Productivity improvements

Their influence on future patterns of agricultural land use in Australia

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Changes in agricultural land use that occur in response to productivity improvements will vary among region because of variations in factors such as climate and soil.

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Substantial changes in broadacre agriculture have occurred in Australia over the past decade. Changes in the quantity and composition of agricultural output have been driven by changes in productivity and world commodity prices as well as by domestic environmental factors. For a discussion of the changes in land use that have occurred in Australian broadacre agriculture over the past decade see Beare, Chapman and Heaney (1999).

An understanding of historical changes in agricultural land use is important, but so too are expectations about future changes in agricultural land use. Such changes have implications for policies aimed at protecting Australia's natural resources and the sustainability of the agricultural sector.

Productivity improvements

Productivity growth in different broadacre industries is a key factor that will influence future changes in Australia's agricultural land use. If Australian farm enterprises achieve greater productivity gains than their competitors in the rest of the world, their costs will be lowered relative to the prices they receive for their output and lead to higher net returns to producers. Conversely, if Australian farm enterprises fail to keep pace with the productivity gains in the rest of the world, their net returns will fall.

If some sectors of broadacre agriculture are able to achieve greater productivity gains than other sectors, resources will shift into those higher productivity activities.

In this article the potential impact of different productivity growth rates among industries on the future allocation of land between broadacre industries is analysed.

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Modeling land use change

ABARE has developed a model to investigate feasible projections of future land use patterns in broadacre agriculture to 2010. The model was adapted from the model described in Howitt (1995) and used to simulate changes in land use that may result from deviations in the productivity of Australian agricultural producers from their counterparts in the rest of the world.

Using ABARE farm survey data, costs and returns to production were estimated for five types of broadacre agriculture activities across five geographic regions of Australia. The five activities are cereals, oilseeds, other crops, sheep and beef cattle. The five regions reflect large scale differences in climate and soil across Australia. The regions are the pastoral zone, high rainfall zone, and a breakdown of the wheat–sheep zone into three regions: the northern, southern and western wheat–sheep zones. See box 1 for a more detailed description of each activity and region.

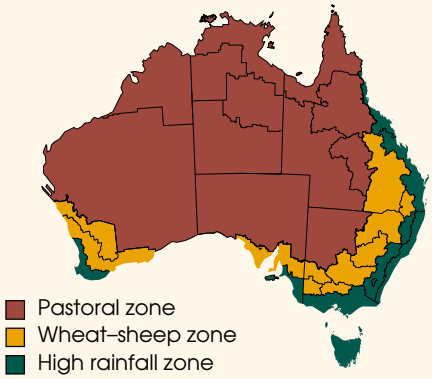
The model represents competitive markets for all agricultural inputs and outputs. For whatever volumes produced, prices

1 Activities and regions included in the land use model

Activities

The ***cereals*** activity includes production of wheat, oats, barley and grain sorghum. ***Oilseeds*** include canola, sunflowers, safflower, linseed and linola. The ***other crops*** activity includes all other broadacre crops not included in the cereals or oilseeds categories. The suitability of these activities to a region depends, among other things, on the climate and soil characteristics of the region. The ***sheep*** activity includes the use of sheep for meat and wool. The ***beef*** activity includes both cattle for slaughter and the live cattle trade.

Australian broadacre zones and regions



Regions

The ***pastoral zone*** includes most of the northern tropical areas and the arid and semiarid regions of Australia. Agricultural land use in this zone is characterised by extensive grazing of native pastures. Although some cropping is undertaken, it is not feasible on most farms because of inadequate rainfall.

The ***wheat–sheep zone*** has a climate and topography that generally allows regular cropping of grains in addition to the grazing of sheep and beef cattle on a more intensive basis than in the pastoral zone. Rainfall is generally adequate for producing a variety of pasture species, usually as part of a crop–grazing rotation. Farms, on average, are smaller than those in the pastoral zone.

The wheat–sheep zone was broken into three regions to reflect soil, rainfall and other climatic differences that result in different agricultural activities undertaken in these areas. For example, summer cropping is confined mostly to the northern wheat–sheep region. While canola is grown quite extensively in the southern and western wheat–sheep regions, it is less suited to the northern wheat–sheep region. In the western wheat–sheep region, wheat production is undertaken to a greater extent than in the southern and northern wheat–sheep regions, but beef production is not as common.

The ***high rainfall zone*** forms the greater part of the coastal belt and adjacent tablelands of the three eastern mainland states, as well as Tasmania and areas of south eastern South Australia and south western Western Australia. Higher rainfall, steeper topography, more adequate surface water and greater humidity make the high rainfall zone less suitable than the wheat–sheep zone for grains based cropping but more suitable for grazing and producing non-grain based crops.

received for agricultural outputs, except wool, are assumed to be equal to given world prices less transport costs and other margins. For wool it is assumed that as Australia is a large producer of wool the volume of Australian production affects the world price for this commodity.

The outputs of all activities are assumed to depend on both land and nonland inputs. Nonland inputs are assumed to be available in unlimited quantities at given prices, while the total area of available land in a region is held constant. Any increase in area allocated to a particular activity in a region is therefore at the expense of the area allocated to at least one other activity in that region.

Farmers are assumed to allocate their land among activities to achieve the greatest economic return from that land. However, as more land is used in a particular activity, farmers are assumed to require a gradually increasing premium before choosing to allocate an extra hectare to that activity. This assumption prevents specialisation in land use in a region.

Influence of productivity improvements

Important influences on land use change are economic factors that affect the net returns to different agricultural activities. These include changes in commodity prices and the productivity of agricultural activities. Where possible, farmers are likely to adjust their production mix in response to price movements between different commodities to improve their net returns. Similarly, improvements in the productivity of a specific activity, everything else remaining the same, will improve returns to that activity and farmers may respond by altering the allocation of land to that activity.

Three changes in the productivity of Australia's broadacre industries compared with the rest of the world have been analysed. In each case, Australia is assumed to have achieved 10 per cent higher productivity in 2010 for a selected activity relative to the rest of the world and the other Australian broadacre activities. For example, a higher level of productivity may be obtained by a breakthrough in the development of new cropping varieties or emerging practices suitable to the Australian climate or by Australia remaining free of a disease or pest while the rest of the world is affected.

This framework is not appropriate for analysing other shocks such as changes in Australian input prices or demand. Analyses of those factors requires a detailed model of world supply and demand to properly evaluate the implications for Australian producers.

In the base case it is assumed that Australia's agricultural industries maintain the same level of productivity as the rest of the world. Under this assumption, prices for Australian commodities remain on par with the rest of the world and there is no change in relative prices between commodities. With no changes in relative returns between commodities there is no change in the area of land allocated to each commodity over time.

While the land use model covers five broadacre activities, for reporting simplicity the three cropping activities — cereals, oilseeds and other crops — have been collapsed into one single activity, crops.

Higher productivity in the Australian sheep industry

If the Australian sheep industry were to achieve 10 per cent higher productivity by 2010 compared with the rest of the world and the other Australian broadacre activities, the returns to land from sheep production would improve. While the world price for wool falls as Australian production increases, this is more than offset by lower production costs. The returns to cropping, however, are still greater than those from either of the livestock alternatives. Therefore, with higher sheep productivity, land used for sheep increases at the expense of beef (table 1).

A large move into sheep production is observed in the pastoral zone and northern wheat–sheep zone. By 2010, sheep area is 55 per cent higher in the pastoral zone and 32 per cent higher in the northern wheat–sheep zone relative to the base case. Both of these regions have around 75 per cent of broadacre land allocated to beef in the base case and very little land allocated to cropping activities.

1 Effects of greater productivity in the Australian sheep industry (case 1)

	Area of land used for each activity					
	Pastoral zone	High rainfall zone	Northern wheat–sheep	Southern wheat–sheep	Western wheat–sheep	All broadacre
	'000 ha	'000 ha	'000 ha	'000 ha	'000 ha	'000 ha
Crops						
Base case	313	1 397	2 710	7 701	7 114	19 234
10% more productive ***sheep*** industry by 2010	313	1 496	2 716	7 876	7 025	19 426
Sheep						
Base case	83 319	7 715	4 874	17 978	9 817	123 703
10% more productive ***sheep*** industry by 2010	129 094	7 968	6 441	18 738	9 862	172 104
Beef						
Base case	247 074	15 685	22 268	6 710	472	292 208
10% more productive ***sheep*** industry by 2010	201 340	15 338	20 694	5 771	438	243 581

The change in the relative returns of the two livestock activities brought about by the productivity improvement in the sheep industry results in significant alterations to the production mix in these regions. In the other regions, the sheep area increases by less than 5 per cent. In the southern and western wheat–sheep zones this is likely to reflect the suitability of land to cropping activities, which maintains high returns even with a productivity improvement in the sheep industry.

2 Mapping regional level land use changes

For some years now ABARE has been producing maps to assist in obtaining a greater insight into regional variations in farm survey data. These maps display local area averages. Details of the technique used to produce these maps are contained in ABARE's 1992 and 1994 *Farm Surveys Report* (ABARE 1992, 1994). In this study, these techniques were used to map the regional changes in land allocated to each activity. Each farm was assumed to change each activity by the same proportion as for the region as a whole. The new mix of land uses was then mapped to highlight variations within regions.

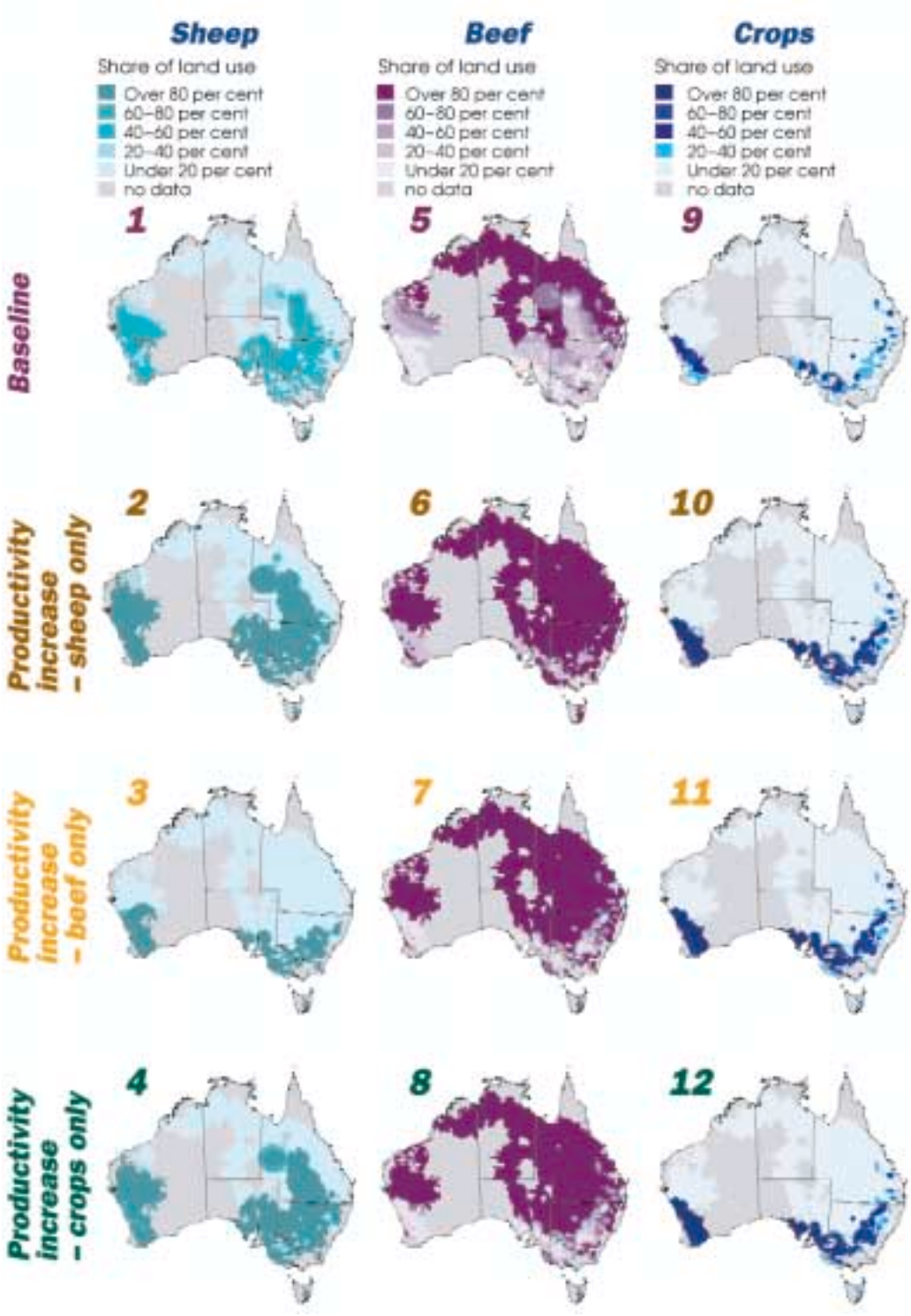
At the national level, the sheep area is almost 40 per cent larger than in the base case. This increase occurs mainly in the pastoral zone (map 2). Maps 2 and 6 show an expansion in sheep area through the middle of Queensland, New South Wales and South Australia, where there is also a corresponding fall in beef area. The high returns to cropping relative to either of the livestock alternatives means there is virtually no change in the area planted to crops relative to the base case (map 10). Box 2 contains a description of how the maps were produced.

Higher productivity in the Australian beef industry

With 10 per cent higher productivity in the Australian beef industry by 2010 relative to the rest of the world and the other Australian broadacre activities, returns to beef improve compared with the returns to sheep. There is a small move out of cropping and into beef, but the majority of the land allocated to beef occurs at the expense of sheep (table 2).

The increase in beef production at the national level is observed in all regions except for the high rainfall zone. Farmers in the pastoral and northern wheat–sheep zones move out of sheep production entirely,

Impact of a 10 per cent increase in productivity on land use in Australia



2 Effects of greater productivity in beef activity (case 2)

	Area of land used for each activity					
	Pastoral zone	High rainfall zone	Northern wheat–sheep	Southern wheat–sheep	Western wheat–sheep	All broadacre
	'000 ha	'000 ha	'000 ha	'000 ha	'000 ha	'000 ha
Crops						
Base case	313	1 397	2 710	7 701	7 114	19 234
10% more productive *beef* industry by 2010	313	1 349	2 692	7 633	7 037	19 024
Sheep						
Base case	83 319	7 715	4 874	17 978	9 817	123 703
10% more productive *beef* industry by 2010	0	7 958	0	17 748	9 310	35 016
Beef						
Base case	247 074	15 685	22 268	6 710	472	292 208
10% more productive *beef* industry by 2010	330 412	15 492	27 160	7 008	1 054	381 126

as can be seen in maps 3 and 7, so that virtually all of the broadacre area in these regions is now allocated to beef. This shift is a result of the improved returns to beef compared with the returns to sheep. Beef production is the dominant activity in these regions in the base case. Virtually no cropping is undertaken in the pastoral zone and sheep production accounts for only 25 per cent of area in this zone and 16 per cent of area in the northern wheat–sheep zone. Thus, changes in relative returns between activities result in beef occupying almost all of the broadacre land in these regions.

In the western wheat–sheep zone, the move into beef occurs at the expense of sheep production and, to a lesser extent, cropping. Sheep area falls by around 5 per cent and the area allocated to cropping is 1 per cent lower than the base case.

The large land use change out of sheep production in these regions leads to a higher world wool price. In the high rainfall zone the resulting improved returns from sheep production are sufficient to outweigh the higher beef productivity, and there is a slight land use change from beef to sheep production in that zone.

At the national level these regional changes result in a 30 per cent greater beef area than in the base case and a substantial decline in sheep area. There is virtually no change in land used for cropping. The significant fall in land used for sheep can be observed in map 3. A large reduction can be seen in Queensland, with sheep production falling to less than 10 per cent of land use. Similarly, substantial declines in land used for sheep production are evident in the pastoral zone north of the wheat–sheep zone of Western Australia, in south east South Australia and the majority of New South Wales.

Higher productivity in the Australian cropping industries

In the base case, cropping is the most profitable activity. With a 10 per cent productivity gain by 2010 for the Australian cropping industries relative to the rest of the world and the other Australian broadacre activities, returns to land from cropping improve so that more land is used for this activity. This is primarily at the expense of beef production which, on average, has a lower return when compared with sheep and cropping activities. However, the expansion in land used for cropping is limited by the availability of suitable land. This productivity gain results in a larger area used

3 Effects of greater productivity in cropping activities (case 3)

	Area of land used for each activity					
	Pastoral zone	High rainfall zone	Northern wheat–sheep	Southern wheat–sheep	Western wheat–sheep	All broadacre
	'000 ha	'000 ha	'000 ha	'000 ha	'000 ha	'000 ha
Crops						
Base case	313	1 397	2 710	7 701	7 114	19 234
10% more productive ***crops*** industry by 2010	383	2 896	3 241	9 683	8 993	25 195
Sheep						
Base case	83 319	7 715	4 874	17 978	9 817	123 703
10% more productive ***crops*** industry by 2010	92 617	7 792	5 199	18 046	7 952	131 607
Beef						
Base case	247 074	15 685	22 268	6 710	472	292 208
10% more productive ***crops*** industry by 2010	237 759	14 113	21 411	4 657	458	278 397

for crops and a smaller area used to produce beef in all regions (table 3).

The expansion in cropping area occurs principally in the areas where cropping is suitable and already undertaken (map 12). Expansion in cropping is particularly evident in south west Western Australia, where there is a corresponding fall in the area of land used for sheep (map 4). There is no change in land use in the Northern Territory, which is less suited to cropping activities.

The largest increase in cropping area occurs in the western and southern wheat–sheep regions, where area cropped rises by around 2000 hectares. Land in these regions is more suited to cropping compared with the other broadacre regions. The western and southern wheat–sheep regions have the greatest proportion of broadacre area used for cropping in the base case (around 41 per cent and 24 per cent of broadacre area respectively). As a result, the area used for cropping in these regions is particularly responsive to changes in returns to cropping.

There is little beef area in the western wheat–sheep zone. The move to cropping is therefore almost totally accounted for by a fall in land used for sheep production. The shift away from sheep production in this region improves returns to sheep at the national level. As a result, in the other regions land is moved out of beef production that offers relatively lower returns than cropping.

Only a minimal increase in crop area is observed for the pastoral zone as this region is more suited to livestock production.

The net results of these region level impacts is a 31 per cent increase in cropping area at the national level and a 6 per cent rise in sheep area. There is a corresponding 5 per cent fall in land used for beef.

Concluding remarks

Historically, there have been substantial differences in productivity growth between the various broadacre industries (Knopke, O'Donnell and Shepherd 2000). In this article, the impact on land use change if these sorts of differences were to continue is considered. These productivity cases are 'what if' scenarios, selected to scope the changes that might occur in Australian agriculture if the assumed changes in productivity were to be realised. They are not indications of expected changes in productivity.

In each of the cases considered it is assumed that a particular broadacre industry in Australia is able to achieve higher productivity relative to the rest of the

world as well as to the other Australian broadacre activities. However, if Australian agriculture fails to keep pace with productivity gains made by the rest of the world, relative productivity will decline. An equivalent percentage decline in relative productivity would generate an inverse or mirror image shift in resources.

It is also important to note that if productivity gains in Australian agriculture were to be matched by productivity growth in the rest of the world, any improvement in returns from a productivity gain would probably be offset by a fall in output prices.

Significant changes in land use are projected to occur under these productivity assumptions. A key factor determining the responsiveness of land use to changing relative returns is the land supply conditions for different activities. These land supply conditions differ by region because of variations in factors such as climatic and physical characteristics that affect the relative profitability of undertaking activities in each region. The land use change that occurs in response to productivity improvements will therefore vary for each region. The results also reflect the effect of changed Australian production volumes on prices for commodities such as wool.

The land use changes presented in this article highlight the complexity of the interrelationships between activities that result from a productivity improvement for one activity alone. In turn, this highlights the need to account for these complex economic factors when attempting to model future land use patterns.

There has been considerable interest in forecasting future land use patterns, particularly with a view to assessing the implications of future land use on the degradation of Australia's resource base. The results presented in this article highlight the need to consider not just the biophysical suitability of land to different activities but also a range of economic factors when attempting to forecast future patterns of land use. Differences in productivity growth between domestic producers and the rest of the world are likely to significantly influence future patterns of agricultural land use in Australia.

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