WHERE HAVE THE FAMILY FARMERS GONE?
CLIMATE CHANGE AND FARM LOSS IN THE
WESTERN AUSTRALIAN WHEATBELT

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Abstract
The Western Australian Wheatbelt has experienced the most abrupt and significant climate change in Australia. Since the 1970s, the regional climate has become drier and increasingly variable, with agricultural production and farm business profitability negatively impacted as a result. Running in parallel to these trends, the Wheatbelt has experienced a near three-fold decline in farm numbers over the same period, falling from 13,106 in 1970 to 4,941 in 2013. Typically, changes in the social make-up of Australia’s rural regions are attributed to changes in the economic or the policy environment. However, as a region highly dependent upon seasonal weather patterns, changes in the socio-economic structure of the Wheatbelt are also likely to be driven by climatic changes. To explore this assertion, a ‘resilience analysis’ is conducted to examine how climate change – both at a regional and a global scale – has interacted with other socio-ecological processes to drive farm loss in the Wheatbelt. This article demonstrates that climate change is exposing and exacerbating vulnerabilities within the structure of the Wheatbelt (conceived as a socio-ecological system) which, in turn, is undermining the viability of traditional modes of family farming and forcing many farmers out of the agricultural sector. Findings from this article suggest that governing for improved agricultural efficiencies may be maladaptive in the context of complex socio-ecological change, and that ‘transformational’ approaches to adaptation will be required if families are to remain the cornerstone of agriculture in the Western Australian Wheatbelt.

Keywords: climate change, resilience, adaptive cycle, Western Australia, Wheatbelt, family farming, agriculture

1.0 Introduction
Anthropogenic climate change is driving undesirable transformations in natural and social systems across all scales (IPCC 2013). Rising average temperatures, shifting rainfall patterns and more violent weather extremes are already exacting significant costs upon climate-sensitive environments, economies and communities. Amongst those positioned on the frontline of these mounting climate risks are people engaged in agriculture. Agriculture has been identified as a human activity uniquely exposed to climate change risks due to its dependence and sensitivity to seasonal variability and longer-term patterns of climatic change (Stokes and Howden 2010; IPCC 2014). A growing number of studies are showing that climate change is already detrimentally impacting agricultural production, with some regions
more affected than others (Asseng et al. 2013; Lobell et al. 2008). The potential for these trends to worsen presents significant risks to global food security and human wellbeing (Ingram, Ericksen, and Liverman 2010; IPCC 2014).

Much of the research to date regarding climate change and agriculture has focused on the twin issues of food production and food security. Faced with a rapidly growing population, the degradation of the Earth’s arable land, and the looming prospects of heightened price shocks and sustained food shortages, climate change threatens to exacerbate existing food security issues and to produce new risks to food-insecure populations (Ingram, Ericksen, and Liverman 2010; IPCC 2014). Although food security and food production are especially important areas of inquiry, particularly given the foundational importance of agricultural production for human wellbeing, relatively little research has examined how climate change may be transforming the socio-economic structures that have historically constituted agricultural regions, communities and cultures in developed countries.

Communities that are dependent upon a narrow range of ecological resources for their livelihoods, lifestyles and social structures, such as those involved in agriculture, are likely to be particularly exposed and sensitive to environmental change (Adger 2000; Marshall 2010). In Australia, this is especially the case for broadacre family farmers operating in the Western Australian Wheatbelt. Located on the south-western tip of the Australian continent, the Wheatbelt is a vast agricultural region comprising some 4,900 broadacre farming enterprises stretched across 13.5m hectares of agricultural land (Trestrail et al. 2013). The majority of the region’s farming enterprises are family owned and operated, and consist of rainfed broadacre cropping/livestock systems. Due to the rainfed nature of the farm systems employed, seasonal variations in rainfall and temperature have large bearing on the financial viability of individual farm businesses and the socio-economic condition of Wheatbelt communities.

Although the Wheatbelt is not unique in the Australian agricultural context, both in terms of its socio-economic composition or its dependence upon seasonal weather patterns, the abrupt and significant climatic changes experienced in the Wheatbelt over the last four decades sets it apart as a region located on the leading edge of climate change risk in Australia. Since the 1970s, growing season rainfall (May to October) has declined at least 20 percent against the long term historical average, with the majority of the drying trend occurring in the early winter months of May and June (Indian Ocean Climate Initiative [IOCI], 2012). Since 2000,
the winter drying trend has intensified and geographically expanded, indicating the stepwise nature of climate change in this region (IOCI 2012). September frost risk and seasonal variability (rainfall and temperature) have also intensified since 2000. Moreover, average temperatures throughout the Wheatbelt have increased by 0.8°C since the 1950s, producing an increased frequency and intensity of heatwave events. When considered together, these climatic changes present complex risks to the productivity and profitability of the Wheatbelt family farming sector (Kingwell et al. 2013).

Running in parallel to these trends, dramatic changes have occurred within the socio-economic structure of the Wheatbelt over the last four decades. As shown in Figure 1a on the next page, the number of farm establishments operating in the Wheatbelt has decreased from 13,106 in 1970 to 4,941 in 2013 – almost a three-fold decline. The rate of farm loss has varied considerably over this period (see Figure 1b): the average rate of farm loss reached 352 per year in the 1970s, before halving in the 1980s, and halving again in the 1990s. The rate of farm loss then doubled in the 2000s, coinciding with the second stepwise shift in the regional climate. Farm numbers then recovered somewhat in the period 2010-2013.

The declining number of family farms in the Wheatbelt over the last four decades suggests that pervasive forces have either undermined farmers’ capacity to retain their financial viability or their willingness to remain within the agricultural sector. While it has been recognised that climate change poses risks to the productivity and profitability of Wheatbelt family farming enterprises (e.g. Kingwell et al. 2013; Farre, Foster, and Asseng 2009; Asseng, Foster, and Turner 2011), little (if any) research has considered how climate change has impacted the socio-economic structure of the Wheatbelt. Within the broader Australian context, rural population decline is typically attributed to changes in the economic or policy environment rather than changes in the biophysical environment. Indeed, much has been written on the introduction of neoliberal agricultural policies and their negative impacts on the financial sustainability of family farmers and rural communities (e.g. Lawrence 1987; Alston 2004; Pritchard 2005a, b) while little attention has been given to the impact of chronic environmental change on the socio-economic structure of these same areas. This is problematic, as farm communities coevolve with their natural surroundings (Waltner-Toews and Wall 1997) and, as such, by overlooking environmental change as a driver of socio-economic transformation is to potentially overlook one of the most powerful drivers of social and economic change affecting rural regions.
Because there is broad desire across the Australian community and within political circles to retain families as the ‘cornerstone’ of Australian agriculture (Commonwealth of Australia 2015, 2), there is a need to understand how climate change has impacted, and is likely to impact into the future, the socio-economic structures of rural Australia. The purpose of this paper, therefore, is to examine to what extent climate change can be said to be driving farm loss in the Wheatbelt, and whether the current policy environment is able to ensure the continued viability of family farming into the future under mounting climate risk. To do so, this paper details findings from a recently completed ‘resilience analysis’ of the Wheatbelt (conceived as a large-scale socio-ecological system [SES]).

Fig 1. The number of farm establishments operating in the Wheatbelt. (a) Trends in the number of farm establishments in the Wheatbelt 1970-2013. Gaps indicate lack of data. (b) Average rate of farm establishment loss per year 1970-2013. Data 1970-1989 sourced from respective Western Australia Year Books. Farm numbers derived from the total number of establishments operating in the ‘Lower Great Southern, Upper Great Southern and Midlands statistical divisions. Data 1990-2013 sourced from Dept. of Agriculture (AgSurf: http://apps.daff.gov.au/AGSURF/). Farm numbers derived from the total number of farming establishments operating in the ‘Central and South West Wheatbelt’ and ‘North and East Wheatbelt’ statistical regions.
'Resilience' refers to the capacity of natural, social, or coupled socio-ecological systems to retain their normal functions despite encountering temporary shocks or disturbances, as well as the capacity of such systems to self-organise and adapt to changing circumstances (Folke 2006; Gunderson and Holling 2002). Originally developed by ecologists in the 1970s as a framework for understanding how ecosystems respond to stress (e.g. Holling 1973), resilience has found growing application over recent years in research investigating how social systems respond and adapt to environmental change (e.g. Marshall and Stokes 2014; Arctic Council 2013; IPCC 2014; Allison and Hobbs 2004). Because resilience is inherently a social construction and therefore can be interpreted in many different ways (Cote and Nightingale 2012), resilience is defined in this paper as the capacity of the Wheatbelt SES to retain family farming as its principal mode of economic and social organisation.

The paper begins by detailing the drivers argued here responsible for shaping the evolutionary trajectory of the Wheatbelt SES, before moving on to track the system’s movement through the ‘adaptive cycle’. By charting the position of a system along the adaptive cycle, one can infer the capacity of a system to withstand disturbance events, as well how close or far away it may be from transitioning from one state of organisation to another. The second part of this paper then considers the future evolutionary trajectory of the Wheatbelt SES given intensifying climatic and economic risks and the continuation of current policy approaches to Australian agriculture. From this discussion, it will be argued that neoliberal-informed agricultural policies centred on ‘deregulation’, ‘self-sufficiency’ and ‘efficiency’ are likely to become increasingly maladaptive if the goal of governance is to ensure families remains the ‘cornerstone’ of agriculture in the Wheatbelt in a climate-changed future.

2.0 The historical evolution of the Wheatbelt SES

2.1 Identifying system drivers
The organisation of regional resource systems (such as the Wheatbelt) typically emerges through the interaction of no less than three but no more than six variables (Gunderson et al. 2002). The drivers discussed below build upon a previous resilience analysis of the Western Australian Wheatbelt conducted by Allison (2003)¹ who examined drivers of environmental degradation in the Wheatbelt and options for its management. Allison identified five drivers of change: 1) land use change; 2) number of agricultural establishments; 3) farmer age; 4)

¹ See also Allison and Hobbs (2004, 2006)
farmers’ terms of trade; and 5) wheat yield. Allison’s list of drivers has been modified for the aims and purposes of this research. ‘Land use change’ has been replaced with ‘climate change’ to reflect the changing importance of these ecological variables on the dynamics of the wheatbelt SES. Also, the variables ‘number of agricultural establishments’ and ‘farmer age’ are repositioned in this analysis as social ‘indicators’ rather than ‘drivers’ of system resilience. While declining farm numbers and the rising age of family farmers certainly have the potential to impact overall system resilience, these trends are argued here to be the result of other drivers operating within and upon the Wheatbelt SES. It is important to note that the drivers discussed here operate across various temporal and spatial scales. Therefore, the Wheatbelt SES can be considered as operating within a ‘panarchy’ (Holling, Gunderson, and Peterson 2002) of environmental and economic change. System drivers included in this study are discussed below.

2.1.1 Climate change
With the introduction of soil trace elements in the 1950s, climate, rather than soil, became the primary limiting factor affecting agricultural production in the Wheatbelt (Passioura 2002). Historically, the Wheatbelt was renowned for having the most consistent winter rainfall in Australia (IOCI 2004). However, since the late 1960s, growing season rainfall decreased over two stepwise periods. As reported by the IOCI (2012) early winter rainfall (May to June) in the period 1969-1999 fell by 10-20 percent against the historical long-term mean (1910-1968). Early winter drying trends then intensified and geographically expanded in the period 2000 to 2008, falling a further 20-50 percent against the long term historical mean. Inter and intra seasonal variability (rainfall, temperature, extreme weather events) also dramatically increased through the 2000s.

2.1.2 Wheat yield
Wheat is the primary commodity produced in the Wheatbelt and provides the main source of revenue for most farm establishments (Kingwell 2011). Despite the drying climate, wheat yields improved substantially through the 1980s and 1990s (Figure 2). Improvements were driven by a raft of new agronomic, technological and mechanical developments (Turner 2011). However, since 2000 wheat yield variance has increased substantially and, in some cases, wheat yield gains have stalled or reversed. As a result, farm productivity gains have also decreased over this period (Che, Kompas, Cook, Feldman, and Xayavong 2012). Stalling wheat yield gains present a significant challenge to farmers contending with declining terms of trade (Kingwell and Pannell 2005), a degrading resource base (Allison 2003; Allison and
Hobbs 2006), and intensifying climate change (Pettit et al. 2015). Due to the sensitivity of wheat yields to growing season conditions and their importance for generating farm income, wheat yield trends provide a clear indication of the extent to which climatic conditions have affected agricultural production and farm revenue in the Wheatbelt.


2.1.3 Market risk
Market risk is defined here as systemic changes operating across global agro-commodity markets that have the potential to undermine the profitability and competitiveness of Australian broadacre family farming enterprises. Examples of market risk include the pervasive downward trend in the farm terms of trade index (the price of inputs versus the cost of prices received for agricultural commodities: see Figure 3 below) and increasing market volatility (particularly in the cash price of grains). The downward trend in the farm terms of trade index is typically attributed to the tendency of agricultural producers to increase supply faster than demand (Barr 2014), whereas recent patterns of market volatility have been attributed to variance in the price of inputs and weather-related factors (OECD/FAO 2011). These and other market risks will be discussed in further detail in Sections 2.2.
2.1.4 Agricultural policy
Social and economic policies enacted by successive State and Federal governments have historically shaped the socio-economic composition of Australia’s rural regions and family farmers’ exposure to climatic and economic shocks (Tonts and Jones 1997). For instance, up until the 1970s, the State played a significant role in the development of the Wheatbelt and its rural communities through the provision of cheap land and finance, settlement schemes, and a range of communication, transport, health and education infrastructures and services (Beresford et al. 2001; Tonts and Jones 1997). From the 1970s onwards, however, Australian agricultural policy shifted from what Tonts and Jones (1997) dub ‘state paternalism’ to ‘neoliberalism’. As a result, relationships between the State and rural communities were renegotiated along market-based lines as ‘deregulation’, ‘efficiency’ and ‘self-reliance’ came to dominate agricultural policy thinking. Neoliberalism and its impact on the resilience of the Wheatbelt SES is explored further in Section 2.2.

2.2 Movement through the adaptive cycle
The resilience of a given system expands and contracts as it moves through the adaptive cycle. The adaptive cycle is a heuristic that describes the movement of complex systems though phases of exponential change (exploitation or r phase), growing rigidity (conservation or K phase), readjustments/collapse (the release or Ω phase), and renewal (reorganisation or α phase) (Folke 2006). Systems are highly resilient during the reorganisation and exploitation phases, and highly vulnerable (low resilience) during the conservation and release phases (Holling and Gunderson 2002). Characteristics of the different phases of the adaptive cycle are shown in Table 1. According to Adger (2000) changes in population (composition,
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demographics, total number) often provide a good indication of system resilience. If this is the case, then patterns of farm loss should correspond with the position of the Wheatbelt SES along the adaptive cycle. This assertion is examined here.

At time of writing in 2003, Allison concluded that the Wheatbelt SES has moved through two iterations of the adaptive cycle. The first cycle began with the introduction of European-styled agriculture to the now Wheatbelt region in 1889 and continued up until 1949 at which point the system began on a new evolutionary trajectory after its collapse during the depression and war years of 1929 to 1945. The second cycle then began with the government-driven expansion of agricultural lands during the 1950s and 1960s. During this period, the State government introduced a raft of settlement and finance schemes to encourage land clearing and farm development. As a result of these policies, the Wheatbelt experienced a ‘rural boom’ as prospective farmers flocked to take up newly allocated agricultural lands.

The following resilience analysis starts from this point at the peak of the ‘rural boom’ and traces the evolution of the Wheatbelt SES to the present day. Because climate change first started to impact the Wheatbelt in the late 1960s, the analytical period of this resilience analysis is limited to the period 1970 onwards. The discussion describes the movement of the Wheatbelt SES through two phases of the adaptive cycle: ‘release’ (1970-1979), and ‘reorganisation to conservation’ (1980 to 2014). In order to facilitate a great depth of discussion into the system drivers and their impact on system resilience, the conservation phase has been disaggregated into three sub-phases: ‘release to early K’ (1980-2000), ‘middle to late K’ (2000-2013), and ‘tipping point’ (2013-2014). These phases and their relationship to socio-ecological resilience are shown in Table 2, and their position along the adaptive cycle mapped on Figure 4.
Table 1. Phases of the adaptive cycle and their association with socio-ecological resilience

<table>
<thead>
<tr>
<th>Phase</th>
<th>Description</th>
<th>Resilience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exploitation (r)</td>
<td>A period of rapid growth in which species, people and/or institutions exploit new opportunities. System conditions are highly uncertain and connections between variables loosely defined, thereby favouring highly adaptable and short-lived entities (e.g. weeds, start-up companies).</td>
<td>High</td>
</tr>
<tr>
<td>Conservation (K)</td>
<td>Capital accumulates and connections between variables increase, thereby favouring the emergence of specialists who manage their exposure and vulnerability to variability through their own mutually reinforcing relationships. Competition ensures non-adaptive entities are squeezed out. Entities control external variability by optimising resource use and seeking efficiencies. The system become increasingly rigid as diversity, flexibility and innovation is lost and connections between variables heighten.</td>
<td>Low</td>
</tr>
<tr>
<td>Release (Ω)</td>
<td>A disturbance event pushes the system beyond a critical tipping point, eliciting rapid system-wide change. Previous patterns of system order are undone as the system moves from a state of high certainty and predictability to a state of chaotic disorder. The system moves into a phase of ‘creative destruction’, giving the opportunity for new patterns of system order to formulate.</td>
<td>Low</td>
</tr>
<tr>
<td>Reorganisation (α)</td>
<td>New patterns of order emerge, shaped by the surviving remnants of the previous system. Novelty and surprise dominate the evolutionary direction of the system. Eventually, new system dynamics emerge and a new system ‘identity’ develops, heralding the transition into a new system regime.</td>
<td>High</td>
</tr>
</tbody>
</table>

Sources: Allison and Hobbs (2004); Walker and Salt (2006), Holling and Gunderson (2002).
Table 2. Phases of the Wheatbelt Socio-Ecological System: 1949 to 2013-2014

<table>
<thead>
<tr>
<th>Period</th>
<th>Title</th>
<th>System phase</th>
<th>Component phase</th>
<th>Resilience</th>
</tr>
</thead>
<tbody>
<tr>
<td>1949-1969</td>
<td>The rural boom</td>
<td>r to K</td>
<td>N/A</td>
<td>High</td>
</tr>
<tr>
<td>1970-1979</td>
<td>The troubled decade and a changing climate</td>
<td>Ω</td>
<td>N/A</td>
<td>Low</td>
</tr>
<tr>
<td>1980-2000</td>
<td>Neoliberal agriculture</td>
<td>α to early K</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>2000-2013</td>
<td>Neoliberal agriculture in an age of increased climate risk</td>
<td>K</td>
<td>middle to late K</td>
<td>Low</td>
</tr>
<tr>
<td>2013-2014</td>
<td>A year of crisis</td>
<td></td>
<td>tipping point?</td>
<td>Very low</td>
</tr>
</tbody>
</table>

Note: Titles for periods 1949-1969 and 1970-1979 were adapted from Burvill (1979) and Allison (2003).

Fig 4: Phases of the Wheatbelt socio-ecological system along the adaptive cycle
Multiple streams of evidence were drawn upon in the development of this resilience analysis. Historical data sets and secondary sources were used to support claims made in reference to the period 1949 to 2013, whereas contemporary news articles and interviews with fifteen key informants representing various governmental, community and industry organisations have been used to support claims made in reference to the 2013-14 agricultural season. Organisations represented here include the Department of Food and Agriculture of Western Australia, Australian Export Grains Innovation Centre, Regional Men’s Health Alliance, WA Farmers and the Rural Financial Counsellors of Western Australia. Interviews were recorded with the permission of the participants and their respective organisations and transcribed verbatim. Interview data was entered into QSR Nvivo 10 and analysed for emergent themes via the conventions of Applied Thematic Analysis (Guest et al. 2012).

2.2.1 *The troubled decade and the beginnings of climate change: 1970-1979*

The 1970s brought various challenges to Wheatbelt family farmers. The first shock came in 1968 when it became apparent that domestic and international wheat markets were supplied beyond demand. As prices for agricultural commodities fell, the Australian Government introduced wheat production quotas in the attempt to limit further price reductions. As a result, wheat production fell by one third by 1971 (Burvill 1979). Because wheat was the primary crop grown on newly cultivated farm land, the quota system in combination with falling prices had a particularly detrimental impact on newly established broadacre enterprises (Burvill). Compounding farmers’ problems, the price for wool tumbled while global inflationary pressures drove the cost of inputs upwards (e.g. labour, fuel, freight and fertiliser), thus causing the farm terms of trade index to plunge from 234 in 1974 to 133 in 1978 (see Figure 3).

Drought conditions also returned to the Wheatbelt during this time, with most areas declared drought affected in 1969 and again throughout the period 1976 to 1979. Encouraged by the consistent and reliable seasons of the 1950s and 1960s, many farmers failed to increase their fodder and water supplies despite increasing their stock levels. Many farm businesses were vulnerable to the dry condition as a result (Morgan 2014). What could not have been known at the time, however, was that anthropogenic global warming was beginning to have a drying effect on the regional climate of south west Western Australia (IOCI 2012). Though perhaps not the cause of the droughts of the 1970s, anthropogenic global warming may have had a role in exacerbating their longevity and severity.
As the environmental and economic stresses mounted, many began to question the wisdom of expanding agricultural production into land known to be ‘marginal’. A 1975 Commonwealth Government Inquiry into the War Service and New Farm Settlement Schemes concluded that the release of farmland in the south-eastern Wheatbelt was ill-conceived and poorly managed (Morgan 2014). Findings from the Inquiry also revealed that little provision had been made for the financial needs of settlers on marginal lands, and that little effort was made to screen applicants to ensure that they had the competencies required to successfully manage a broadacre farming enterprise (many applicants who took up new land plots were found to have had no prior farming experience). As a result, many farmers were unable to cope with the climatic and economic stresses imposed upon them and were subsequently forced out of the industry. The number of farm establishments fell from 13,106 in 1970 to 9,439 by the end of the decade (Figure 1a).

When considered together, global market pressures, chronic drought conditions and reactionary agricultural policies exposed vulnerabilities within the structure of the Wheatbelt SES. This pushed the system from a period of steady growth (K) into a period of instability and eventually into collapse (Ω). Though production potential remained strong and relatively high wheat yields were achieved in some years (Figure 2), the social structure of the Wheatbelt was dramatically altered, as evidenced by the rapid decline of the number of farms operating in the Wheatbelt at that time (Figure 1b).

It is a property of complex adaptive systems that when one level in a panarchy undergoes a collapse, processes operating at a higher level have the potential to shape the manner in which the collapsed system will reorganise (Holling et al. 2002b). As demonstrated in the next section, the international emergence of neoliberalism in the 1970s and 1980s significantly affected how the Wheatbelt SES reorganised after this period of release. The reorganisation of Australian agriculture along neoliberal lines would inadvertently produce a new set of latent vulnerabilities that would later reify with the abrupt shift to a drier and more variable climate in the 2000s.

2.2.2 Neoliberal agriculture (1980-2000)

The period 1980 to 2000 saw dramatic changes occur in Australia’s agricultural policy environment. In response to the economic shocks of the 1970s, global economic relationships were renegotiated through the lens of ‘neoliberalism.’ Though a nebulous concept resisting precise definition, neoliberalism can be understood as an economic and political worldview
which assumes ‘free markets’ unfettered from the distorting influence of government intervention best serve the efficient distribution of global capital for the betterment of human prosperity and wellbeing (Harvey 2005; Klein 2007). In Australia, neoliberalism would provide the ‘intellectual wellspring’ from which a new era of domestic agricultural policy would emerge (Pritchard 2005a). Broadly, the new era of neoliberal governance involved the deregulation of agricultural markets, the roll back of state support for farmers and rural communities, and an emphasis on ‘competitiveness’ as achieved through ‘efficiency improvements’ (Pritchard 2005a, b; Lawrence 1987). The imposition of neoliberal principles upon Australian agricultural policy would set into motion a new evolutionary trajectory for rural regions.

The era of neoliberal agriculture was one in which overall production and productive efficiencies soared whilst rural communities became subject to uneven global markets, the rationalising logic of free- market economics, and intensifying climate risk. With little new land to expand into, farmers were encouraged to expand their operations and to adopt new practices, larger machinery and new technology to improve their productive efficiencies. As a result, farm sizes grew, water use efficiency doubled (Turner 2011), broadacre farm productivity increased by 3.5% per annum (Kingwell and Pannell 2005) and average wheat yields almost doubled (see Figure 2). However, despite the impressive production and efficiency gains, the 1980s and the 1990s were a period of considerable ‘belt tightening’ for family farmers throughout Australia. Drought coupled with pervasive declines in the farm terms of trade index saw rural poverty increase at a time when State support for rural communities were slashed in the name of ‘rational’ economic reform (Alston 2004). The days in which farmers were considered a “distinctive social and political category warranting special support from the State” had disappeared by the mid-1990s, replaced by a more “hard-edged” conception of farmers as “business people whose fate rested on their ability to survive within the market economy” (Smith and Pritchard 2015, 60).

As economic and environmental thresholds to production/profitability shrunk, many farm establishments were forced out of the sector. Between 1980 and 2000, the number of farms operating in the Wheatbelt fell from 9439 to 6879 (Figure 1a). In addition, as farm sizes grew and capital requirements increased, the structural requirements of this new era of ‘efficient farming’ started to prevent new farmers from entering into the industry. As reported by Barr (2014), the mean age for farmers in the Wheatbelt increased from 48 to 52 years between 1990 and 2000. It is interesting to note that the rate of farm loss halved in the 1980s and then
halved again in the 1990s (Figure 1b), suggesting that the improved capacity of farmers to negotiate the vagaries of the neoliberal era and the growing stability of the broader system. However, as noted by scholars critical of the neoliberal turn in agriculture, this may have been achieved by running down environmental, social and personal capital (Pritchard 2005a; Lawrence 1987; Vanclay 2003). Indeed, as argued by Alston:

[the] narrow focus on economic efficiency has led to a lack of attention to the human, institutional, and social capital needs of rural Australians engaged in agriculture and those rural communities dependent on agriculture. As a consequence, the interests of a reified “efficient agriculture” are being served by exploitation of the people and resources engaged in the industry. If this continues […] family farming as the dominant form of social relations in agricultural production and the rural communities dependent on agriculture face an uncertain future (p. 37).

By the end of the 1990s it was apparent that Australian agriculture had embarked on a significantly different evolutionary trajectory than was the case before the ‘troubled decade’ of the 1970s. ‘State paternalism’ had given way to ‘neoliberalism’ (Tonts and Jones 1997); and as the Wheatbelt SES came to settle within this new regime, the system had entered into a new phase of conservation as capital and output became concentrated amongst a shrinking number of farm establishments. Not only did this transition fundamentally alter relationships between farmers, the State and society, and drive many farm establishments from the sector, it also created a new set of latent vulnerabilities that would later become exposed in the 2000s.

2.2.3 Neoliberal agriculture in an age of increased climate risk (2000-2013)
The new millennium brought with it various climatic and economic risks that would expose vulnerabilities within the structure of the Wheatbelt SES and the tenets of a neoliberal agriculture. First, the 2000s saw a second step-wise shift occur in the regional climate. Early winter rainfall fell between 20 to 50 percent against the historical average and seasonal variability (rainfall and temperature) dramatically increased (IOCI 2012). As a consequence, wheat yield variance more than doubled throughout the Wheatbelt, and in some areas wheat yield gains stalled or declined (Stephens et al. 2011). Second, anthropogenic global warming coupled with volatility in the price of world energy markets saw huge variance in the cash price for agricultural commodities from 2006 onwards (OECD/FAO 2011). Suddenly, family
farmers’ biophysical and economic environment had become much more variable and therefore risky.

Family farmers’ exposure to these risks was exacerbated by a continued push for neoliberal economic reform. After the deregulation of the Australian Wheat Board in 2008, the Australian agricultural sector had become the second least government-supported in the world (OECD 2013). Not only had Australian farmers become even further exposed to the vagaries of the global market in this period, but the introduction of the exceptional circumstances program, followed by the drought pilot program, sent clear signals that individual farmers and not the State would shoulder the burden of adapting to a riskier and more variable operating environment. The State would not directly intervene in the affairs of the market, and therefore non-competitive entities would be allowed to be rationalised from the sector.

Confronted with mounting climatic, production and price risks, as well as a need to become increasingly self-reliant in the face of climatic adversity, farmers undertook further productivity-enhancing measures in the attempt to retain their viability. After the collapse in the price of wool in the later 1990s, many farm businesses began the new millennium by restructuring their enterprises towards a crop-dominate system. Though potentially more profitable in favourable years than traditional mixed crop-livestock systems, crop-dominated systems were capital intensive and reliant upon high-cost inputs and therefore ill-equipped to recover quickly from poor production/price years (Lawes and Kingwell 2012).

Studies by Lawes and Kingwell (2012) and Kingwell et al. (2013) also show that many farmers made efforts to improve their technical and scale efficiencies during the 2000s. However, both strategies proved problematic. With regard to technical efficiencies, many farmers improved their productivity by investing in existing technologies rather than investing in new technologies that may have expanded their production horizons (Lawes and Kingwell, 2012; Kingwell et al. 2013). With regard to scale efficiencies, the trend towards farm amalgamation that commenced in the 1970s and 1980s continued in the 2000s. By 2011, the average size of farms in the Wheatbelt with grain as part of their overall enterprise mix was twice the size of comparable farms in South Australia and New South Wales, and four times as large as comparable farms in Victoria and Queensland (Land Commodities n.d.).

In order to expand their enterprises many farmers were forced to take on debt. By 2013, it was estimated sectoral debt had reached $14bn (AUD) (D. Park, personal communication 27
March, 2014). This was driven by very good farm returns in the early 2000s and low interest rates which encouraged farmers to borrow to expand their operations and to convert to a crop-dominant farm system (Keogh, Tomlinson, and Potard 2013). Poor seasonal conditions throughout the 2000s, however, constrained farmers’ ability to service their debts. From 2000 to 2012, the average farm debt-to-income ratio in the Wheatbelt increased from 1.0 to 1.68 and average farm equity dropped from 85 percent in 1998 to approximately 72.5 percent in 2013 (Planfarm and Bankwest 2013). In light of these results, it is perhaps not surprising that a study of broadacre farms in the Wheatbelt revealed 15 percent were in a ‘less secure’ financial position by 2013 (Kingwell et al. 2013).

As a result of mounting structural vulnerabilities in the Wheatbelt SES, there was a dramatic decline in farm numbers through the 2000s. Between 2000 and 2013, the number of farms operating in the Wheatbelt fell from 6879 to 4941 (Figure 1a) and the average rate of farm loss doubled from 93.2 per year in the 1990s to 196.9 per year in the 2000s (Figure 1b). The median age of farmers also rose from 45 years and below in 1987 to between 50 and 60 years by 2011 (Barr 2014), suggesting the rate of intergenerational transfer within farming families had also declined in this period.

Although the Wheatbelt SES had endured higher rates of farm loss in the 1970s and a comparable rate of farm loss in the 1980s, the cause of these losses were largely rooted in transformational changes that had occurred in the structure of Australian agriculture as a result of the shift towards the neoliberal socio-political paradigm. However, in the 2000s, structural vulnerabilities within neoliberal agriculture became apparent with the abrupt shift to a drier and more variable climate. The push towards ‘efficient’ agriculture had eliminated sources of diversity as farmers reorientated their enterprises towards larger, more capital intensive and increasingly crop-dominant farming systems. In addition, the policy push towards ‘deregulation’ and ‘self-reliance’ also increased farmers’ exposure to production and market risks stemming from heightened climatic variability and market volatility. As a result of these risks, it is argued here that by the beginning of the 2013-14 season the Wheatbelt SES had entered into the very late stages of the conservation phase of the adaptive cycle and therefore had become highly exposed and vulnerable to external sources of risk. A crisis point was taking shape.
2.2.4 A year of crisis: the 2013-2014 season

By the end of 2012 it was evident that Wheatbelt farmers faced mounting problems. Drought, coupled with frost and unseasonal rainfall during harvest, had resulted in another below average production year (Grain Industry Association of Western Australia 2013). While high prices for grain helped to offset the financial losses associated with the poor production year, it did little to reverse the deteriorating financial position of the Wheatbelt broadacre sector. Towards the end of 2012, industry analysts reported sectorial debt was 30 percent above safe operating limits and that farmers were likely to experience difficulties securing finance for the upcoming 2013-14 season as lending institutions made movements to insulate themselves from mounting risks (Cattle 7 Dec. 2012).

In response to growing community concerns, multiple agricultural crisis meetings were held in the first half of 2013, attracting record-breaking attendance from farmers and rural community members. After much community pressure, the State Government announced a modest $7.8 million assistance package for up to 100 farmers in the Eastern wheatbelt. Only those who had secured on-going farm finance would be eligible for the financial support payment; a clause that was criticised by grower groups who argued that those in the direst financial positions would be unable to access assistance (ABC 16 Jul. 2013).

Despite enjoying the best start to a season in over a decade, the confidence was short lived. Many areas throughout the central and north-eastern Wheatbelt then experienced their driest June on record. Terms such as ‘desperation’ and ‘crisis’ became prevalent in media reporting at this time. Fears of a large displacement event by the end of the year began to circulate through the eastern Wheatbelt as some farmers sold off-farm assets to support their failing farm businesses (Wilson 27 Jun. 2013). A survey of nearly 400 farmers found one in three expected to foreclose by the end of the year if fortunes did not improve. The coldest overnight minimum temperature in over half a century then hit many areas through the central and upper great southern Wheatbelt regions, threatening moisture-deprived crops (Westcott 8 Jul. 2013). By mid-July fears of a failed season loomed as crops wilted and, in some cases, became irreparably damaged.

On the 11th of July, fears of a failed season were alleviated by the arrival of a broad-sweeping cold front which brought desperately needed rain to struggling farmers throughout a majority of the central and north-eastern Wheatbelt. Favourable rains continued to throughout July, and by the beginning of August DAFWA industry director, David Bowran, estimated that 85
percent of the Wheatbelt appeared to be in a ‘reasonable position’ (Thompson 1 Aug. 2013). Rain then continued to fall throughout September and into October, bringing an extremely favourable finish to the season. Favourable late-season conditions not only brought many farmers back from the brink, it also delivered a 17.5 million tonne harvest, the largest in the State’s history (Grain Industry Association of Western Australia 2014a). This coincided with high prices for wheat and low market volatility, allowing some farmers to improve their business equity by up to 10 percentage points. By the end of the harvest it was evident that the Wheatbelt had experienced a remarkable turnaround and that the crisis that had loomed had been avoided.

2.3 Discussion
From this resilience analysis three outcomes are clear. First, patterns of farm loss in the Wheatbelt over the last four decades are consistent with the operation of the adaptive cycle. Population displacement is a key indicator of a loss of resilience (Adger 2000), and from this analysis it is clear that the highest rates of farm loss occurred in decades where resilience was at its lowest (i.e. 1970s and 2000s). Fears of a major displacement event in the 2013-14 season are also consistent with the notion that a socio-ecological tipping point had taken shape during this year of crisis. This suggests that the evolutionary trajectory of the Wheatbelt SES is consistent with the operation of the adaptive cycle, and that this heuristic has explanatory power when applied to this case study.

Second, no one variable neither is responsible for driving the Wheatbelt SES through the phases of the adaptive cycle, nor for creating the crisis point that emerged in the 2013-14 agricultural season. Rather, the evolution of the Wheatbelt SES is driven by various environmental, economic and social drivers operating internally and externally to the SES. As a consequence, farm loss must be understood as an outcome of complex socio-ecological processes, and climate change seen as a driver of risk and vulnerability within a complex adaptive system. For instance, while climate change certainly eroded the financial viability of family farmers, particularly in the 2000s, the climate risks encountered by farmers were amplified by an SES already exposed and vulnerable to external sources of disturbance. The structure of the family farm had become highly sensitive to fluctuations in wheat yield with the shift to a crop-dominant farm system, and these risks were amplified by neoliberal socio-economic policies that exposed farmers to fluctuations in global commodity markets. Furthermore, the influence of neoliberal doctrine on Australia’s drought policies also ensured that farmers would shoulder environmental risks latent within the structure of the Wheatbelt.
SES. So while it cannot be stated with certainty the exact extent to which climate change has eroded the resilience of the Wheatbelt SES or contributed to farm loss throughout the region, it can be concluded that the stepwise shifts in the regional climate exacerbated vulnerabilities already present within the structure of the Wheatbelt SES and created new risks for Wheatbelt family farmers highly dependent on consistent and predictable seasonal conditions.

The third conclusion to be derived from this resilience analysis is that the risk of encountering another crisis point in the future persists despite Wheatbelt farmers enjoying high production years in the 2013-14 and 2014-15 seasons. Key informants were quick to point out that one season would do little to address the overarching debt problem in the Wheatbelt family farming sector. As CEO of WA Farmers, Dale Park, indicated, despite the record-breaking harvest, the 2013-14 season only paid off $1 billion of the sector’s estimated $14 billion debt (personal communication, 27 March, 2014). Furthermore, the record-breaking harvest did little to address the structural vulnerabilities latent within Wheatbelt SES, nor reduce its exposure to external sources of climatic and economic risk. Such a situation could become highly problematic for the continuing social order of the Wheatbelt, as climatic and economic risks are likely to intensify into the future. This is discussed in the next section.

3.0 Family farming in a climate-changed future

3.1 Future system trajectory
Climate models indicate that the south-west of Western Australia will become hotter, drier and increasingly prone to extreme weather events into the future (CSIRO and Bureau of Meteorology 2015; IOCI 2012). There is uncertainty about the degree to which these trends will play out into the future due to their contingency upon future greenhouse gas emission scenarios. In the short term, however, there is a very high likelihood that winter rainfall will decrease another 15 percent by 2030, that average temperatures will rise in accordance with global averages, and that heatwaves and droughts will become increasingly frequent and severe (CSIRO and Bureau of Meteorology 2015). These intensifying patterns of climate change are likely to detrimentally impact future wheat yields across the Wheatbelt, particularly in areas already subject to significant warming and drying (e.g. Farre and Foster 2010; Asseng, Foster, and Turner 2011).
Climate risks are likely to be compounded by mounting market risks. Though demand for agricultural commodities is set to significantly rise as the global population grows, Wheatbelt farmers will face growing competition from low-cost producers such as Brazil, Russia, Kazakhstan and Uzbekistan (Grain Industry Association of Western Australia 2014b). Wheatbelt farming systems also remain energy and input intensive relative to farm systems employed in other parts of the world (Caper 2014), and are therefore disproportionately exposed to fluctuations in the price of inputs and longer-term structural changes in the supply of non-renewables, such as phosphorous and oil (Eadie and Stone 2012). Agricultural commodity markets are also likely to become even more volatile into the future as extreme weather events and oil price volatility (amongst other factors) amplify global supply/demand imbalances (OECD/FAO 2011). Moreover, Wheatbelt farmers and other agricultural regions located across the southern part of the Australian mainland are expected to be on the losing side of the uneven geographies of climate change risk, with key competitors such as Canada, Russia and the Ukraine likely to be less affected by climate change than Australian agricultural producers (Eadie and Stone 2012).

Faced with these conditions, it will be the manner in which the Wheatbelt SES responds to mounting environmental and economic risks that will influence its capacity to remain as a functioning ecological, economic and social unit organised around family farming. Currently, the improvement of agricultural efficiencies is employed by farmers and promoted by government and industry groups as the dominant strategy for mitigating mounting climatic and economic risks. Indeed, the pursuit of agricultural efficiencies has been a central pillar of Australian agricultural policy since the 1980s (Pritchard 2005a, b; Smith and Pritchard 2015) and there is very little evidence to suggest that an alternative course of action will usurp the ‘efficiency mantra’ any time soon (Smith and Pritchard 2015). This is clearly demonstrated in the recent Grain Industry Association of Western Australia (2014b) report to the Western Australian State Government outlining various policy directives aimed at doubling the value of the agricultural industry by 2025, as well as the recent Agricultural Competitiveness White Paper (Commonwealth of Australia 2015) which seeks to secure the competitiveness of Australia’s agricultural sector largely through measures that promote agricultural efficiencies and market capture.

An overarching concern with efficiency improvement can undermine socio-ecological resilience, as the process of enhancing efficiency usually entails stripping the system’s capacity for self-organisation, innovation, and flexibility (Walker and Salt 2006). For
instance, as discussed previously, a majority of Wheatbelt family farmers have already moved towards higher-efficiency machinery and agronomic packages in response to the heightened climatic and market risks experienced over the previous three decades (Kingwell et al. 2013). While agricultural production boomed as a result, these investments also exposed many family farming enterprises to a heightened degree of risk as capital requirements rose, debt levels soared, and production volatility (and therefore revenue volatility) skyrocketed. In the future, if biophysical and economic thresholds to production contract further, it is likely that family farmers will be compelled by market forces to become even more efficient in order to remain competitive in the global market place.

Already, the pursuit of agricultural efficiencies is transforming the types of farming enterprises that currently populate the Wheatbelt sector. Over recent years there has been a rise in ‘family-corporates’. In such arrangements, a single family may own several farms, which are then consolidated under the umbrella of a single family farming enterprise. Owing to its large size, the family farm, though still owned and operated by a single farming family, takes on corporate characteristics as managerial tasks become delegated, outsourced expertise is sought, machinery leased and farm work tendered out to hired labour. In addition, there has been a rise in traditional corporate (or ‘corporate-corporate’) farm enterprises. These are enterprises owned by corporate entities which are then operated by hired ‘farm managers’. The number of ‘family corporates’ and ‘corporate-corporates’ operating in Australia has risen by an estimated 99 percent through the 2000s, with corporate farms now making up 1.8 percent of the total farm population (Muenstermann 2013). Though only a small percentage, corporate farming generated 39 percent of Australia’s agricultural production in 2011 (Clark, personal communication 2011 as cited in Muenstermann). This is part of a larger trend, in which a smaller number of large farms now contribute a greater percentage of total broadacre output (Jackson and Martin 2014). The number of corporate farms and their contribution to total production are expected to rise in the future – particularly in the cropping industry as scale and technical requirements exceed that which can be achieved by traditional modes of family farming (Greijdanus and Kragt 2014). As a result, it is likely that a growing number of family farmers will be forced out of the sector as the policy environment encourages the emergence of more ‘corporate’ modes of farming enterprise. This will place further strain on already stressed rural communities struggling to retain enough residents to sustain vital services.
It is important to note that the rise of corporate farming does not constitute a new paradigm of agricultural production; rather, it can be seen as the logical extension of a system that rewards scale efficiencies and capital-intensive production. As climatic and economic risks mount, even the largest and most capital intensive operations may encounter limits to production and profitability. It is at this point, where there are no more efficiency gains to be made, costs to be cut, or methods for extending one’s profitability, that the already depleted social structure of the Wheatbelt SES will become highly susceptible to critical tipping points and sudden regime change. Although favourable climatic and market conditions may temporarily move the system away from the brink of such critical tipping points, without significant transformation these points may be encountered suddenly and unexpectedly, forcing abrupt structural change to occur to the detriment of family farmers and the social sustainability of Wheatbelt communities.

3.2 Transforming the Wheatbelt SES
Recently, a number of authors have noted that incremental approaches to adaptation may have limited capacity for ensuring the long-term sustainability and viability of Australian agriculture in regions exposed to the leading edge of climate change risk (e.g. Rickards and Howden 2012; Marshall et al. 2012; Park et al. 2012; Marshall et al. 2013). Not only is there the possibility that the rate of incremental improvements in agricultural efficiency and productivity will be unable to keep pace with future climatic and economic changes, an overarching concern with efficiency as an end in itself may also inadvertently exacerbate the risks it is supposed to alleviate. In response, there has been growing interest in the notion of ‘transformational adaptation’ (TA) and its applicability to the Australian agricultural context (Rickards and Howden 2012; Park et al. 2012; Marshall et al. 2013; Marshall et al. 2012).

Broadly defined, TA involves changing fundamentally the structure of socio-ecological systems through the ‘radical’ renegotiation of “values and beliefs, patterns of social behaviour, and multilevel governance and management regimes” (Resilience Alliance, n.d.). TA is sought in situations where systems have little capacity to adapt and are at risk of becoming overwhelmed by mounting vulnerabilities (Kates, Travis, and Wilbanks 2012; Walker and Salt 2006). Not merely a technical task (though the development of new technologies are certainly an important aspect of TA), TA also requires critical reflection upon the values, knowledge and assumptions that give rise to systems that proliferate socio-ecological issues of concern. Therefore, TA is as much a cultural and psychological process
as it is a technical or economic one (Bishop and Dzidic 2014; O’Brien 2012; Olsson, Galaz, and Boonstra 2014).

Only recently has the conversation begun regarding the sorts of transformational adaptations required, the scale at which they should be introduced, the likely costs associated with TA, and who is responsible for undertaking and driving the required changes if Australian agricultural and rural communities are to remain viable in the 21st century. Currently, the small body of TA literature as it applies to the Australian agricultural context is focused on the capacity of individual family farmers to adapt to changing climatic conditions, with little emphasis placed on how broader economic and policy systems may be transformed to ensure the social and ecological sustainability of Australia’s agricultural regions (e.g. Kingwell et al. 2013; Marshall et al. 2013; Park et al. 2012). This is problematic, as individual adaptations are necessarily constrained by institutional arrangements which serve to define the context within which adaptive actions are developed and implemented (Adger, Arnell, and Tompkins 2005). Furthermore, there seems to be a generalised lack of consideration for what and for whom we intend to carry out TA (O’Brien 2012). It is unclear whether the goal of such transformations is to secure food production, the profitability of the agricultural sector, or the continuing viability of family-based modes of agricultural enterprise. Considering that these goals, depending how they are approached, may be incommensurate, critical reflection is required upon the assumptions guiding TA, whose values count, and what is trying to be achieved. Attempts at deliberative transformation without such critical reflection may in effect propound the risks that such transformations are trying to alleviate, and inadvertently exacerbate family farmers’ and rural communities’ exposure to harm. Clearly, further research is required to address these issues.

4.0 Conclusions
It is unclear whether families will continue to underpin agriculture in the Western Australian Wheatbelt in the 21st century. Faced with mounting climatic and economic risks, as well as policy setting that encourages more ‘corporate’ modes of socio-economic organisation, traditional family farming, as well as the social sustainability of Wheatbelt communities, will continue to be exposed to inexorable pressures that threaten their very existence. As Gaynor (2015, 170) recently observed of the Wheatbelt:

Now the industrial paradigm is facing a bleak future. Utterly dependent upon fossil fuels and agrochemical inputs to grow crops and conserve the soil, while demanding
ever greater economies of scale that whittle away at its social sustainability, it is not clear that the industrialised Wheatbelt as a social and economic unit will survive the next century.

While it is clear that recent patterns of climate change have contributed to farm loss in the Wheatbelt, it has not acted alone. Instead, climate change is one of many environmental, economic and social drivers that are transforming the social and economic composition of the Wheatbelt region. To this end, the analytical approach taken in this article - based on resilience, complex adaptive systems, and the adaptive cycle - has proven useful for revealing the structure of the Wheatbelt SES, its evolutionary trajectory, and the impact of a changing climate on its development over the last forty years. Furthermore, this approach also has allowed inconsistencies to be revealed between the rhetoric underpinning neoliberal agriculture and the reality it creates for family farmers. If families really are to remain the ‘cornerstone’ of Australian agriculture (Commonwealth of Australia 2015), then current policy settings are unlikely to be able to achieve this in a future characterised by contracting biophysical and economic margins to production, increasing operating volatility, and mounting climatic and market risks.

The resilience analysis presented in this article necessarily raises important questions about the types of adaptations required if the Wheatbelt is going to remain a functioning ecological, economic and social unit into the future. Because complex adaptive systems can exist in multiple steady states and humans have some level of control over how they evolve, communities and governments have agency in shaping the future evolutionary trajectory of the Wheatbelt SES. However, this will not only require innovation with regards to technical and economic means of adaption, but also critical reflection upon the assumptions, values, politics and power structures that influence system behaviour. If transformational adaptation is to occur, then all cards need to be on the table so to speak, not just those that reinforce the tenets of a neoliberal agriculture and that place the onus of responsibility for adaptation on individual actors. It is important for social scientists, policy thinkers, community members, industry leaders, and government officials to contribute to a conversation about the future of the Wheatbelt, its family farmers and rural communities, and the governance structures that shape its development. Indeed, as with so many issues arising from climate change, ensuring the social sustainability of the Wheatbelt, as well as the integrity of its agricultural and natural ecosystems, will require a capaciousness of mind and flexibility of thought that we are only just beginning to grasp.
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