# Global Geographies of Innovation Diffusion: The Case of the Australian Cattle Industry

## Abstract

The geographies and histories of the introduction of cattle breeds to Australia in the period since white settlement are documented as an example of the diffusion of agricultural innovations. Three phases of development are identified: a colonial expansion phase from the late eighteenth to the early twentieth century during which a number of primarily British cattle breeds were imported by the colonial settlers; an innovative phase in the mid twentieth century when both governments and private interests sought to produce or import new breeds deemed to be better adapted to Australian environments; and a multifunctional phase in recent decades. In this final phase, government deregulation and new technologies, such as the long distance transport of genetic packages, have facilitated the importation and development of many new cattle breeds in Australia. While this has produced a significant rise in the total number of breeds represented nationally, many recent and historic breeds currently exhibit extremely small numbers and a few generally well-established breeds such as Holstein, Hereford and Angus, still dominate the national herd. This study of changing breed types and introductions provides some evidence of post-productivism and of a multifunctional transition in that several cattle breeds favoured by hobby farmers and boutique breeders are now represented, but the aggregate numbers for these breeds remain small and the numbers for several of the traditional (or colonial) breeds are currently in decline. Overall, it is apparent that Australia's cattle industry retains a strongly productivist ethos and that, particularly given the country's very great environmental variation, its levels of breed diversity remain low.

Key words: Australia; cattle breeds; innovation diffusion; productivism; multifunctionality

## Introduction

One of the central characteristics of settler societies is they way in which they take on many of the social institutions, cultural attributes, and technological innovations of their colonising nation(s)(Hardt and Negri 2000; Blunt and McEwan 2003). It is also clear that, over time, these societies begin to adapt and change in response to, *inter alia*, local geopolitical circumstances, environmental conditions, and shifting economic realities. Thus, settler societies might often be regarded as 'hybrid', blending characteristics of their cultural histories with contemporary developments (Anderson 2000; Jones and Birdsall-Jones 2008). This hybridity is particularly evident in agricultural systems, with colonial agricultures adapting over time and taking on new forms to reflect their more immediate environmental, economic and socio-cultural circumstances. The aim of this paper is to examine the evolution of one aspect of Australian agriculture, the cattle industry, from its colonial origins to its current status as one the world's largest beef and dairy producers. The paper follows Yarwood and Evans' (1998; 2000) call to examine the physique, distribution and number of specific livestock breeds to assess how they reflect, and indeed affect, structural changes in agriculture and society. In doing so, contributions are made to the strand of animal geography that seeks to understand how social practices and meanings have shaped the relationships between societies and animals (Whatmore 2002).

While a considerable body of research at the farm level has revealed the importance of local knowledges, technologies and practices in livestock farming (Holloway 2001; Gray,

1996; 1998), it is also recognised that farms are part of economic, technological and social networks that extend well beyond their front gates (e.g. Gray 2000; Yarwood and Evans 2006). Research conducted at the national scale has revealed how individuals and institutions, as well as changing practices and policies, impact upon and reflect the geographies of livestock breeds (e.g. Walton 1984; Yarwood and Evans 2006). However, given that rural areas are intimately and increasingly connected to other parts of the world (Woods 2007), it is surprising that research on animal geographies has not paid more attention to global livestock migrations, particularly as these relate to colonialism and the emergence of agriculture in settler societies. Accordingly, the present paper focuses on the introduction of cattle to Australia through one of two mechanisms: i) the relocation or migration of breeds; ii) the development of indigenous breeds. It argues that both the relocation of cattle, and the development of new breeds of cattle, in the Australian context can be understood with reference to the conceptual literature on the geography of innovation diffusion. In essence, the evolution of the contemporary cattle industry is an outcome of both innovation, and the diffusion of innovations across geographic space. These diffusions occur at multiple scales, from global through to local, and are contingent on a range of institutional, environmental, socio-cultural and economic imperatives.



**Agriculture and the Geography of Innovation Diffusion**

The adoption of new technologies and practices in agricultural industries has long been of interest to geographers, sociologists and economists (e.g. Ryan and Gross 1943; Hagerstrand 1967; Brown 1981; Ison and Russell 2000; Vanclay 2004). While there is

considerable debate regarding the processes that lead to adoption, there is a general consensus that the application of new technologies and practices is largely based on the desire of farmers to maximise economic returns (Birkhaeser *et al.* 1991; Black 2000; Huffman and Evenson 2006). Under normal circumstances, new technologies and farming practices are adopted within particular environmental contexts to increase productivity, reduce costs, or both (Leeuwis and Van den Ban 2004). The adoption of new technologies and practices can result in significant transformations in farming systems and agricultural landscapes. This is particularly apparent in the production of grains, where the use of new technologies, such as larger seeding and harvesting equipment, disease and drought resistant crops, and minimum-till techniques have increased production and decreased costs (Gardner 2002; Henzell, 2007). At the same time, they have contributed to an extensification of grain farming through which processes of farm amalgamation and expansion are seeing smaller producers replaced by much larger operators (Brasier 2005; Lawrence 2005).

Such transformations are also common to livestock production, largely through the introduction or development of new breeds. This process normally occurs in one of two ways. First, livestock breeds are 'migrated' from one place to another. Indeed, there is considerable evidence of livestock migrations across a range of geographical scales as a means of improving the productivity and profitability of farming (Jordan 1969; 1972; Walton 1999). In the United States, for example, the introduction of the heat and parasite tolerant Zebu (humped) cattle from India during the second half of the 1800s contributed to a marked increase in beef production in the country's hotter and more humid regions

(Sanders 1980). A second mechanism for introducing new varieties of livestock is through cross-breeding programmes. These programmes enable the development of cattle suited to specific environmental conditions or market requirements.

The migration of cattle to new locations, and the development and spread of new breeds are, in effect, forms of innovation and diffusion (Rogers 2003; Leeuwis and Van den Ban 2004; Abdulai and Huffman 2005). At the heart of much of the literature on innovation and diffusion is the work of Schumpeter (1934) who defined three phases of technological change: invention, innovation and the dispersal of innovation. While Schumpeter saw invention as something quite rare that leads to the creation of entirely new knowledge or technologies, he regarded innovation as a more widespread phenomenon that involves a process of transformation (Schumpeter 1934; 1947). In essence, he argued that innovation involves taking pre-existing technologies or practices and adapting them to improve productivity and profitability (Carter 2007).

In Schumpeterian terms, the central agent in the process of change is the innovator (Schumpeter 1947). In his view, the innovator is responsible for transforming the process of production by displacing redundant technologies and/or practices in favour of new, more creative and profitable alternatives: a process he described as 'creative destruction' (Schumpeter 1934). However, and in contrast to the view of Schumpeter (1947), there is a growing consensus in the literature on the geography of innovations that the innovator is not necessarily an individual but an agency. In an agricultural context, government agencies (e.g. government departments of agriculture), breed societies (Anderson 2003;

Yarwood and Evans 2006), and, increasingly, private firms(Lundvall 2001; Gertler and Wolf 2002; Polenske 2007) are key innovators of new technologies and practices (Brown, 1981; Wolf and Zilberman 2001).

While innovations are indeed important in the process of economic transformation, what is equally significant is their diffusion across geographic space. This spatiality of innovation and diffusion is particularly evident in the context of agriculture (Ilbery, 1985). Some of the most significant contributions to understandings of these spatial processes of innovation and diffusion emerged in the field of agricultural geography during the 1960s and 1970s. Perhaps the most widely cited work is that of Hagerstrand (1967), which emphasised the role of communication and learning processes. Central to his thesis is that the spatial diffusion of innovation reflects flows of information and "biases and distortions in from various social and physical resistances" (Ilbery, 1985, p.84). In other words, diffusion is a geographically uneven process reflecting both the nature of networks and the characteristics of particular places. While Hagerstrand's ideas were developed largely in relation to the diffusion of innovation amongst Swedish farmers, there is no reason why such general processes might not operate at wider geographic scales. For example, a study of the migration of Aberdeen Angus cattle into Argentina points to the role of communication networks stretching across the Atlantic between Britain and Argentina, and a willingness of local farmers to adopt the breed (Winsberg, 1970). The work of Hagerstrand inspired a rich body of research in agricultural geography that focussed on the geographical spread of ideas through farming systems and landscapes (e.g. Bowden, 1965; Johansen, 1971).

In many respects, Hagerstrand's perspective was reflective of the emerging behavioural approaches in human geography of the time, with a clear emphasis on the role of both the information networks and decision-making process of individual farmers. One of the major criticisms of this work is that it was excessively focused on the role of individuals, and tended to overlook the role of public and private institutions (Brown, 1975; 1981). In response, a number of scholars began to place greater emphasis on the public and private sector agents through which an innovation is distributed or made available. This can include government agencies, non-government organisations, breed societies, and private firms. In this approach the role of infrastructure, promotional communication, price signals and market selection are critical in shaping the geographical dynamics of diffusion. Thus, it begins to address the limitations of the behavioural approach by considering some of the structural drivers of innovation. By considering this alongside the behavioural approach of Hagerstrand, it is possible to conceive of innovation as being driven by a blend of individual decisions, spatially uneven flows of information, socio-cultural traits, political and institutional dynamics, and economic considerations (Grigg, 1984; Ilbery, 1985; Black 2000; Vanclay 2004).

The spatial pattern that emerges when an innovation diffuses generally reflects the combination of these factors. Yet, at the heart of the process remains the importance of information flow and local receptiveness. Both act to shape the places where diffusion is likely to occur. Local knowledge of an innovation, such as a breed of cattle, is necessary if adoption is to be an option. As such, until levels of knowledge and confidence in

innovations develop within particular geographical contexts, adoption of an innovation is unlikely. The key controls over these forms of knowledge include geographical proximity/distance, communications, private and public institutions, and the socio-cultural linkages that tie disparate places together. There are also unique place-based conditions that shape patterns of innovation diffusion and adoption. Ormrod (1990) deploys the concept of 'place receptiveness' to highlight the interdependence of innovation adoption and environmental settings. The central argument here is that the geographic diffusion of innovations is linked to specific ecological, institutional and social (and economic) contexts, and that their successful transfer depends on their suitability to new environments.

In the case of livestock, both new breeds and existing breeds in alternative locations might face a range of barriers to geographic diffusion and adoption. These include local knowledge about and attitudes towards breeds, locally and regionally accepted farming styles, and economic determinants, including the cost of local production, market demand, and the price received for the commodity (Black 2000). In these contexts, breed societies play a key role in promoting particular breeds (Yarwood and Evans 2006) and, by implication, particular farming discourses (Anderson 2003). Moreover, the extent to which breeds are suited to local and regional ecological conditions is a key determinant in the spatially uneven process of innovation diffusion.

Given the economic, social and environmental importance of the spatial diffusion of innovations, surprisingly little research has considered how these processes have shaped

the imperial and global geographies of agriculture. Much of the research that has been conducted in this area has focused on the diffusion of agricultural innovations at local scales (Black 2000) or, in some cases, within particular nation states (Jordan 1972; Walton 1984; Abdulai and Huffman 2005). However, it is also apparent that these processes operate at much wider global scales. In the case of livestock, for example, colonial agricultures were founded almost entirely on the relocation of breeds from colonising nations (Jordan 1972; Simoons 1974; Sanders 1980). The ongoing development of agriculture in these new world environments was generally on the basis of further livestock migrations. Aside from general descriptive accounts of these movements, very few studies have attempted to explore systematically the processes of innovation and spatial diffusion operating in this global context.

To begin addressing these gaps, this paper uses the example of cattle to examine diffusion and innovation in Australia's livestock industry. The first breeds were introduced (rather unsuccessfully) in 1788, yet Australia is now the world's largest exporter of beef and the third highest exporter of dairy produce (Chambers, 2007). The focus on cattle farming also allows innovation and diffusion to be examined in the context of a truly remarkable, global and rapid transformation of agriculture.

**The Australian Cattle Industry in Context**

Since European settlement in 1788, Australia has a history of importing cattle breeds from other parts of the world and, through cross-breeding, of developing cattle suited to

local ecological conditions (Figure 1). While the cattle industry was initially a relatively small enterprise based on the provision of meat and dairy products for the local population, it soon became an important player in the national agricultural sector (Henzell 2007). The industry also began to become increasingly specialized during the 1880s, moving from dual dairy-beef production to being primarily oriented towards either dairy or beef (Taylor 1930). This growing specialisation was accompanied by a geographical separation, with dairy producers favouring higher rainfall and coastal areas, while beef production tended to disperse into the harsher inland and tropical areas.

[INSERT FIGURE 1 ABOUT HERE]

During the 20th century, the cattle industry continued to expand. In the dairy sector, improvements in refrigerated transport opened up new markets in Europe, North America and South-east Asia from the 1890s (Camm 1971). Continued expansion during the 20th century saw Australia become the source of around 16 per cent of world dairy exports by 2000. Even more spectacular has been the growth of the beef cattle industry, which occupies some of the harshest environments in Australia and yet comprises some 25 million cattle. By the end of the 20th century the industry was the largest producer of beef in the world, with the majority of exports focused on Japan, South-east Asia and the Middle East (Bindon and Jones 2001). Ultimately, the prosperity of both the dairy and beef industries in Australia is linked to the successful adoption of innovations, encompassing both imported breeds and locally developed new breeds. Figure 2 shows that, since colonization in 1788, some 64 breeds have been introduced to Australia.

These introductions occurred over three basic phases: i) a colonial expansion phase, between initial settlement and the 1920s; ii) an innovative phase between the 1930s and the 1970s; iii) a multifunctional phase from the 1980s onwards. The subsequent diversity of breeds has meant that both the dairy and beef industries have not only adapted to Australia's wide range of environmental conditions, but also to changing global market fashions and tastes.

[INSERT FIGURE 2 ABOUT HERE]

**The Colonial Expansion Phase, 1788 – 1920s**

Australia's early history of farming was shaped by its colonial relationship with Great Britain. As a consequence, more than a century of early farming technologies and practices were essentially imported from Britain and adapted to fit Australian conditions (Powell 1988). This colonial influence is particularly evident in the cattle breeds introduced to Australia in the few decades immediately following white settlement. The first cattle recorded in Australia arrived with the first fleet in 1788, although initial attempts to establish herds were hampered by unfamiliar and difficult environmental conditions, including a lack of feed and water (Hancock 1930). The breeds introduced in 1788 reflected the origins of the colonial settlers, and comprised Dairy Shorthorn and Devon cattle from England, and Dexter cattle from Ireland.

While the pioneers who established the first Australian herds encountered a range of environmental challenges, by the mid 1800s the industry had begun to establish itself as a viable provider of meat and dairy products for local markets. This was largely as a result of improving knowledge about climatic conditions, disease and pest risks, and the gradual influx of individuals with farming experience from Britain (Cameron 1981; Henzell 2007). Indeed, one of the priorities in early settlement schemes was to increase the level of migration amongst British farmers to improve the agricultural capacity of the early colonies (Crowley 1960). The outcome was a transfer of farming knowledge and practice from Britain to Australia, which produced a system of agriculture that closely resembled the small farming systems that the colonising farmers had experienced in their homeland. In many respects, this represented the diffusion of forms of agricultural innovations out of one geographical context (Great Britain) and into another (Australia).

This diffusion incorporated both farming practice and the commodities at the centre of much British agricultural production. In the case of cattle, the first half of the 1800s saw a number of British breeds being progressively introduced. These included the Beef Shorthorn[1] (1825), Shorthorn (1825) and Hereford (1826), all from England, and the Angus (1820) from Scotland. The only exception to this British dominance was the introduction of Zebu cattle from India in 1800, although of course there was a strong link here with another part of the wider British Empire. While the breeds introduced into Australia during the first 40 years or so of European settlement were strongly influenced by colonialism and the characteristics of the new settlers, there also appear to have been

[1] In this paper, all dates of cattle introductions to Australia are taken from Parsons (2003) and Chambers (2007).

more pragmatic reasons for their breed selections. In all cases, the preferred cattle types were widely regarded as hardy and capable of adapting to a range of different conditions (see Parsons 2003). This was particularly important in a region where the level of formal scientific support for farming was minimal and veterinary care was generally limited to what farmers themselves could provide. With the exception of the Zebu, the breeds were also good producers of both milk and meat. In the case of the Zebu, its capacity to thrive in hot tropical conditions, and its resistance to Australian flies and parasites, made it a particularly attractive proposition to the gradually expanding pastoral industry in the north of the country.

A further wave of cattle migrations occurred around the 1850s, with the introduction of Ayrshire (1848), Highland Cattle (1850) and Galloway (1858) from Scotland, Red Poll (1850) from England, Jersey (1850) from the Channel Islands, and the Holstein (1850) from the Netherlands. Again, throughout this period the dominance of British breeds continued, with only two breeds originating from elsewhere. This theme continued until the onset of the Great Depression, with a further two British breeds being introduced (Lincoln Red and South Devon, both in 1900). The only other breeds introduced before 1930 were the Guernsey (Channel Islands) and the Poll Hereford (USA, but clearly an adaptation from an English breed). Thus, by the start of 1930, of the 19 breeds of cattle that had been introduced to Australia, only five originated from places outside the British Isles, although these might still be regarded as 'culturally British'.

The nature of cattle migrations during the first 140 years or so of settlement needs to be understood from more than a colony/coloniser perspective. Underlying the development of the Australian cattle industry, and shaping its character, was a complex set of socio-cultural, political and economic interactions. Of particular significance is how these interactions played out in agricultural and settlement policy. For much of this period, colonial policymakers were captivated by particular constructs of both landscape and farming practice (Tonts 2002). According to Anderson (2003), successful farming reflected a triumph of settler society over nature. Thus, embedded in the discourse of much settlement policy is a desire to establish small yeoman farms and agricultural landscapes reminiscent of England (Cameron 1981). As Powell (1988) points out, the most important characteristic of this landscape was that farms were freehold properties, family operated and cultivated.

This ideal was strongly reflected in government policy. For example, in Western Australia, which was largely typical of most other Australian colonies in its agricultural policies, the final report of a Royal Commission on Agriculture held between 1887 and 1891 argued for the continued promotion of small scale farms "in an advanced state of cultivation" (Commission on Agriculture 1891, p. 11). The report went on to argue that no farm should be without cattle and that, in most cases, British breeds were superior in both meat and dairy production. The Royal Commission also advocated continued migration from England, with the Premier of the day, Sir John Forrest, going on to call for the establishment of "a bold peasantry, their country's pride, men of small means but strong arms and stout hearts" (PDWA 1893, p. 230). Forrest was also in little doubt

about where these people should come from, claiming "…and we should continue to look to the rural counties of England, Scotland and Wales to build this new society". While the development of an extensive grains industry from the early 1900s saw the rhetoric shift toward a larger scale of operation in that sector, in the dairy industry these colonial discourses were maintained until at least the 1920s (Bolton 1981), and remained firmly wedded to the notion of establishing relatively small farms with British migrants, technologies and practices.

In the context of the theories of diffusion of innovations, both knowledge flows and local receptiveness appear to have been important in shaping the pattern of cattle introductions to Australia during this colonial period. Local knowledge of innovations (in this case, of particular cattle breeds) was largely influenced by new agrarian settlers, the majority of whom were from Great Britain (Crowley 1960). At the same time, this created a socio-cultural context that was receptive to the introduction and use of British breeds. While the number of migrants originating from rural areas is unclear, there is evidence that those with some agricultural experience helped shape early farming practices. In effect, a situation was created in which new farmers were simply continuing with practices, traditions and even livestock that reflected their histories and experiences.

It is also apparent that there was institutional opinion and influence regarding the apparent benefits of British breeds, with various government reports and policies actively promoting their use. Thus, government helped to create an environment that was receptive to the introduction of British breeds and, indeed, actively supported this

process. More pragmatically, the breeds introduced in the first 140 years of settlement were well attuned to local ecological conditions and market demands. Not only were the introduced breeds resilient and adaptable (Parsons 2003), but it is likely that local tastes meant that there was a market for beef with similar textures and flavours to those then available in Great Britain. Indeed, as Robinson (2004) points out, there is a long history of migration resulting in the transplanting of food tastes and therefore of production systems.

**The Innovative Phase, 1930s – 1970s**

By the 1920s and 1930s, Australian agriculture was in a process of transition (Davidson 1981). Much of this was linked to the changing technological and scientific bases of farming, with increasing use of large-scale farm machinery, artificial fertilisers, improvements in pest and disease control, and state-sponsored plant and animal breeding programmes. However, it was also a period of substantial economic upheaval. Even before the onset of the Great Depression, farmers were facing a worsening cost-price squeeze[2] and were actively searching for ways of increasing productivity and reducing input costs (Burvill 1979). Perhaps the most significant shift emerging out of these intersecting technological, scientific and economic factors was the move towards larger and more intense farming systems. In many respects, the antecedents of the highly productivist 'factory farming' model that has dominated Australia since the 1940s can be traced to this period of adjustment (Mauldron and Schapper 1974).

[2] A situation in which the cost of farm production rises at a faster rate than the prices received for commodities.

In the cattle industry, this shift was reflected in the increasing size of both properties and holdings. It also contributed to the emergence of new breeds that were better suited to environmental and market conditions. One of the major priorities of Australian governments during this period was to increase agricultural activity in northern Australia, where tropical conditions had hindered the development of a more productive beef cattle industry. Most of the British breeds introduced during the colonial phase of agricultural expansion were unsuited to these conditions, and while the Zebu had been introduced in 1800 as a means of increasing production in the north, its adoption had been limited (Parsons 2003).

This challenge to expand cattle in northern Australia contributed to a vastly different pattern of cattle migration from that which had dominated the first century and a half of white settlement. Rather than British or European breeds, the focus shifted to breeds from those parts of the world with similar environmental conditions to northern Australia. The first of these new introductions were Brahman, brought to Australia from the United States in 1933. These were heat and drought tolerant, and well-suited to the tropics. While the Great Depression and World War II saw cattle migrations cease for nearly two decades, in the period between 1950 and 1960 four new breeds were introduced to increase beef production in arid and tropical regions: Africander (1950) from South Africa; Sahiwal (1950) and Sindhi (1954) from Pakistan; and Santa Gertrudis (1952) from the United States. The only other breed introduced during this period was the

British White (1958), which tends to be most common in temperate regions and used as a dual producer of beef and dairy products.

One of the central drivers of these new breed migrations was the Commonwealth Scientific Industry Research Organisation (CSIRO). During the post-war period, this government body played a critical role in improving the scientific and technological bases of agriculture in Australia, largely through its research and development activities. Working in collaboration with State government departments for agriculture, the CSIRO also played an active extension role, using demonstration farms, field visits with farmers, and various publications to promote and diffuse innovations at the local level. The CSIRO's research into livestock breeds suited to northern regions ultimately contributed to their introduction to Australia. In effect, the CSIRO was the conduit to the diffusion of these new cattle breeds into Australia. In Hagerstrand's (1967) terms, CSIRO not only enhanced information flows across geographical space but increased local receptiveness by both introducing new breeds and then demonstrating their potential at the local level. However, evidence presented in Parsons (2003) suggests that, in addition to the activities of the CSIRO and State government agencies, it was often individual cattle enthusiasts who 'championed' new breeds and contributed to their adoption at the local level. As Black (2000) has suggested, it is often these individuals and their social networks that played a critical role in diffusing these innovations beyond an institution (see also Vanclay 2004). To date, however, virtually no research has examined these champions, their social networks and the associated local and regional geographies of diffusion in Australia's livestock industry.

Institutional innovations in cattle production were not limited to the migration of breeds from other parts of the world. The post-war period also saw a number of government agencies establish cross-breeding programmes aimed at developing indigenous breeds that were suited to Australian environments, and particularly to tropical and arid conditions. However, it was not only institutions that led innovation in this area, but also individual breeders. Indeed, of the seven indigenous breeds developed between 1930 and 1962, four were created by individual breeders.

While Australia's first local breed, the Murray Grey, was produced in 1905 through a chance mating of Shorthorn Cows and Angus bulls, cross-breeding programmes by individual breeders resulted in the development of two new breeds in 1930: the Illawarra in New South Wales, and the Droughtmaster in Queensland. The Illawarra was developed as a dairy breed, and includes bloodlines from a range of British and European breeds, although breeding programmes tended to revolve around Shorthorn and Ayrshire cattle. The Droughtmaster, by contrast, was bred as part of an effort to expand beef cattle production in the tropical and arid areas of Australia. Essentially, Droughtmaster cattle are a blend of Zebu, Shorthorn and Brahman bloodlines (Figure 3). The outcome was a breed that incorporated the Shorthorn's high meat yield, but that could tolerate heat, drought and local parasites. Importantly, the development of this breed represented the start of a concerted effort to develop cattle that would thrive in some of Australia's more difficult environments.

Following World War II, these cross-breeding endeavours benefited from programmes established by government agencies. The outcome was the development of the Adaptaur and the Australian Milking Zebu by CSIRO in 1950, and the Australian Friesian Sahiwal by the Queensland Department of Primary Industries in 1960. These institutional programmes were accompanied by the continuing efforts of individual breeders, with the Simbrah developed in 1960 and the Braford in 1962 (also in Fig 3). Typically, these breeding programmes blended a number of desirable characteristics of British breeds (e.g. high meat yields per carcass) with the qualities of some of the tropical/arid area breeds (e.g. drought and heat tolerance, disease and parasite resistance). Figure 3 provides a summary of the blends of selected indigenous breeds developed during the 1950s and 1960s.

[INSERT FIGURE 3 ABOUT HERE]

Cross-breeding also led to the establishment of two other breeds now represented in Australia, the Brangus (1961) and the Charbray (1969). These were not, however, indigenous breeds, since both were originally developed in the United States. In both cases, it was the import of a 'breed standard' (effectively a set of standards defined by breed societies against which a breed is classified) that underpinned their development. In the case of the Brangus, the breed was developed by crossing Angus and Brahman cattle, while Charbray is the result of crossing Brahman with Charolais. The development of these breeds is significant in terms of innovation diffusion, in that they represent the movement of what is, in effect, a 'blueprint' (i.e. the breed standard) from

one part of the world to another. This movement of intellectual knowledge alone is a significant change from earlier patterns, where the flows invariably consisted of both knowledge and livestock.

The rise of various cross-breeding programmes in the 1950s and 1960s partially coincided with an embargo on live cattle imports into Australia between 1958 and 1981. Only live cattle from New Zealand could be imported to Australia during this period. The embargo, introduced to prevent the introduction of blue-tongue disease into Australia, meant that new breeds had to develop locally. As a result, no further cattle breeds were introduced to Australia through live migrations until the early 1980s. This meant that Australia had become 'locked in' to using the 29 breeds that had been introduced or developed prior to the embargo. This presented a number of major challenges to the beef industry in particular, which struggled to remain internationally competitive in the late 1960s and early 1970s (Smith and Smith 1979). Australia's cattle herd, based largely on British and tropical breeds, was not well suited to the increasing demand for grain-feed beef in the rapidly growing Japanese and South Korean markets. In addition, largely as a result of growing awareness of health and dietary issues, domestic demand for low fat beef was also influencing cattle markets. While selective and cross-breeding programmes played an important role in adjusting the national herd to suit market requirements, the industry's responses were limited by the import embargo. In effect, this acted as a barrier to the adoption of innovations (i.e. new breeds) that would improve productivity and profitability. From the perspective of local

receptiveness to an innovation, it was not a lack of knowledge or appropriate socio-cultural conditions that prevented diffusion, but a regulatory barrier.

This impasse was overcome in the late 1960s with the development of artificial insemination technologies. In essence, a new technical innovation paved the way for the introduction of more innovations in the form of new breeds. As a result, between 1969 and 1976 a total of 12 new breeds were introduced using this technology (Table 1). The majority of these originated in continental Europe, and have a number of common traits, including high growth rates, high meat yields per carcass, and either fine textured lean meat or meat suitably marbled for the Japanese market. Importantly, these breeds were not only used as meat (and dairy) producers in their own right, but were often incorporated into cross-breeding programmes to improve the characteristics of other established breeds.

*[INSERT TABLE 1 ABOUT HERE]*

**A Multifunctional Phase? Mid 1970s - present**

Since the mid 1970s, the Australian cattle industry has consolidated and improved its productivity and international competitiveness (Clark *et al.* 1992). The liberalisation of markets in North Asia and North America has contributed to increasing export opportunities, particularly for beef cattle. At the same time, the diversification of food tastes within domestic and international markets (see Atkins and Bowler 2001) has

ensured that the national herd continues to diversify. One of the most significant reasons for this is the growing emphasis on food quality and consistency. This not only reflects the demands of consumers, but also the retailers and processors that interact directly with farmers. At the farm level, the outcome has been a range of innovative breeding programs and cattle introductions aimed at ensuring both consistency and high standards. In many respects, this represents the role of the diffusion agents discussed by Brown (1981), whereby a combination of market factors and institutional agents influence the nature of production. Of particular importance are the contractual and pricing arrangements between retailers, processors and farmers which, in combination, are shaping the nature of production at the farm level. This all tends to run counter to Euro-centric views that agricultural might be moving to a post-productivist phase. Indeed, the evidence from Australia suggests that cattle farming is becoming increasingly productivist. Levels of production per unit area have continued to increase across much of the tropical and arid zones (Holmes 2002), while intensive feedlot production is also increasing rapidly (Tonts *et al.* 2003).

Since 1979, a total of 17 new breeds have been introduced to Australia with the direct aim of increasing production. The consolidation of beef farming in tropical areas was reflected in the introduction of a number of breeds well suited to such environments, including the Wagyu (Japan, 1988), Boran (East Africa, 1990), Tuli (Zimbabwe, 1990), Bonsmara (South Africa, 1998) and Senepol (Caribbean, 2000). In addition to thriving in tropical conditions, these breeds produce high quality meats that are well-suited to North Asian markets (Parsons, 2003). Other highly productive breeds were also introduced to

help meet the demands of these markets, including Salers (France, 1985), the Belgian Blue (Belgium, 1988) and Piedmontese (Italy, 1989).

While Australian cattle farming shows few signs of moving into a post-productivist phase, it does show considerable evidence of multifunctionality (Wilson, 2001; refs). The drive towards higher levels of production in some parts of the cattle industry and in certain regions is in part countered by a shift towards smaller scale and, in some cases, 'lifestyle agriculture' (Barr 2005). As Argent *et al.* (2007) have pointed out, across many of the more accessible and high rainfall parts of Australia, there has been a growing influx of amenity migrants, many of whom have become involved in small scale agriculture (see also Bunker and Houston 2003; Halpin 2004; Barr 2005; Houston 2006). This represents a growing complexity of the Australian agricultural landscape, and is consistent with view that rural spaces are becoming increasingly multifunctional, with highly productivist activities being accompanies by alternative land uses (see Holmes 2002; 2006; Smailes 2002; Borkhaug and Richards 2008).

The emergence of these smaller farms has been linked to the development or introduction of a number of relatively docile and easy to manage breeds, including the Lowline (Australia, 1974), Welsh Black (Wales, 1980), Square Meater (Australia, 1996) and Miniature Hereford (United States, 1997). The Dexter, originally introduced in 1788, has also regained popularity. In a number of cases, such as the Lowline and Miniature Hereford, cattle were specifically developed by enthusiast breeders for the small-scale, lifestyle farms.

In terms of innovation, breed development during the multifunctional period reflects changing market demand, as well as the more complex shifts occurring in agricultural regions. Patterns of innovation diffusion in the highly productivist segments of the industry appear to have followed an established pattern over this period. This includes the introduction or development of new breeds to tackle particular environmental and market conditions. At the same time, in the less productivist, smaller-scale segments of the industry, breeds have been introduced or developed that suit different landscape conditions (i.e. small holdings) and farmer characteristics (e.g. lifestyle producers). It is also clear that the geographical pathways of innovation diffusion have further diversified. While the colonial period was dominated by British breeds, and the productivist phase focussed on tropical, indigenous and European breeds, the multifunctional period has drawn from extremely diverse source areas, including Japan, Africa, the Caribbean, the United States, Britain, and Australia. In furthering this research agenda, more needs to be known about the processes involved here, including the role of institutions, key individuals, social networks, and economic imperatives.

**The Situation Today: Innovation or Destruction?**

So far, this paper has considered the introduction and innovation of cattle breeds. It has given the impression that the Australian national herd is diverse and diffuse. While many breeds have indeed been introduced to Australia both in the early stages of European settlement and more recently, there is a strong reliance on not only a handful of key

breeds, but a very narrow genetic pool. In 2003, Holstein cattle accounted for 70 per cent livestock in the dairy sector (Chambers, 2004), Jerseys accounted for 10 per cent and Jersey-Holstein crosses a further four per cent. Given that a further 13% of animals in the national dairy herd were of an 'unknown breed', other recognised breeds only accounted for three per cent of Australia's national dairy herd. The beef sector showed marginally more variety with British breeds (especially Herefords and Angus animals) accounting for 57 per cent of the national herd; tropical breeds (particularly Brahman and Santa Gertrudis) for 19.3 per cent and European (Charolais, Limousin and Simmental) for 12.3 per cent of beef breeds. All of these dairy and beef cattle are the most efficient and productive animals in their class and location, lending weight to Evans et al's (2002) assertion that a supposed transition from productive to post-productive agricultural regimes may have been exaggerated. Clearly the economies and discourses of productivism dominate the Australian cattle industry. One of the issues associated with this highly productivist system is that in-breeding of animals is reducing the genetic pool of Australian livestock, a trend also common in North America (Chambers 2004). Although data on this issue are complex, it appears that rates of in-breeding are increasingly leading to concerns for the long-term health and vitality of the national herd.

The overall picture is one of a national herd dominated by a handful of breeds, and a large number of 'boutique' and even rare breeds. For Schumpeter (1934), the decline and/or marginality of these minority breeds, or their failure to be adopted widely, represents the process of 'creative destruction'. He argues that part of the creative process within capitalism means that new innovations by necessity destroy (or make

redundant) inefficient technologies. In the case of cattle, this means that some breeds lose favour to those that have attributes that are more suitable in particular environments or markets. Of course, the creative destruction concept only partly explains why some breeds become rare or extinct. In some cases, the level of adoption at the local level may be relatively low following the introduction or development of a breed. This may be because of a lack of information about a breed, or low levels of local receptiveness or, quite simply, fashion or 'taste' (Yarwood and Evans 2006). Consequently the popularity of some animals can fluctuate. Over recent years, for example, Angus animals have been more popular than Herefords and Red Polls. There continue to be high numbers of each breed and so their relative popularity may simply reflect changes in fashion and/or short-term market fluctuations.

Although no breeds of cattle introduced to Australia appear have been lost to the country (Chambers 2007), some are perilously close to local extinction and the decline of some of these livestock breeds has prompted greater interest in rare breeds in Australia. Table 2 summarises cattle breeds that have reached very low levels based on assessments undertaken by the Rare Breeds Trust of Australia (RBTA). The RBTA has identified a number of Australian breeds that have become scarce, including the Milking Zebu, Adapteur, and Belmont Red. Interestingly, protected breeds from outside Australia are almost exclusively of British origin and date to the colonial phase of the development of the cattle industry. This suggests that British breeds are still highly valued in Australia, reflecting a longstanding colonial legacy. Some breeds that originated in Britain are classed as rare in Australia, such as Devon Cattle, although they are not classed as such in

their country of origin. By contrast animals with low and falling registrations that do not originate from Britain have not, as yet, been afforded protected status. For example tropical breeds such as Tuli, Boran, Chiangus, and European ones, such as Belgium Blue and Brauvieh, all show very low registrations. One explanation for these discrepancies might be that at least some of these breeds are relatively new introductions and are expanding from a low base rather than declining (as is the case for Wagyu cattle (Parsons 2003)).

*[INSERT TABLE 2 ABOUT HERE]*

Although the geographies of rare breeds often show local associations (Yarwood and Evans, 2006), the preservation of rare livestock breeds is now an international movement with societies in many countries following the lead of the Rare Breed Survival Trust (RBST) in the UK. Although genetic diversity and farming sustainability are important to the RBST, the RBTA places more emphasis on these dimensions and highlights that 'food security is the RBTA's overarching objective and encouraging biodiversity is one of its primary goals' (Chambers 2004, p.5). However, if this is the case, the RBTA should perhaps pay more attention to breeds that are non-British in origin.

**Discussion and Conclusion**

This paper has traced the introductions of cattle breeds to Australia. In doing so it has highlighted a number of factors that are important to the expansion of the number and diversity of cattle breeds in Australia. Although other papers have considered these issues at national scales, the Australian example has fore-grounded the importance of global linkages in geographies of livestock and, more generally, of farming practices. Moreover, it suggests that understanding these global linkages and the pattern of introduction can be understood with reference to the literature on processes of innovation diffusion.

Reflecting on the theoretical perspectives developed initially by Hagerstrand (1967) and extended by other agricultural geographers in the 1960s and 1970s, it is clear that both information networks and the decision-making processes of individual farmers are critical in shaping the spread of cattle breeds. It is also apparent that processes of innovation diffusion operate not only within particular regions and nations, but at a wider global scale. The spread of information within the British Empire, and later, within new network forms played a crucial role in the pattern of cattle migration and development. However, it is also clear that there are strong institutional and market-based elements to this process, consistent with the work of Brown (1981). The role of breed societies and research organisations (such as the CSIRO) in contributing to cattle migrations and development has been crucial in the Australian context. This is particularly evident in the focus placed on tropical breeds, where cattle imports were not simply about agricultural production, but also the economic development of northern Australia. As Crown (1975) has suggested, these institutional dimensions are coupled with market signals. Thus, changing consumer demand and the emergence of new international markets has

contributed to the import and/or development of breeds to cater for these new tastes and economic opportunities. This paper has just touched on some elements of the way innovation diffusion processes might operate at wider scales, and clearly there is a need for more detailed analysis and conceptual work in this area.

It is also apparent that the process of innovation diffusion at the global scale needs to be understood against a broader socio-cultural background. For example, the ongoing interest in British breeds seems to reflect not only the productive capacity of these animals, but an enduring cultural legacy linked to an agricultural system that emerged under Empire. Yet, the growing popularity of other European, tropical and Australian breeds points to underlying changes not only in the economic structure of farming, but also its cultural orientation. Thus, cattle migrations and development in an Australian context needs to be understood as an outcome of complex and dynamic economic, socio-cultural and institutional factors. Based on the analysis in this paper, five main factors can be seen to have influenced the introduction and the geographies of livestock breeds in Australia, namely: the colonial legacy; climatic conditions; state policy; individual enthusiasts and breed societies; and international trade relations.

The story of Australia's cattle industry reflects the country's broader ambivalence over its colonial past whereby an acknowledgement of the formative nature of British influence on the country has consistently been moderated by a desire to achieve a distinctive Australian identity. Almost all the rare cattle breeds over which concerns have been officially expressed are British in origin and Britain has provided Australia with more

imported cattle breeds than any other overseas country. Nevertheless, members of these breeds were initially transported to a very different environment and, within the space of less than a century, Australian pastoralists were attempting to establish a cattle industry in the arid and tropical parts of the country's north. In these circumstances it was inevitable that farmers would look to import cattle from analogous environments overseas, such as India and Africa, and that both colonial/state and federal governments and individual breeders would seek to facilitate the development of such characteristics as tropical disease resistance, drought tolerance and easy birthing in new Australian cattle breeds more suited to the "sunburnt country" of Dorothea McKellar's (1906) imaginary. These processes of diffusion and innovation – and of diffusion of innovation - were readily apparent in Australia's first century or so of white settlement and all have continued to operate up to the present.

In more recent decades, however, further forces have come into play as Australian agriculture has become increasingly deregulated and increasingly integrated into global circuits of trade and knowledge. At one extreme this has allowed individual breeders to follow their enthusiasms to introduce or to create what might be termed boutique cattle breeds, several of which have particular appeal to hobby farmers. At the other, it enables the vast majority of commercial cattle farmers to study and, through the composition of their herds, to respond to a range of market demands and tastes. While these might include designer products, such as organic, or Wagyu beef, Australian cattle production overall remains firmly focussed on mass market orientation and thus on the maximisation of output. In these circumstances, a geography in which different breeds may be most

suited to specific environmental conditions emerges to a certain extent, particularly in relation to beef cattle where a clear tropical/temperate divide is evident.

In addition to providing a long term and long distance agricultural case study of the diffusion of innovation, this paper has also shed light onto some of the changes in Australian agriculture and, more broadly, on current debates in agricultural geography, in particular those relating to post-productivism and multifunctionality. Holmes (2002) queried whether the changes occurring in Australia's rangelands represented 'a post-productive transition with a difference?'. At a time when the genetic diversity of livestock breeds has the potential to become a major food security issue, it would be useful to know just how 'different' the changing geographies of cattle breeds in Australia are from those in other settler – and non-settler - societies.

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Figure and Table Captions

Figure 1 Country of Origin of Cattle Breeds in Australia

Figure 2 The Introduction of Cattle Breeds to Australia (cumulative frequency)

Figure 3 Development of Selected Australian Breeds of Cattle

Table 1 Breeds Introduced Via Semen Imports, 1969-1976

Table 2 Rate Cattle Breeds in Australia

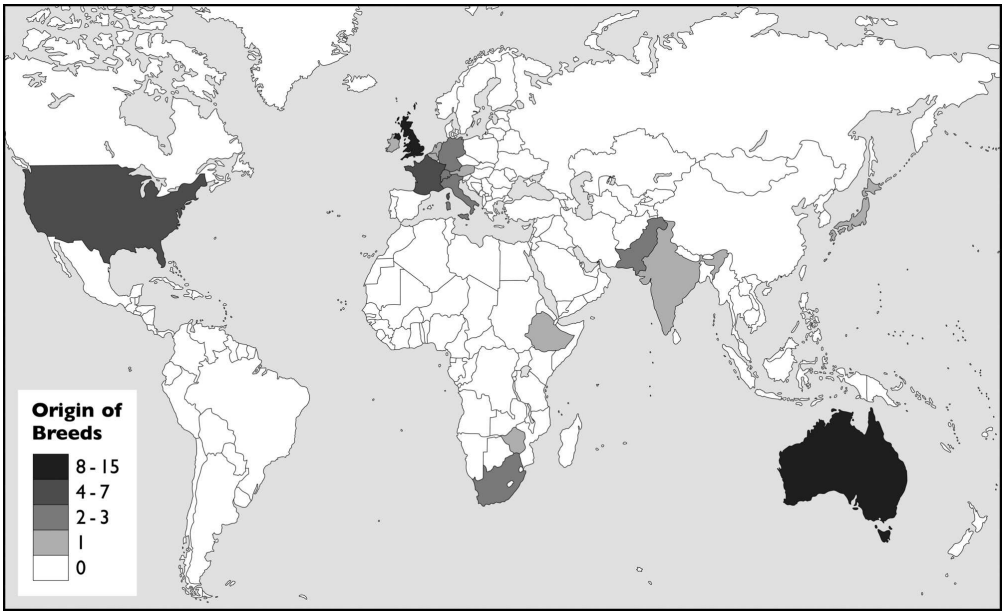


Figure 1 Country of Origin of Cattle Breeds in Australia
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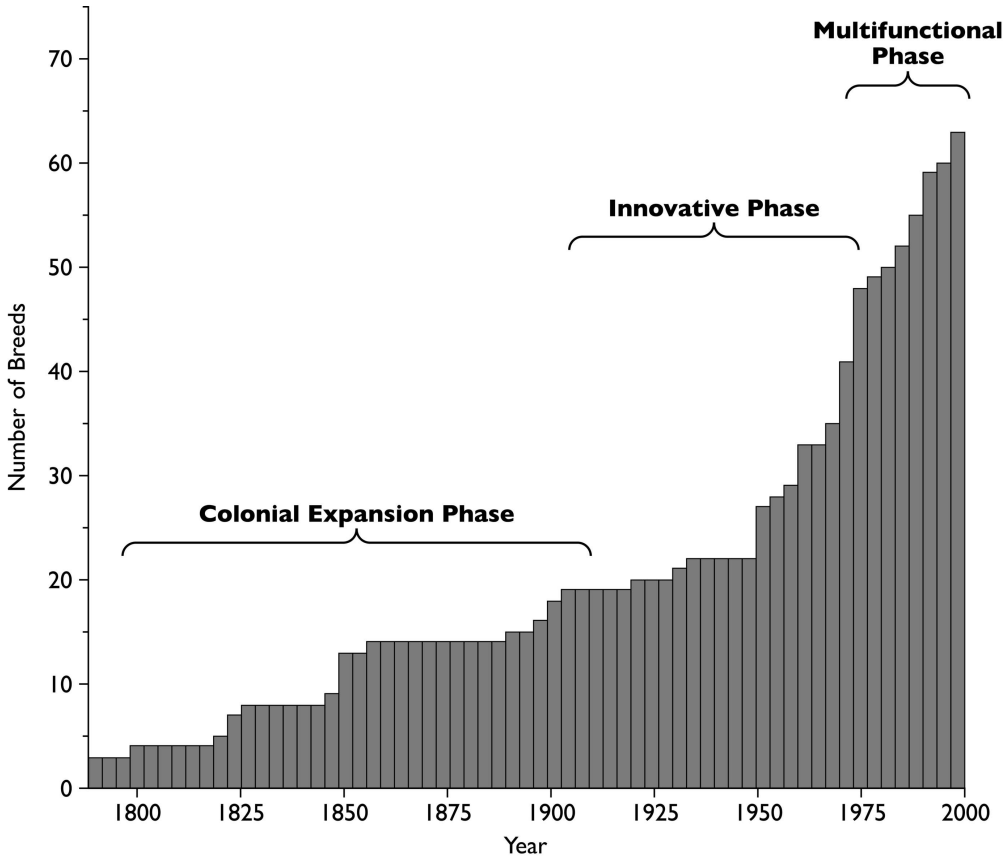


Figure 2 The Introduction of Cattle Breeds to Australia (cumulative frequency)
117x99mm (600 x 600 DPI)

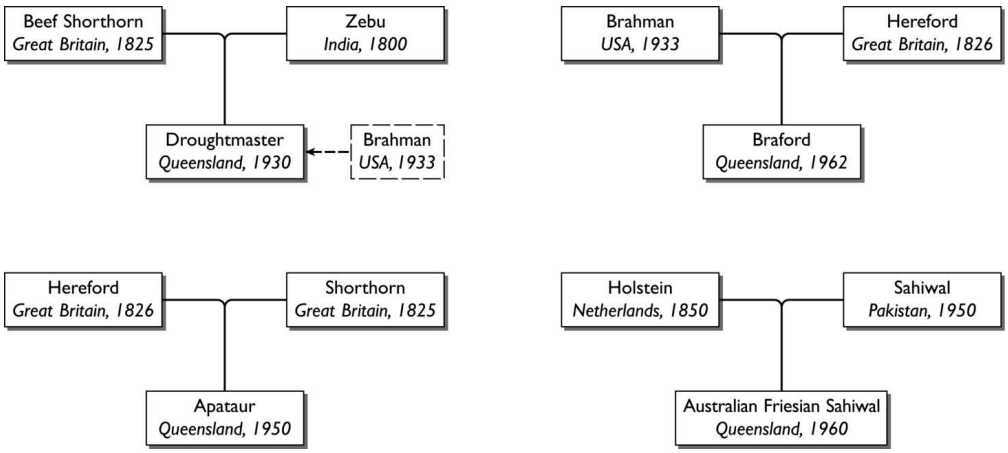


Figure 3 The Development of Selected Australian Breeds of Cattle
61x27mm (600 x 600 DPI)

**Table 1 Breeds Introduced Via Semen Imports, 1969-1976**

| Breed | Year of Introduction | Place of Origin |
|---|---|---|
| Charolais | 1969 | France |
| Simmental | 1971 | Switzerland |
| Blonde d'Aquaitaine | 1972 | France |
| Braunvieh | 1972 | Germany/Austria/Switzerland |
| Limousin | 1973 | France |
| Maine Anjou | 1973 | France |
| Brown Swiss | 1974 | Switzerland |
| Chianina | 1974 | Italy (via Canada) |
| Belted Galloway | 1975 | Scotland |
| Chiangus | 1975 | United States |
| Romagnola | 1976 | Italy |
| Glebvieh | 1976 | Germany |

**Table 2 Rare Cattle Breeds in Australia**

| Breed | Approximate Date of Origin in Aust. | Place of Origin | Status |
|---|---|---|---|
| Adaptaur | 1950 | Aust. (Queensland) | Critical |
| Australian Friesian Sahiwal | 1960 | Aust. (Queensland) | Vulnerable |
| Australian Milking Zebu | 1950 | Aust. (Queensland) | Critical |
| Beef Shorthorn | 1825 | Britain | At Risk |
| Belmont Red | 1979 | Aust. (Queensland) | At Risk |
| British White | 1958 | Britain | Critical |
| Devon | 1788 | Britain | At Risk |
| English Longhorn | c1860 | Britain | Vulnerable |
| Galloway | 1858 | Britain | At Risk |
| Red Poll | 1850 | Britain | At Risk |
| Traditional Angus | 1820 | Britain | Endangered |
| Traditional Dairy Shorthorn | 1788 | Britain | Endangered |
| Traditional Hereford | 1826 | Britain | Endangered |
| White Park | 1988 | Britain | Critical |

(Source: Chambers 2007)