Spatial patterns and temporal trends in productivity of Australian agriculture

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Abstract
We derived national patterns and trends of total biological productivity expressed in the common denominator of dry sheep equivalents (DSE) using data from the Australian Bureau of Statistics. Historically, agriculture has passed through phases when first sheep, then cattle and latterly grain cropping constituted the dominant phase. Productivity shows a spatial association with total rainfall, with consistently high areas occurring in coastal Queensland, the irrigation areas of southern NSW and northern Victoria, and dairy areas of southern Victoria and northeast Tasmania. Most areas increased in agricultural productivity between the early 1980s and the middle 1990s, although some decreases occurred in the Darling Downs and some isolated parts of NSW and Victoria.

Key Words
Dry sheep equivalent, distribution

Introduction

Most agricultural scientists would probably take the opinion of the King of Brobdingnag (in Jonathon Swift's *Gulliver's Travels*) that "whoever could make two ears of corn or two blades of grass to grow upon a spot of ground where only one grew before, would deserve better of mankind and do more essential service to his country than the whole race of politicians put together", as an article of faith. More seriously, increasing productivity as a means of improving the profitability and competitiveness of the agricultural industries is a major goal of governments and the individual industries themselves. This paper looks at how well Australia has done at growing 2 ears of corn.

Methods

To compare the number of ears of corn and blades of grass, or biological productivity, over regions with a range of land uses it is convenient to convert the different products to a standard measure. We used dry sheep equivalent (DSE) as the standard unit because it captures the conversion of forage to a product. There are known conversions from cattle to sheep (1,2,3,4), and various conversion factors were calculated for the major broadacre crops based on their energy availability for livestock (metabolisable energy – ME) and then to DSEs based on a DSE consuming 2,550 MJ ME per year (7 MJ ME per day) using the factors given in Table 1. Pig and poultry production were ignored because they are largely fed from grain, while crop residues, hay and silage were assumed to be eaten by sheep and cattle. Horticultural production was too complex (a very wide range of products with highly variable moisture contents and often unknown energy contents) for these calculations and, except for potatoes and grapes, was omitted but in terms of biological production this would be relatively small.

Base information comes from the annual Australian Bureau of Statistics (ABS) Agricultural Census (AgStats) compiled for a Statistical Local Area (SLA). For spatial analysis the data were concorded to standard SLA boundaries and a cutoff value for the Estimated Value of Agricultural Operations of $22,500. Each SLA may have several land uses that have different products. Potential errors in the calculations come from a) feedlot animals being counted in SLA of location whereas many animals may be moved between SLAs, b) grain consumption by sheep and cattle for drought or intensive feeding could mean some double counting, c) no account being taken of vegetables and fruit which have a low dry matter content and d) some grazing animals such as horses not being included.

Results

Agriculture in Australia from its beginning has faced considerable challenges, and responded by seeking out opportunities. A relatively small population is insufficient to provide a market for all the agricultural activities possible in Australia so that export markets were essential for the viability of Australian farms. The successes of Australian agriculture have really depended on the degree to which a large overseas market

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existed for a product, which could be produced using little labour, but required large areas of land and which could be transported cheaply (5). Wool was the first product that easily fitted these requirements.

Table 1. Metabolisable energy (ME) contents of common products and conversion factors to DSE.

Product	Units	Moisture content	ME (MJ/kg DM)	DSE/unit product
Cotton lint	tonne	10	8.5	3.0
Cotton seed [γ]	tonne	14	14.1	4.8
Grapes	tonne	80	12.7	1.0
Sugarcane*	tonne	70	10.0	1.2
Barley[β]	tonne	13	13.8	4.7
Canola[β]	tonne	10	21.0	7.4
Lupins[β]	tonne	11	13.4	4.7
Maize[β]	tonne	12	14.1	4.9
Oats[β]	tonne	13	11.9	4.1
Peas[β]	tonne	13	13.4	4.5
Potatoes [γ]	tonne	79	12.5	1.0
Sorghum [β]	tonne	11	13.4	4.6
Sunflower[χ]	tonne	10	16.6	5.9
Wheat (rice, triticale) [β]	tonne	12	14.4	5.0
Other oilseeds	tonne			6.0
Other pulses/legumes	tonne			4.5
Other cereals & grains	tonne	12	14.0	4.8
Dairy cows [α]	beast			16.2
Beef cattle [α]	beast			8.2
Total cattle [α]	beast			8.5

* 13.0% sugar with 12.7% MJ and 17% bagasse etc with 8.0% MJ

α Reid, RL (2) p841; β ibid p470; γ MAFF (1).

The historical phases of agricultural development in Australia are shown in Figure 1, with the outputs of the major industries converted to DSE. On this measure the sheep and cattle industries were largely increasing in size and productivity until about 1970. From then until 1975 cattle rapidly accounted for the larger component of total DSE and, despite fluctuations caused by market changes, has maintained an advantage to 2000. Beginning about 1960 grain production increased strongly and had exceeded sheep production by the mid 1990s, and has contributed the largest growth in biological production since 1975. Recently there has been some growth in the intensive broadacre crops such as cotton, sugarcane and grapes.

A map showing total agricultural productivity per hectare for 1996-97 in the areas of intensive agriculture (Figure 2) indicates particularly high levels of biological productivity in coastal Queensland where sugar cane is grown, in the irrigation areas of southern NSW and northern Victoria, and in the dairying areas of southern Victoria and northeast Tasmania. Other high levels of production (5 - 10 DSE/ha) occur in regions that include the sheep-wheat belt in Western Australia, Yorke Peninsular of South Australia, central Victoria, New South Wales and the Darling Downs of Queensland, as well as the coastal fringes of New South Wales, Victoria, northern Tasmania, south eastern South Australia and south west Western Australia. This general pattern of productivity reflects the winter rainfall distribution, with some allowances for temperature limitations in the highlands of New South Wales, Victoria and the midlands of Tasmania.

Changes in biological productivity between the early 1980s (represented by the average of 1983, 1984 and 1985) and the mid 1990s (represented by the average of 1995, 1996 and 1997) were prepared but not presented here because of space limitations. Overall, most SLAs showed an increase in agricultural productivity over this period, but the rates of increase varied between regions. The increases appeared greatest for the cane-growing districts of coastal Queensland and for the dairy districts of Victoria and Tasmania. Areas with high productivity gains appear to be in the northern grain belt of Western Australia, the irrigated areas along the Murray and Murrumbidgee Rivers, and the central grain belt of New South Wales. Areas of lower productivity growth include most of Queensland except the coastal areas, the high rainfall sheep and beef grazing areas of New South Wales, Victoria, and Tasmania, and the more arid grazing and cropping regions of South Australia. Some areas appeared to show a decrease in productivity,

particularly in the larger Darling Downs up to the Burnett in Queensland, likely to be a consequence of the drought during 1994 to 1996.

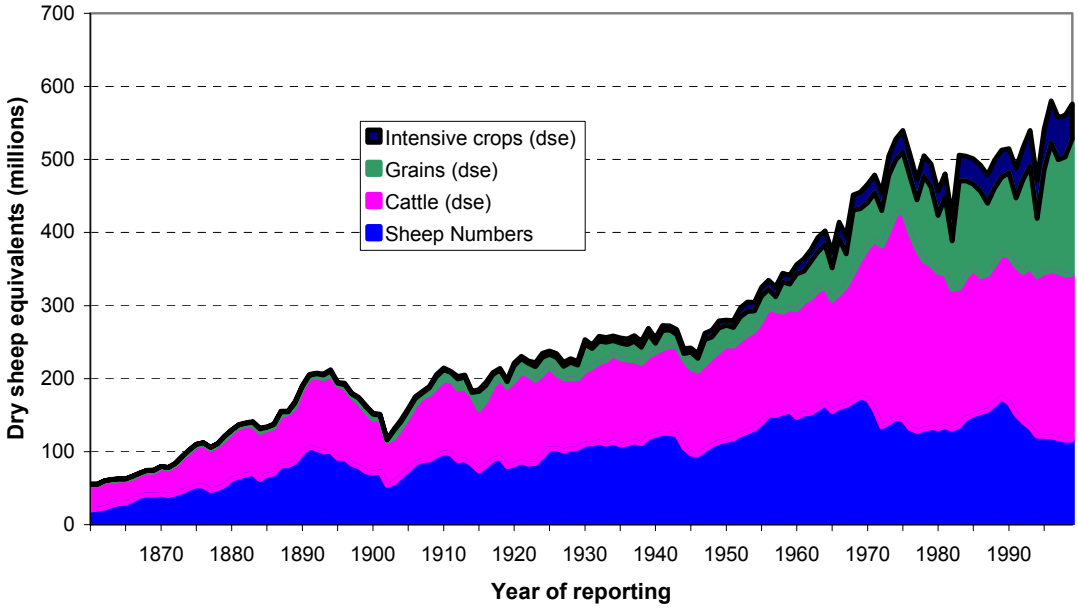

Figure 1. Total biological production by agriculture in Australia 1860-2000 in terms of dry sheep equivalents. Source ABS.

Another measure of productivity is total factor productivity (TFP), which expresses productivity as a ratio of total outputs to total inputs and therefore measures the net effect of factors such as technical efficiency, better production and animal husbandry methods, and the underlying quality of the resource base. A calculation of broadacre agriculture (excluding dairy) over the twenty years 1978-79 to 1997-98 using ABARE farm survey data, which smoothed sample data to provide local averages (6), showed significant regional variation in the attributes and economic performance of farms. In particular, it appears that the distribution of broadacre cropping industries is a key factor contributing to the observed patterns. The largest productivity gains (over 4 % pa) have occurred in the wheat-sheep zone where cropping activities are concentrated. Moderate productivity gains (0-3 % pa) appear to have occurred in the regions where livestock activities dominate the broadacre production mix. The areas of lowest growth (less than 0 % pa) occurred in some marginal areas of central and northern Australia, and also surprisingly in some areas of high rainfall where the combination of livestock-focussed activities and small farm size may have contributed to the relatively lower productivity gains.

Conclusion

These general increases in productivity occurred despite large areas experiencing droughts (1982, 1994), rainfall deficiencies at other times, and floods, while whole industries experienced large changes such as in the price of wool, the global surpluses of wheat in the 1980s which then declined affecting export prices. However, productivity would have been assisted by new technologies: computers developed from a novelty to common place use on farms; phones became mobile; herbicides facilitated conservation farming practices; remote sensing of landscapes allowed some monitoring of land condition. Major policies affecting agriculture were initiated: the Rural Research and Development Corporations in the 1980s; the Decade of Landcare initiated in 1989; the National Strategy for Ecologically Sustainable Development launched in 1992; and Agriculture Advancing Australia in 1997.

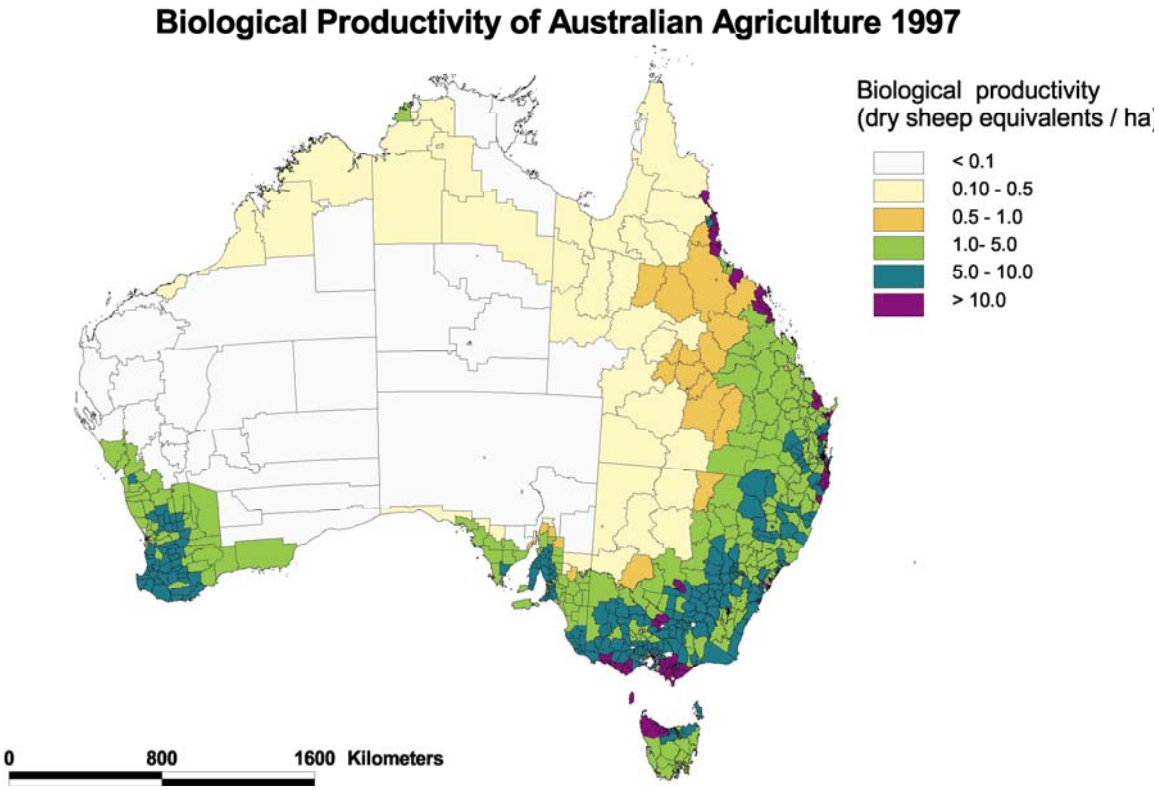

Figure 2. Total biological productivity by Australian agriculture in 1997 expressed as dry sheep equivalents. Data from ABS AgStats.

Land quality or condition is pertinent to productivity because the area or amount of land for agriculture has been essentially static for the last 20 years and will most likely remain so or decline in the future. While soils are at the centre of land values, clearly there are other components such as native biota, water, scale of operation and even climate that are included in the concept of 'land'. It is possible and in some areas quite likely, that land at present used for agricultural production will someday encompass a wider range of activities including conservation of native biodiversity, gamekeeping, ecosystem services, sporting activities (eg horse racing, fishing) by addressing different markets such as tourism, recreation, entertainment and sports.

Over the last 20 years the land resources of Australia, with additional inputs, have continued to yield useful and desirable products of food and fibre so that Australia, in general, has contributed its share of the extra ears of corn and blades of grass. The challenge now is to ensure this increase in productivity continues.

Acknowledgement
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