it seems likely that dairy cow numbers will decline further before stabilising (Strachan 1992), there are very good prospects for the Australian dairy industry, with its present emphasis on high-value products, being able to repeat its modest but important post-War performance (Table 1). In relation to environmental problems, the issue probably is whether dairying, which depends heavily on irrigated pasture, will be able to afford the future costs of maintaining and operating irrigation schemes, including those of measures to control waterlogging and salinity.

IV CONCLUSIONS

Despite very serious economic and marketing constraints, Australian agriculture has achieved a remarkable increase in volume of production since World War II. In many ways, Australian agriculture has performed as a sunrise industry, though its time scale for development of new export products is a good deal longer than that of high technology manufacturing and service industries. There are no insuperable resource or sustainability limitations that would prevent a similar success being achieved in future for meat, dairy, wheat and other grain crops, and sugarcane. With irrigated crops, any constraint on expansion of cottongrowing is likely to be balanced by the considerable potential for expansion of irrigated horticulture. The prospects for increased volume of wool production are more difficult to assess because they depend so much on the future development of sown pastures in southern Australia. However, the realisation of the great future potential of Australian agriculture, while solving its environmental problems, will be increasingly dependent on an effective level of R&D and on lifting the managerial skills of its farmers and graziers. The danger is that Australian Governments, in attempting to overcome the present dire economic problems of the manufacturing and service sectors, will reduce support for agricultural science. Recalling that William Farrer, in addition to being an outstanding plant breeder, had a deep interest in soil management and pasture agronomy, we will need many future William Farrers in Australia.

**TABLE 1:
PRODUCTIVE CAPACITY CREATED SINCE WORLD WAR II (%)**

Wool	40	Wheat	60
Meat	50	Barley	90
Dairy	10	Sugar	75
Cotton	95		

**TABLE 2:
COMPOSITION OF WORLD EXPORTS (%)**

	1913	1983
Foodstuffs	27	10
Raw Materials	30	6
Fuels	6	21
Manufactures	37	63

Source: Pinkstone 1992, Table 48

**TABLE 3:
UN MEDIUM VARIANT POPULATION PROJECTION (BILLIONS)**

	1990	2020
Developed Countries	1.1	1.2
Developing Countries:		
Africa	0.6	1.4
Latin America	0.5	0.7
Asia	3.1	4.8
World	5.3	8.0

TABLE 4:
CONTRIBUTION OF AGRICULTURE TO AUSTRALIAN GROSS PRODUCT (%)

1840	40
1900	20
1960	11
1988	4

Sources: Malcolm & Lloyd 1987; ABARE 1991

TABLE 5:
CAUSES OF HUMAN-INDUCED SOIL DEGRADATION IN OCEANIA (%)

Vegetation Removal	12
Overgrazing	80
Agricultural Activities	8

Source: World Resources Institute 1992, Table 19.4.