Resilience characteristics of transformations in social-ecological systems: a case study of the Tamar Valley Organics Group

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Abstract

This thesis applies a resilience lens to investigate conversions of farmland from conventional to organic status as transformations in social-ecological systems. Transformation is widely promoted in resilience literature yet there are relatively few empirical studies of transformation at multiple scales. This research addresses this distinct gap in understanding by analysing dimensions of transformations including the roles of key individuals, social-ecological innovation, and different capacities to manage dynamic change.

Resilience concepts and ideas are embedded in action research practice to provide new directions and insights on transformation. These insights are the result of a process of research that engaged with the Tamar Valley Organics Group, UK, during the period 2012 to 2016. Reflective interviews, mental models interviews, and participatory scenario planning research activities facilitate past, present and future perspectives on transformation. The findings of these research methods are synthesised to elaborate a resilience perspective on transformation.

Transformations are identified as intertwined fundamental shifts in understanding and management of agroecosystem fertility. These transformations emerge from processes of self-organisation and social learning that are shaped by distinct contributions from key individuals across temporal and spatial scales. Innovation builds capacities to manage uncertain dynamics of agroecosystem fertility. Signals of social-ecological innovation are identified but are considered more akin to processes of adaptive management. These findings act as the foundations for a more nuanced set of issues to emerge. Transformations involve complex cross-scale interplay between small and large changes. It is the way in which these cross-scale dynamics work with each other, and the ways in which different capacities change, that informs a more grounded understanding of transformations in social-ecological systems.
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1 Introduction

1.1 Transformations in agricultural systems

Many of the ecosystems that humankind relies on for its wellbeing are reaching or have passed critical thresholds for their continued existence (Rockström et al., 2009). The functioning of ecosystems and their subsequent ability to provide society with particular resources is threatened by a multitude of global drivers of environmental change (Cardinale et al., 2012; O'Brien, 2012). Conventional, industrialised agriculture is one such driving force of change (Bennet et al., 2015). The past fifty years of development in agricultural systems is characterised by extensive increases in food production brought about by innovations emerging from the Green Revolution of the 1960s. Scientific advances and technological innovations such as irrigation systems, chemical fertilisers and pesticides, and high-yielding cultivars contributed to a substantial increase in yield of staple crops such as rice and wheat, and significant reductions in food prices and global levels of hunger (Dalgaard, 2003; Gliessman, 2014).

The benefits of the boom in agricultural production are clear to see. However, these benefits come at distinct risk to the long term viability of society’s capacity to produce and access food. Industrialised agriculture is roundly criticised for its high levels of dependence on non-renewable energy sources, damage to the ecological integrity of ecosystems, reduction in soil fertility, dominance of corporate interests over those of smallholder farmers, and issues of justice around access and distribution of food (Bennet et al., 2015; Gliessman, 2014; Pretty, 2008). Agriculture is at a cross-roads; limited availability of new agricultural land, and significant increase in the size of the global population have led to calls for the sustainable intensification of agricultural systems (Royal Society, 2009; Poppy et al., 2014). The impacts of agricultural development are cross-scale and differentiated. Agriculture is a driver of change that both contributes to and constrains capacities for a healthy and thriving life. The weight of evidence suggests that agriculture’s current pathway must be transformed across scales, yet understanding of transformation is clouded by a lack of empirical rigour and analysis.
1.2 Environmental governance of British agriculture

The governance of British agriculture is heavily shaped by the European Union’s Common Agricultural Policy. The Common Agricultural Policy was established in 1962, and has undergone significant revisions to the programme of subsidies and incentives through which the policy is implemented. The programme has shifted from one that directly linked incentives to increasing levels of agricultural production, to a programme that now aims to incentivise improved food safety, environmental, and animal welfare standards (European Union, 2012). Funding for the Common Agricultural Policy comes largely from contributions from European Union member states, and accounts for around 45% of the total European Union Budget.

The Common Agricultural Policy integrates environmental concerns through “polluter pays” and “provider gets” principles (European Commission, 2016). The European Commission argues that such an approach creates a set of rules and standards that should be pursued at the farmer’s cost, and a set of environmental objectives that should be incentivised and rewarded as they go beyond the expectations of environmental legislation (European Commission, 2016a). The polluter pays principle is regulated through cross-compliance and reductions in subsidies for non-compliance, whilst the provider gets principle is enacted through particular agri-environmental schemes. Such agri-environmental schemes are key determinants of the type and extent of environmentally beneficial activities undertaken by British farmers. For example, from 2005 onwards individuals who elected to convert some or all of their farmed land to organic status were offered a five-year conversion subsidy through the UK government’s Organic Entry Level Stewardship scheme (Defra, 2014b). Organic status requires farmers to conform to strict regulations that ensure food is produced in a system that severely limits the application of chemical fertilisers and pesticides (Defra, 2014b). The five-year subsidy, paid per acre of land placed into organic conversion, provides financial compensation for the reduction in turnover whilst conventionally farmed land is converted to organic status. Once the five-year conversion period is complete individuals receive an ongoing payment per acre of land in organic production through the organic entry level stewardship scheme. Additional agri-environmental schemes such as the Entry
Level and Higher Level Stewardship Schemes, both of which ceased in 2013, incentivised and rewarded farmers for pursuing active and environmental beneficial practices such as maintaining hedgerows, planting trees, removing pesticides or fertilisers from production systems, or providing educational tours on farms (Hodge and Reader, 2012). Since 2015 these stewardship schemes have been superseded by the ‘Greening’ requirements of the 2013 Common Agricultural Policy Reform. In their most simplified form, the Greening requirements oblige farmers to diversify crops, maintain permanent grassland and, if applicable, dedicate a minimum of 5% of arable land to ecologically beneficial activities in return for the direct subsidy they receive per hectare of land farmed (European Commission, 2016b). Organic farmers will automatically qualify for the Greening subsidies yet may experience a reduction in funding in comparison to the preceding Organic Entry Level Stewardship Schemes (Defra, 2015a). The potential yet unrealised changes driven by the Greening requirements therefore present an increasingly uncertain future for organic farmers.

Direct subsidies are not the only means for the Common Agricultural Policy to address environmental concerns. For example, agricultural learning around environmental change has been shaped by the 2007-2013 Rural Development Programme for England. The Rural Development Programme for England shaped agricultural learning by directing funds towards a diversity of knowledge exchange projects that involved varying levels of participation of the British farming community. For example, the SWARM Hub knowledge exchange project was administered and implemented by the Duchy College, and aimed to enhance learning on agricultural natural resource management by providing a web-based portal that detailed and exemplified how to improve the environmental sustainability of farming practice whilst improving the financial integrity of farm enterprises (SWARM Hub, 2016). This classic top-down approach to knowledge exchange, in which farmers had limited opportunity for participation and instead acted primarily as knowledge recipients, was complemented by other projects in which farmers were offered greater opportunity to participate through receipt of subsidies that supported farmer organised learning activities. For example, the South West Regional Skills Programme aimed to enhance the sustainability and productivity of South West England’s farms by acting as both a provider of
vocational training, and by also providing subsidies for farmer-organised learning events.

Despite financial support for addressing environmental concerns, the effectiveness of the Common Agricultural Policy is commonly questioned. Low levels of uptake or miss-guided implementation of agri-environmental measures means that the schemes often fail to deliver the desired effects (Christen et al., 2015). Critics of agri-environmental schemes suggest that all too often the schemes are not well aligned with local conditions, or are so inflexible that farmers are unable to shape how the schemes are implemented (Stobbellar et al., 2016). Indeed, the capacity of British agriculture to effectively address environmental concerns relies on increasing the level of farmer participation and engagement in the design of agri-environmental schemes (Lastra-Bravo et al., 2015; Whittingham, 2011). Such levels of increased participation do not currently exist.

I have so far identified that intensive agriculture threatens the very integrity of the environmental systems on which it relies for food production. The Common Agricultural Policy attempts to shift British agriculture towards more environmentally sensitive practices such as organic farming. However, the limited opportunity for farmers to participate and influence the Common Agricultural Policy highlights the distinct challenge in creating systems of governance that are adaptive to the situated nature of environmentally sensitive agricultural knowledge and practice, and that also empower farmers to pursue the transformed futures that address these environmental concerns. In June 2016 Great Britain voted to exit the European Union. Agriculture, like many other systems, faces a prolonged period of uncertainty in how it will be governed as negotiations take place on how Great Britain will exit the European Union. This period of change will likely present many challenges and opportunities for farmers, yet the extent to which the farming community is able to shape the future of agri-environmental governance remains uncertain.
1.3 A resilience perspective on transformation

This thesis applies a resilience lens to explore the conversions of farmland from conventional to organic status as transformations in social-ecological systems. Resilience has gained significant traction across scholarly, political and popular media as a tool for explaining how individuals and society can respond to disturbances and pursue transformational change (Brown, 2014). A resilience perspective on transformations in social-ecological systems embraces two key assertions. Firstly, social-ecological systems are constructed on the understanding that human-nature systems affect each other so strongly that they cannot be analysed in isolation (Chapin et al., 2006; Liu et al., 2009). In essence, the “delineation between social and ecological systems is artificial and arbitrary” (Folke, 2006: 434). Secondly, a resilience perspective on social-ecological systems provides this thesis with a set of conceptual tools that embraces change across scales through ideas of “non-linear dynamics, thresholds, uncertainty and surprise, how periods of gradual change interplay with periods of rapid change and how such dynamics interact across temporal and spatial scales.” (Folke, 2006: 253).

Interest in the idea of transformation has grown amid concerns over the conceptual utility of adaptation to help society actively steer towards more just and equitable social-ecological systems. Transformation involves a more deliberate, profound and empowered sense of change than that of adaptation, which “often focuses on accommodating change, rather than contesting it and creating alternatives” (O’Brien, 2012: 667). Resilience literature understands transformations as profound and significant shifts that move one state, function, form or location to another (Brown, 2014; Brown et al., 2013; Marshall et al., 2012; Nelson et al., 2007; Olsson et al., 2014), yet efforts to develop an integrated and informed idea of what constitutes transformational change are constrained by the social sciences’ diverse and competing interpretations of the concept (Brown et al., 2013).

A resilience lens on transformations directs attention towards the capacities that increase the potential for transformation. Capacity for transformation is a property of resilience that relates to the ability to fundamentally change system behaviour,
or cross thresholds when a social-ecological system’s current state is no longer viable (Béné et al., 2013; Folke et al., 2010). Capacity for transformation is not homogenous and depends on scale; differences in capacity for transformation at the scale of the individual interact with capacities for transformation of groups and wider systems (Marshall et al., 2012). However, resilience literature’s understanding of the extent to which capacities for adaptation and transformation differ is characterised by high levels of debate and uncertainty. For example, Béné et al. (2015) propose that the type of capacity necessary for change is a function of the severity of disturbance and intensity of response required. In this context, capacity for transformation is drawn on during disturbances of higher severity and elicits a more intense response than those of absorptive and adaptive capacities. Marshall et al. (2012), however, argue that delineating capacities for adaptation and transformation can seem arbitrary as both capacities are similar and at times not easily distinguishable from each other.

Resilience understanding of transformation is typified by its focus on shifts towards processes of adaptive co-management and adaptive governance of ecosystems (Olsson et al., 2004; Olsson et al., 2006). However, resilience scholars are yet to sufficiently empirically explore and theorise processes of transformation at the scale of the individual and collective (Brown et al., 2013; Moore et al., 2014). Resilience literature has made strides to characterise the role of key individuals in transformations to processes of adaptive co-management and adaptive governance. Key individuals are commonly understood to build capacity for transformations towards adaptive co-management and adaptive governance through processes of leadership and entrepreneurship (Apgar et al., 2015, Evans et al., 2015; Westley et al., 2013). Resilience understanding of the roles of key individuals in building capacity for transformations at the smaller scales of social-ecological systems, and outside of transformations to processes of adaptive co-management and adaptive governance is, however, not as widely documented.

Novelty, experimentation and innovation are identified as vital for society to pursue deliberate and desirable transformations (Folke et al., 2010). However, we experience a paradox of innovation as “innovation is both a contributing cause for our current unsustainable trajectory and our hope for tipping in new more
resilient directions.” (Westley et al., 2011: 763). For example, the Green revolution in Asia substantially increased crop yields yet damaged ecosystems and displaced millions of smallholders (Olsson and Galaz, 2013). The concept of social-ecological innovation addresses this paradox by directing analysis towards how innovation can influence feedback loops with effects that manifest across social and ecological domains. Questioning whether feedback loops are recognised, and whether innovations can be used to directly change the behaviour of components of processes within feedback loops, provides one means of analysing for the presence of social-ecological innovation.

In summary, this section illuminates the contested yet equally ambiguous understanding of transformation in resilience literature. Exploring the roles of key individuals, social-ecological innovation, and different capacities to manage change across scales will contribute a timely and more informed understanding of transformations in social-ecological systems. These gaps represent the starting point for this thesis are analysed in greater depth in chapter two.
1.4 Research questions

The primary aim of this thesis is to explore the distinctive resilience characteristics of transformations in social-ecological systems. This thesis synthesises four key research questions that act as the launch pad for an exploratory process of research:

- What roles do key individuals play in building capacity for transformations?
- Are feedbacks recognised across the temporal and spatial scales of a social-ecological system?
- Can social-ecological innovation be identified?
- How do individuals understand their capacities to shape change in external systems?

1.5 Outline of thesis

This thesis comprises of seven chapters. Chapter two introduces and critiques literature on the main concepts and theoretical frameworks of interest to this thesis. Chapter three presents the process of research that guides this thesis. The chapter justifies the reasoning for the methodological approach, research activities, and analytical tools used. The chapter also introduces the single case study group of farmers who have converted farmland from conventional to organic status. Chapters four to six apply a resilience lens to analyse empirical data that addresses and goes beyond the key research questions. Chapter four starts by analysing mental models and reflective interview data to identify transformations in understanding and management of agroecosystem fertility. The chapter advances analysing how processes of self-organisation and social learning build capacity for the identified transformations in understanding and management of agroecosystem fertility. The chapter illuminates the distinct motives and roles that key individuals play in the processes of change. The chapter examines dynamics of social learning at two scales; firstly, within and
across the case study group; and, secondly, between the group and wider networks.

Chapter five applies a resilience lens to examine how innovation builds capacity to manage change at the scale of the agroecosystem. This thesis identifies agroecosystems as ecosystems situated within the spatial scale of the farm. The chapter illuminates why innovation is understood as a particularly necessary and important means of building capacity to manage change within agroecosystems. Causal link diagrams of mental models data illustrate how specific innovations address agroecosystem dynamics. The chapter analyses for the presence of social-ecological innovation. The chapter questions whether feedback loops can be identified, and examines how the social-ecological innovation of mob grazing influences change in identified feedback loops with effects across social and ecological domains. The chapter then elaborates on the factors that mediate the extent to which social-ecological innovation is integrated into members’ agroecosystems.

Chapter six applies a resilience lens to examine how individuals understand their capacities to shape change external to their agroecosystems. The chapter begins by examining the influence of external forces of change, and trigger events on decisions to convert from conventional farming systems. The chapter then explores how windows of opportunity enable individuals to pursue decisions to convert farmland to organic status. The chapter analyses the extent to which individuals identify change in how they connect to external forces of change. Analysis goes on explore interesting tensions between the extent to which individuals understand their capacities to adapt to, or address, change in the external system.

Chapter seven synthesises the findings from chapters four, five and six. The chapter presents a summary of findings that address the key research questions, and presents reflections on the processes of research set out in chapter three. The chapter analyses the key contributions of the thesis to resilience and transformation literatures.
2 A resilience lens on transformations in social-ecological systems

This thesis uses a resilience lens to analyse transformations in social-ecological systems. The following review of literature elaborates on the key concepts and gaps in understanding addressed in this thesis. The review builds the foundations for the thesis by illuminating the conceptual utility of a social-ecological systems approach to change. The review goes on to analyse how a resilience perspective helps to explain change in social-ecological systems. The final section of the review sheds light on contemporary understanding of transformations, and concludes by summarising the key gaps in understanding that explored in this thesis.

2.1 Social-ecological systems

A social-ecological system is an “Integrated system of ecosystems and human society with reciprocal feedback and interdependence.” Folke et al. (2010: 20). A social-ecological systems perspective on change reflects an understanding that human-nature systems affect each other so strongly that they cannot be analysed in isolation (Chapin et al., 2006; Liu et al. 2009). Indeed, “delineation between social and ecological systems is artificial and arbitrary” (Folke, 2006: 434). Social-ecological systems are predicated on the fundamental assumption that social and ecological systems are linked. This link is understood to enable a more holistic conceptualisation of change than the study of social or ecological systems in isolation (Enfors, 2013).

Analysis of social-ecological systems necessitates the identification of a focal system. For example, the Ibiraquera lagoon in southern Brazil (Berkes and Seixas, 2005), and the wetlands of the lower Helgeå River in southern Sweden (Olsson et al., 2004) have been analysed as focal social-ecological systems. Social-ecological systems comprise multiple subsystems, composed of fast and slow variables that manifest across and between different scales (Ostrom, 2009; Walker et al., 2006). Controlling variables determine whether change in the focal system is endogenous or exogenous, and also determine the speed and frequency of any resulting change. For example, Hodbod and Eakin’s (2015: 476) likening of a food system to a social-ecological system suggests “Change can be
both episodic and gradual, triggered by fast, external perturbations (such as a price spike or disease outbreak) or slower internal drivers (such as soil nutrient depletion or shifts in consumer values), which also mediate the impact and dynamic of fast perturbations.” The representation of a food system advanced by Hodbod and Eakin (2015) illustrates how complex change in a social-ecological system is driven by variables that operate across and between levels and scales of a social-ecological system.

Scale and level are key concepts in the analysis of social-ecological systems. Scale is defined as “the spatial, temporal, quantitative or analytical dimensions used to measure and study any phenomenon” (Gibson et al., 2000: 218). An example of a temporal scale includes the range across seconds, minutes, hours, days, weeks, months and years, and example of spatial scale includes the range across patches, landscapes, regions and the globe (Cash et al., 2006). Level is defined as “the units of analysis that are located at different positions on a scale” (Cash et al., 2006). Social-ecological systems studies are typified by their focus on temporal, spatial and jurisdictional scales, yet examination of other scales such as management, networks and knowledge may also provide insights into the dynamics of complex systems (Cash et al., 2006). Social-ecological system scholars place great emphasis on the influence of cross-scale interplay, understood as “Influences between the dynamics of systems at one scale and the dynamics of those that are embedded in it or enfold it.” (Resilience Alliance, 2015). Examination of cross-scale interplay is particularly important as it elaborates an enhanced understanding of the complex and difficult to predict dynamics of change in a focal social-ecological system (Cash et al., 2006). However, distinct gaps exist in understanding cross-scale dynamics between the individual and collective, and how these dynamics affect changes across wider scales (Brown and Westaway, 2011).

Frameworks used to analyse social-ecological systems “differ significantly in their goals, disciplinary background, their applicability, the temporal, social, and spatial scale addressed, and their conceptualization of the social and ecological systems as well as their interaction.” (Binder et al., 2013: 26). However, the fundamental dynamics of social-ecological systems are characterised by concepts and ideas drawn from general systems and complexity science (Berkes et al., 2003).
General systems theory drives attention towards whole systems through concepts such as connectedness, context and feedbacks. A complexity perspective on general systems directs attention towards defining characteristics of “non-linearity, uncertainty, emergence, scale, and self-organization” (Berkes et al., 2003: 5). Social-ecological systems comprise multiple sub-systems each with their own internal controlling variables (Ostrom, 2009). It is the cross-scale interactions between these controlling variables, each operating with different frequencies and rates of change across a slow-fast scale that characterises and determines the complexity of the dynamics of change in a social-ecological system (Walker et al., 2006). Integration of these concepts into analysis facilitates examination of links between human intent and the avoidance or surpassing of critical ecological thresholds; and, the presence of human perceptions can shape how humans interact with and attempt to manage ecological components (Walker et al., 2006). However, the ecological foundations of social-ecological system research has resulted in assumptions that actors’ motivations are primarily concerned with environmental factors, and that social dimensions such as social processes, power and values are not sufficiently theorised (Fabyini et al., 2014).

Feedback loops, defined as a “closed sequence of causes and effects” (Richardson and Pugh, 1981: 4), are a key dynamic of change in a social-ecological system. The temporal scales of feedbacks are commonly characterised with reference to their degrees of tightness or looseness (Hull et al., 2015; Levin, 2000). Tight feedbacks are characterised by fast return of change to the originating source, the outcome of which can be a speed of change that outstrips capacities for effective response. Loose feedbacks are characterised by slow return of change to the source, and can result in surprise due to unanticipated lag effects (Hull et al., 2015). Reinforcing feedback loops, also known as positive feedback loops, amplify the effects of an originating cause of change, whilst balancing feedback loops, also known as negative feedback loops, dampen the effects of an originating cause of change (Biggs et al., 2015; Sterman, 2000). Jones et al. (2010) suggest that a greater understanding and management of positive feedback loops, characterised as virtuous cycles, can help to break linear thinking that assumes systems are based on an abundance of fossil fuel energy and a capacity for natural systems to absorb the impacts of pollution and waste that emerge from consumption of the fuels. Virtuous
feedbacks are identified in a composting and biogas system that provides multiple, closed systems of food production, energy, fertiliser and construction materials.

Whilst feedback loops provide one useful conceptual means of examining cross-scale dimensions of change in social-ecological systems, studies are criticised for too commonly focusing on social or ecological feedbacks in isolation (Hill et al., 2015). Recent studies address this gap by examining feedbacks between individual decision-making and landscape ecologies (BenDor et al. 2015; Spies et al., 2014). Fazey et al.’s (2006) study of the implicit knowledge and perceptions of managers of conservation in the Macquarie Marshes, Australia provides an insightful example of how resilience scholars attempt to reconcile how individuals understand the dynamics of feedback loops. Figure 2.1 presents a causal loop diagram of the Macquarie Marshes social-ecological system from Fazey et al. (2006).

Figure 2.1 Causal loop diagram of the Macquarie Marshes social-ecological system from Fazey et al. (2006).
The different temporal and spatial scales of the controlling variables in feedback loops presented in Figure 2.1 illustrates the complex and cross-scale nature of change that can emerge from directly and indirectly interacting feedback loops. Feedback loops are, however, considered difficult to detect and respond to in the absence of ecological knowledge and understanding of ecosystem dynamics (Fazey et al., 2005; Folke et al., 2005).

In summary, a social-ecological systems perspective on change directs attention towards notions of complexity, interdependence, feedbacks and scale. Feedbacks regulate the behaviour of social-ecological systems yet they can prove difficult to identify, understand and manage. Understanding cross-scale interactions is particularly important as they shape dynamic change in a social-ecological system. The following section analyses how a resilience lens contributes to understanding change in social-ecological systems.

### 2.2 A resilience lens

Resilience has attracted widespread interest, debate and diversity of interpretation as an analytical framework for explaining dynamic change (Baggio et al., 2015, Brown, 2014). Resilience is widely understood as the capacity of a social-ecological system to absorb disturbance whilst maintaining the same attributes, controls or functions (Baggio et al., 2015; Biggs et al., 2015; Nelson et al., 2007). The conceptual and theoretical foundations of resilience emerge from Holling’s (1973) seminal work on ecological resilience. Prior to the emergence of resilience, ecology was dominated by notions of single steady states and equilibria (Folke, 2006). However, resilience counters these dominant perceptions of change by introducing and embracing ideas of "non-linear dynamics, thresholds, uncertainty and surprise, how periods of gradual change interplay with periods of rapid change and how such dynamics interact across temporal and spatial scales." (Folke, 2006: 253). These cross-scale interactions are key determining factors of emergence and surprise in social-ecological systems (Béné et al., 2011).

A resilience lens on social-ecological systems contends that systems exist within the boundaries of a specific basin of attraction (Folke et al., 2010), a term that
describes the conditions that tend towards a specific system state, or stability domain (Walker et al., 2004). The dimensions of the stability domains are defined “by the set of controlling variables that have threshold levels (equivalent to a system regime)” (Folke et al., 2010: 20). The dynamic nature of change means that system states are not fixed but move within the limits of the basin of attraction. Furthermore, a social-ecological system may exist within multiple basins of attraction, known collectively as the stability landscape (Walker et al., 2004). For example, the stability landscape of a savanna is characterised by change in stable states over a long temporal scale between grassy and woody dominant states (Kinzig et al., 2006). The notion of stability is not, however, one that aligns well with the dynamic representation of change that scholars propose characterises a social-ecological system. Folke (2006) usefully suggests that ‘regime’ is a more appropriate means of explaining the state of a system as it embraces the notion of dynamic change better than ‘stability domain’, which implies an impression of equilibria and stasis.

Resilience literature proposes that social-ecological systems can become caught in traps. Rigidity traps occur when durable and connected institutions become capable of absorbing disturbance (Butler and Goldstein, 2010; Carpenter and Brock, 2008). These rigidity traps constrain capacities to manage change and pursue desired trajectories. For example, Enfors (2013) analyses how institutional changes, population growth and increasing frequency of dry spells degrade agricultural yields and restrict the capacities of poor individuals to manage change. Innovation is identified as a key factor that enables individuals to destabilise the feedback effects that create the rigidity trap. Poverty traps occur when connectedness and resilience are low yet capacities and potential to pursue alternative trajectories are not realised (Carpenter and Brock, 2008). Poverty traps occur when resources are misused and individuals continue to persist in highly challenging environments (Maru et al., 2012).

Analysis of resilience necessitates consideration of the general and specific resilience of the system under consideration. Specific resilience, or “Resilience of what, to what?” (Carpenter et al., 2001: 765), directs attention towards specific variables or sub-systems, and their resilience to specifically identified disturbances (Folke et al., 2010). General resilience, however, widens the lens of
resilience analysis to incorporate the entire focal system and all potential disturbances. Consideration of both general and specific resilience in parallel highlights the challenges inherent in understanding and managing the cross-scale dynamics of resilience; too narrow a focus or increasing the resilience of specific variables or subsystems can cause a decrease in the general resilience of the focal system to respond effectively to disturbances (Folke et al., 2010). Identifying the most relevant dimensions of specific and general resilience is, therefore, key for both the analysis of resilience and the impacts of any analysis for those who will be most affected by the research. However, Bergstöm and Dekker’s (2015) recent analysis of resilience at micro, meso, macro and cross-scales contributes a conceptualisation of resilience as fractal, with “recognizable or recurring features at a variety of spatial scales.” (Bergstöm and Dekker, 2015: 22). The fractal nature of resilience extends past analysis of resilience at a particular focal scale to explore commonalities and differences depending on the level of resolution of a study (Bergstöm and Dekker, 2015).

The capacity of a social-ecological system to absorb disturbance implies that systems seek to persist in their current state (Berkes and Seixas, 2005; Folke, 2006). However, resilience is argued to be much more than a set of incremental adjustments that maintain a status quo. Resilience is about new opportunities, renewal, and emergence of new trajectories (Folke, 2006). ‘Resilience thinking’, proposed as a means of clarifying confusion around the meaning and nature of resilience, extends the resilience lens of analysis to incorporate adaptation, and the more extreme dimension of transformational change (Folke et al., 2010). However, the widening of the resilience lens on change does not represent a panacea in the study of environmental and social change. Indeed, resilience literature is critiqued for both under-theorising the social dimensions of social-ecological resilience (Brown, 2014) and assuming that social resilience is linked to ecological resilience (Adger, 2000). The under-theorisation of social dimensions of resilience drives three key criticisms, those being “the failure to recognize resilience as socially contingent, rarely addressing the question of ‘resilience for whom?'; second, its mainstream usage is conservative, focused on the persistence of a ‘system'; third, it focuses on a system which is disturbed by external or exogenous forces, so it underplays the internal, endogenous and social dynamics of the system.” (Brown 2014: 109). These inconsistencies
illustrate how resilience literature experiences difficulties in understanding the relationship between persistence, adaptation and transformation. Transformation, in particular, is represented quite diversely, ambiguously, and contradictorily within resilience literature. The following section analyses how resilience and broader literatures attempt to understand and critique the current state of knowledge of transformations.

2.3 Transformations

Scholarly interest in the idea of transformations has grown amid concerns over the conceptual utility of adaptation to shift society towards more just and equitable social-ecological systems, whilst simultaneously enhancing capacities to respond to abrupt and large-scale environmental change (Matyas and Pelling, 2015; McAlpine et al., 2015; O’Brien, 2012). Efforts to establish an integrated and critical understanding of transformational change are, however, hindered by the social sciences’ diverse and competing interpretations of the concept (Brown et al., 2013). The hazy and ambiguous understanding of transformation is particularly prevalent in resilience research. More specifically, contemporary understanding of the resilience characteristics of transformations is not well theorised or sufficiently empirically tested. This thesis addresses this gap by conducting an exploratory process of research into the resilience characteristics of transformations. The following sections elaborate on how transformation is understood by resilience and broader literatures, and identifies key gaps in understanding that will be addressed through this thesis.

2.3.1 Relation to resilience

A resilience perspective understands transformations as profound and significant shifts that move one state, function, form or location to another (Brown et al., 2013; Brown, 2014; Marshall et al., 2012; Nelson et al., 2007; Olsson et al., 2014). Transformations can be triggered by stressors from social and ecological domains (Brown et al., 2013; Moore et al., 2014). The untenable and undesirable natures of the system cause the crossing of critical social and ecological thresholds into new basins of attraction (Béné et al., 2013; Moore et al., 2014; Olsson et al., 2004; Pelling, 2011; Walker et al., 2004). Thresholds are defined
as “the point at which one relatively stable state or regime gives way to another” (Kinzig et al., 2006: 20). Thresholds are surpassed when the resilience of a system declines and disturbances trigger the thresholds of the controlling variables to tip past their critical state and foster renewal and reorganisation that leads to a regime shift (Hodbod and Eakin, 2015). Kinzig et al. (2006) observe that a social-ecological system can comprise multiple slow, controlling variables each with their own threshold effects, situated across spatial and temporal scales. The crossing of one threshold can trigger the crossing of other linked thresholds, but the extent to which this change is reversible or irreversible remains contested (Kinzig et al., 2006; Marshall et al., 2012).

Identifying transformational change is “dependent on being explicit about scale.” (Marshall et al. 2012: 034022). Identification of the scale at which transformations occur has subsequent implications for how we understand the relation of transformations to resilience at different scales of interest. However, whilst transformations can involve fundamental shifts at scales including the individual, institutions, regimes and infrastructure (Matyas and Pelling, 2015), a diversity of interpretations of transformation, each with a different scale of focus, simultaneously helps and muddies efforts to identify the fundamental change that constitutes transformation. For example, transformative change must, at a minimum, involve change in both social and ecological components across scales (Moore et al., 2014); can occur at the scale of shifts in perceptions and understanding of the world in one or a number of people (Pelling, 2011); or, occurs at the scale of governance arrangements (Olsson et al., 2004). However, resilience literature is yet to sufficiently explore and theorise processes of transformation at the scale of the individual and collective (Brown et al., 2013; Moore et al., 2014).

As identified in section 2.2, resilience is typically conceptualised as the capacity of a system to absorb change, or adapt in the face of disturbance (Baggio et al., 2015; Biggs et al., 2015; Nelson et al., 2007). The conceptualisation of resilience in terms of persistence and resistance therefore acts against the more profound forms of change caused by transformations (Brown, 2014). Matyas and Pelling (2015) propose that resistance, incremental adjustment and transformation are types of change that contribute to the resilience of a system. In this
conceptualisation of change, transformation becomes a function or subset of resilience. Whilst the delineation between the types of change provides a greater conceptual clarity to the analysis of what specifically influences resilience, resilience scholars are also aware that transformations “could occur simultaneously in a system at different scales, as easily complementing as antagonising one another.” (Matyas and Pelling, 2015: 58). The cross-scale relationships that concurrently antagonise and complement one another therefore have distinct implications for how transformations relate to resilience. In this context, multiple interacting processes of persistence, adaptation and transformation, linked through cross-scale interplay, contribute to and are shaped by the resilience of the system at higher scales (Brown, 2014; Folke et al., 2010; Holling, 2001).

Transformations at smaller scales are shaped by and contribute to resilience at larger scales (Folke et al., 2010; Olsson et al., 2014). Panarchy is a heuristic device that represents resilience as multiple interacting nested adaptive cycles across and between multiple scales (Folke, 2006; Folke et al., 2010; Holling, 2004). Panarchy is a particularly useful concept for understanding the dynamics of transformations as it focuses attention on the cross-scale interactions between adaptive cycles, as illustrated in the panarchy heuristic model presented in Figure 2.3.
Figure 2.2 Panarchy representing cross-scale interactions between nested adaptive cycles. From Folke (2006).

Whilst the representation of the panarchy presented in Figure 2.3 suggests a hierarchical level of organisation of adaptive cycles, panarchy was chosen in order to move from a structured and top-down representation of change to a dynamic and adaptive representation of change across temporal and spatial scales (Holling, 2001; Holling et al., 2002). Interactions, or panarchical connections, between nested adaptive cycles cause the processes of collapse and destruction in the release phase of small and fast adaptive cycles to cascade upwards and cause crises in the conservation phase of slower and larger adaptive cycles (Holling, 2001). This cross-scale interplay is characterised as a process of ‘revolt’, denoted by the ‘Revolt’ arrow in Figure 2.3, due to its capacity to cause critical change in vulnerable adaptive cycles. Change across the panarchy is not, however, controlled solely by change in small and fast variables cascading up to cause change at slower and larger scales. The ‘Remember’ arrow in Figure 2.3 suggests that the conservation phase of adaptive cycles at slower and larger levels shapes the opportunities and limitations caused by crises in adaptive cycles at faster and smaller levels of a social-ecological system (Holling, 2001). In this context, adaptive cycles at larger and slower levels
stabilise change through the wisdom and memory of previous periods of experimentation and novelty (Holling, 2001).

Transformations are most commonly characterised with reference to profound shifts towards processes of adaptive co-management or adaptive governance of ecosystems. Olsson et al. (2004: 2) observe that transformation in ecosystems management structures towards adaptive co-management involve three distinct phases “1) preparing the system for change, 2) seizing a window of opportunity, and 3) building social-ecological resilience of the new desired state.” These sequential and apparently linear phases are facilitated in particular by processes of social learning across scales, and the actions of particular key individuals. However, the processes and phases of transformations proposed by Olsson et al. (2004 and 2006) are criticised for their lack of integration of social dimensions such as vulnerability, power, and politics (Moore et al., 2014; Pelling, 2011). Indeed, processes of transformation are shaped by power, and will invariably involve outcomes that are perceived and experienced unequally by different groups of winners and losers (Cinner and McClanahan, 2015; Pelling and Manuel-Navarrete, 2011).

2.3.2 Questions of capacity

Capacity is of particular importance to transformations as it relates to “the ability to generate an outcome or perform a task and also to learn, and the potential for growth and development” (Brown and Westaway, 2011). Capacity for transformation, or transformability, is a system property that relates to the capacity of actors to fundamentally change system behaviour, or cross thresholds when the system’s current state is no longer viable (Béné et al., 2013; Folke et al., 2010). Capacity for transformation is not homogenous and depends on scale; differences in capacity for transformation at the scale of the individual influence capacities for transformation of groups and wider systems (Marshall et al., 2012). However, not all individuals express the same capacity for transformation (Marshall et al., 2012), nor do we sufficiently understand how capacities for transformation at individual and collective scales relate to change in wider systems (Brown and Westaway, 2011).
Identifying and fostering capacity for transformation is of clear importance to how we understand the dynamics of transformations yet agreement on what constitutes capacity for transformation, and the extent to which it differs from adaptive capacity, are contested. Furthermore, resilience literature is yet to establish a strong empirical understanding of capacities for transformation; theoretical hypothesis dominates over empirical testing and probing. Wilson et al. (2013) argue that capacities necessary for transformation are both similar and discrete to those that facilitate resilience. Béné et al. (2015) propose that transformative capacity is an extension of the absorptive and adaptive capacities that constitute resilience. Figure 2.4 presents Béné et al.’s (2015) heuristic of transformative capacity that illustrates how transformative capacity is different from, yet co-exists with absorptive and adaptive capacities.

![Figure 2.3 Heuristic model of resilience capacities. From Béné et al. (2015).](image)

The heuristic of resilience capacities presented in Figure 2.4 suggests that transformative capacity is drawn on during severe disturbances and contributes to a profound intensity of response. The delineation between adaptive and transformative capacity can, however, seem arbitrary as both capacities are similar and at times not easily distinguishable from each other (Marshall et al., 2012).
Understood through a critical lens, capacity for transformation is about recreating systems through the exercise of power (Manyena and Gordon, 2015), and must address underlying causes of vulnerability (Béné et al., 2015). Recent analysis of the relation between capacity for transformation and system dynamics draws on ideas from Giddens’ (1984) theory of structuration. For example, Arnall (2015) proposes that capacity for transformation is the ability to respond to a negative event by seizing on opportunities for structural change through reflexive processes of monitoring of social interactions. Capacity for transformation, in this context, relates to the capability to transform the social dimensions of the system by confronting, intervening in and changing controlling dynamics of change. Saravanan (2015) offers additional insights by suggesting that negotiation and integration of diverse institutions, driven by individual agendas and unconscious motives, represents capacity for transformation.

Scholars attempt to differentiate adaptive and transformative capacities by the characteristics that contribute to each capacity. Characteristics of capacity for transformation include preparedness to contribute to building social networks and social capital, leadership, proactivity, creating new visions and goals, and a sense of unity that acknowledges and accepts differing perceptions (Apgar et al., 2015; Wilson et al., 2013). However, the emergent understanding of capacity for transformation means that its characteristics are not yet easily identifiable. If capacity for transformation differs from adaptive capacity only by its temporal scale then it reasons that the characteristics of capacity for transformation are similar to those of adaptive capacity (Marshall et al., 2012). This assertion is particularly poignant as it places the pre-existing body of literature on adaptive capacity as the foundation for examination of capacity for transformation. Individual capacities for transformation can therefore include a diverse number of factors including “an individual’s skills, circumstances, perceptions and willingness to change.” (Marshall et al., 2012: 034022). Folke et al. (2003) propose that learning to live with change and uncertainty, nurturing diversity for reorganisation and renewal, combining different types of knowledge for learning, and creating opportunity for self-organisation are key characteristics of adaptive capacity. Table 2.1 presents Brown and Westaway’s (2011) categorisation of the four key characteristics of adaptive capacity.
Self-organisation, learning and social memory are widely understood as key adaptive capacities (Barthel et al., 2010; Folke et al., 2005; Johannessen and Hahn, 2013; Pelling, 2011; Reed et al., 2010). Self-organisation is a particularly important dimension of resilience as it relates to the capacity for collectives to form without incentive or direction from higher-level forces (Pelling, 2011). For example, Olsson et al. (2006) analyse examples of self-organisation in Canada and Sweden in which local collectives establish relationships with institutions and organisations to enact processes of adaptive co-management. Learning contributes directly to social-ecological memory by building and embedding a collective body of understanding around ecosystem change (Olsson et al., 2004).

Learning is a core component in interpretations and definitions of resilience (Folke, 2006). For example, Carpenter et al. (2001) interpret resilience as being determined by the extent to which a social-ecological system demonstrates and builds capacity for learning and adaptation. Learning is a particularly important
component of a resilience lens on change in social-ecological systems as it enables scholars to consider how individuals, groups, and systems manage and shape change, rather than act as mere reactionaries (Folke, 2006). Social learning is emphasised as a form of learning that builds capacity for transformation by profoundly changing an individual’s understanding and subsequent behaviour towards a natural resource (Rodela, 2012), and by building knowledge of ecosystem dynamics and enhancing collaboration in processes of transformation towards adaptive co-management arrangements (Olsson et al., 2004).

Reed et al’s (2010) review of social learning in natural resource management literatures presents social learning as a multi-scale process. For example, social learning is most commonly understood at the scale of individual learning, for example Bandura’s (1977) theory of social learning that highlights the role of social context and social norms on an individual, and at the scale of organisational learning, for example communities of practice (Wenger, 1998), and single and double loop learning (Agyris and Schön, 1978). In order to account for the multi-scale nature of social learning, this thesis ascribes to an understanding of social learning as a process that must “(1) demonstrate that a change in understanding has taken place in the individuals involved; 2) demonstrate that this change goes beyond the individual and becomes situated within wider social units or communities of practice; and (3) occur through social interactions and processes between actors within a social network.” (Reed et al., 2010: 1). However, social learning is commonly valorised as a normative goal; it is characterised by a lack of analytical rigour that restricts a deeper understanding of “the factors that determine if, who, how, when and what type of learning actually occurs” (Armitage et al., 2008: 87). Issues of power, marginality, risk, incentives to learn, and monitoring and evaluation also remain poorly understood (Armitage et al., 2008).

I have so far analysed the importance of social learning to resilience and transformation, yet have demonstrated clear gaps, assumptions, and criticisms in the resilience understanding of social learning. How can the superficial and normative understanding of social learning that prevails in resilience literature be
addressed when considering transformation? Pelling and Manuel-Navarette (2011) propose that conscientization (Freire, 2000) acts as a means for marginalised individuals and groups to understand, critically evaluate, and challenge disempowering aspects of reality. This emancipatory understanding of learning is further complemented by Mezirow’s (1991) theory of transformative learning. Transformative learning is most commonly understood with reference to adult learning and is promoted as a normative goal for adult education. To be transformative, learning must be autonomous, and enable a frame of reference to move toward one “that is more inclusive, discriminating, self-reflective, and integrative of experience.” (Mezirow, 1997: 5). In other words, transformative learning occurs when individuals develop their own interpretations instead of assimilating those of other individuals or groups. Shifting the frame of reference relies on understanding and questioning the meaning of our experiences through critical questioning of assumptions that inform our values, beliefs, and world views. Understood as a process, transformative learning involves more than the elaboration of an existing point of view, or establishment of new points of view. Transformative learning involves a profound growth in our governing habit of mind, for example the gradual yet fundamental shifts in how we understand different cultures, or by transforming our ethnocentric habit of mind, which involves developing a critical awareness of our biases towards other groups (Mezirow, 1997). At its core, transformative learning involves “transforming frames of reference through critical reflection of assumptions, validating contested beliefs through discourse, taking action on one’s reflective insight, and critically assessing it.” (Mezirow, 1997: 11). The critical perspectives offered by conscientization and transformative learning advance knowledge of social learning for transformation by emphasising the importance of individual agency and capacity for self-determination. These key individual dimensions of learning have distinct implications for transformation as they suggest that transformation of a broader system is reliant on transformations at the scale of the individual. By increasing their agency and capacity for self-determination, individuals are more capable of pursuing and shaping change in their social-ecological systems. Furthermore, the lenses provided by transformative learning and conscientization extend the resilience understanding of the role of social learning in transformations as merely relational and knowledge oriented, to a process that
acknowledges critical and human dimensions such as emancipation, empowerment, and inclusivity.

This section has so far presented contemporary attempts to forge an understanding of what constitutes capacity for transformation. Literature also attempts to identify factors that shape and influence capacities for transformation. Walker et al. (2004: 9) suggest that capacity for transformation is influenced by “novelty, diversity, and organization in human capital—diversity of functional types (kinds of education, expertise, and occupations); trust, strengths, and variety in institutions; speeds and kinds of cross-scale communication, both within the panarchy and between other systems elsewhere.” Resource dependency, attachment to place and occupation are key influencing factors on capacity for transformation (Marshall et al., 2012). Attachment to place can motivate actors to find transformative solutions that allow them to maintain their attachment, yet equally hinder transformative capacities by restricting desire to move away from a place when transformation is no longer an option. Strong attachment to occupation can mean that options for transformative change that involve a change in occupation become less desirable, and vice versa. Insights from human development suggest that ethnic identity and culture influence individual and collective capacities for transformation (Brown and Westaway, 2011). Incumbent and rigid values, beliefs, commitments and interests are also identified as capable of restricting capacities to transform (O’Brien, 2012).

In summary, this section analyses how capacity for transformation relates to resilience. The section identifies that emergent strides to characterise the distinctive features of capacity for transformations are inconclusive. The extent to which capacities for transformation differ from those of adaptive capacities is unclear. Indeed, attempts to separate the two forms for capacity are considered arbitrary and ambiguous. The next section elaborates further on the resilience understanding of capacities for transformation by analysing how literature understands the roles and characteristics of key individuals in building capacity for transformation.
2.3.3 Key individuals

Resilience scholars have developed an established body of literature on the contribution of key individuals in building capacity for transformation to, and continued operation within, systems of adaptive co-management and adaptive governance. The following section illuminates how resilience literature characterises the roles and traits of key individuals, and identifies key gaps in understanding that will be addressed in this thesis.

Traits-based characterisations of key individuals are common place in research into profound shifts to processes of adaptive co-management (Folke et al., 2005). Folke et al. (2005: 368) highlight the diverse traits and backgrounds of key individuals, acting independently or as part of actor groups, that allow them to take on multiple and varied functional roles such as “knowledge carriers and retainers, interpreters and sense makers, stewards and leaders, networkers and facilitators, visionaries and inspirers, innovators and experimenters, entrepreneurs and implementers, followers and reinforcers.”. Key individuals are also identified as playing a vital and shaping influence over processes of learning that enable experimentation (Folke et al., 2005; Westley et al., 2011). Key individuals are commonly situated in shadow networks. Key individuals are characterised as brokers who contribute new ideas and share access to cross-scale shadow networks that offer alternative perspectives, access to individuals in positions of power and new resources (Folke et al., 2005). Shadow networks are informal networks that facilitate transformations through innovative responses to challenges, sharing valuable information, extending knowledge and providing nodes of expertise (Olsson et al., 2004). Such capacity for innovation is facilitated by an informal, independent structure designed to operate outside of, and within established systems of governance, thereby creating freedom to test alternative options to mainstream ideas, capacities for learning across scales and creative problem solving (Gunderson, 1999; Olsson et al., 2006; Westley et al., 2011). For example, Sendzimir et al. (2008) analyse how a shadow network of activists and scientists concerned for the river management regime of the Tzisza river basin in Hungary tested alternative management strategies through processes of informal learning across the network. Shared vision and a common vocabulary are
identified as key for converging diverse opinions and focusing attention towards transformation.

Leadership, commonly provided by key individuals, is identified as a key capacity necessary for processes of transformation. Frontier research into leadership has advanced to consider “(1) multiple, interacting leaders, (2) leadership practices and processes, (3) leadership in different contexts, and (4) leadership outcomes from different perspectives.” (Evans et al., 2015: 50). Visions for transformative change emerge from leaders and are adopted by wider networks that play distinct roles in the transformation of higher level governance structures (McCarthy et al., 2014). Leaders foster trust and social capital through different and changing characteristics, actions, roles in networks and visioning and sense-making processes (Folke et al., 2005, Scheffer et al., 2003; Walker et al., 2006; Westley et al., 2011). However, an absence of attention to the fundamental details of what comprises leadership means that the concept is commonly assumed to be a positive and uncontested driver of change (Evans et al., 2015).

Insights from organisational and social innovation literatures illuminate the role of entrepreneurship in transformations. Studies of institutional entrepreneurship contribute an understanding of agency in networks, and are commonly examined with reference to the capacity of social innovations to influence or transform social-ecological systems (Moore and Westley, 2011; Westley et al., 2011). Institutional entrepreneurs open possibilities for new regimes by destabilising rigid institutions and presenting viable alternatives through shadow networks and niche regimes (Glasbergen, 2010; Westley et al., 2011). The roles of institutional entrepreneurs are particularly well documented in processes of innovation, in which they introduce innovations and then work to manipulate changes that foster an enabling environment that encourages adoption and impact of the innovation across scales (Moore and Westley, 2011). Literature suggests that by identifying institutional entrepreneurs and supporting their innovations or alternative pathways then opportunities for durable and impactful change is increased (Westley et al., 2011). Rosen and Olsson (2013) examine the role of institutional entrepreneurship in the transformation of management of the Coral Triangle coastal and marine resources. Transformation of management of the Coral Triangle occurs when institutional entrepreneurs, each with their own shadow
networks and structures of support, forge agreements across national and international scales. Other studies of entrepreneurship in social-ecological systems include policy entrepreneurs in water policy (Huitema and Meijerink, 2009), and social entrepreneurs in local watershed management (Biggs et al., 2010), both of which are akin to institutional entrepreneurship in their contributions to transformations.

In summary, this section identifies a wide body of literature on the roles of key individuals in transformations. Resilience literature does, however, focus on the roles of key individuals across large scale shifts towards new means of ecosystems management such as adaptive co-management and adaptive governance. The roles of key individuals in different contexts and at smaller scales, for example collective action, are not as well defined in resilience literature (Brown and Westaway, 2011). Strengthening understanding in these areas would provide a more coherent and complementary body of knowledge. This thesis addresses this gap by analysing the roles of key individuals in transformations at smaller scales, and in contexts of transformation outside of processes of adaptive co-management and adaptive governance that currently typify resilience studies.

2.3.4 Innovation and its many guises

Innovation and novelty are key determinants of transformations in social-ecological systems (Brown et al., 2013; Chapin et al., 2010). Resilience understands the role of innovation as one that initiates transformations from an undesired state to a new stability landscape (Allen and Holling, 2010; Enfors, 2013; Folke et al., 2010; Moore and Westley, 2011), or to stop a system from crossing critical thresholds and shifting to an undesirable state (Olsson and Galaz, 2013). Critically, however, innovation is a double-edged sword as it “is both a contributing cause for our current unsustainable trajectory and our hope for tipping in new more resilient directions.” (Westley et al., 2011: 763). For example, whilst innovations such as chemical fertilisers and pesticides that facilitated the Green revolution in agricultural production significantly increased yields and available nutrition to large segments of the world’s population, the same innovations are blamed for significantly degrading the quality of ecosystems, creating human health implications and reducing the capacity of
smallholder farmers to sustain their livelihoods (Altieri, 2012; Olsson and Galaz, 2013).

Innovation provides a means of managing and learning from change in dynamic ecosystems. Adaptive management is a management process that enhances capacities to manage the inherently dynamic and unstable nature of ecosystem change through reflective processes of learning-by-doing and experimentation (Béné et al., 2011; Fazey et al., 2005; Walters and Holling, 1990). Small-scale experiments situated in processes of iterative learning and reflection allows actors to test and probe their understanding of ecosystem dynamics without threatening their desired pathways (Béné et al., 2011). Lessons from panarchy suggest that small-scale changes can cascade upwards to effect transformational change at larger scales (Holling et al., 2002). This is reflected in Olsson and Galaz’s (2013) understanding of adaptive management, in which they posit that small-scale experiments can act as safe environments in which to test the potential for innovations to have transformative outcomes. Recent reflections on the capacity of adaptive management to contribute to transformations suggest that adaptive management may not, however, be a useful lens for analysing capacity for transformation. Olsson et al. (2014) argue that the capacity for a social-ecological system to persist within the same regime is enhanced if only adaptive and incremental changes are undertaken. These contradictory understandings of adaptive management illuminate clear scale issues in the extent to which small-scale changes are understood to contribute or hinder larger-scale transformative change.

Sustainability transformations has gained recent attention as an organising umbrella that fuses a resilience understanding of transformation with social innovation, transitions management, and social movements literature (Moore et al., 2014; Olsson et al., 2014; Pereira et al. 2015). Sustainability transformations is a particularly interesting area of research as it strengthens understanding of social dimensions of innovation that are commonly missing from resilience literatures. Social innovation is widely understood in resilience literature as “a complex process that profoundly changes the basic routines, resource and authority flows, or beliefs of the social system in which it occurs.” (Westley and Antadze, 2010: 1). Social innovation focuses on issues of context such as triggers
of change, the roles of actors such as community groups, non-governmental organisations and governments, and the processes through which their new ideas scale up to create transformative change (Biggs et al., 2010). For example, McCarthy et al. (2014) examine how successful implementation of conservation policy that protected the Oak Ridges Moraine in Canada from ensuing development emerged from a vision that countered the neo-liberal development agenda of the then government, to gain support from actors and activists, and ultimately become accepted as a change in policy.

The acknowledgement of context highlights how many transformations are understood to be triggered by change in environmental dynamics and are supported by changing perceptions, institutional support, entrepreneurship and collaboration (Biggs et al., 2010). The role of individual agents, commonly acting as entrepreneurs, is particularly significant in enabling social innovations to contribute to transformations (McCarthy et al., 2014; Moore and Westley, 2011). Perspectives of social innovation from human development provide additional insights into processes of transformation as they direct concerns towards issues such as the satisfaction of unmet needs, change in social relations and empowerment (Moulaert et al., 2013a). A social innovation perspective on transformations directs attention towards the contextual nature of change, with a specific focus on how empowerment at the individual and collective ‘micro’ levels interacts with exclusionary and alienating forces at higher, ‘macro’ levels (Moulaert et al., 2013b).

Resilience and transitions management literature elaborate a complementary perspective on transformation as both perspectives incorporate an analysis of the complex, multi-scale and adaptive properties of system transformations (Olsson et al., 2014; Smith and Stirling, 2010). Rooted in socio-technical systems theory, transitions management and strategic niche management studies examine how novel or anti-establishment ideas, understood as niche innovations, grow in popularity and power to create new and dominant regimes of production, consumption, practices and key actors (Haxeltine and Seyfang, 2009). Niche innovations emerge from protected spaces, or niches, that allow technological and social innovations to be nurtured through co-evolutionary processes (Schot and Geels, 2008; Seyfang and Haxeltine, 2012). For example, Haxeltine and
Seyfang (2009) examine how the Transitions Towns movement has diffused from its original roots in Totnes, UK, to become established in towns and cities across the UK. The Transitions Town movement aims to rebuild the resilience of communities to respond to peak oil and climate change. However, the transitions management perspective applied by Haxeltine and Seyfang (2009) argues that whilst Transitions Towns offer potential as a niche innovation, the capacity of the movement to create wider transformation in practices relies on the capacity of the movement to develop and implement a more action and social learning oriented strategy that influences key actors in the regime.

Social-ecological innovation provides a conceptual lens through which resilience scholars can explore the transformative potential of innovations by emphasising the capacity of innovations to influence change across social and ecological domains. Such change is understood as necessary for transformation (Moore et al., 2014). Social-ecological innovation is defined as “technological and social innovation - including new strategies, concepts, ideas, institutions, and organizations - that enhance the capacity of social-ecological systems to generate bundles of essential ecosystem services. These have the potential to improve the capacity to learn from, respond to, and manage environmental feedback from dynamic ecosystems.” (Stockholm Resilience Centre, 2013). This definition can be interpreted in multiple ways, and analysed through multiple lenses. For example, in order to identify as social-ecological innovation it could be argued that an innovation must be perceived as both social, for example involving a process that fundamentally shifts beliefs in a social system (Westley and Antadze, 2010), and ecological, for example enhancing capacities to understand, respond to, and manage environmental feedback. Social-ecological innovation could also be interpreted as an innovation than enhances capacities to understand, respond to, and manage feedback effects across social and ecological domains. Furthermore, this latter interpretation of social-ecological innovation is predicated on a fundamental assumption that feedback effects across social and ecological domains, and by default the feedback loops that create the feedback effects, can be understood, responded to, and influenced. This thesis therefore contributes to emergent discussions of social-ecological innovation by exploring the extent to which innovation is used as a means to influence feedback loops with effects that span social and ecological domains.
2.4 Summary

The primary aim of this thesis is to identify the distinctive resilience characteristics of transformations in social-ecological systems. The chapter identifies three key research gaps that act as the launch pads for an exploratory process of research into the resilience characteristics of transformations:

- Resilience literature has established a body of literature on the roles of key individuals in building capacity for transformations to processes of adaptive co-management and adaptive governance. However, there is relatively little understanding of the roles of key individuals in building capacity for transformations outside of these contexts, and at the smaller scales of a social-ecological system. This thesis addresses this gap by analysing the roles of key individuals in building capacity for transformations across multiple scales.

- Social-ecological innovation is understood to build capacities for transformation yet its recent introduction to resilience literature means that the concept has received relatively little empirical attention. This thesis addresses this gap by analysing the extent to which social-ecological can be identified.

- Understanding of capacities for transformation is largely theoretical and does not present a clear understanding of how, or even whether, the characteristics of capacities for adaptation and transformation differ. Furthermore, literature lacks clarity of how capacities at the scale of the individual and collective relate to change across wider scales.

The following chapter proposes the research process that addresses the research gaps outlined above.
3 Action research and analytical resilience

3.1 Introduction

The primary aim of this thesis is to identify the distinctive resilience characteristics of transformations in social-ecological systems. The thesis addresses the primary aim by asking four key questions:

- What roles do key individuals play in building capacity for transformations?
- Are feedbacks recognised across the temporal and spatial scales of a social-ecological system?
- Can social-ecological innovation be identified?
- How do individuals understand their capacities to shape change in external systems?

This chapter presents the action research practice, analytical resilience methodology, and research activities that enable this thesis to use the four key questions as stepping stones for an exploratory process of research into the distinctive resilience characteristics of transformations in social-ecological systems. The chapter also elaborates on the single case study community participating in the research, and provides an overview of the ethical issues addressed in this thesis.

3.2 Action research practice

This thesis uses action research practice as the guiding approach to this process of research. Action research is an inquiry focused approach to research that supports communities in finding answers to pressing issues or questions they may face. The practice is grounded in Lewin’s (1947) field theory, in which systemic study of participant values, objectives, power and participation formulated the foundations of action research. The approach’s philosophical roots lie in critical theory, social construction, phenomenology, systems thinking
and liberal humanism (Reason and Bradbury, 2008). Action research is understood as “a participatory process concerned with developing practical knowledge in the pursuit of worthwhile human purposes. It seeks to bring together action and reflection, theory and practice, in participation with others, in the pursuit of practical solutions to issues of pressing concern to people, and more generally the flourishing of individual persons and communities.” (Reason and Bradbury, 2008: 4). The definition, by Reason and Bradbury’s (2008) recognition, is a work in progress; a situation that reflects action research’s evolving nature. Indeed, the over-riding objective of an action research approach is to contribute to positive social change (Reason and Bradbury, 2008).

Action research raises critical questions of the emphasis placed by positivist epistemologies on issues of validity and generalisability. Validity does, however, remain a key concern for action research. Brydon Miller et al. (2003: 25) observe that “Conventional researchers worry about objectivity, distance, and controls. Action researchers worry about relevance, social change, and validity tested in action by the most at-risk stakeholders.” Herr and Anderson (2014) propose that validity in action research is addressed through critical reflection on the process and outcome validity of a research project. Outcome validity is the extent to which a research project addresses the concerns that stimulated the research project. Process validity relates to whether concerns are constructed in a manner that enables ongoing learning. These validity criteria are not fixed, and may not apply to every project; it is up to the action researcher to justify and defend the criteria identified as applicable to a process of research.

Positivist concerns of generalisability are addressed by highlighting action research’s capacity to generate a substantial body of local knowledge, and its relevance and value for the people engaged in the research processes (Bradbury Huang, 2010; Brydon Miller et al., 2003). Action research embraces the local context of social and cultural processes in mediating the creation of knowledge (Brydon Miller et al., 2003; Gearty, 2009; Reason and Bradbury, 2008). The capacity for action research to integrate multiple forms of knowledge is proposed to have higher relevance to the participants who are, ultimately, the end users and adopters of the knowledge (Brydon Miller et al., 2003). The desired increased level of relevance is pursued by reflecting participants’ own understandings of
their actions and experiences of change (Reason and Bradbury, 2008; Stokols et al., 2013).

Quality in action research is commonly assessed against seven choice points, including articulation of objectives, partnership and participation, contribution of research to theory and practice, methods and processes, actionability, reflexivity, and significance (Bradbury Huang, 2010). Action research projects rarely address all seven choice points but should be open about the choice points selected, and any associated limitations (Bradbury Huang, 2010). This research process addresses the choice points of partnership and participation, actionability and significance. Please see section 7.5 for reflections on the extent to which this thesis addresses the selected choice points, and the decisions that were made in the process. Reflections are provided in section 7.5 as they relate to particular aspects of the synthesis presented in chapter 7.

Action research addresses issues of bias by embracing critical subjectivity. Critical subjectivity encourages action researchers to embrace an understanding that research is influenced by the subjectivity and biases of the researcher (Ladkin, 2005). Researcher reflexivity enables an action researcher to acknowledge these biases upfront and minimise the likelihood of these biases distorting the process and outcomes of the research project (Herr and Anderson, 2014). This research forms part of a long process throughout which I have striven to contribute to the potential for a more sustainable and just agricultural system. I have worked voluntarily on organic farms, studied an MSc in Sustainable Agriculture, and worked for land based organisations such as the Soil Association and Duchy College. I realised during my MSc that research was the vehicle through which I could make my contribution, and this thesis emerges from that desire. My desire to contribute to the agricultural community therefore brings with it beliefs and perspectives that I understood could influence my interactions with participants, and the way I approach this research process. For example, I acknowledged that it was vital to ensure all participants’ contributions were treated equally, and that I should not prioritise the voice of particular individuals over others, even if I identified more with the beliefs of particular individuals.
Having considered the relevance of action research as the practice that guides this thesis, it is critical at this juncture to question why action research is more appropriate than other established methods of qualitative research. Bradbury Huang (2010) constructively distinguishes between action research and qualitative research by the practical uses of each line of research by the research participants. Traditional qualitative approaches such as ethnography conduct research about practice, yet action research develops research with practitioners. I believe that the distinction between the two approaches is more ambiguous and hazy than Bradbury Huang’s (2010) useful distinction suggests. This thesis addresses both fields by conducting an exploratory empirical investigation of the distinctive resilience characteristics of transformations, and by striving to ensure the research addresses the action research quality choice points of participation and partnership, actionability, and significance.

3.3 Analytical resilience methodology

The preceding section establishes the capability of action research practice to connect research to the needs and desires of participating members. The section analyses how action research addresses issues of validity, bias and quality that arise in pursuit of contributing to change amongst research participation. This section advances by proposing analytical resilience as the research methodology through which action research is practiced. I begin the section by characterising approaches to analytical resilience, and then move to illuminate how levels of participation in analytical resilience are understood to contribute to participants’ capacities to manage change.

Analytical resilience is most commonly characterised by the largely descriptive approach of resilience assessment. Resilience assessment is understood as a process that “integrates a set of key concepts to provide an alternative way of thinking about and practicing natural resource management.” (Resilience Alliance, 2010: 4). Many documented resilience assessments are heavily shaped by guidance offered by The Resilience Alliance’s (2010) ‘Assessing Resilience in Social-Ecological Systems: Workbook for Practitioners’. The workbook is used by resilience practitioners worldwide and acts as the ‘go to’ resource for
assessments (Sellberg et al., 2015). Figure 3.1 presents a flow chart of the process of resilience assessment proposed by the Resilience Alliance (2010).

**Figure 3.1 Resilience assessment framework. From Resilience Alliance (2010).**

The ambition of the process presented in Figure 3.1 is to characterise the resilience of a focal social-ecological system by applying key resilience concepts such as general and specific resilience, cross-scale change, multiple states, thresholds, and governance. Users of the Resilience Alliances’ (2010) workbook are advised that some concepts and questions may be more relevant than others, and so the process should be used in a guiding, instead of prescriptive manner. The aims and outcomes of resilience assessments guided by the Resilience Alliance’s (2010) workbook are most commonly characterised by descriptive studies of focal social-ecological systems, from which author-led recommendations for capacity building activities are proposed. For example, Liu et al. (2014) analyse the factors that enhance or impinge on the resilience of the town of Caledon, Canada, to urban growth. Liu et al. (2014) provide recommendations for building resilience including improved communication.
between Caledon’s governance and its public, increased support for farmers, and transitions to low-impact technologies. Wasylycia-Leis and Fitzpatrick (2014) assess the resilience of Itabira, Brazil, to large-scale extraction of minerals. The assessment process leads to recommendations such as increased power for local governments over corporations that extract minerals and increased willingness to collaborate outside of statutory structures. Whilst it is not within the remit of this study to assess the worthiness of these recommendations, nor the efficacy of the processes through which the recommendations emerge, the action research quality choice points of partnership and participation, actionability, and significance that guide this thesis prompt critical questions around the extent to which a process of analytical resilience can usefully contribute to capacities of participants through and during the process of research.

Glandon (2015) observes increasing interest and demand for academic understanding of resilience to be translated into practical action. In this context, analytical resilience becomes a process through which resilience is both analysed and constructed. Glandon (2015: 7) argues that “The only way to make sure this happens is to actively engage local communities, not just through perfunctory consultations or buy-in from key leaders at the beginning, but throughout planning, implementation, and assessment.” The Resilience Adaptation Transformation Assessment Framework (O’Connell et al., 2015) acknowledges the aspirational opportunity to build capacities through participatory processes of resilience analysis. However, its specific and guided design with reference to developing indicators for resilience at the national scale means that is not applicable or relevant to the desires of all resilience analyses. Outside of the guided approach of O’Connell et al. (2015), I identify a much wider and diverse group of studies that aspire to build capacities through participatory research activities. Capacity building is achieved through a diverse array of participatory research activities including but not restricted to group mental modelling (Béné et al. 2011; Sendzimir et al., 2008); focus groups (Béné et al. 2011; Wilson et al. 2013); participatory lifecycle analysis (Larsen et al., 2011); participatory mapping (Béné et al., 2011; Haider et al., 2012; Kaul and Thornton 2014; Schwarz et al. 2011); scenario planning (Johnson et al., 2012); and, participatory game design (Haase, 2011). These methods are claimed to contribute to the capacities of the individuals and groups engaged in the research.
process by facilitating learning, increasing knowledge of system dynamics, building relationships between key actors, and challenging individual and shared assumptions. For example, the use of participatory modelling in Sendzimir et al. (2008) enhances trust, dialogue and relationships between actors whose increased collaboration is understood as necessary for transformation of management of the Tsiza Water Basin in Hungary. Ballard and Belsky (2011) illustrate how their assessment process leads to the creation of new relationships that will support future processes of learning.

A small number of analytical resilience studies use action research as their guiding approach. This group of studies establish a platform for participants to learn of, and question assumptions surrounding, the resilience dynamics of the focal social-ecological system, challenge power asymmetries, and mobilise participants to pursue change that is relevant and connected to their needs (Ballard and Belsky, 2010; Colliver, 2011; Haider et al., 2012). For example, Béné et al. (2011) use action research methodology to facilitate a process of analytical resilience that aims to operationalise resilience thinking, and actively intervene in ecosystem management through facilitated processes of adaptive learning amongst two fisheries communities in the Niger Basin. The analysis interestingly attempts to build the capacities of participants by distinguishing between solutions focused, and diagnostic approaches to analytical resilience. Analytical resilience “is not about looking for the unique or optimum solution, it is about negotiating a set of acceptable configurations, and agreeing on interventions, incentives or constraints to ensure that the system stays within these negotiated accepted configurations.” (Béné et al. 2011: 1181). Action research practice, in the context of Béné et al. (2011), is understood to increase the social acceptance and relevance of the processes of analytical resilience. The evidence presented in this section highlights the capacity for increased levels of participation and action research practice to both analyse and build resilience. However, participation is not a panacea for building capacity. Ballard and Belsky (2010) draw attention to ethical implications of increased levels of participation and action research practice as they reflect on how they had to curtail research activities that posed significant risk to the political vulnerability of participants. Placing the participants’ ethical concerns as the first priority will, therefore, contribute to developing a socially relevant and ethical research process.
3.4 Case study community: Tamar Valley Organics Group

The research presented in this thesis is the result of multiple interactions with the single case study community of the Tamar Valley Organics Group (TVOG\(^1\)) during the period 2012 to 2016. A single case study approach was adopted as it presents the opportunity to explore a rich quality of qualitative and context specific data (Yin, 2009). This is particularly important for the exploratory nature of the research questions. A single case study also provides access to a depth and richness of data that would not have been possible through multiple case studies, or quantitative approaches such as surveys which seek to enumerate data through frequencies or incidences (Gomm et al., 2000; Yin, 2009). Opportunity for misinterpretation or researcher bias are minimised by triangulating multiple, distinctly different yet complementary qualitative research activities (Stake, 1995; Yin, 2009).

Tamar Valley Organics Group is a farmer discussion group that formed in 2008 and continues to operate at the point of submitting this thesis. The group has experienced varying membership levels since its inception, with a maximum of seventeen members at any one point in time. At the point of publishing this thesis the group comprised of fifteen males and one female. As farm enterprises are commonly run by more than one individual, all members are able to bring partners and family to learning events at their will. The group is chaired by Adam, facilitated by Brian, and financially administered by Dan. The group’s activities are part funded through membership subscriptions of £100 per member per annum, and additional sources of funding from institutional knowledge exchange projects when available. The group’s name suggests a geographical bounding to its membership and learning activities. However, over the course of the group’s lifetime it has expanded to include members who are situated outside of the Tamar Valley. All members who participated in this research were organically certified as there were no conventional members at the time of research. The

\(^{1}\) During the process of research TVOG changed its name to TVOG(+B). See section 6.5 for analysis of the name change. TVOG is, however, applied throughout this thesis for reasons of consistency, and to avoid confusion.
The group was, however, considering opening membership to conventional farmers yet had not made its decision at the time of the research process.

The Tamar Valley extends to the north and south coasts of the South West of England, and dissect the counties of Devon and Cornwall. The climate of the South West of England experiences large maritime control of temperature and rainfall levels (Met Office, 2015). The climate can typically be described as mild and wetter than average. Rainfall and wind are largely associated with Atlantic depressions, which are more vigorous in autumn and winter (Met Office, 2015). The strong maritime control of temperature usually restricts particularly low temperatures. The mean annual temperature range across the South West of England ranges from 9°C in Cornwall, to 12°C near Bristol (Met Office, 2015).

The Tamar Valley comprises the Tamar estuary, the rivers Tamar, Tavy and Lynher, and freshwater Tamar lakes. The Tamar Valley is situated in the wider Tamar catchment. The topography of the Tamar catchment includes uplands such as Dartmoor and Bodmin national parks and farmland comprised of low porosity clay soils and granite bedrock (West Country Rivers Trust, 2012). Figure 3.2 presents the land use and agricultural practice of the Tamar catchment.
The contribution of agriculture to the economy of the Tamar catchment and the wider South West of England is estimated to be four times higher than the national average. Beef and sheep farms constitute 30% of farms in the catchment, whilst dairy constitutes 12% (West Country Rivers Trust, 2012).

From 2011-2012 I worked as an applied researcher with Clear About Carbon, a multi-partner project that aimed to understand and increase levels of carbon literacy across Cornwall. My role with the Duchy College, a land based Further Education institution in Cornwall, UK, provided me with an understanding of many of the key debates, perceptions and challenges experienced by the agricultural community in Cornwall. These experiences formed the context for my PhD proposal and created an awareness of potential case study communities.
However, purposive selection of case studies can result in selection bias (Seawright and Gerring, 2008). Two key informant interviews were therefore conducted as a means of reducing the opportunity for selection bias. Key informants were stakeholders with extensive knowledge of land management activities in Cornwall, UK. Informants were asked to provide details of groups, or networks, within the farming community that were understood to have experienced significant change, or who were engaged in particularly novel and experimental practices.

Tamar Valley Organics Group was selected over other potential case studies as it became apparent that the conversion of members’ farmland from conventional to organic status represented processes of large-scale change; the group were testing innovative practices in various forms and ways; and, because the group expressed willingness for me to participate in, and research their learning activities. These factors emerged through the key informant interviews and processes of relationship building with TVOG between October 2012 and January 2013. See Table 3.1 for a timeline of the research process guiding this thesis. Processes of relationship building have a shaping influence on a subsequent process of inquiry (McArdle, 2008). The four-month period of relationship building allowed me to spend time immersing myself in the community’s activities, and for the group to become familiar with who I was. Understanding language, interests, needs, concerns and characters allowed me to attempt to connect the research to the needs of participating members. This was a particularly interesting yet challenging aspect of the research. Members of TVOG were particularly interested in research that would directly benefit their practice and understanding of change on their farms. For example, members had previously engaged with agricultural scientists who were able to inform them of how their practices interacted with biological processes in the soil. Members were also keen to understand the extent to which their practices sequestrated greenhouse gases. These areas were particularly fascinating yet my role as a social scientist meant that I was unable to directly contribute to improvements in agricultural practice. However, Adam and Brian expressed a keen desire for the group’s experiences and activities to be shared more widely with the agricultural community. The process of research that guides this thesis therefore sought to connect to this particular concern. See section 7.5 for analysis of the extent to
which this thesis succeeded in connecting to this concern through critical reflection against the action research quality choice points of partnership and participation, actionability, and significance.

3.5 Research activities

The process of research that guides this thesis is the combination of multiple interactions with members of TVOG. Three key research activities provide a temporal sweep of TVOG’s conversion of farmland from conventional to organic status. Reflective interviews explore historical dimensions of change, mental models explore current understanding of change, and a participatory scenarios workshop explores future oriented perceptions of change. Importantly, I understand these activities as an emergent and iterative process of research. The iterative process involved converging lines of inquiry, and adaptation of activities to meet the practical needs of participants. Practical needs include concerns such as available time, relevance and interest in the research activities. Table 3.1 details the timeline of the process of research, and the number of members involved in each research activity.
Table 3.1 Timeline of research process

<table>
<thead>
<tr>
<th>2013</th>
<th>August</th>
<th>September</th>
<th>October</th>
<th>November</th>
<th>December</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>January</td>
<td></td>
<td>January</td>
<td>February</td>
<td>March</td>
</tr>
<tr>
<td></td>
<td>Attend Oxford Real Farming Conference with TVOG</td>
<td>Write new article for local newspaper on TVOG’s attendance of Oxford Real Farming Conference.</td>
<td>Conduct reflective interviews with ten TVOG members in total.</td>
<td>Attend public learning event in Berkshire with TVOG members.</td>
<td>Attend public Soil Carbon Masterclass hosted at TVOG member Adam’s farm.</td>
</tr>
<tr>
<td></td>
<td>June</td>
<td></td>
<td>April</td>
<td>May</td>
<td>June</td>
</tr>
<tr>
<td></td>
<td>Attend public Soil Carbon Masterclass hosted at TVOG member Adam’s farm.</td>
<td>Attend inter-group TVOG learning event at member’s farm.</td>
<td>Analyse reflective interviews data.</td>
<td>Pilot mental models interviews.</td>
<td>Conduct mental models interviews with thirteen TVOG members in total.</td>
</tr>
<tr>
<td></td>
<td>August</td>
<td></td>
<td>August</td>
<td>September</td>
<td>October</td>
</tr>
<tr>
<td></td>
<td>November</td>
<td></td>
<td>November</td>
<td>December</td>
<td>2015</td>
</tr>
<tr>
<td></td>
<td>Mental models analysis.</td>
<td>Attend and present initial empirical findings from reflective interviews at TVOG annual winter get-together.</td>
<td>Mental models analysis.</td>
<td>Mentor participatory scenarios workshop.</td>
<td>Conduct participatory scenarios workshop with nine TVOG members.</td>
</tr>
<tr>
<td></td>
<td>March</td>
<td></td>
<td></td>
<td>2015</td>
<td>March</td>
</tr>
<tr>
<td></td>
<td>Analyse participatory scenarios workshop data.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The process of research detailed in Table 3.1 was much more than just the three key research activities of reflective interviews, mental models interviews, and participatory scenario planning workshop. I attended multiple learning events, and communicated regularly with members by telephone and email. I was, in essence, a participating member of TVOG. However, my desire to remain critically reflective of my capacity to influence the research meant that I only contributed to discussions in circumstances when I believed I was not steering conversation away from issues of clear importance to participating members; when I believed that I could add to members’ learning in a positive way; or, when I was invited to contribute an opinion. The following three sections elaborate on the key research activities that enable empirical analysis in chapters four, five and six.

3.5.1 Reflective interviews: Co-constructing individual narratives of change

This stage of the research activities contributes a historical perspective of the distinctive resilience characteristics of transformations in social-ecological systems. Reflective interviews were used as they are one component of Roth and Kleiner’s (1998) learning histories approach that I originally sought to use in this research. My desire to develop learning histories emerged from my use of the approach during my role with Clear About Carbon that I discussed in section 3.4. Learning histories are both a product and process, and are comprised of four elements including multi-stakeholder co-design around key accomplishments, insider/outsider teams leading reflective interviews, distillation and thematic writing of a learning history document, and validation and diffusion with participants and others (Roth and Bradbury, 2008). However, it became quickly apparent during the relationship building stage of the research that a full learning histories approach would not fit with participating members’ desires and needs of the research. Participants were unable to offer the time and resource to a full learning histories approach. Furthermore, my role as an outsider to the group meant that I was bringing my own set of desires and values to bear on research participants. In this instance, members expressed no desire to act as co-researchers, nor did they express capacity to become involved in potentially lengthy processes of reflection that would take them away from their priority of
managing their farms and associated enterprises. I aspired to ensure that the process remained relevant and useful to participants, and so I immediately adapted the research activity to comprise of only the reflective interviews and participatory timelines dimension of learning histories. Reflective interviews, also identified as the interview guide approach (Patton, 2002), are of particular relevance to the research questions as they:

- provide access to tacit knowledge and experience of previous periods of experimentation, thinking and arguments (Roth and Kleiner, 1998). Access to tacit knowledge is particularly important to characterising the distinctive features of transformative capacity as it enables a more nuanced understanding of the dynamics and dimensions of change;

- enable participants to construct themselves or others as protagonists, antagonists or third party witnesses to a process of change (Labov, 2010). Identifying and characterising the key agents of change in a narrative therefore facilitates exploration of the roles of key individuals;

- promote participants to the role of narrators (Roth and Bradbury, 2008) and in doing so provide participants with the opportunity to express change in their own terms, and focus on experiences that were of particular significance to them;

- are emergent and so facilitate an exploratory process of inquiry beyond the exploratory questions that emerge from the review of literature in chapter two.

Reflective interviews were piloted in order to test and adapt interview questions (Kvale, 2008). Pilot reflective interviews were conducted with two land managers using similar grazing practices to those of members of TVOG in order to test for language, flow and relevant data. Resulting concerns were addressed and a final interview protocol produced. Appendix 1 presents the reflective interview protocol used for this thesis.
Ten members, all of whom are male, participated in reflective interviews during January and February 2014. Table 3.1 outlines the timeline of the research process. The ten members who participated in this stage of research were identified by Adam and Brian as those most engaged with the group’s learning activities at the particular point in time. The total of ten interviews sits within the range of six to twelve interviews within which meta-themes are suggested to emerge (Guest et al., 2006).

Reflective interview invited members to clarify their understanding of mob grazing systems, and elaborate on significant experiences that revealed critical aspects of learning related to the systems. Mob grazing emerged as a grazing system of interest during the relationship building stages of the research process, in which Brian and Adam reflected on the group’s interest in, and activities related to the system. However, it emerged during interviews that five of the ten participating members had been involved only in processes of learning related to mob grazing, and had not integrated the system onto their farms. The emergent and narrative nature of the interviews allowed these members to continue to reflect on their understanding of the mob grazing and the processes of learning associated with it, and additionally elaborate on the learning related to the grazing systems specific to their own farms.

Members were invited to construct participatory timelines during the interview. Participatory timelines were used as a means to aid participants’ recollections and reflections on the distinctive features of their most significant experiences. Production and annotation of timelines was not obligatory and could be performed by me at the participants’ desires. Four of the ten participants chose to annotate their own timelines. The six members who did not choose to annotate their timeline were happy for me to construct a timeline on their behalf during the interview. In all instances, the timelines became useful tools for participants to focus their responses on their significant experiences. The focus on significant experiences represented a subtle yet key point of distinction between the adapted approach used in this thesis, and the prescribed approach to learning histories recommended by Kleiner and Roth’s (1996) learning history field manual. Learning histories emerged from, and are commonly applied in, organisational contexts where the discourse around noticeable results is common. However,
during the period of relationship building it became apparent that whilst results were important to participants, members reflected on a much broader spectrum of experiences and dimensions of change than just those related to results.

Interview questions were guided by Labov’s (1972) narrative structure, as presented in Table 3.2.

**Table 3.2 Narrative structure. From Labov (1972).**

<table>
<thead>
<tr>
<th>Structure</th>
<th>Detail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Summary of the story</td>
</tr>
<tr>
<td>Orientation</td>
<td>The where, when, who and what of the story</td>
</tr>
<tr>
<td>Complication action</td>
<td>The plot, including a turning point</td>
</tr>
<tr>
<td>Evaluation</td>
<td>The meaning given to the story</td>
</tr>
<tr>
<td>Resolution</td>
<td>The outcome</td>
</tr>
<tr>
<td>Code</td>
<td>Bringing the story back to the present</td>
</tr>
</tbody>
</table>

Labov’s (1972) narrative structure provided the research with a useful tool to promote story based dialogue with participants. However, elicited narratives are commonly only partial or may not be sequenced in the order suggested by the structure (Riesmann, 2008). The guide was therefore used as an outline with sequencing of questions determined in line with the unfolding dynamics of the interview. A list of probing questions was used to enable additional depth of exploration when important findings emerged during interviews.

Interview transcripts were analysed using the six phase approach to inductive thematic analysis suggested by Braun and Clarke (2006). An inductive approach was selected due to the exploratory and emergent nature of the study. The six phases of analysis presented by Braun and Clarke (2006) suggest a linear approach to coding, development and reviewing of themes. However, I employed an iterative and cyclical approach to development of themes as new findings, and subsequent different meaning, emerged from each new interview transcript. The iterative process was facilitated by asking sensitising, theoretical and practical
questions akin to that suggested in development of grounded theory (Corbin and Strauss, 2008). For example, I asked questions such as “who were the main protagonists and antagonists in each account of change?”, “what did members identify as particularly important enabling and constraining dimensions of change?”, and “are there any patterns or themes in participants’ reflections?” Thematic development was supported by ongoing development of associated memos in which I clarified my reasoning and thinking behind each emergent code. QSR International Nvivo software was used for the full process of thematic analysis, from initial coding through to ultimate themes.

3.5.2 Mental models: Eliciting individual cognitive dimensions of change

This stage of the research contributes a current snapshot of capacities to the temporal sweep that characterises the research process. Mental models are “internal representations of external reality that people use to interact with the world around them” (Jones et al., 2011: 46). They provide a means of understanding the cognitive structures that underpin people’s reasoning, decision-making and behaviour and so help us to understand how people might interact with their perceived worlds (Jones et al. 2011; Mathevet et al., 2011). Templates or constructs in mental models enable people to understand the world, predict what will happen and react accordingly (Abel et al., 1998). Mental models differ from person to person and group to group as they are created based on a person’s unique experiences, perceptions and understandings of the world (Jones et al., 2011). Mental models are, however, incomplete; as with any construct or theory, the complexity of reality is never fully captured and so an individual’s or group’s mental model will always offer only a limited representation of reality. Awareness and exploration of mental models in human-environment contexts is growing in popularity, most commonly as a tool to better understand the extent of a model’s internal coherence with an external reality (Lynam and Brown, 2012). Jones et al. (2011) claim that mental models allow research to account for the plurality of values and goals linked to a particular resource, and the range of stakeholder perceptions concerning how natural resource management systems function. Please see Jabbour et al. (2013) and Abel et al. (1998) for examples of such studies. A mental models approach is particularly relevant to this thesis as it enables the research to address the research
questions identified in section 1.4 by providing participating members with a launch pad from which they can reflect on how they understand their capacities to manage change across different scales.

Appendix 2 details the mental models interview protocol used in this thesis. A total of twelve semi-structured qualitative mental models interviews were conducted during August 2014. Nine of the twelve members participating in mental models interviews also participated in reflective interviews, as set-out in the preceding section. Semi-structured interviews were conducted using open-ended questions. Optional probing questions were asked after each open-ended question in order to elaborate a greater depth of responses. Probing questions were developed based on the approaches of Abel et al. (1998) and Jones (2012). Initial findings from reflective interviews were used to inform the focus of mental models interviews. During reflective interviews members placed emphasis on understanding the extent to which their grazing systems managed soil quality. This focus was used as the launch pad to elicit mental models of most significance to members. Two pilot interviews were performed with land managers who used similar practices to the research participants. These pilots proved vital; in particular, to the sequencing and wording of probing questions, which were updated to inform the ‘live’ interview protocol.

Mental models methods are categorised by their direct and indirect elicitation techniques (Jones et al., 2011). Direct techniques ask participants to create diagrammatic representations of their models by using pictures, symbols or words. Participants are, therefore, able to validate and verify their model at the point of representation. Indirect elicitation is conducted by extracting concepts and relations from written documents or oral interview transcripts. Jones et al. (2011) suggest that the verbal structure within a text acts as a sample of the full symbolic representation of an individual’s cognitive structure. In order to improve the social relevance and accessibility of research methods to those directly involved in the assessment process, participants were offered the opportunity to co-construct their models through either oral and/or diagrammatic representation. Eleven of the twelve participants chose to represent their mental models through oral means only. One participant chose to pursue oral and diagrammatic representation. The participant used the diagram as an aid to support and focus
his oral responses. However, the diagram conveyed a temporal evolution of different grazing systems and did not provide a representation of system change. For this reason, the diagram was not included in subsequent data analysis.

Differences in interview location have been found to cause variations in elicited mental models (Jones et al., 2011). Jones (2012: p.176) proposes that “the creek environment in which the interviews took place better matched the environment where participants’ mental models developed and potentially evolved over time, compared to the house environment. This may have assisted interviewees to recall and therefore express more details of their existing mental models.” Applying Jones’s (2012) interpretation of situation to the context of this research implies that interviews should be conducted in an outdoor, farm based environment, such as the transect walks applied by Abel et al. (1998). However, this deterministic assumption does not account for the potential encoding of mental models occurring through other activities such as individual reflection or processes of social learning in non-situated locations. Participants were therefore offered the opportunity to choose a location of their preference for the interview. The freedom for participants to select their interview location ensured consistency with action research’s ambition to have relevance and value for the people engaged in the research (Bradbury Huang, 2010). Due to poor weather conditions, and the timing of many interviews during breaks or at the end of the working day, only one participant chose to conduct the entirety of their interview in an outdoor environment. The other eleven interviews were conducted in participants’ homes. However, five participants concluded their interviews with a guided farm walk in which they demonstrated some of the concepts and relationships discussed earlier. Considering this outcome in the context of Jones (2012) suggests that participants’ mental models of their grazing systems were encoded in both situated and non-situated environments. The outcome also highlights the importance of providing participants with an environment that they are able to determine is most relevant or suitable to their responses.

Mental models are constructed of concepts and relations that can be identified through content and functional linkages analysis respectively (Jones, 2012). Content analysis was used to identify concepts in each of the twelve interview transcripts. I now present the coding choices and strategy that ensured a
systematic and replicable approach to coding of each transcript (Carley, 1993). Extending Jones’s (2012) definition of the concept variable, I define concepts to include objects or nouns (such as nutrients, market price of beef, or stocking rate), processes (such as erosion, experimenting, or climate change) or actors (such as farmer, supermarket or learning organisation) and their associated characteristics. During the development of the coding frame it became apparent that categorising a concept in isolation from its associated characteristics would result in a loss of meaning for the concept and subsequent construction of the member’s mental model. For example, ‘heavy soil’, or ‘wet soil’, provide a different and richer understanding of the concept than ‘soil’ in isolation. I therefore decided to include concepts and their associated characteristics when developing the emergent coding frame. Consistency of concepts across participants’ mental models was achieved by categorising concepts into themes that were relevant and applied across all transcripts. Themes reflected participants’ spoken words as far as practicably possible. The process of generating themes involved iterative cycles of re-categorising concepts into themes as coding of each new transcript was completed. Coding of concepts was facilitated by the qualitative analysis software tool Nvivo, with a final list of all concepts exported into Microsoft Excel. As per the approach of Jones (2012), duplicate concepts were deleted from the list.

Functional linkages analysis was employed to identify relations between concepts. Identifying relations between concepts enables construction of systems of concepts and therefore supports conceptualisations of agency and feedbacks in social-ecological systems. Functional linkages are defined as “an action or function (typically indicated by a verb) which links two concepts (Concept A and Concept B)” (Jones, 2012: 102). The Excel list of concepts for each interview was updated to included column headings of ‘Subject concept’, ‘Functional Linkage’ and ‘Object Concept’. All concepts were initially placed in the ‘Subject Concept’ column. Functional linkages identified in transcripts were then placed in the ‘Functional linkage’ column on the same row as their corresponding subject concept. The object concept was then entered into the same row. Table 3.2 presents an example of how a statement is coded for concepts and functional linkage.
Table 3.3 Example coding of statement for mental model concepts and functional linkage.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Subject concept</th>
<th>Functional linkage</th>
<th>Object concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>….we’re hoping to combat compaction by using chicory</td>
<td>Chicory</td>
<td>Combats</td>
<td>Compaction</td>
</tr>
</tbody>
</table>

The logically ordered statement presented in Table 3.2 is not representative of all statements in interview transcripts. As noted by Jones (2012), the complex nature of the English language means that many concepts were not linked by the subject-verb-object structure detailed above. For example, concepts and their functional linkages could be spread across a number of sentences. A level of interpretation was therefore required in instances where a clear order of statement was not present.

Feedback loops are constructed of a closed sequence of cause-effect relationships (Sterman, 2000). Identification of feedback loops in mental models therefore requires translation of themed concepts and their associated functional linkages into cause-effect relationships. Sterman (2000) suggests that diagrams of linked cause-effect relations provide a means of overcoming the linear and unlinked nature of text based cause-effect relationships. Representation of a mental model as a system diagram is not uncommon yet the methods and formats of representation are diverse. For example, Abel et al. (1998) use influence trees to illustrate how concepts relate to each other. Whilst valuable for visualising relationships between concepts the diagrams are unidirectional and linear and so do not offer a means of understanding relations that feed back to their originating point. Mathevet et al. (2011) and Ozesmi and Ozesmi (2004) use cognitive maps to represent participant’s mental models of social-ecological systems yet their quantitative approaches do not align with the qualitative methods of this research process. Causal loop diagrams, however, present a means of representing qualitative cause-effect relationships as feedback loops in diagrammatic form. Fazey et al. (2006) construct causal loop diagrams that represent feedback loops in mental models of experiential knowledge of conservation managers in Macquarie Marshes in south eastern Australia. See
Figure 2.1 for an example of how Fazey et al. (2006) represents feedback loops constructed from participant mental models.

This study adopts the labelling conventions of causal link and causal loop diagrams proposed by Fazey et al. (2006). However, classification of delays was not possible due to the high level of subjectivity in deciding what constituted a delay. Despite the application of a convention for labelling causal loop diagrams, the potential for researcher interpretation and bias towards data presented concerns over the ultimate validity and representativeness of the causal loop diagrams. Fazey et al. (2006) overcomes this challenge through co-validation of mental models during individual and group research activities. However, members’ preferences for oral elicitation over diagrammatic elicitation meant that I could not co-validate representations of mental models as causal loop diagrams during interviews. A systematic process of analysis was therefore developed to ensure a robust and accurate construction of causal loop diagrams. Figure 3.3 presents the strategy used for translation of text-based causal relationships into causal link diagrams.
As discussed earlier, the complexity of the English language meant that a level of researcher interpretation of functional linkages was necessary. Interpretation was also required for conversion of some functional linkages to cause-effect relationships. Once all cause-effect relationships were generated in the Microsoft Excel spreadsheet they were then converted to causal loop diagrams using the software package Vensim. The feedback loops function in Vensim was used to automate identification of feedback loops in causal link diagrams.
3.5.3 Participatory scenario planning: Dimensions of transformative capacity

This stage of the research activities contributes a future oriented window on capacities to the temporal sweep that characterises this research process. The action research practice that guides this thesis led me to critically question the extent to which the reflective and mental models interviews contributed to participants' capacities to manage change. Participatory scenario planning was identified as a method that I hoped would address these concerns. This section elaborates on what participatory scenario planning is, why it is relevant to the research participants and questions, and how the process was enacted.

Scenarios are plausible stories and visions about what the future might look like (Oteros-Rosas et al. 2015; Evans et al. 2006). The method is particularly relevant to questions of transformation as such fundamental change “requires a capacity to identify alternative futures and for those individuals to be sufficiently articulate that these futures are plausible” (Wilson et al., 2013: 22). Wollenberg et al. (2000) usefully distinguish between projections and scenarios by their processes and outcomes. Projections are focused on outcome and indicate what the future will look like, yet scenarios pay more attention to process and encourage participants to consider future change in alternative, deliberative and creative ways. Scenarios help us to creatively vision what might happen in the future and what role we can play in it. Participatory scenario planning is a research method than enables a systematic process of analysing scenarios in the context of complex and uncertain change (Biggs, 2007; Enfors et al., 2008). The process is particularly useful for assisting communities to critically consider how their diverse interests around natural resources can be pursued despite the presence of driving forces of change that are outside of their control (Evans et al., 2006).

Participatory scenario planning has been used widely with agricultural communities in developing country contexts, for example Enfors et al. (2008), Climate Change, Agriculture and Food Security (2011), yet has only recently gained in popularity in a British context, for example Forum for the Future (2012) and Global Food Security (2014). The relevance of participatory scenario planning to the research questions guiding this thesis is highlighted by the
method’s capacity to explore resilience concepts such as drivers of change, uncertainty and potential feedbacks across the temporal and spatial scales of a social-ecological system (Enfors et al. 2008; Oteros-Rozas et al., 2015). Critical thinking around system dynamics is considered to promote change in existing mental models by challenging assumptions and cognitive biases (Wollenberg et al., 2000). Stimulating critical thinking and deliberation around resilience concepts promotes opportunity for participating members to generate new understandings of their capacities to pursue the futures they desire.

My engagements with TVOG occurred during a challenging time for the group. The group was not meeting as regularly as it had experienced a significant reduction in available funding for group learning activities. See section 4.3.1 for additional information on the group’s funding. Questions also existed over the group’s capacity to extend its learning into new domains, and over the group’s identity in the wider agricultural community. See sections 4.3.2 and 6.5 for analysis of each of the respective challenges. The participatory scenario planning workshop therefore provided TVOG with an opportunity to meet collectively, discuss these challenges and consider their capacities to pursue effective responses to their challenges through a systematic and democratic process. However, the open and exploratory nature of participatory scenario planning meant that I did not predetermine the particular points for discussion; these emerged through deliberation amongst participating members.

Drawing on the preceding literature review and questions guiding the research process, the aims for the scenario planning workshop were as follows:

- Explore individual and collective reflections on dimensions of capacities for transformation.

- Build individual and collective capacities to manage change by promoting participant-led deliberation around resilience concepts.

See Appendix 3 for the participatory scenario planning workshop protocol. A total of nine individuals participated in the participatory scenario planning in February 2015. The workshop lasted three hours in total. The process used in this study
was adapted from the scenario and visioning methods proposed by Evans et al. (2006). My prior contribution to the development and facilitation of an earlier unrelated participatory scenario planning workshop provided me with additional insights that informed development of the participatory scenario planning process for this research. The participatory scenario planning was led by me and supported by two additional facilitators who helped foster discussion during small group breakouts and took notes that captured important insights during deliberations. Facilitators were provided with training and guidance prior to the workshop. Ground rules help to create research environments in which participants can feel safe to discuss their views on issues (Kesby and Gwanzura-Ottemoller, 2007). Participants were reminded of their rights to participate, or not, at any stage of the process and to be mindful of not overly dominating discussion. Participants were encouraged not to interrupt other members and to value others’ opinions even if they strongly disagreed. As participatory scenario planning is a creative process I also encouraged participants to have fun and not be fearful of introducing humour where they felt fit. Audio recording, transcription and analysis of data followed the same process as that described for the reflective interviews presented in section 3.5.1.

The first stage of the workshop asked participants to identify driving forces of change that might be important to their farms in fifteen to twenty years’ time. Drawing on an adapted version of the Millennium Ecosystems Assessment (2003) definition, driving forces were defined as any natural or human-induced factor that directly or indirectly caused a change to a participant’s farm in fifteen to twenty years’ time. In order to acknowledge the uncertain nature of change participants were encouraged not to fix or extrapolate from current perceived driving forces of change. The saliency of a fifteen to twenty-year timescale emerged during preceding reflective and mental models interviews. Many members expressed concerns over retirement, and intergenerational succession of management or ownership of their farms. By choosing the fifteen to twenty-year timescale I therefore hoped to make the process of scenario planning useful and connected to participants’ concerns. Individual driving forces of change were written onto sticky notes and posted on a board so that all participants were aware of what the others had identified.
The second stage of the process involved collective ranking of the perceived importance and uncertainty of the identified driving forces of change. Due to the high number of identified forces of change I asked participants to rank the ten most important drivers, with the top driver being the most important. The ambition for this stage of the process was to explore the extent to which participants collectively agreed or disagreed over the importance of future driving forces of change. Ranking of uncertainty was achieved by asking participants to score how they expected the drivers to develop in fifteen to twenty years’ time. Scoring was conducted by placing a sticky-note under ‘More/better’, ‘Uncertain’ and ‘Less/worse’ columns for each driving force of change. The two driving forces of change with the most equal spread of votes across the columns, or highest number of votes for ‘Uncertain’ were then taken forward as the forces of change against which scenarios would be plotted. Deliberation around resilience concepts was facilitated by asking why the development of particular driving forces was perceived as more or less certain, and whether any shocks or surprises would be expected over the period of development. The concepts of shock and surprise were introduced in order to promote thinking and discussion around the temporal dimensions of change and the associated capacities required to deal with the change.

The third stage of the process focused on development of the scenario narratives. Four scenarios were created by plotting the two most important and uncertain drivers identified in the preceding stage against each other. For example, plotting scenario A on a vertical axis, with a worse to better scale, and plotting scenario B on a horizontal axis, with a worse to better scale, resulted in four quadrants, each of the which represented a different scenario starting point. Participants were asked to split into groups of three and collaboratively develop one of the scenarios. Importantly, the scenarios were not restricted to the driving forces against which they were plotted. These offered a starting point from which participants could include any other driving forces of change that they felt important. Development of scenarios was guided by a list of questions that promoted discussion around uncertain dynamics of change, how change manifested itself on and away from the farm, what choices for change existed and how the choices could be pursued. Once scenarios were developed participants were then asked to share their narratives and reflect on how they
understood their capacities to monitor and influence change. The ambition for this stage of deliberation was for participants to share perceptions and hopes that emerged towards and from the constructed scenarios. The final stage of the workshop encouraged reflection and deliberation around how participants felt about the likelihood and desirability of scenarios. Importantl, this stage of discussion encouraged participants to consider their capacities to pursue the most desirable scenario and what they needed to do to achieve it.

3.6 Research ethics

Ethical issues are of central concern to action research projects. Although action research is recognised as a process that can assist marginalised individuals and communities to pursue their desires (Reason et al., 2009), equal concerns exist of the protection, care and confidentiality of individuals participating in the research process (Grant et al. 2008). Informed consent, confidentiality and participation are three key ethical concerns for this thesis. Informed consent was facilitated by discussion and agreement around a customised consent form detailing rights to participation and confidentiality. The form was developed based on the Learning History Fieldwork Manual (Kleiner and Roth, 1996), and the University of Exeter's research consent form and Data Protection Policy. Informed consent was revisited with participants before each new research activity. Participants were reminded of their rights to cease participating, or even increase levels of participation, in the research both before and after each research activity.

The situated and in-depth nature of this research presented concerns over the confidentiality of research data. Working with a small, cohesive group meant that I needed to be attentive to the bonds and relationships that pre-existed my engagement with the group. The contracting stage of the research therefore paid careful consideration to the risks that any participant might encounter through participation in the research process. Consent and confidentiality were expressed as of prime importance to participants. In parallel with rights to participation detailed above, participants were reminded of the context and purpose of the research and their rights to confidentiality both prior to and at the start of each interview. Permission to digitally audio record interviews was sought before each
After interviews audio data was copied from the digital recorder onto an encrypted laptop and then deleted from the recorder. During interviews many participants requested certain comments not to be transcribed. Other comments were redacted from transcripts based on my individual judgment of the potential sensitivity of the participants’ reflections. In both circumstances I chose not to transcribe the data and omitted it from the research altogether. The Tamar Valley Organics Group is the real name for the group that bounds the collective of participants engaged in this research. Reflecting the real name of the group was particularly important to participating members as they expressed a keen desire to have their stories heard and shared widely. However, I have preserved the anonymity of individual participants by using pseudonyms in place of their real names. The pseudonyms used may appear familiar to those readers familiar with ‘The Archers’ radio show on BBC Radio 4. Pseudonyms for each member were allocated using a random selector in Microsoft Excel.

The above ethical considerations were approved by the University of Exeter Ethics Committee prior to any contact with research participants. Risk assessments were completed for all interview tasks and research design amended where significant risk to participant or researcher existed. For example, conducting the research on participants’ farms resulted in an increase in the risk of harm from machinery and livestock. I therefore ensured that all research activities were conducted in areas of the farm that participants identified as safe.

3.7 Summary

The action research practice that guides this thesis facilitates an exploratory process of analytical resilience by using the research questions as a launch pad for analysis of the distinctive resilience characteristics of transformations in social-ecological systems. Quality is explicitly addressed by analysing the process of analytical resilience against choice points of partnership and participation, actionability, and significance. Tamar Valley Organic Group represents the single case study community for the research. The complementary and converging methods used in the process of research are characterised by their temporal symmetry. Reflective interviews explore the past, mental models
interviews explore the current, and participatory scenario planning explores the future oriented dimensions of transformations. Empirical data are analysed using approaches that facilitate triangulation and provide multiple perspectives. The chapter sets out why particular methodological and ethical decisions are made. The following empirical chapters are thematically organised. The chapters address, and go beyond, the research questions that result from the review of literature.
4 Processes of transformation

4.1 Introduction

Transformations are processes of change that involve profound and significant shifts from one state, function, form or location to another (Brown et al., 2013; Brown, 2014; Marshall et al., 2012; Nelson et al., 2007; Olsson et al., 2014). However, many studies conflate transformations with the processes that support them or, more specifically, are not sufficiently precise about whether, or what, is actually transformed (Brown et al., 2013). This chapter analyses the conversion of farmland from conventional to organic status as transformations in social-ecological systems and in doing so aims to identify the key processes that build capacities for transformation.

The chapter addresses the first key research question by asking what roles key individuals play in building capacity for transformations. The review of literature presented in chapter two identifies how resilience literature understands the roles of leadership (Evans et al., 2015), entrepreneurship (Moore and Westley, 2011; Westley et al., 2010) and broader traits-based characterisations of key individuals (Folke et al., 2005) in processes of transformation to systems of adaptive co-management and adaptive governance. However, an established body of literature is notably lacking on the roles of key individuals in building capacity for transformations at different and smaller scales.

The chapter begins by analysing the profound shifts that represent transformation throughout this thesis. The chapter then proceeds by examining the processes of self-organisation and social learning that build capacities for the analysed transformations. Two sub-sections elaborate on the roles of key individuals in processes of social learning, these being learning within TVOG’s membership, and learning across wider networks. Both sub-sections identify how learning happens, what knowledge is created and how key individuals influence the processes. Finally, the chapter summarises the main findings identified in the preceding sections.
4.2 Transformations in understanding and management of agroecosystem fertility

A key challenge for the study of transformations is the identification of the scale at which transformations occur or, that is, what specifically is transformed (Brown et al., 2013; Marshall et al., 2012). The following section illuminates how transformations can be tracked as two reciprocal and fundamental shifts that result from participation in the processes of self-organisation and social learning presented in sections 4.3 and 4.4. Transformations are identified as a fundamental shift in individual understanding of agroecosystem fertility and, secondly, as a fundamental shift in the management of agroecosystem fertility. Analysis of the two fundamental shifts draws on coded data and causal link diagrams from individual mental models interviews, and narratives from reflective interviews.

As I identify in section 2.3.1, interpretations of transformation are diverse in both resilience and broader social science literatures. Resilience literature commonly understands transformations as profound and significant shifts that move one state, function, form or location to another (Brown et al., 2013; Brown, 2014; Marshall et al., 2012; Nelson et al., 2007; Olsson et al., 2014). Applying this resilience understanding of transformation to this thesis, I identify transformations as reciprocal fundamental shifts in individual understanding and management of agroecosystem fertility. The fundamental shift in understanding identifies as transformation as it represents a profound shift in the conceptualisation of the physical systems that contribute to agroecosystem fertility. Members’ understanding of agroecosystem fertility profoundly shifts from one in which fertility is formerly derived from chemical systems, to one of a system based on biological components and processes. These shifts in understanding were dependent on the combination of slow and incremental, and fast and abrupt processes of learning that I analyse in section 4.3.

….before you were organic you were chemical. There’s the physical, chemical and biological side of things. [Brian]
The transformation in understanding of agroecosystem fertility from chemical to biological processes is exemplified by members’ distinct reflections on how they had reconceptualised the role of soil and its associated sub-components and processes. Table 4.1 presents selected examples of soil concepts identified during analysis of mental models interviews. Only two examples of coded content are provided for soil carbon levels and soil organic matter as these were the only references to the concepts identified during coding of mental models transcripts.

<table>
<thead>
<tr>
<th>Mental models soil concept</th>
<th>Example coded content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil biology</td>
<td>Bacteria, biology, enzymes, microbes, mycorrhizal fungi, worms.</td>
</tr>
<tr>
<td>Soil carbon levels</td>
<td>Carbon, soil carbon.</td>
</tr>
<tr>
<td>Soil nutrient levels</td>
<td>Indexes, organic phosphorous, nitrogen, nutrients, soil nitrates, trace element.</td>
</tr>
<tr>
<td>Soil organic matter</td>
<td>Organic matter, soil organic matter.</td>
</tr>
</tbody>
</table>

Soil biology, presented in Table 4.1, is identified as a key driver of agroecosystem fertility that was previously unrecognised or poorly understood in members’ conceptualisation of chemical dynamics of fertility. Mycorrhizal fungi, a concept coded under soil biology in Table 4.1, are understood to create a complex web of fungi throughout the soil that connected to plant roots and enhanced the uptake of nutrients into pasture plants. Worms are understood to be both an indicator of fertile soils, and an organism that helps to create drainage channels. Drainage channels minimise the effects of fertility restricting events such as flooding and poaching. Furthermore, the channels help to reduce the effects of compaction of soil structure on fertility by creating looser soils through which roots seek nutrients.

The profound shift in understanding of agroecosystem fertility was coupled with a reciprocal profound shift in management of agroecosystem fertility. Adam’s reflections on his perceived capacity to create new soil exemplifies the linked nature of the transformations in understanding and management of agroecosystem fertility.
...if I can create more soil I've got more nutrients. I can have more water retention. I can draw more minerals from deeper down. It just goes on doesn't it? It's a big thing thinking you can create more soil.

[Adam]

The transformation in management of agroecosystem fertility is evidence through the distinct and multiple shifts in practice that resulted from the prohibition of use of chemical inputs on members’ organically certified farmland. Fertility in members’ preceding conventional farming systems relied on externally sourced chemical fertilisers that managed or masked the signals and behaviour of components and processes that members relied on for fertility in their agroecosystems. Organic certification meant that chemical fertilisers were no longer available yet members had not established a new means of management and practice that enabled them to derive the high levels of control and predictability that had characterised their conventional farming systems.

I wasn't farming organically I was farming without nitrogen to start with.

[David]

You've got a lot more back-up if things do go wrong. You can always fall back on sprays, fertilisers, or buy whatever you like. [Dan]

You thought you could get away with it and grow anything, that something else would cover it up. [Tony]

The uncertainty that emerged from the absence of chemical fertilisers in members’ agroecosystems is exemplified through the increased levels of vulnerability to unseasonably cold or wet conditions. For example, the cold spring experienced during 2014 resulted in slow and delayed pasture growth. The delay in growth caused significant concern amongst members over the extent to which they could feed their herds without relying on externally sourced silage or feeds. The transformation in management of agroecosystem fertility is exemplified by the profound shift in how members intervened in their agroecosystems.
Instead of the usual way as farmers we feed the crop and the crop feeds the soil, we're probably looking at it the other way that actually we feed the soil so the soil can then feed the crop. [Brian]

The transformation in management is evidenced through the significant shift away from high cost fertilisers applied at the scale of the crop, through to low cost interventions and practices at the scale of the soil. Low cost practices were necessary due to the lower productivity of milk and meat per unit of land in members’ agroecosystems. Whilst members received a premium price for the organic certification of their products, the lower levels of productivity meant that any significant increase in costs would reduce capacities to sustain conversions to organically certified farmland. Members’ desire for low cost systems led them to place increased value on nurturing and stimulating the fertility building dynamics of their agroecosystems. Members self-identified as catalysers, manipulators and orchestrators of fertility in their agroecosystems.

Actually what you’re trying to do is catalyse natural processes and make them work. Try and understand so that you’re orchestrating a natural system that works rather than orchestrating an artificial system. [Charlie]

The conventional farmer won’t hesitate to go buy a bag of fertiliser but he’ll let it go off as gases. He’s throwing that away but he wouldn’t mind putting in money to buy a bag of something and putting it on. So why not look after it and hold it in to the land so we don’t have to buy it. [Dan]

The increased value placed on agroecosystem components and processes for fertility building illustrates how the profound change in understanding and dependence moved from external flows of costly resources such as chemical fertiliser to internal flows of resources between agroecosystem components and processes such as those presented in Table 4.1. Members developed an understanding that soil provided a wider array of nutrients and minerals than just the nitrogen, phosphorous and potassium that had typified their understanding of soils in their conventional systems.
A further reciprocal link between transformations exists in members’ desires to shift away from practices that were understood to disrupt and reduce fertility in their agroecosystems. The presence and relation of soil carbon to fertility was commonly unknown to members whilst they farmed conventional systems. Soil carbon was identified as an agroecosystem component that contributed to fertility by increasing nutrient retention and increasing the water holding capacity of soil. Ploughing was perceived to be an integral and fertility building practice in members’ conventional systems as it was understood to improve soil structure and stimulate pasture fertility by increasing the availability of nutrients to subsequently sown pasture. However, the transformation in understanding of agroecosystem fertility generated an understanding that whilst ploughing offered the aforementioned benefits, it would also threaten fertility by disrupting beneficial soil biological processes, release soil carbon, and cause compaction in deeper layers of the soil. These processes were particularly important to fertility in the absence of chemical fertilisers. Furthermore, the financial costs of ploughing, including diesel, wear on machinery and the time taken by the member to plough the land, made the practice prohibitively expensive.

Overall, this section identifies and analyses transformations as profound shifts in understanding and management of agroecosystem fertility. The transformations in understanding are characterised by distinct shifts from chemical to biological conceptualisations of fertility. These profound shifts inform the transformations in management of agroecosystem fertility, which are characterised by shifts away from practices that disrupt biological processes, shifts in intervention from the scale of the crop to the soil, and shifts from high to low cost systems. The reciprocal nature of the two transformations illuminates how members’ capacities to manage agroecosystem fertility are built by linked transformations at different scales. The following sections analyse the key processes, and the scales at which they manifest, that build capacity for the transformations analysed in section 4.2.
4.3 Self-organisation

The early years of members’ conversion of farmland from conventional to organic status were characterised by high levels of uncertainty and surprise at distinct reductions in levels of fertility in their agroecosystems. Reductions in agroecosystem fertility are commonplace in conversions to organically certified farmland (Gliessman, 2014). However, change in agroecosystem dynamics was difficult to identify and understand; sometimes abrupt and obvious, sometimes subtle and difficult to detect. Members reflected on the noticeable sense of vulnerability that emerged from a perceived increase in levels of complexity and uncertainty in their agroecosystem dynamics. Some members recounted how residual fertility from their conventional systems meant that their organically certified farmland generated surprisingly high levels of fertility in the first two years following their conversions to organic systems. However, fertility dropped significantly after this period and members recounted how their poor understanding of agroecosystem dynamics meant that they could not respond effectively to the drop in fertility.

....somehow we’ve got to get this producing. We’ve been through all the scary cycles of organic where sometimes you’re putting nothing into the ground and you get to a cycle with organic and actually it’s doing nothing. Some fields did nothing. [Eddie]

Levels of surprise were experienced differently across participating members. For example, David reflected on how his conversion from a conventional to organic dairy system was relatively seamless and without distinct surprises or shocks. Both pasture and cattle were performing beyond David’s initial expectations. However, David recounted how he believed that his system was capable of higher levels of fertility and productivity, yet his poor understanding of agroecosystem dynamics meant that he could neither pinpoint the specific components or processes that may have been inhibiting his system, nor was he sure of how he could create change through adaptations to his practices.

The changes in fertility and poor understanding of agroecosystem dynamics were identified by Adam as his key motivator for initiating the processes of self-
organisation that led to the inception of TVOG. Adam experienced concern over the extent to which his conversion to organic certification could be sustained into the future without a significant increase in understanding how to manage fertility in his agroecosystem. Whilst attending a meeting on organic conversion subsidies, Adam became aware that a number of individuals within the physical locality of the Tamar Valley were considering organic conversion, or had already converted and were experiencing similar concerns. The meeting was pivotal in raising Adam’s awareness that the challenges he experienced were not isolated to him. Adam immediately suggested that the individuals hold an informal meeting at a local pub in order to gauge interest in a collaborative approach to knowledge development that would address their concerns.

…”there were a lot of us just converted. It only started at a meeting at a pub, talking about setting the group up so we could have discussions. So we’ve not got chemicals now, how are we going to make crops grow? It started off and motivated from there. [Adam]"

Participants in the meeting agreed that they would create a formalised farmer discussion group with a specific focus on developing a shared body of agroecological knowledge that would help them address the uncertainty in understanding and capacities to manage fertility in their agroecosystems. Agroecological knowledge is understood in this thesis as relating to “new, modified, or adapted practices or techniques that contribute to a more environmentally friendly, ecological, organic or alternative agriculture.” (Wezel et al., 2009: 9). Agroecological knowledge builds capacities to derive outputs from flows of resources within agroecosystems, and thereby reduces reliance on externally sourced inputs (Foran et al., 2014).

Farmer discussion groups are representations of processes self-organisation and social learning that are understood to enhance farmer participation and ownership of knowledge in contrast to more conventional forms of top-down agricultural knowledge extension (Morgan, 2011). Participation in TVOG provided members with access to a shared body of agroecological knowledge that would otherwise not have existed had they continued to act independently.
…this is where a discussion group comes in, is seeking the help of other members of the discussion group saying what should you do? What advice have they got? Have they encountered that same problem themselves? If they did, how did they overcome it or not? So that’s, you know, where your discussion group is so important. It’s another feedback loop. [Charlie]

Adam hoped the formation of TVOG would result in beneficial outcomes for all of its participating members. However, Adam reflected on how his proposal to form the discussion group emerged from a desire to protect and sustain the conversion of his own farmland to organic status.

I think it was probably for my own sake as I knew I was in too deep and probably wasn’t going to get crops to grow. So I thought the best way to get something set-up was to get together and discuss it round a pint and move it on from there. [Adam]

Capacity for transformation depends on the skills of specific individuals (Marshall et al., 2012). This thesis identifies how a number of key individuals use motivational, relationship building and facilitative skills to initiate and support process of self-organisation that contribute to the transformations in understanding and management of agroecosystem fertility. These skills draw parallels with the qualities of key individuals that build adaptive capacities. For example, Folke et al. (2005) identify facilitators, knowledge carriers, visionaries and inspirers as key to building adaptive capacities. These qualities relate specifically to the roles of Adam, Brian and Dan. Initial TVOG meetings were led by Adam, whilst Dan played a key role in motivating interest and participation amongst the group’s early members. Adam believed that without the motivational and persuasive skills of Dan the group may not have gained sufficient interest to warrant its continuation. However, Adam understood that the group’s membership was constituted of individuals who were in similar positions to his own and believed that learning could only progress if he could attract one or a number of individuals with significant knowledge of the dynamics of agroecosystems to join the group. A fortuitous meeting between Adam and Brian, at an unrelated learning event in Kingsbridge, Devon, provided Adam with such an opportunity. Brian was known to Adam as a
respected agricultural nutrition consultant with expertise in agroecological practice and knowledge of the dynamics of organic grazing systems.

Facilitators play instrumental roles in farmer discussion groups by contributing expert knowledge, guiding learning and identify learning opportunities that can improve members’ understanding of the phenomena of interest (Morgan, 2011). Brian was invited to act as facilitator to TVOG’s learning due to his preceding role as a conventional dairy farmer and his current role as an agricultural nutrition consultant. Brian’s prior experience as a conventional dairy farmer validated him within the group and provided him with direct, first-hand experience of the types of challenges the group might face. For example, Brian questioned the efficacy of costly and time consuming practices that dominated perceptions of how to over winter cattle. Instead of silaging fresh pasture in the summer months, Brian allowed his cattle to graze the pasture and subsequently extended his grazing window through to November. Simultaneously, Brian stopped allowing a neighbouring farm to graze their sheep on his pasture over the winter months. By removing the sheep Brian was able to return his cattle to his pasture at an earlier stage in the spring months. The combined effects of the reduced silaging and removal of sheep meant that Brian reduced his period of over wintering from seven to four months, the outcome of which increased the financial viability of his grazing system.

Members’ reflections highlight the importance of the capacity of facilitators to understand and share in-depth knowledge of agroecosystems and agroecological practices. The knowledge developed by Brian through his previous role as a nutritionist for an agricultural cooperative, and through the advisory services provided to his organic clients through his private consultancy meant that he could potentially contribute expert knowledge to the group’s learning. Furthermore, Brian’s participation within agroecological knowledge networks increased the group’s opportunities to attend learning events and access an otherwise difficult to reach pool of agroecological knowledge. Brian’s role as an independent consultant also provided the group with an individual who was understood to be less likely to link their learning to another organisation’s profits. The invitation to facilitate the group did, however, present some mutual
benefits to Brian. Brian hoped to translate the group’s experiences and knowledge to those of his private clients.

…to actually learn from that experience helps me when going out to my other farms and, you know, I do one-to-ones with other farmers so I can then relate back and say, ah, I know a farmer that’s done this in such and such a way and it’s all improved on this same type of soil by doing this same type of action. And it helps me as well, so it’s my own benefit as well to get it done right. [Brian]

Access to TVOG’s learning increased the likelihood of Brian providing relevant and correct advice to his private clients. Furthermore, Brian was able to increase the validity of his advice by testing his theoretical and scientific understanding of agroecological practices and organic grazing systems against the group’s qualitative insights and experiences. Having established his role as facilitator to the group, Brian’s first task was to establish a focus for the group’s learning. Understanding that his desires for learning may be different to those of the group’s members, Brian proposed a deliberative process that he hoped would promote reflection around the challenges each member experienced in managing change in their agroecosystems.

…I handed them all three pieces of paper…I said, “Okay, write the three things that you want most to be done. What are your problems? What issues do you have? I just want a short statement or one word that sums up what you want.” [Brian]

The deliberately democratic process through which members reflected on and shared their key concerns enabled them to contribute equally to the formation of the group’s learning focus. Furthermore, Brian was able to establish whether concerns were shared across the group’s members, or whether concerns were specific to particular individuals. The identification of shared concerns enabled Brian to build a sense of identity and raison d’être for the group’s activities.

And it came back 60-70% replies were not being able to buy fertiliser any more, how do I build fertility? You know, other things were, you
know, what grass do I buy, or what stock do I need? But the main thing was how do I maintain if not improve fertility? So that became the main driving force to the group. [Brian]

Building soil fertility. That’s what we needed to do. We needed to learn how to get our soils working again. [Dan]

The emergence of fertility as the unifying concern within the group illustrates how capacities for transformation are enhanced by a sense of unity and vision (Apgar et al., 2015; Wilson et al., 2013).

In summary, the processes of self-organisation analysed in this section build capacities for transformation in understanding and management of agroecosystem by enabling individuals to collaborate around shared concerns relating to uncertainty in, and vulnerability towards, reductions in agroecosystem fertility resulting from conversions to organically certified farmland. Processes of self-organisation emerge as a direct response to individual feelings of uncertainty, surprise, and desire to protect individual interests. Processes of self-organisation are catalysed and guided by individual capacities to motivate, understand the value of collective knowledge, identify shared concerns and facilitate participatory processes. The facilitator plays a distinct role in identifying and guiding processes of self-organisation towards a unified focus for processes of learning. The following section analyses how processes of social learning emerge as a direct result of the processes of self-organisation analysed in this section, and subsequently enable the transformations in understanding and management of agroecosystem fertility. Processes of social learning are analysed at the scale of learning within TVOG’s membership, and across the scales of wider networks of key individuals.

4.4 Social learning

This section analyses the processes of social change that enable the transformations in understanding and management of agroecosystem fertility through the lens of social learning. As I identify in section 2.2, this thesis ascribes to a multi-scale understanding of social learning as a process that must “(7)
demonstrate that a change in understanding has taken place in the individuals involved; 2) demonstrate that this change goes beyond the individual and becomes situated within wider social units or communities of practice; and (3) occur through social interactions and processes between actors within a social network.” (Reed et al., 2010). The transformations in understanding and management of agroecosystem fertility demonstrate the profound change in understanding that took place across TVOG’s membership. This section advances by analysing for additional dimensions of social learning such as the the extent to which the learning goes beyond the individual, and the roles of key individuals and networks.

4.4.1 Inter-group learning

Learning activities internal to TVOG’s membership are characterised by half-day meetings situated at members’ farms. Meetings were structured by roundtable discussions and farm walks accompanied by ongoing discussion of the meeting’s specific topic. Topics were identified through discussions between Brian and the hosting member in order to ensure the learning was focused on particular dimensions of fertility that the hosting member believed they could demonstrate on their farm. Meetings were initiated by Brian introducing the host farm, the specific focus for the meeting, and the objectives for the event’s learning. Examples of focuses for meetings include composting of manure, sub-soiling or herbal leys. Each member was then invited to share any concerns, successes or unexpected change in their systems since the group’s previous meeting. The roundtable reflection further instilled the democratic processes of participation identified in section 4.3 by providing each member with an opportunity to contribute and, importantly, seek advice on any challenges they were facing. Following on from the roundtable discussion, the hosting member then led a group walk through his farm. The member described his system and reflected on points including:

- the type of system they implemented and their reasons for doing so;

- specific practices and the extent to which they had or had not worked as the member hoped;
• specific system components or processes, for example soil or hedges, and their role in their system;

• the member’s ambitions for the short and long term future of the farm;

• and, any particular problems that the member was struggling with and sought input from the group.

Combining different types of knowledge contributes to building adaptive capacity (Berkes and Seixas, 2005; Folke et al., 2003). Brian was able to combine different knowledges by integrating theoretical and experiential knowledge developed through his roles as a nutritional consultant and facilitator to TVOG’s learning. Sharing experiences from clients’ farms allowed Brian to integrate learning across scales that would otherwise not have been possible had the group not invited him to facilitate their learning. Brian would commonly dig a small soil pit in a randomly selected field and then qualitatively analysed the clump of soil he had dug from the ground. Group discussion was then facilitated by Brian around system components of the soil such as its type, structure, level of compaction, root depth and pasture species, and likely interactions between the components and system fertility. Whilst members acknowledged that soils differed from farm to farm, and even field to field within each farm, this stage of learning promoted understanding of principles and best practice for managing agroecosystem fertility.

Participating members played dual roles in the farm walks. Firstly, they drew on their own understanding and experiences to offer suggestions when they felt they could help the hosting member. Secondly, they asked questions of the hosting member and wider group when they felt there was a distinct opportunity for them to learn something from the host member’s farm. The situated nature of this aspect of the meeting was identified as pivotal to members’ learning. Brian understood that situated learning was preferable to other means of learning such as formal education or independent reading as it allowed members to witness practices and systems that were subject to similar dynamics of change as their own farms.
I take them to the farms that are doing it. They’re seeing it. It’s not something that’s just written and is in the book. Seeing is believing.

[Brian]

The experiential and practice driven approach to learning draws parallels with processes of adaptive management, in which processes of social learning are complemented by a ‘learning by doing’ approach (Béné et al., 2011; Fazey et al., 2005). Experiencing a practice or system in action allowed members to learn the intricate dynamics of the practice or system under analysis, assess the applicability of the practice or system to their own context, and assess whether they believed a practice would enhance fertility in their agroecosystems. For example, David reflected on how situated learning allowed him to evaluate a hosting member’s practices against the health of the hosting member’s livestock.

You go to their places and see their stock and it’s, yeah, you know the system can work, that’s the happy thing about it really. [David]

In this instance, situated learning allowed David to compare practices against indicators of importance to his own agroecosystem. Members emphasised the importance of adopting a level of criticality over the applicability of other members’ practices or systems to their own contexts due to variances in climate, hydrology, topography and geology between each other’s farms. The variance in conditions meant that members remained pragmatic to the extent to which a hosting member’s system was applicable to their own.

…it’s always of interest other peoples’ farms but you’re really seeing trying to pick out what you can apply to your own farm. [Tony]

A key component of TVOG’s social learning was members’ desire to share experiences of successful and failed experiments. Sharing these lessons allowed the group to develop a more informed understanding of change in their agroecosystems and agroecological practices, and thereby reduce the risks of prolonged or failed experiments. Indeed, the opportunity to learn from failure was highlighted as a key facet of the group’s approach to learning. The culture of the
group enabled members to share their negative experiences in the knowledge that they would receive supportive and constructive feedback on their challenges.

*But the good thing about the group is that fact that if something works, I suppose with any farmer, if something works they'll tell you about it. But in conventional farming if it doesn't work they shut up, but we don't!* [Dan]

…*then we’d wander off, look at different things on the farm, and then as we went into a field somebody would go, bloody hell, you’ve got that! How did you get that? I’ve been trying to do this!* [Dan]

The processes of collaboration and sharing knowledge established a body of social-ecological memory (Folke et al., 2003) that enhanced individual capacities for transformation in understanding and management of agroecosystem fertility. Situated meetings helped members to compare and learn of new practices and, in some instances, raise awareness of previously unknown biological components and processes. For example, Ian, an agronomy and soil fertility consultant, was invited to lead a group meeting on Dan’s farm that aimed to create awareness of the presence and benefits of mycorrhizal fungi to fertility in members’ systems. Ian unearthed some winter triticale in one of Dan’s fields and highlighted that the way the soil was clustering around the roots of the plant indicated the presence of mycorrhizal fungi. Ian suggested that closer inspection of the roots under a microscope would present a web of fungi attached to the roots of the triticale. Ian subsequently advised the group of the utility of the fungi to fertility in their agroecosystems, how to identify the fungi, and how to ensure their practices did not damage the fungi. Brian highlighted the importance of the meeting to both establishing a basic awareness of mycorrhizal fungi and simulating future interest in it.

The influence of the structure of inter-group learning on developing capacities for transformations in understanding and management of agroecosystem fertility was complemented by the internal dynamics of group membership. Capacities to develop new knowledge relied on sustained and worthwhile participation in learning activities throughout the group’s membership.
...in a discussion group, as you get more and more involved in it and you start implementing, you get onto quite a fast track and you’ve got a bunch of guys that are all giving each other support and advice.

[Charlie]

Members understood that whilst their participation in meetings would always be welcome, their presence at every meeting was not a necessity. Some members were pragmatic in their approach and assessed the relevance of each proposed meeting before deciding to attend. Others attended meetings of less relevance to their practices as they maintained an open mind to the opportunity to learn something new, even if it did not subsequently cause a significant change in their understanding or practices. Some members reflected on how membership of the group provided them with a means of breaking the feeling of isolation that commonly accompanies a role in land management.

And I think actually that helps all of us, that we come out, because we do get off farm and talk to people. It’s hellish isolating if you’re not careful. [Dan]

The varying levels of participation, fluctuating membership numbers, and different individual capabilities and desires to learn posed difficulties for the group’s learning over a temporal scale. Tensions existed between the needs of established members and those of newer members. Established members developed varying levels of agroecological knowledge over the duration of their membership yet newer members commonly sought knowledge on the fundamentals of agroecosystem fertility. The contrasting learning needs created difficulties in ensuring the learning responded to the needs of all members. A selective approach to the recruitment of new members partly addressed the concerns of established members by ensuring that new members demonstrated desire and capacity to learn at a fast rate, or by attracting members who could offer alternative or advanced perspectives on agroecosystem fertility. However, identifying desirable new members was problematic due to the relatively limited pool of available members within the physical locality of the Tamar Valley. Brian reflected on the challenges of sustaining learning in farmer discussion groups if
wider group members do not contribute sufficiently to the learning, or if the group’s membership believes a particularly important learning outcome has been achieved. For example, Charlie reflected on how a discussion group focused on New Zealand grazing systems folded due to its own success. Some founding members learned so much that they increased the scale of their farm businesses to the point where they could afford to employ farm managers. The farm managers were sent to the discussion group in place of the founding member but their lack of in-depth understanding of New Zealand grazing systems meant that learning faltered and in fact regressed to the fundamentals that were covered in the preceding years. The lack of progress meant that the remaining founding members saw no benefits to group membership and so left, thereby dissolving the group in the process.

Over the period 2007-2015, TVOG’s learning was led and stimulated by a cohesive and likeminded sub-group of five key members including Adam, Brian, Dan, Charlie and Toby. These members stimulated participation through frequent one-to-one discussions with the group’s wider membership, and by contributing alternative understandings of change and approaches to inquiry that enthused the group’s wider membership to participate.

…but you need a core of likeminded individuals who are thinking outside the box, you know, mentally agile. They have a lot of experience they can draw from and they’re not completely sort of highbrow in how they apply those experiences. “Ah yeah, supposing we, that experience we had, supposing we put twists on it, maybe that will make it work and make it work really well.” And that’s how you progress. [Charlie]

Adam and Brian reflected on how their approaches to inquiry and knowledge were shaped by the formative roles of other key individuals during earlier stages of their lives. This brings into light the temporal dimensions of the influence of key individuals. Relationships with the key individuals were held over long temporal scales and pre-existed members’ conversions to organically certified farmland. Adam reflected on how his initial awareness and interest in soil biology resulted from a relationship with a key individual that began as far back as 1985. The key
individual, working as a representative for a dairy supplies company, became acquainted with the member after selling him milk replacement powder to help him overcome challenges with his conventional dairy system. The key individual had developed a strong knowledge of soil biology and, over the course of his friendship with Adam, advocated that he could improve his capacities to manage his system by developing a strong understanding of soil biology. Similarly, Brian reflected on the valuable role a key individual played in encouraging humility and continual inquiry in his facilitative and consultative skills.

...he used to have one of those massive magnetic L plates with him...he said, when you start the meeting put the L plate on the outside. If you wonder what the L plate is for it’s not because I’m learning to drive, he said, but because as consultants and farmers we never stop learning. So again, he taught me to keep learning and keep asking questions. To go out there and, you know, push the boundaries as such. [Brian]

Relationships between the members and the key individuals began on a professional basis and commonly developed into long standing friendships. The close nature of the relationships meant that the key individuals invested time to nurture and encourage interest and individual inquiry by:

- inviting the member to meetings that might inform their understanding of particular topics related to their systems;

- stimulating and contributing to incremental and progressive dialogue around issues of relevance to the members’ systems;

- investing time to talk through problems and offer support when possible;

- and, making unexpected gestures such as visiting a member’s farm instead of calling by phone when a member experienced challenges with his system.
The influence of these key individuals was reflected in the group’s desire to continually advance their understanding of agroecosystem fertility. Adam and Brian’s leading roles in TVOG enabled them to translate their individual approaches to inquiry into inter-group learning. Members reflected on the importance of Adam, Brian, Dan, Charlie and Toby to introducing new ideas, challenging assumptions and nurturing processes of inquiry.

*I always say that some people think outside the box and Charlie thinks outside the container the boxes are imported in, ha!* [Dan]

*Adam, especially, I completely take my hat off to him. I’m in awe really to the knowledge he has.* [David]

Charlie, characterised above as “thinking outside the container the boxes are imported in”, stressed the importance of questioning his own assumptions and beliefs about change in his system before he made any changes to his practices. For example, Charlie explained that short term decline in fertility could sometimes be remedied through an immediate change in practices. However, Charlie reflected on the importance of questioning his belief that the drop in fertility was indeed a problem, and not in fact a short term decrease before a long term increase. The uncertainty in system dynamics made effective long-term decision-making difficult, yet Charlie believed that his critical and considered approach to inquiry increased the likelihood of beneficial decisions being made across a longer temporal scale. The contribution of Adam, Brian, Dan, Charlie and Toby to TVOG’s learning was not isolated to internal group learning events. The individuals initiated frequent one-to-one discussions with TVOG’s wider membership in order to share new knowledge and perspectives that might help others with their understanding of agroecosystem fertility.

The core group of members were also regarded for their capacities to enthuse and inspire other members by demonstrating passion and energy towards their learning and pursuit of new knowledge. The capacity to inspire was especially important for learning within the group, with some members highlighting the importance of Adam’s demonstrable passion and enthusiasm for soil biology and wider agroecosystem dynamics.
…he’s an inspiration. He’s been there, done it, he’s passionate.

[David]

Inspiration was particularly important to members who did not continually pursue opportunities to advance their learning. For example, Adam commonly shared new knowledge with members in a manner that inspired them to consider integrating the new practice or understanding into their system. Passion could, however, sometimes confuse members’ sense-making process as it could at times be difficult to assess the extent to which the new knowledge could make a difference to their own systems.

Scientists were identified as playing a key role in the group’s situated learning by adding scientific rigour and explanation to their qualitative experiences and understanding of agroecosystems. Scientific understanding of agroecosystems provided an additional layer of understanding to the reasons behind the success or failure of particular practices or experiments. Members developed partnerships with scientists from Rothamstead Research and Newcastle University. These partnerships provided the group with access to research, thinking and resources around soil science that were otherwise unavailable to them. For example, members were invited to participate in a project led by West Country Rivers Trust and Rothamstead Research. The project aimed to explore the soil types and agricultural practices that help to improve soil organic carbon. Members understood that soil carbon helped to improve soil structure, nutrient retention and water holding capacity and through the research project could begin to understand how particular practices influenced soil organic matter levels. By providing access to land and management records, members understood that their contribution would be reciprocated with a report on how the soil types and practices specific to the area studied on their farms influenced soil organic carbon. The project has only recently been initiated and so it is too early for this research to report on any outcomes for the group’s understanding of their agroecosystems. However, participation in a scientific project linked to agroecological practice illustrates the important role of scientists in co-creating new agroecological knowledge for the group.
In summary, this section analyses how processes of social learning within and across TVOG’s membership enable members’ individual understandings agroecosystem dynamics to become shared and embedded within the group. Social learning is characterised by situated, experiential, and targeted learning, embedded in a culture of support and critical reflection. Social learning enhances capacities for transformation in understanding and management of agroecosystem fertility by building individual and collective knowledge of the dynamics of fertility, and by sharing practices that enable the shifts away from application of chemical fertilisers. Key individuals play distinct yet differentiated shaping roles in building capacities for the analysed transformations. Key individuals play determining roles by influencing approaches to inquiry over a temporal scale that long precedes conversions to organically certified farmland. The facilitator structures and guides inter-group learning. A sub-group of key individuals are instrumental to progressing inter-group learning by introducing radical perspectives, challenging assumptions and high levels of passion for new agroecological knowledge. The following section widens the lens of analysis to examine how key individuals, situated in wider international agroecological knowledge networks, contribute to TVOG members’ capacities for transformation in understanding and management of agroecosystem fertility.

4.4.2 International agroecological knowledge and shadow networks

This section analyses how social learning that incorporates international agroecological knowledge builds capacities for transformation in understanding and management of agroecosystem fertility. The section highlights the distinct role of social interactions and social networks (Reed et al., 2010) to TVOG members’ social learning. I examine the influence of key individuals, situated in shadow networks, in providing access to international agroecological knowledge. Shadow networks are informal networks that build capacities for transformation by creating and assessing viable mainstream alternatives, sharing valuable information, extending knowledge and providing nodes of expertise (Olsson et al., 2006; Sendzimir et al., 2008). This section begins by analysing the importance of international agroecological knowledge to the transformations identified in section 4.2. I then analyse how pioneer key individuals, situated in international
agroecological knowledge shadow networks, enhance members’ capacities for transformation in understanding and management of agroecosystem fertility.

Members identified international agroecological knowledge as particularly influential to their transformations in understanding and management of agroecosystem fertility as it challenged their sometimes rigid and limited understanding of agroecosystem fertility. International knowledge was most commonly introduced through engagements with international key individuals.

"Well, yeah, I went to college over here… You work over here but you don’t see any other way do you? But then suddenly somebody from outside influences you." [Adam]

Toby reflected on how an individual from New Zealand helped him to overcome disease issues in his flock of sheep. The individual recommended the member integrate Romney sheep, a breed from New Zealand, into his breeding regime and provided guidance on the associated culling and breeding regime for the sheep. Toby reflected on how issues with feet, worms and general maintenance of his flock dropped dramatically due to the introduction of Romney sheep. Other members adopted a counter approach and instead sought their own international experiences. Josh gained work experience in New Zealand in order to learn the intricacies of a New Zealand grazing system that he hoped to apply on his farm upon his return to the UK. Brian visited Australia in 1999 to spend time with a number of respected animal nutrition scholars.

"So it was quite an experience to see how they lived over there. And I can understand that people go to Australia thinking I’m going to go farming over there and why they got stuck. Farmers here in the UK can’t even cope with two months of dry weather and in Australia they have to cope with three years of dry weather. So it’s quite a learning experience." [Brian]

Members commonly identified that levels of rainfall and poaching were key driving forces of change in their agroecosystems yet their Australian counterparts faced near opposite challenges through lack of rainfall and drought. However, the
opportunity to learn about systems that are adapted to a higher likelihood of drought, such as those in Australia, provided the group with knowledge and perspectives that would otherwise have proven difficult to access within their physical locality. Members emphasised the importance of evaluating the applicability of international agroecological knowledge to their own contexts.

You’ve got to be a bit careful why people are doing different things because there’s different land, different rents and their figures are probably completely different to our parts of the world. Our animal prices and land prices are different compared with different parts. [Eddie]

However, members understood the profound contribution that international agroecological knowledge could make to their understanding of biological components and processes of agroecosystem fertility and so they continued to embrace opportunities to gain new international agroecological knowledge in spite of its potential limitations and relevance. This desire was in part driven by an understanding that members’ knowledge had eventually advanced to such an extent that they had become leaders of agroecological thinking in the UK.

Well, learning is the problem. You know, people aren’t about. We’ve been struggling all the way through to find people with more knowledge than we’ve got now. It’s been difficult. [Dan]

It is getting awkward really trying to find people who are thinking like us but are further down the road. [Charlie]

Section 4.4.1 analyses how TVOG’s membership dynamics and limited pool of potential new members meant that opportunities for advanced perspectives on agroecosystem fertility became limited. These concerns, coupled with the group’s awareness of the potential benefits of international agroecological knowledge, led members of TVOG to seek new knowledge across international agroecological knowledge shadow networks of pioneer key individuals. Pioneers, in the context of this research, are individuals who have gained recognition for extending the boundaries of agroecological knowledge through means that counter
conventional understandings of change. These novel and experimental ideas are understood to build capacities for change (Folke et al., 2005). Members distinguished between two groups of pioneers:

- British pioneers with international experience;

- International pioneers visiting the UK to deliver learning events or provide consultancy.

Funding to host and attend learning events led by pioneers was derived from a variety of different sources available at different points since the group’s inception in 2007. These funding sources included individual member subscriptions of around £100 per annum, 50% co-funding provided through the Rural Business School’s Skills Programme from 2011 to 2014, and individual contributions when no other funding sources were available. The availability of 50% co-funding from the Rural Business School provided a valuable and notable increase in funding for the group’s activities. The funding stream allowed the group to decide on the learning objectives for each event and which key individual they would invite to lead the event. The relevance and applicability of the event was entirely linked to the group’s needs. However, the time limited nature of the Skills Programme meant that funding ended in 2014 and therefore removed a valuable source of financial support for the group’s activities. From 2014 onwards the group’s reduced funding meant that attendance of identified learning events was funded through the £100 per annum membership fee identified in section 3.4.

British pioneers with international experience are exemplified by the roles of Nuffield Scholars. The Nuffield Farming Scholarships Trust provides individuals working in agriculture and related sectors with the opportunity “to travel to expand knowledge and understanding.” (Nuffield Farming Scholarships Trust, 2015a). The trust grants scholarships for individuals to conduct international research in their chosen field with the aim of creating future leaders and innovators in the British farming community. Research is not restricted to agroecological practice and spans a diverse array of topics including, but in no way restricted to, intensive agriculture, health and wellbeing, financial management, animal welfare, and family farms. Once overseas research activities are complete Nuffield Scholars
document their research and present their findings at the annual Nuffield Scholars presentation. Importantly, Nuffield Scholars are expected “to use all other means at your disposal to spread the knowledge you have gained within your industry and beyond.” (Nuffield Farming Scholarships Trust, 2015b). The requirement for scholars to actively disseminate their knowledge illustrates the Trust’s desire for the individuals to take on integral and leading roles in the development of their peers. Promoting communication and sharing of the scholars’ research meant that the knowledge could extend past the boundaries of the Trust and its scholars.

Members’ interactions with Nuffield scholars were multiple and occurred across a variety of situations including events hosted by the scholars, and others in which the scholars participated.

*There was someone who had done a Nuffield Scholarship, a woman called Pip. She was running soil workshops and beginning to explain stuff to people that was talking all about the minerals. So I went along to one of her farm meetings and was quite impressed and asked where she was getting all the information from.* [Charlie]

Members aimed to establish an understanding of the practices being promoted by the scholars, and identify the sources of knowledge that the scholars used to improve their own practices. In addition to situated learning events, members also pursued learning opportunities with the scholars at the Oxford Real Farming Conference. The Oxford Real Farming Conference convenes leading thinkers and practitioners from the UK’s sustainable farming movement to “explore agroecological solutions to common farming challenges” (Oxford Real Farming Conference, 2015). Nuffield scholars were commonly invited to present at, and commonly attended the ORFC. The conference provided members with access to the research of new, previously unknown Nuffield Scholars, whilst already established scholars could again present on their research and, importantly, share reflections on how they were applying their research in their own farm environment.
….both Christopher and Neil, they’ve done their Nuffield Scholarship and seen it actually happening. That’s what drove them to do it. They see farms around the world doing it. [Brian]

A number of members highlighted the significance of a visit to Christopher’s organic dairy farm during a period of drought in the summer of 2012. The drought led to significant concern amongst members that if sufficient rain did not fall in the immediate future then they would experience a feed shortage due to insufficient pasture growth. A feed shortage would be detrimental to animal welfare and animal growth, and would require members to purchase externally sourced organic feeds that would be in short-supply and expensive. During an unrelated learning event Brian spoke with the Christopher’s consultant and asked him how Christopher was faring with the drought conditions.

Christopher’s consultant was there. I said by the way how’s Christopher doing? He said well I went there the other day and he said he still had enough grass there for another six weeks. This is on the Cotswold brash, a very dry area, whereas my guys on heavy clay were burning up or had burned up by that time. [Brian]

Brian acknowledged the urgency of the impending feed shortage for TVOG’s members and hoped that the group would challenge their own understandings of the dynamics of their agroecosystems if they witnessed fertile pasture in an area that was perceived to be tougher to farm in.

I asked the question, if anything significantly can change the way that my farmers think about things, you know, which that would be one of them, because the only time you change the system is if your back’s against the wall. [Brian]

Brian’s reflections clearly exemplify the desire to build capacity for transformations in understanding and management of agroecosystem fertility. Whilst the event challenged members’ understanding of the dynamics of their systems and motivated some to ultimately change their practices, members’ capacities to create change on their farms meant that the understanding was not
immediately translated into practice. For example, changes to a grazing system place different demands and requirements on pasture growth in certain areas of farms, at certain times of the year. Immediate change in systems can therefore create feed shortages across a short timeframe. Some members remained critical of the applicability of Christopher’s practices to their own situations due to the comparably different context in which Christopher was demonstrating his capacity to deal with drought. Despite the differentiated perceptions of Christopher’s practices, the story illustrates Brian’s desire to create opportunities for TVOG’s members to significantly change how they understood their capacities to deal with change, and the motivation of the group’s members to pursue opportunities that could help them with their current and future planning.

The group’s desire to engage with Nuffield Scholars is exemplified by TVOG’s invitation to Charlie to join their group. Charlie was known to the group through his longstanding and valued relationship with Brian, his relative physical locality to members’ farms, and, crucially, his recent completion of a Nuffield Scholarship. Charlie’s scholarship explored links between pasture health and human health, and so had direct relevance to members’ learning around agroecosystem dynamics. As an early instigator and member of a variety of farmer discussion groups across the UK, Charlie had developed a strong understanding and experience of grazing practices in Ireland and New Zealand. Furthermore, his previous career as an investigative journalist promoted an inquisitive approach that he carried forward into problem solving and analysis on his own farm. Charlie operated a dairy system that countered conventional thinking around productivity and inputs. Organic dairy farmers commonly supplement their pasture-based systems with externally purchased feeds in order to maintain consistent and competitive milk yields and therefore, subject to changes in milk prices, a more consistent level of income. However, Charlie adopted a counterintuitive approach and minimised the use of externally purchased inputs as far as practically possible. The resulting lower yielding system meant that Charlie did not achieve industry benchmarks. However, the removal of inputs from his system meant that the financial viability of Charlie’s system was not in question.

Charlie’s increased dependence on flows of resources within his agroecosystem meant that he sought innovative means of increasing the quality of his soils and
harnessing fertility in his agroecosystem. For example, Charlie used the practice of mob grazing to test and manage agroecosystem fertility. See section 5.3 for analysis of mob grazing. Charlie hosted a learning event for TVOG members at this farm in 2013. Adam and Brian’s ambition for the learning event was to provide a potentially radical context against which members could compare and reflect on their individual understandings of agroecosystem dynamics. Whilst some members reflected on the difficulty of applying Charlie’s practices to their own farms, others highlighted how his involvement with the group had inspired them to question their own understanding of change in their systems. The critical challenging of assumptions contributed to transformations in understanding and management of agroecosystem fertility by enabling members to adjust their understanding of the relationships between components and processes in their systems.

Members stated that the efficacy of a pioneer key individual was assessed against the extent to which the individual’s international agroecological knowledge had contributed to successful outcomes despite challenging circumstances. For example, achieving success in spite of difficult financial or personal circumstances, dealing successfully with the different challenges presented by being a tenanted or owner-occupier farmer, or the capacity to develop their own niche in an area where seemingly little knowledge and support previously existed.

…it’ll listen most to the person that’s had to find his way up through because he’s really had to make it work. [Jack]

Jack dismissed the relevance of a pioneer’s knowledge to his own system as he believed the pioneer’s system only existed due to a financial buffer provided by wealth accumulated in a previously unrelated career. Jack highlighted how the efficacy of the pioneer’s knowledge diminished once he became aware that the system had evolved in a potentially protected environment in which the system did not face the same stressors or challenges as those faced by him. In this instance, Jack believed the individual’s wealth meant that the system did not, and could not effectively respond to the dynamics of broader change over a temporal scale.
As identified in page 98, international pioneers visiting the UK for consultancy and learning events presented the group with an additional capacity to access international agroecological knowledge. Members maintained awareness of learning opportunities with international pioneers visiting the UK through their extensive network of contacts including individuals and organisations such as RegenAg UK². Members were particularly interested in, but not restricted to, learning from international key individuals from Anglophone countries.

You got to have somebody who’s got to have the time to be looking at these things that are coming out of America, or Australia, or whatever because we haven’t got enough money to really get hold of the guys. Occasionally somebody will come over and we can nab them for half a day. [Adam]

Individuals in countries such as Ireland, New Zealand, Australia, Canada and the United States had established worldwide reputations as agroecological thought leaders in knowledge domains of direct relevance to members. For example, members attended learning events led by international pioneers across topics including broad acre grazing systems, soil science, bio-fertilisers and subsoiling practices. Some pioneers gained additional traction due to their efforts to increase the quality of livelihoods of farming communities worldwide. For example, one pioneer introduced biofertiliser to farming communities throughout North, Central and South America. The biofertiliser empowered communities to simultaneously reduce their reliance on costly fossil fuel derived inputs and, through the pioneer’s open source approach to agroecological knowledge development, placed production of the biofertiliser in the hands of the farming communities.

Learning events with international pioneers included formal classroom based learning, field based workshops in which new practices were learned and tested and individual consultancy on members’ farms. Where funding was available the group hosted their own learning events with pioneers. Hosting events meant that

² RegenAg UK (http://www.regenerativeagriculture.co.uk/) is a provider of learning events that connects international agroecological pioneers British farmers. Learning events take the format of short courses, seminars, workshops and consultancy.
members did not need to travel across the UK and, importantly, provided members with the opportunity to experience any recommended practices or knowledge in the situated physical locality of the Tamar Valley. More recently, the reduction in available funding for the group’s activities meant that hosting events with an international pioneer proved particularly difficult to achieve as consultancy fees, combined with travel expenses and other associated costs, made an event in the group’s locality unfeasible. Charlie was aware of the visit of Jim to the UK in August 2014 and contracted him for two days’ consultancy. Jim was known for his contribution to agroecological movements, and his agroecological approaches to broadacre farming. Charlie sought advice on how to configure his Yeoman’s plough and integrate keyline ploughing onto his farm. Keyline ploughing is a type of subsoiling practice that is understood to reduce moisture loss and erosion by creating keylines that run with the contours of the landscape (On Pasture, 2015). The process of subsoiling was also understood to break the compacted soil pans created by previous ploughing. The integration of keyline ploughing into the members’ farm was, however, the result of a considered process of reflection.

The evidence presented so far in this section informs us how international agroecological knowledge and its associated shadow networks of pioneer key individuals contributed to incremental processes of learning that enabled the transformations in understanding and management of agroecosystem fertility identified in section 4.2. These progressive processes of learning were complemented by additional abrupt shifts in understanding catalysed by pioneer key individuals.

…..and then he just like opened up the world I’d never even seen, of ways you can do things completely different. [Jack]

Members reflected on the particular significance of a soils workshop run by Caroline. Members pursued the learning opportunity based on the reputation of Caroline as one of the world’s foremost and most inspiring thinkers in soil science.

*She said right, draw your favourite plant. So everybody drew a picture of a tree or crop of corn. She said you haven’t drawn the most*
important bit. Everybody drew the bit you could see. Nobody drew the roots….and she said now that’s the trouble, she said, that the conventional guys farm dirt and she said organic farmers farm soil.

[Dan]

Members stressed how important the workshop had been to their transformations in understanding and management of agroecosystem fertility as it highlighted the integral role of soil to fertility in their agroecosystems. These stories illustrate how key individuals catalyse abrupt changes in understanding using simple metaphorical and visual means that stimulated counterintuitive understandings of change. Furthermore, these particularly abrupt moments of learning suggest signals of the critical reflection on pre-existing assumptions and opening of new worldviews that constitute transformative learning (Mezirow, 1991). However, despite the seemingly transformative nature of the learning, the analysis presented in this section suggests only limited signals of transformative learning. For example, the absence dimensions such as profound shifts to members’ ethnocentric habits of mind that would involve members critically evaluating their awareness of their biases towards other groups such as conventional farmers (Mezirow, 1997).

In summary, this section identifies how social learning that incorporates international agroecological knowledge builds capacities for transformations in understanding and management of agroecosystem fertility by introducing new ideas and perspectives that challenge incumbent or stagnant understandings of fertility. Pioneer key individuals, situated in shadow networks, play central roles in providing access to international agroecological knowledge. International agroecological knowledge is not, however, readily accepted and applied. The efficacy of knowledge espoused by pioneer key individuals is assessed against the extent to which the key individuals can demonstrate their independent success over a long temporal scale. The alternative perspectives and practices contributed by pioneer key individuals suggest signals of transformative learning that enable TVOG members to challenge their understanding during times of immediate and pressing challenges.
4.5 Summary

This chapter analyses how processes of self-organisation and social learning lead to transformations at two distinct and linked scales. Transformations are identified as fundamental shifts in individual understanding of agroecosystem fertility, and fundamental shifts in management of agroecosystem fertility. The fundamental shift in understanding is evidenced through a profound shift from chemical to biological understanding of fertility in agroecosystem dynamics. The fundamental shifts in management of agroecosystem fertility are evidenced by changes in members intervene in their agroecosystems. Preceding conventional systems relied on chemical inputs external to the system and a focus on interactions at the level of the crop. In contrast, organic systems required practices that could harness and minimise disruption to agroecosystems’ endogenous fertility building processes. The focus of intervention profoundly shifts from the scale of crops to the scale of soil. The profound shifts in understanding and management of agroecosystem fertility represent the transformations that I continue to analyse throughout this thesis.

This chapter addresses the research question “What roles do key individuals play in processes of transformation?” The question provided a launch pad for my analysis of the processes of self-organisation and social learning that build capacity for the identified transformations in understanding and management of agroecosystem fertility. The chapter identifies how processes of self-organisation, leading to the formation of TVOG, are catalysed by distinct individual feelings of shock, uncertainty and vulnerability to change in the dynamics of agroecosystem fertility. Processes of social learning enable individuals to shift from isolated, independent learning to collaborative and participatory processes of social learning. The chapter finds that the social learning of TVOG occurs across different temporal and spatial scales, as evidenced through individual learning, inter-group learning, and learning across international shadow networks. The profound shifts in organisation and learning that emerged from this stage of analysis suggest that the processes could themselves be construed as transformations. This observation is reflected on in greater depth in chapter seven.
Key individuals play distinct roles in the processes of self-organisation and social learning across different temporal and spatial scales. Each member's transformation involves combinations of contributions from the same and different key individuals over different temporal scales. It is the cumulative effects of these differentiated interactions with key individuals that build individual capacities for transformations in understanding and management of agroecosystem fertility. Key individuals are identified as nurturers of learning, facilitators and pioneers. The facilitator builds capacity for shifts in understanding of fertility by building group cohesion through identification of shared learning aims around fertility; creates structure and process for learning activities; integrates scientific and experiential knowledge to learning; seizes on specific moments for learning to cause abrupt shifts in understanding; and, presents the group with access to a wide network of other key individuals.

Shadow networks of pioneer key individuals situated across local to international scales are vital to the group’s learning as they provide access to other individuals who have extended the boundaries of their own understanding of agroecosystem fertility. Pioneer key individuals are identified as instrumental to TVOG’s learning as they contribute international agroecological knowledge that introduces alternative perspectives and ideas on the dynamics of agroecosystem fertility that enable the group to respond to different learning needs and understanding of individual members. These findings suggest that the qualities of key individuals that build capacities for adaptation are equally applicable to those that build capacities for transformation. Taken as a sum, the findings of this chapter also enable us to characterise the processes supporting members’ transformations in understanding and management in accord with Reed et al.’s (2010) interpretation of social learning. The identified transformations in understanding of agroecosystem fertility are enabled through interactions with key individuals, situated in international agroecological shadow networks and go beyond each individual member of TVOG to become situated within the broader memory and practices of TVOG. The extent to which the processes and outcomes identify as transformative learning are, however, limited by an absence of evidence of the
extent to which members fundamentally change their ethnocentric habits of mind. The latter dimension of transformative learning is analysed further in section 6.5.

The following chapter continues the exploratory process of research into transformations in social-ecological systems by examining how innovation is used as a tool to build capacities to influence change across social and ecological domains. The chapter moves from the interplay of processes between individuals, TVOG and shadow networks, to focus specifically on how innovation is understood at the scale of the agroecosystem.
5 Innovation in agroecosystems

5.1 Introduction

Contemporary understanding of transformations emphasises the role of innovation and novelty in building capacity for transformations (Folke et al., 2010; Moore and Westley, 2011; O’Brien, 2012). Chapter four analyses the processes of self-organisation and social learning that build capacity for transformations in understanding and management of agroecosystem fertility. This chapter builds on the findings of chapter four by applying the lens of innovation to understand how, following transformations in understanding and management of agroecosystem fertility, members of TVOG were able to manage change at the scale of their agroecosystems. The chapter draws on analysis of mental models and reflective interviews data to explore TVOG members’ understanding and approaches to innovation more broadly, and then narrows the lens of analysis to analyse whether social-ecological innovation can be identified. However, as I identify in chapter two, the extent to which social-ecological innovation enhances capacities to understand, manage and respond to feedback effects has received relatively little empirical attention, and is predicated on the fundamental assumption that feedback loops exist.

This chapter therefore investigates two of the key research questions by asking are feedbacks recognised across the temporal and spatial scales of a social-ecological system, and can social-ecological innovations be identified? The first section of the chapter examines the types of innovative practices used by members of TVOG, and how such practices are understood to build capacities to manage change in agroecosystems. The second section narrows the lens of analysis to examine whether, more specifically, social-ecological innovations are identified in causal link diagrams of members’ mental models. In chapter two I propose that the identification of social-ecological innovation relies on the recognition of feedback loops with feedback effects across social and ecological domains, and the extent to which innovation is undertaken to directly influence the behaviour of recognised feedback loops. The third and fourth sections present an in-depth analysis of the social-ecological innovation of mob grazing. I present a brief literature review of mob grazing and justify why the practice identifies as
social-ecological innovation. The chapter ends by analysing the factors that mediate members’ decisions to integrate mob grazing into their agroecosystems.

5.2 Dimensions of innovation

In section 4.2 I analyse how members’ profound shift in understanding of agroecosystem fertility was coupled with a significant shift in management of agroecosystem fertility. The shift in management was characterised by constraints on capacities to use mainstream approaches to fertility building. For example, organic certification meant that members were constrained in their capacities to apply chemical fertilisers to pasture. These constraints were coupled with a desire not to disrupt fertility building components and processes, and a need to maintain a low cost system due to the lower yields derived from their organically certified farmland. These factors lead to a high level of uncertainty in how, specifically, to intervene in and manage agroecosystem fertility. Members emphasised how they felt forced to consider innovative practices that countered mainstream approaches to managing fertility.

So to find those questions, to find those answers, you’ve got to go outside the box and you’ve got to do your own things. [Adam]

The key innovative practices identified by members include the direct drilling of seeds coated in mycorrhizal fungi, keyline ploughing, the sowing of herbal leys, use of a mob grazing system, and on-farm production of bio-fertilisers. The following section presents evidence from causal link diagrams of individual mental models to illustrate how members understood the capacity of a number of the aforementioned innovations to manage agroecosystem fertility and derive wider system benefits.

The sowing of herbal leys was identified as an innovation that enabled members to replace many of the benefits previously derived through chemical fertilisers and disruptive practices such as ploughing. Herbal leys are identified as innovative as they counter the dominant and widespread use of monoculture rye grass pasture that characterise grazing systems, irrespective of conventional or organic status. Members learned that monoculture rye grass pastures offered
only limited nutritional content, poor palatability and limited capacities to improve fertility. Herbal leys are grown from mixed species grass, clover and herb seed mixes such as plantain, chicory, clovers, yarrow, timothy, trefoils and cocksfoot. Figure 5.1 presents a causal link diagram of Adam’s mental model that illustrates how herbal leys are understood to interact with agroecosystem components and processes. See section 3.5.2 for the process used to construct causal link diagrams, and guidance on how to understand the dynamics of causal link diagrams.

Figure 5.1 Causal link diagram of interactions between herbal leys and agroecosystem components and processes.

Figure 5.1 illustrates how herbal leys enable Adam to respond to change, for example minimising the impacts of periods of drought, and drive change, for example increasing animal health and wellbeing. The latter benefit was expected as species of herbal ley such as chicory and trefoils contain tannins that act as a suppressant to parasitic activity in livestock. By suppressing parasitic activity cattle welfare is improved and the cost of veterinary bills is reduced. Increasing root activity is understood to improve soil structure and, therefore, reduce the need for disruptive mechanical intervention in the soil such as ploughing. The importance of increased root activity to members’ systems further exemplifies the extent to which their understanding of system dynamics fundamentally changed. The previous focus of conventional systems on crops across a horizontal, above-soil scale, changed to include vertical scales of plant activity below soil. Figure 5.2 presents a causal link diagram of the interactions identified by one member
between the increased root activity of herbal leys and other components and processes in his agroecosystem.

Figure 5.2 Causal link diagram of interactions between root activity and agroecosystem components and processes.

Figure 5.2 highlights how the member understood his capacity to influence root activity through the deep rooting activity of herbal leys. Furthermore, allowing herbal leys to grow to a greater height than is traditionally practiced was understood to increase the depth of roots and, therefore, improve soil structure and the capacity of the herbal leys to access minerals and nutrients in the deeper layers of soil. Root activity was also identified as contributing to a balancing effect over soil compaction by breaking through compressed areas of soil caused by heavy machinery or over-grazing.

Adaptive management enables actors to use small-scale experiments, situated in processes of iterative learning and reflection, to test and probe their understanding of ecosystem dynamics without threatening their desired
pathways (Béné et al., 2011). These observations are particularly pertinent to the processes of experimentation and innovation used by members of TVOG. The use of herbal leys provides a prime example of such an approach. Members were not uniform in the extent to which they integrated herbal leys into their agroecosystems. Some members quickly integrated herbal leys into reseeding regimes across the entire farm. In these instances, herbal leys were sown throughout the farm once each field or area was due for re-sowing. Others preferred to experiment with one or a couple of fields to assess whether the leys provided anticipated benefits. Members desired quantifiable evidence of the benefits of herbal leys yet expressed frustration at their capacities to reliably monitor the effectiveness of the innovation. Data such as sward density and soil nutrient testing would allow members to understand benefits to fertility and plan pasture utilisation more effectively yet the time and financial investment required to generate the data resulted in infrequent attempts to monitor change. Plate meters\(^3\) enabled members to quantify pasture cover, assess the efficacy of herbal leys, and plan pasture utilisation more effectively. However, the majority of monitoring was commonly qualitative and based on individual historical knowledge of the dynamics of change related to each field or specific area on their farms. Reflections on the small or wide scale integration of herbal leys were then shared through the processes of social learning identified in chapter four.

The innovation of herbal leys represents the introduction of new components. In contrast, other innovations emerged through a shift in understanding of the roles of existing agroecosystem components and processes. For example, members learned of the benefits of allowing their cattle to graze the hedges and trees that already existed on their farms. Hedges were traditionally perceived as boundary markers that allowed members to allocate certain fields to grazing. However, the processes of social learning and fundamental shifts in understanding of how to manage agroecosystem fertility identified in chapter four raised awareness of the

\(^3\) Plate meters are devices that measure height and density of the sward. The average height of the paddock is measured in compressed centimetres and then converted into kilos of dry matter per hectare via an equation. The method generally used in the UK is \(x \times 125 + 640\). (AHDB 2016)
beneficial roles that hedges and trees could play in their agroecosystems. Figure 5.3 presents two causal link diagrams of the anticipated benefits that members expected to derive from allowing cattle to graze hedges and trees.

Figure 5.3 Causal link diagrams of interactions between utilisation of hedges and agroecosystem components and processes.

Members reflected on how their cattle would unexpectedly graze hedges and trees when given access to a fresh area of pasture. Understanding that these sources of forage provided similar medicinal benefits to the herbal leys example presented in page 113, members allowed their trees and hedges to grow outwards so that cattle could reach an increased amount of the forage they provided. Figure 5.3 illustrates how one member understood that allowing his trees and hedges to grow freely would create a shield against the drift of his conventional neighbours’ chemical fertilisers and pesticides. Reducing the drift of the chemicals was stated as vital to the efficacy of the members’ organic certification and claims to chemical free production of food. Other members
reflected on how regular brush cutting of hedges was significantly reduced by allowing livestock to graze the hedges, and thereby significantly reduce diesel consumption, wear and tear of mechanical equipment and time invested in maintaining the hedges.

In summary, this section analyses how increased emphasis is placed on innovation as a direct consequence of the constraints caused by organic certification of farmland. The benefits derived through herbal leys and reconceptualisation of the roles of trees and hedges demonstrates how innovations enhance members’ capacities to manage agroecosystem components and processes that influence fertility, and derive wider benefits such as improved animal health and wellbeing, and reduced use of mechanical interventions. However, as I set out in chapter two, the extent to which these innovations identify as social-ecological innovations relies on testing whether innovations directly influence the behaviour of feedback loops that drive environmental feedback, and whether the innovation influences change across social and ecological domains. The following section addresses this concern firstly by examining whether feedback loops are identified; secondly, by analysing whether any identified feedback loops have feedback effects across social and ecological domains; and, thirdly, whether any innovations are understood to directly influence the behaviour of identified feedback loops and, therefore, the resulting feedback effects across social and ecological domains.

5.3 Analysing social-ecological innovation

5.3.1 Recognising feedback loops

In section 2.3.4 I define social-ecological innovation as “technological and social innovation - including new strategies, concepts, ideas, institutions, and organizations - that enhance the capacity of social-ecological systems to generate bundles of essential ecosystem services. These have the potential to improve the capacity to learn from, respond to, and manage environmental feedback from dynamic ecosystems.” (Stockholm Resilience Centre, 2013). However, the focus of social-ecological innovation on environmental feedback effects implies that feedback loops must exist in the social-ecological system
under analysis. Questioning whether feedback loops can be recognised is, therefore, one step in the process of analysing social-ecological innovation. Analysis in this section draws on causal link diagrams of participants’ mental models. See section 3.5.2 for details of the process through which causal link diagrams are constructed from individual mental model interview data.

Twenty-nine feedback loops are identified in causal link diagrams of mental models of seven of the eleven members who participated in mental models interviews. No feedback loops are identified in causal link diagrams of the mental models of the remaining four of the eleven members who participated in mental models interviews. See Appendix 4 for causal link diagrams of the twenty-nine identified feedback loops. Table 5.1 presents the number of feedback loops identified in causal link diagrams of each of the seven members’ mental models.

<table>
<thead>
<tr>
<th>Member</th>
<th>Number of identified feedback loops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brian</td>
<td>17</td>
</tr>
<tr>
<td>Eddie</td>
<td>4</td>
</tr>
<tr>
<td>Adam</td>
<td>3</td>
</tr>
<tr>
<td>Dan</td>
<td>2</td>
</tr>
<tr>
<td>David</td>
<td>1</td>
</tr>
<tr>
<td>Roy</td>
<td>1</td>
</tr>
<tr>
<td>Toby</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>29</strong></td>
</tr>
</tbody>
</table>

The most distinct observation of the data presented in Table 5.1 is the difference in number of identified feedback loops between Brian and other members. This observation draws parallels with studies that examine differences between expert and non-expert mental models (Abel et al. 1998; Jones et al., 2011). The classification of members as expert and non-expert does not pay due respect to members’ knowledge or experience. However, the distinctly higher number of
feedbacks identified in Brian’s mental model can be explained by his role as expert to TVOG’s learning. I identify Brian as an expert due to his capacity to combine a high level of scientific and theoretical knowledge with the experiential knowledge he developed through his preceding role as a dairy farmer. Brian’s working role as a nutritional consultant, coupled with his role as facilitator to TVOG’s learning activities required him to enhance his clients’ and TVOG members’ capacities to manage fertility in their agroecosystems. It was therefore important that he could both demonstrate and communicate an understanding of patterns of behaviour across members’ systems.

The resilience lens used in this study directs attention towards the scales across which feedback loops manifest. Analysing scale and interactions across scales is particularly important as it enhances understanding of the complex and difficult to predict dynamics of change in a focal social-ecological system (Cash et al., 2006). Analysis of causal link diagrams identifies that all feedback loops include concepts situated at the scale of members’ agroecosystems. This importantly means that causal link diagrams present scenarios in which members can potentially interact with, and intervene in the behaviour of feedback loops. Analysis of the concepts situated within feedback loops identifies that all are comprised entirely of environmental components or processes. Environmental concepts included in the feedback loops manifest across smaller temporal and spatial scales, for example soil biology, soil aerobic conditions and soil organic conditions situated on members’ agroecosystems, and across much larger spatial and temporal scales such as that of weather. The absence of social components or processes in the feedback loops suggests three insights. Firstly, environmental feedback loops may be easier to identify than those that contain a mix of environmental and social concepts, or those that are totally comprised of social concepts. This insight allies with the observations of Folke et al. (2005), who suggest that individuals who manage ecosystems, and hold particular ecological knowledge are more likely to identify environmental feedback loops. Secondly, identification of feedback loops containing only environmental concepts could suggest that members express a situated capacity to manage the regulating dynamics of behaviour within their agroecosystems. That is, members understand their capacity to manage environmental behaviour through their practices and interventions in their agroecosystems. Thirdly, the result may be an
outcome of the research activity itself. The process of eliciting the mental models, including the location and focus of questions on grazing systems and agroecosystem fertility, may have increased the likelihood of eliciting feedback loops containing only environmental concepts. However, whilst feedback loops contain only environmental concepts, their effects manifest across social and ecological domains, as evidenced by the feedback loops directly influencing change in social and ecological components and processes in members’ mental models. These feedback effects across social and ecological domains are identified in causal link diagrams of members’ mental models, and through my interpretation of members’ implicit thinking during the process of eliciting their mental models.

In summary, this section establishes that twenty-nine feedback loops are identified in causal link diagrams of seven members’ mental models. I identify distinct differences in the number of feedback loops identified between Brian, the group’s facilitator, and the remaining six members, all of whom are farmers. This observation can be explained by differences in knowledge held by the individuals. I also find that feedback loops contain only environmental concepts, an outcome that presents potential insights into the ease of identifying environmental feedback loops over feedback loops including social concepts, and additional insight into the situated nature of members’ perceived capacities to influence change. Identified feedback loops directly influence change across social and ecological domains, and therefore provide the foundation for continued analysis of social-ecological innovation.

5.3.2 Using innovation to influence feedback loops

The preceding section identifies twenty-nine feedback loops that directly influence change in across social and ecological domains in causal link diagrams of mental models of seven of the members who participated in mental models interviews. This section continues the analysis of social-ecological innovation by questioning whether any innovations are used to directly influence the behaviour of the identified feedback loops. The ability to use innovation to intentionally change the behaviour of feedback loops strikes at the heart of social-ecological innovation as it provides a means of enhancing capacity to respond to and
manage feedback effects across social and ecological domains. The following section presents selected feedback loops from causal loop diagrams of mental models and analyses for the presence of innovations that directly change the behaviour of feedback loops. Due to the complexity of mental models diagrams it is not possible to present the feedback effects of any identified social-ecological innovation. Analysis of social-ecological innovation is therefore conducted by presenting causal loop diagrams of feedback loops, and any innovations that directly change their behaviour.

Figure 5.4 presents a causal loop diagram of interactions between ploughing and three reinforcing feedback loops. Soil biology plays a core role in the behaviour of all three feedbacks loops in Figure 5.4. Soil biology holds positive relationships with soil aerobic conditions and soil organic matter (feedback loops R2 and R3 respectively). Feedback loop R1 highlights the balancing relationship between the members’ desire to enhance soil biology and ploughing. One can replace the other, the outcome of which feeds back to effect change in R2 and R3.

Figure 5.4 Feedback loops in causal loop diagram of mental model of Adam

Members expressed a clear understanding that increasing soil biology was a low cost means of enhancing agroecosystem fertility. However, the fundamental shifts in understanding raised awareness that conventional approaches to ploughing would in fact disrupt the fertility building processes of soil biology.
Conventional approaches to ploughing do not, however, identify as innovative and so do not suggest signals of social-ecological innovation.

Figure 5.5 presents a causal loop diagram of interactions between the interventions of externally sourced inputs, for example whey, green waste and manure, and cattle stocking ratio, in the reinforcing feedback loops R1 and R2.

Figure 5.5 Feedback loops in causal loop diagram of mental model of Dan.

Whilst it could be argued that use of externally sourced inputs such as whey could be perceived as innovative, I argue that they do not counter conventional understandings of how to increase agroecosystem fertility. In this instance, members’ previous dependence on chemical inputs for pasture fertility is replaced by a dependence on organically certified inputs that build fertility. Externally sourced inputs do not, therefore, identify as social-ecological innovation.
Figure 5.6 presents a causal loop diagram of Brian’s mental model that illustrates the role of the interval between grazing in feedback loops B1 and R1.

![Causal Loop Diagram]

**Figure 5.6 Feedback loops in causal loop diagram of Brian’s mental model**

Figure 5.6 illustrates how the extremity of weather conditions is understood to balance the interval of time between which a unit of pasture is re-grazed. The interval between grazing is a decision-making factor Brian understands to build capacities to influence pasture utilisation and, therefore, attempt to minimise the impacts of episodes of extreme weather. However, the interval between grazing does not qualify as an innovation and again means that social-ecological innovation is not detected. The examples presented in Figures 5.4, 5.5 and 5.6 are indicative of all interventions that are situated within identified feedback loops. That is, none of the interventions situated within feedback loops are understood as innovative and so do not identify as social-ecological innovation. See Appendix 5 for a list of all interventions identified within feedback loops.

Having established that social-ecological innovation is not identified as a component within feedback loops, I now widen the lens of analysis to explore
whether the behaviour of feedback loops is directly influenced by innovations that connected to, but situated outside of, the loops. This phase of analysis identifies mob grazing as the only innovation that directly changes the behaviour of feedback loops, and therefore suggests signals of social-ecological innovation. The remainder of this section elaborates on my reasoning for identifying mob grazing as social-ecological innovation. Mob grazing originated in Zimbabwe over forty years ago and has since experienced an incremental stream of revisions and refinement (Joseph et al., 2002). The dynamics of the practice are commonly characterised with reference to the perceived mimicry of the inter-dependent relationship between large herds of wild, roaming bison and their related pastoral ecosystems (Sustainable Food Trust, 2013). Figures 5.7, 5.8 and 5.9 present photographic illustrations and accompanying annotation that illustrate how mob grazing is understood to build agroecosystem fertility.
Figure 5.7 illustrates the dense stocking of cattle in a small unit of land. The unit of land is created through use of electric fences. The fences restrict the free movement of cattle and thereby reduce selective grazing of pasture.

Figure 5.7 High density stocking of livestock in a mob grazing system.
Figures 5.8 and 5.9 present cattle grazing a fresh unit of pasture, and the contrast between fresh and ungrazed units of pasture respectively. The height and diversity of pasture species is understood to increase agroecosystem fertility, provide medicinal benefits and improve soil structure.

Figure 5.8 Contrast between grazed and ungrazed areas of pasture in a mob grazing system.
Figure 5.9 Cattle grazing an area of fresh pasture in a mob grazing system.
Figure 5.10 presents the treading of manure and vegetation into the soil. The high stocking density of cattle results in a higher concentration of fertile manure deposited in the stocked area. The high level of stocking increases cattle disruption of the soil and treads manure into the disrupted area. The disruption and manure are understood to increase pasture fertility.

Allan Savory, the key architect of mob grazing, claims that when used as one component of a planned grazing system, mob grazing can enhance capacities to sequester atmospheric carbon, enhance the quality of degraded pasture, and, in some desertified areas, even regenerate some arid locations to the extent that they can be grazed again. The practice is also claimed to improve degraded ecosystems and improve hydrological cycling (TED, 2013).

The most significant and widely documented period of refinement of mob grazing was performed during the Charter Rangeland Trials. The trials aimed to test
claims that mob grazing could enable twice the stocking density of conventional practices, regenerate pasture quality and increase farmer profit (Joseph et al., 2002). However, results of the study were inconclusive and could neither fully substantiate nor disprove Savory’s claims. Evidence from other studies has provided equally inconclusive or contrasting findings. Holecheck (2000) observes that mob grazing practices improve livestock management and pasture utilisation. However, these observations are countered by more recent evidence that questions the capacity of rotational grazing practices, of which mob grazing is one, to enhance soil quality and improve hydrological function (Briske et al., 2008). In contrast to the inconclusive findings of scientific trials discussed above, evidence presented by Byck (2014) on experiential evidence from a variety of land managers suggests the practice provides benefits such as regeneration of pasture and improvements to soil organic matter and soil water filtration. Land managers claim these benefits have enabled them to more effectively respond to and manage the risks and impacts of periods of drought and high rainfall.

Mob grazing is not a new invention and current understanding of the practice has emerged through forty years of incremental refinement. Why, then, should mob grazing be considered an innovation in the context of this research? Figures 5.11 and 5.12 present signals of social-ecological innovation as they identify mob grazing as a practice that directly influences change in two feedback loops, the effects of which manifest across social and ecological domains. I further establish mob grazing as social-ecological innovation due to the extent to which it counters mainstream understandings of how to manage agroecosystem fertility. Members emphasised the novelty of mob grazing by comparing the contexts in which mob grazing is commonly practiced against their own:

1. Climate - Mob grazing was understood to be most commonly practiced in semi-arid or arid areas such as the North American prairies and Nebraska Sandhills. Members identified the practice as novel as it was not believed to be commonly practiced in areas with high rainfall such as that experienced in members’ agroecosystems.

2. Soil degradation - Members perceived the soils in North America to have been highly degraded through prior intensive grazing practices. Mob
grazing was therefore believed to have a greater scope for improvement of fertility in degraded areas than their own systems in which soil degradation was not identified as an issue.

3. Spatial dimensions – mob grazing practices are commonly applied in rangeland contexts over wide spatial scales, using large herds of cattle. The smaller herds and lower levels of available pasture in members’ farms represent a novel application of the practice of mob grazing.

Figures 5.11 and 5.12 illustrate how mob grazing interacts with feedback loops identified in the causal link diagrams of two members’ mental models. Figure 5.11 presents a causal loop diagram of Roy’s mental model that illustrates interactions between mob grazing and a balancing feedback loop involving the use of chemical pesticides and the control of undesirable plants. It is important to note that the use of pesticides was identified through the process of eliciting mental models and was not actually practiced on Roy’s farm at the time of interview.

Figure 5.11 Causal link diagram of Roy’s mental model illustrating interactions between mob grazing and a feedback loop.

I have added the relationship between chemical pesticides and the power of agribusiness, denoted by a dotted blue line, as it reflects Roy’s implicit thinking that mob grazing practices can minimise the power of agribusiness by reducing the use of chemical fertilisers on his farm. Mob grazing therefore enhances capacities to intentionally influence change across social and ecological domains.
The diagram presented in Figure 5.12 illustrates how Brian understands mob grazing to enhance capacities to manage for drought by balancing the impacts of the extremity of dry conditions. Annotation of feedback loops in Figure 5.12 has been omitted due to the complexity of the diagram. See Appendix 4 for annotation of each separate feedback loop.

Figure 5.12 Causal loop diagram of Brian’s mental model illustrating interactions between mob grazing and feedback loops.
Whilst mob grazing does not prevent drought conditions, the practice is understood to minimise the severity of drought conditions and therefore increase the members’ capacities to manage fertility in their agroecosystems. Mob grazing is also identified as holding reinforcing relationships with soil drainage, soil biology, soil organic matter and the interval between grazing. The aforementioned reinforcing relationships are considered beneficial to fertility and so illustrate that mob grazing is conceptualised as capable of enhancing capacities to manage change. I have added the relationships between health of the water shed, soil organic matter, and soil drainage, as denoted by the dotted blue lines, as they reflect Brian’s implicit thinking that mob grazing practices can improve the health of the water shed and, therefore, have downstream benefits for social systems by providing cleaner water for human consumption, and cleaner water ways for human recreation. As with Figure 5.11, mob grazing therefore directly influences feedback effects across social and ecological domains.

In summary, this section makes a critical finding by observing signals of social-ecological innovation. Mob grazing is conceptualised as social-ecological innovation as it directly influences change in feedback loops that have effects across social and ecological domains, challenges mainstream perceptions of how to manage agroecosystem fertility, and by influencing change across social and ecological domains. The following section contributes to the emergent understanding of social-ecological innovation by analysing the factors that mediate its adoption within TVOG’s membership.

5.3.3 Factors mediating adoption of social-ecological innovation

The preceding section explores interactions between mob grazing and feedback loops identified in causal loop diagrams of two members’ mental models. The practice has, however, been integrated more widely across TVOG than the two members who identify mob grazing as managing change in feedback loops. Mob grazing is utilised by five of the eleven members who participated in mental models interviews. Of the remaining six who had not integrated mob grazing onto their farms, all expressed a level of understanding and perceptions towards the
practice. Many of these perceptions centred on the extent to which mob grazing represented a risk to capacities to manage agroecosystem fertility.

The five members who adopted mob grazing expressed high levels of belief in the capacity of the practice to manage agroecosystem fertility. Mob grazing was conceptualised as a tool that enabled these members to manage and address the complex dynamics of change in their agroecosystems. This group of members believed that the practice would, over a course of time involving learning and minor adjustments to the practice, increase pasture utilisation, reduce costs and, therefore, contribute to sustaining their conversions to organically certified farmland. Figure 5.13 presents a causal link diagram of Toby’s mental model that illustrates interactions between mob grazing and agroecosystem components and processes.

Figure 5.13 Causal link diagram of Toby’s mental model illustrating interactions between mob grazing and agroecosystem components and processes.
Figure 5.13 illustrates how mob grazing is understood to improve pasture management by increasing control of undesirable plants in pasture, and increasing access to fresh pasture over the course of a year. The practice is also understood to manage fertility by trampling vegetation into the soil, and utilising hedges for grazing. Interestingly, Toby also identifies the potential for mob grazing to improve his health and wellbeing by both increasing his enjoyment of his agroecosystem, and by providing additional exercise due to the increased level of management activities required.

Members who adopted mob grazing stressed the importance of ensuring the practice fit with their individual goals for agroecosystem fertility. The capacity of mob grazing to contribute to these goals was assessed through processes of forward planning and monitoring.

‘…it’s part of the bigger picture in terms of trying to get to where it is that you want your farm to be.’ [Charlie]

‘But I think it’s understanding what you’re trying to do with mob grazing and why you’re doing it.’ [Toby]

Members who adopted mob grazing were reflective about the perceived severity of negative outcomes of the practice. For example, Charlie reasoned that he understood mob grazing would need to be adjusted to his situated context over a period of time. Any mistakes or negative outcomes were framed as opportunities to learn and accordingly adjust the practice so that the same issues would be less likely to occur again. Toby highlighted that he was happy to accept that integrating mob grazing into his system would require flexibility and change in his management system. Planning effective pasture utilisation was therefore difficult in the early years while Toby learned how his agroecosystem was suited to the dynamics of mob grazing. Toby applied the practice throughout 2013 but had to stop in late December of that year as he did not have sufficient ungrazed pasture remaining to continue with the practice. Toby also reflected on how he hoped to use the practice to regenerate pasture in a now redundant field. Costly and time intensive ploughing and reseeding would be replaced with mob grazing.
practices that disturb the soil, push organic matter into the disturbed area and promote worm activity.

Members who did not integrate mob grazing onto their farms expressed concerns about the scale of uncertainty that the practice would cause in their capacities to manage agroecosystem fertility. The desire for stability in management of agroecosystem fertility is a key influencing factor on members’ decisions not to adopt mob grazing.

*But just at the moment I’ve got confidence in what we’re doing.* [David]

…..*at the end of the day my accounts are more important to me. As long as that figure at the bottom supports me and the family and enabled me to do what I need to do then I’m going to carry on and I’m not going to jump into changing things radically if things aren’t broken already.* [Tony]

Members who did not integrate mob grazing onto their farms remained open to change in their practices but only through means that did not present significant risk to their capacities to manage agroecosystem fertility. For example, practices such as better utilisation of farmyard manure were perceived to offer the same or increased benefits as mob grazing but for a lower level of risk to their capacities to manage agroecosystem fertility. Threats to the stability of members’ conversions were driven primarily by concerns over the suitability of the practice to the situated environmental contexts of each agroecosystem, and the extent to which the practice required changes to other decision-making factors.

The environmental conditions in which mob grazing emerged, and has subsequently been practiced, provided a point of reference against which members assessed the efficacy of the innovation to their ongoing conversions. Members assessed the suitability of mob grazing against the soil type, and levels of rainfall experienced on their farms. As identified previously, mob grazing emerged from and has been most widely practiced in areas that experience low rainfall or drought. However, the location of members’ farms in Cornwall and
Devon, UK, meant that they experienced the temperate yet wet conditions that typically characterise areas dominated by Atlantic weather systems.

Differences between the environment in which mob grazing had emerged and members’ agroecosystems were further complicated by the situated nature of members’ systems.

*Farming is so relative to your own personal situation of what your farm is, what you’re doing on it, what your soil type is, what your rainfall is and whether you can out-winter your animals.* [Eddie]

The situated dynamics of agroecosystems resulted in significant variations in climatic and ground conditions between each member’s agroecosystem, despite the relatively small locality across which they were situated. For example, soil type varied from those with high clay content to others with higher loam content. Temperature differed to the extent that one member expressed his frustration at how soil temperature data, from specific locations within his locality, proved to be so different to those that he experienced on his farm, that it rendered the temperatures redundant for decision-making purposes. Rainfall also differed greatly dependent on topography. The different situated conditions resulted in different perceptions of risk to members’ capacities to manage agroecosystem fertility. Concerns over high levels of poaching of soils, coupled with the perceived capacity of soils to recover sufficiently during winter months, led some members to express distinct concern about the capacity of mob grazing to positively contribute to fertility.

*I really don’t think on 65 inches of rain and heavy clay soils, I’m really not sure whether we could do it sustained.* [David]

*Our farm’s basically too wet for mob grazing.* [Eddie]

*The ground won’t take much stock in the winter. You end up with a mess if you do.* [Tony]
Members’ responses highlight the importance of integrating practices that allow them to graze through winter when conditions permit. Mob grazing was, however, identified as a threat to capacities to over-winter cattle. Over-wintering cattle allowed members to minimise the costs of their grazing system as cattle could graze outdoors on pasture instead of being housed and fed either silage or purchased feeds. Furthermore, the group’s focus on managing fertility through low cost means needed to be complemented by effective utilisation of pasture. The perceived high levels of severity of impacts of mob grazing were not, however, uniform across the group. Questions over how easily mob grazing could be sustained over the winter months therefore raised concerns amongst some members that their increasingly rationalised and situated systems, developed through cycles of incremental and iterative adjustments, would be threatened by the unsuitability of the practice to their situated conditions. The risk of mob grazing to capacities to manage agroecosystem fertility was tempered in some instances by suggestions that they remained open to the eventual integration of mob grazing to their systems, but only once they had assessed its successful practice in an environment highly comparable to their own over a long temporal scale.

The evidence presented in this section thus far identifies concerns over the suitability of mob grazing to the situated environmental contexts of members’ agroecosystems. The contribution of mob grazing to members’ capacities to manage change was further assessed against a number of additional factors. Table 5.2 presents a summary of the additional decision-making factors against which members who did not adopt mob grazing assessed the practice.
Table 5.2 Additional decision-making factors for integration of mob grazing into agroecosystems.

<table>
<thead>
<tr>
<th>Decision-making factor</th>
<th>Assessment of mob grazing against decision-making factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrastructure</td>
<td>Mob grazing would require significant financial investment in and change to farm infrastructure such as cattle tracks and water sources.</td>
</tr>
<tr>
<td>Labour</td>
<td>Mob grazing would significantly increase daily grazing management activities. This represented an undesirable increase in invested time and finances.</td>
</tr>
<tr>
<td>Retirement</td>
<td>Proximity to retirement meant that there was no driving desire to disrupt a currently enjoyable and profitable system.</td>
</tr>
<tr>
<td>Perceived aesthetics of system by other individuals</td>
<td>The increased height of pasture, increased growth of weeds and increased poaching were undesirable in comparison to the visual effects of pasture used in current organically certified farmland.</td>
</tr>
</tbody>
</table>

The decision-making factors presented in Table 5.2 illuminate the multiple and differentiated nature of perceptions of the risk of mob grazing to the stability desired by some members. Infrastructure, labour and retirement concerns represented significant risks to the financial ambitions of the individual members. The investment of time and money required to install tracks and water sources for cattle made mob grazing prohibitively expensive to some members. Members were also hesitant to increase their daily management activities with additional work such as moving fences up to three times a day to allow cattle to graze a fresh unit of pasture. Interestingly, a number of members reflected on how they and their relations had become accustomed to the standardisation of the aesthetics of their pastures. The ‘messy’ look of pasture, caused by allowing pasture to grow to an increased height, an increased presence of weeds, and higher diversity of pasture species, were considered counterintuitive to the near uniform look of rye grass pasture.
In summary, this section analyses multiple and differentiated perceptions of the factors mediating adoption of the social-ecological innovation of mob grazing. Adoption of mob grazing is determined by perceptions of efficacy and risk. Members who integrate mob grazing into their systems express a sense of efficacy in their capacities to use the practice as a means of managing change. The practice is recognised as a tool that contributes to managing agroecosystem fertility. However, members who do not adopt mob grazing recognise the practice as a distinct risk to the stability of the dynamics of their agroecosystems. The identification of mob grazing as a threat to stability sits in distinct contrast to members’ large scale conversions of farmland from conventional organic status. These interesting yet contradictory dimensions of change are reflected on in greater depth in chapter seven.

5.4 Summary

Transformations involve fundamental shifts in social and ecological components of a system (Moore et al., 2014). Social-ecological innovation represents one conceptual means of understanding how to effect such change by analysing whether innovations build capacity to influence change across social and ecological domains. This chapter addresses the relative lack of empirical analysis of social-ecological innovation by asking are feedbacks recognised across the temporal and spatial scales of a social-ecological system, and can social-ecological innovation be recognised?

I began this chapter by characterising how innovations such as herbal leys and integration of trees and hedges into agroecosystem are used as means of managing agroecosystem fertility and deriving wider system benefits such as improved animal health and wellbeing, and reduced use of mechanical interventions. Innovations are characterised by the introduction of new concepts into mental models, and shifts in how pre-existing concepts are understood. The need for particular innovations emerges as a direct result of the constraints on practices in organically certified farmland that limit access to mainstream approaches to managing agroecosystem fertility.
The chapter explores social-ecological innovation by analysing whether feedback loops are recognised, and the role innovations play in influencing the behaviour of identified feedback loops. The chapter establishes that twenty-nine feedback loops are identified in seven of the eleven causal link diagrams of members’ mental models. All feedback loops comprise entirely of environmental components and processes situated across the scale of the farm to wider weather systems. I offer three potential explanations for this observation. Firstly, individuals who manage agroecosystems are more likely to identify ecological concepts than social concepts; secondly, members may express situated capacities to manage change at the scale of the farm; and, thirdly, the result may be an artefact of the process of analysis used to elicit feedback loops.

The chapter identifies mob grazing as social-ecological innovation as it represents a practice that counters mainstream approaches to managing agroecosystem fertility, and is a practice that manages change in feedback loops with effects that manifest across social and ecological domains. However, the chapter illuminates how differentiated perceptions of the efficacy and risk of mob grazing to change in agroecosystems are manifest in limited adoption of the practice within TVOG’s membership. The chapter identifies how a desire for stability in approaches to managing agroecosystem fertility contradicts the large scale shifts to organically certified farmland analysed in chapter four. The contradictory observations are reflected upon in greater depth in chapter seven.
6 Navigating change in the external system

6.1 Introduction

Capacities to manage change are influenced by complex and interrelated dynamics of change that manifest across and between multiple scales of a social-ecological system (Folke, 2006; Folke et al., 2010). The preceding empirical chapters present a multi-layered account of the processes and dynamics through which individuals build their capacities to manage change at the scale of the agroecosystem. Chapter four illuminates how processes of self-organisation and social learning across the scales of the individual, collective and network build capacities for transformations in understanding and management of agroecosystem fertility. Chapter five analyses how individuals use innovation to manage agroecosystem fertility. The need for particular innovations occurs as a direct consequence of the constraints of an organically certified farming system.

The following chapter widens the lens of analysis to explore how individuals understand their capacities to manage change in the external social-ecological systems within which agroecosystems are nested. This chapter therefore asks how do individuals understand their capacities to shape change in external systems? The chapter provides a temporal sweep of members’ understanding of their capacities to address change in the external system by drawing on historical perspectives of change from reflective interviews narratives, and future oriented visions of change from the participatory scenario planning workshop. The chapter begins by analysing how external forces of change influence individual decisions to shift away from conventional farming systems. Analysis then shifts to consider how members understood their capacities to exploit windows of opportunity that enabled the conversion of their farmland from conventional to organic status. The chapter goes to analyse future-orientated perspective of change by exploring the extent to which members understand their capacities to respond to and influence particular aspects of change in the external system. Finally, the last section summarises the main findings from analysis of the historical and future perspectives of individual and collective capacities to influence change in the external system.
6.2 Forces of change and trigger events

A resilience perspective understands that external forces of change and triggers of transformation can be both social and ecological (Brown et al., 2013; Moore et al., 2014). For example, transformations can be triggered by changes in ecological components such as climate or soil, or social components such as civil unrest or new technologies (Moore et al., 2014). This section analyses members’ perceptions of the key external forces of change and trigger events that catalysed their decisions to convert from conventional farming systems.

Members emphasised how a dominant conventional farming approach based on yield maximising systems that relied on high use of external outputs stimulated their decisions to convert from conventional farming systems. Acceptance of the yield maximising approach created a sustained and uncontrollable pressure to increasingly intensify levels of production.

*In the forefront of the mind is yield. We’re a yield mentality in the Western world. We’re yield minded. We’re driving to build bigger. Bigger machines, bigger tractors, bigger this, bigger that. [Jack]*

The pressure to increase the intensity of production was driven by a complex combination of interacting external forces including market dynamics that determined the prices members paid for their externally sourced agricultural inputs and the prices they received for their products; the advisory services received from consultants and agents of agribusiness corporations; government incentives to increase production; and, competition from within the agricultural community itself. Members widely characterised a perceived drive for yield maximisation as shifting their decision-making toward “chasing milk” and “squeezing a quart into a pint”. These metaphorical descriptions highlight the extent to which members believed they were stretching the capacities of their conventional agroecosystems in order to conform to the broader dynamics of change that governed their conventional systems. Members stated that in order to persist with their conventional agroecosystems they needed to be effective at farming more intensively on the farm’s current acreage, rent or buy new land on which to increase production, or invest heavily in new infrastructure that could
accelerate processes of production. In many instances, the latter option resulted in obtaining bank loans that increased already high debt levels charged against their farms.

The extent to which the yield maximising approach affected members was also influenced by changes in personal circumstances. One member identified how bereavement caused him profound emotional shock and a shift in responsibilities to the extent that he became responsible for a conventional farm that was struggling to conform to the perceived demands of the yield maximising approach. The personal loss acted as a trigger for the member to reconsider the extent to which he wished to continue to strive to adhere to the yield maximising approach. These examples illuminate how decisions to convert from conventional farming systems were the result of external forces of change alone, or a combination of interactions between personal circumstances and the external force of change.

Members reflected on how the volatility in price of externally sourced agricultural inputs, and prices they received for their produce, caused distinct feelings of uncertainty and vulnerability. High levels of dependence on externally sourced agricultural inputs such as fertilisers, pesticides and animal feeds meant that members were commonly subject to uncertain and short-term change in availability and prices due to the global dynamics of supply and demand of the commodities. Toby reflected on how he attempted to adapt to a price spike in nitrogen fertilisers in the mid-90s by using agroecological practices such as the sowing of red clover leys, which he hoped would increase fertility by sequestering nitrogen from the atmosphere. However, Toby’s use of red clovers unexpectedly resulted in increased levels of costly re-sowing and an ultimate drop in fertility. This example illustrates how Toby was attempting to adapt within the constraints of his conventional system but was not able to manage change through the means he desired.

Other members reflected on how their decision-making and long-term planning were commonly frustrated by the volatile nature of prices received for their produce. Charlie identified that prior to 1993 the Milk Marketing Board monopolised the British milk market and insulated milk prices from the influence
of external forces of change, such as supermarket buying power. The Milk Marketing Board, an organisation run by and for milk producers, controlled milk prices by guaranteeing to buy surplus milk at pre-specified prices and therefore ensured that prices remained stable for producers. However, deregulation of agricultural markets in 1993 led to the break-up of the Milk Marketing Board and subsequently caused a dramatic drop in the milk prices received by members.

...and then with the break-up of the milk marketing board monopoly, the increasing power of the supermarkets, and also that supermarkets were using milk as a loss leader to get people into their shops, it became very political and the milk price went into free fall. So all of a sudden what happened was that the milk price went from 25 pence a litre when farmers thought they were actually doing quite well, it crashed down to about 13-14 pence. [Charlie]

The significant and sudden drop in prices was of particular concern to individuals who were concerned about their capacity to maintain repayments on the high levels of borrowing they owed to banks. The dissolution of the Milk Marketing Board was understood to increase supermarkets’ power over milk prices and quality of products demanded, and subject members to increasingly volatile market dynamics over the temporal scales that preceded their decisions to convert from their conventional systems. This example illustrates how historical trigger events such as the dissolution of the Milk Marketing Board create ongoing uncertainty due to a transfer of power from one group, in this instance milk producers, to another group, in this instance supermarkets. The trigger event caused disruption and a sense of disempowerment by changing how members were connected to, and influenced by external driving forces of change.

The privatisation of agricultural knowledge and advisory services acted as a key trigger event that contributed to decisions to convert away from conventional systems. Members reflected on how they and their peers had derived a sense of security from the relationships of trust they developed with independent advisers and those tied to agribusiness corporations. Both types of adviser provided consultation on the type of grazing systems to implement, the type of inputs to use, and daily management activities in members’ conventional systems. Ceding
power for decision-making to an external actor created a sense of security in the advice being provided.

*It’s like your father telling you what to do. Because somebody else has advised me to do that it wasn’t my sole decision to do that. It’s safer. People like safety, or reassurance.* [Edie]

*a lot of, even large dairy farmers, don’t actually run their own businesses. They almost let the adviser run it for them. They do what they tell them. They feel safer that somebody else has told them this is going to work. This is what we’re going to do and follow it.* [David]

The comfort zone provided by external advisory services accords with the themes of stability and risk related to the practice of mob grazing in section 5.3.3. In this instance, shifts to alternative means of accessing advice and knowledge represented a major risk to the stability provided by external advisory services. These factors are reflected on in greater depth in chapter seven.

Privatisation of agricultural knowledge and advisory services meant that much of the advice received by members was provided by agribusiness corporations with vested interests in the advice being offered. Members lamented how the privatisation of agricultural research services throughout the 1980s and 1990s led to a system that created individual and collective dependence on large agribusiness organisations for knowledge and advisory services. Brian identified British Prime Minister Margaret Thatcher as playing a central role in creating a system of knowledge and advisory services that no longer represented and responded to the needs of the farming community. Brian expressed frustration at how the ultimate privatisation of publicly owned agricultural advisory services such as those provided by ADAS, at the time the UK’s publicly owned National Agricultural Advisory Service, led to a situation whereby research was only performed by private agribusiness corporations with sufficient financial strength to fund the research.
there was no ADAS anymore. There weren't any open days anymore. Since 1984, when Mrs Thatcher said, you know, “ok I don't want to do any market research in agriculture any more. I want it to be theoretical research or government based research, but not there to help farmers anymore. If farmers want research, then they have to do it themselves.” The only ones that paid for it were large companies that were trying to sell farmers material. It's not for farmers, you know, not there to benefit farmers. [Brian]

The shift in dependence on knowledge and advisory services from ADAS to a diversity of agribusiness corporations who linked their research to commercial imperative created a perceived loss of capacity for members to make relevant and effective decisions in their conventional systems. For example, members expressed frustration at how their dependence on agribusiness corporations for chemical inputs was then compounded by dependence on the same organisations for knowledge and advisory services. In these instances, knowledge and advice on conventional agroecosystem fertility was linked directly with the vested commercial interests of the agents and agribusiness corporations. The sense of trust and security eroded as members grew aware of the extent to which they were locked-in to situations that agents were believed to be manipulating to their advantage.

they get them on the treadmill and then they can’t get off. [David]

Consultants were criticised for their inflexibility and lack of desire to develop systems that responded to and reflected the situated needs and circumstances of the individual members. For example, Brian highlighted how consultants did not question the common prioritisation of silage production over consumption of fresh pasture when creating feed budgets for members’ grazing systems. Consultants commonly advised individuals to produce large quantities of silage to cover the winter months when grass growth falls. However, whilst the conservation of feed for winter months seemed a common sense approach to pasture management, the focus on silage production created high workloads, required financial investment and reduced available fresh pasture at a time when it was growing most freely. The reliance on uniform and at times maladaptive
advice meant that members did not commonly pursue alternative practices that could enhance their capacities to manage change.

Nationwide incidences of animal disease events such as foot-and-mouth and bovine spongiform encephalopathy (BSE) triggered sudden and traumatic shifts in members’ desire to convert away from their conventional systems. The nationwide outbreak of foot and mouth disease in 2001 was highlighted as one such major trigger event. Foot and mouth is a disease that harms livestock through painful blisters and potential lameness (Defra, 2014a). The disease poses minimal risk to human health yet its highly infectious and harmful characteristics for livestock mean that decisions to enact widespread culling of herds by government, as experienced in 2001, is commonly the chief means of controlling large scale outbreaks of the disease (Defra 2011). Individuals from the wider farming community whose livestock were infected by foot and mouth experienced distinct anguish at the loss of their herds but were fortunate to receive government compensation for each animal slaughtered. However, Toby’s herd was not infected by foot and mouth yet he stated that he suffered greater financial impacts than those whose livestock were infected by the disease. The drop in demand for British livestock products and preceding decisions to increase stock numbers meant that the member was forced to sell his livestock at a point when livestock prices had plummeted due to the nationwide prevalence of the disease.

And then obviously foot and mouth came and came within a few miles of us and I had a problem because I carried too much stock, didn’t have enough feed and then I had to sell. So I lost a fair bit of money because of that event, whereas other farmers were getting, you know, £1million pay out for two hundred animals and I'm running about 250 animals and I couldn’t feed them so I had to get rid of them. That was hard and financially that was a tough one. [Toby]

Whilst Toby acknowledged that he was carrying a high level of stock for the feed he had available at that time, the disease diminished his capacity to sell the stock at a time that would allow him to manage his system according to his plans. Of the members interviewed, only Tony confirmed that his herd was culled. Tony
reflected on how the culling of his entire pedigree herd resulted in a period of eight months in which he was unable to sell milk due to the drop in demand for British dairy products caused by the disease, and the time it took the member to restock his herd. The disease acted as the final trigger event that catalysed Tony’s ultimate decision to convert away from his conventional agroecosystem. The increasing intensity of Tony’s conventional system meant that he was sometimes forced to milk his cattle three times per day, in contrast to the traditional twice per day that he commonly expected. Tony was unable to respond effectively to the cattle’s increased needs and struggled to ensure that the cattle’s welfare was not negatively impacted by the resulting wet cubicles and beds. Furthermore, the high level of financial debt secured against Tony’s farm meant that he could not easily convert away from his conventional system until another source of income was identified that would help him to maintain his loan repayments.

*Foot and mouth came along and gave me a blank sheet of paper.....The payments weren't really too much to do with it. It was really the stress of farming conventionally. And also I could see, or to me, I felt it would be nice to be able to do something different. You know, you can carry on with the rat race, which was the way I was looking at it. Everyone else was chasing yield and cow numbers and everything else. I’d had enough of high yielding cows really and the problems they bring.* [Tony]

Comparison of Tony’s experiences to those of Toby, whose herd was not culled, illuminates how the same trigger event was experienced differently, by different individuals. Furthermore, Tony’s experience highlights how trigger events can simultaneously limit and enhance capacities to pursue change. In Tony’s context, foot and mouth restricted his capacities to manage production in this conventional system but also enhanced his capacity to escape the yield maximising approach. The compensation acted as a window of opportunity for change. The following section analyses how members understood the influence on windows of opportunity on their capacities to shift away from their conventional systems.
In summary, this section illuminates how external forces of change and trigger events influence decisions to convert away from conventional agricultural systems. The section identifies how individual decisions to convert from conventional farming systems are simultaneously driven by common and different external forces of change over long and short temporal scales. Furthermore, the section illustrates how common external forces of change such as foot and mouth, can be experienced differently and result in different feelings and outcomes. External forces of change manifest differently; some forces cause sudden and abrupt surprises, for example animal disease events and fertiliser price spikes, whilst other forces such as the yield maximising approach, and dependence on privatised agricultural knowledge and advisory services, are experienced over slower, more gradual scales. The chapter also identifies how individual personal circumstances interact with external forces of change. Taken as a whole, these findings illustrate the differentiated and complex nature of external forces of change that catalyse and trigger decisions to convert from conventional farming systems.

6.3 Exploiting windows of opportunity

Transformations are messy and fragmented processes of change (Brown et al., 2013). The complex nature of the processes that support the transformations in understanding and management of agroecosystem fertility is reflected in the non-linear nature of the conversion of farmland from conventional to organic status. The preceding section illuminates how external forces of change caused members to experience constraints on their capacities to manage change. These forces of change ultimately triggered desires and decisions to convert from conventional agroecosystems. However, decisions to convert from conventional systems did not automatically lead to decisions to convert farmland to organic status. This section analyses the extent to which decisions to convert farmland to organic status compete against other viable alternatives. The section also analyses the role of windows of opportunity in incentivising ultimate shifts to organically certified farmland.

A classic resilience understanding of change emphasises the importance of diversity (Walker et al., 2004). Diversity and flexibility build resilience by
minimising the opportunity for rigidity or poverty traps, and by increasing the capacity to create alternative desirable futures (O’Brien, 2012; Schoon et al., 2011). Diversification was a particularly important aspect of the non-linear processes of conversion pursued by a number of members. The number, type and desirability of alternative options differed at the scale of the individual member. Jack reflected on how the high levels of debt and lack of perceived viable options to continue in farming created a strong desire to sell the farm and exit farming altogether. However, the decision to sell the farm relied on, but failed to achieve, agreement across multiple generations of Jack’s family, and so continuing to farm remained the only option open to him. Other members decided to reduce the scale of their farming enterprises due to the superior financial and lifestyle opportunities offered by other enterprises of their diversified operations. For example, Eddie reflected on how he could pursue a better life by increasing the time he invested in letting out cottages on his farm to tourists. Harrison reflected on the importance of the veterinary surgery that formed part of his family’s enterprise. The surgery provided both an important source of income, and a well-performing business against which the member could assess the financial efficacy of the decisions he made in his conventional grazing system.

In contrast to the adaptive option of diversification, other members sought options that represented more fundamental types of change. Charlie used the financial decline of his conventional farming enterprise as a period of reflection to consider other alternative options available to him. Charlie believed that he needed to create a fundamentally different alternative that disconnected him from the external forces of change that created self-defeating decisions in his conventional system.

…..my view on it was technically I was never going to be as good as many of the farmers and so my issue with it was that if you’re going to be involved in that race to the bottom, a sort of arms race against your superiors, what do you do? So actually the only thing that you can do is to do something differently or, effectively, to use that awful word, to have a shift in your paradigm. You know, in your thinking, and actually make your own rule, or it’s so different to what you’re doing you’re off on a completely different trajectory. [Charlie]
Charlie’s reflections illustrate how he aspired to create a blank canvas from which he could pursue a diversity of options that were profoundly different to the future he envisaged would occur had he continued with his conventional system. This example draws similarities with the experiences of Tony in the preceding section, in which I analyse how Tony’s dairy herd was culled in response to the herd contracting foot and mouth disease. Tony identified the traumatic event as key to triggering his decision to convert from a conventional system, but also identified the event as pivotal in providing him with a basis from which he could consider creating a fundamentally different system, that disconnected him from the yield maximising approach that constrained his conventional system. These examples illustrate that members considered a diversity of options, some more fundamentally different than others, before they decided to convert their farmland from conventional to organic status.

Transformations are catalysed by the capacity of actors to seize on windows of opportunity for change (Olsson et al., 2004; Olsson et al., 2006). The majority of participating members identified the availability of organic conversion subsidies, a feature of the Common Agricultural Policy outlined in section 1.2, as key windows of opportunity that catalysed their transformations in understanding and management of agroecosystem fertility. Members identified differentiated reasons for seizing on the window of opportunity presented by the organic conversion subsidies. Toby stated that he had been managing a quasi-conventional-organic grazing system for a number of years prior to his decision to apply for organic conversion subsidies. Toby had integrated agroecological practices into his conventional system in direct response to the volatility in fertiliser prices, and the foot and mouth disease event, but had not taken the final step of pursuing organic certification. Toby reflected on how the financial benefits derived through his conversion were juxtaposed with his concern that the freedom in practices he had previously enjoyed would become restricted due his required conformance to organic certification regulations.

…..there’s quite firm guidelines and practices you’ve got to keep to and then it becomes very strict. [Toby]
Toby’s reflections illuminate some interestingly contradictory insights into the dynamics of change in the external system. Toby’s comments illustrate how change at different scales of the external system can constrain practices in both conventional and organically certified farmland, and equally present a window of opportunity to convert from one system to another.

Eddie used the organic conversion subsidy to provide him with a financial buffer that would allow time and space for him to reflect on his conventional system and consider alternative paths for future change. In this instance, Eddie had no specific desire to convert his farmland to organic status and instead used the subsidies as a means of escaping the disempowering situation of his conventional system. Dan recounted how he believed he would be subject to challenging market forces due to the reintroduction of British cattle into the food supply chain following the BSE crisis identified in the preceding section. Organic certification provided Dan with a more robust and extensive farming system that he hoped would reduce incidences of animal disease and would be better accepted by customers. However, Dan stated that irrespective of the anticipated challenging market conditions, the financial benefits of organic conversion alone would have been sufficient for him to convert his farmland to organic status. This feeling was shared by a number of other members, all of whom stated that despite the challenging circumstances they experienced, the organic conversion subsidy fortuitously provided a financial profit that simply would not have been achievable within the constraints of their conventional systems.

*I didn’t go into farming organically for the ethos of organic farming. I went into it for the money. I’m not ashamed to say it. I looked at that time when the sheep price was rubbish and beef prices were rubbish. I was going to get £40-50,000 to convert my farm over five years. I looked at it and thought I can’t make that sort of money doing anything the way the prices are at the minute. I’ll take the money and see if it works and it bloody works. So I’ve stayed in it. But I wouldn’t have done it if it hadn’t been for that money in the first place. I wouldn’t have chanced it. I thought it was going to be a disaster but it didn’t turn out like that.* [Harrison]
In these instances, windows of opportunity simultaneously allowed members to escape the constraints of their conventional systems and provide them with a financial benefit that they would likely not have received even if they wanted to continue with their conventional systems.

Organic conversion subsidies did not act as the only window of opportunity for conversion of farmland from conventional to organic status. David identified an unexpected opportunity to rent organically certified farmland on a neighbouring farm as the key window of opportunity that enabled the conversion of his farmland to organic status. The extra land presented David with the opportunity to respond effectively to falling milk prices, and high levels of financial debt secured against his farm, by expanding his herd size and increasing milk production. However, a stipulation of the tenancy meant that the land had to remain organically certified and thereby pushed David to convert his farmland to organic status.

…if that extra land hadn’t become available we wouldn’t have become organic… [David]

David highlighted how the neighbouring land was perceived so optimistically due to the influence of nitrate vulnerable zone regulation, created as a result of the European Union’s Nitrate Directive (91/676/EEC), that he anticipated would constrain his conventional practices. A nitrate vulnerable zone, not yet enforced at the point of the member’s conversion in 2009, was expected to restrict agricultural activities in areas where over-application or miss-application of nutrients such as chemical fertilisers or slurry posed significant threat to the quality of water courses. The location of David’s farm in the watershed meant that the use of chemical inputs in his conventional system were likely to fall under the remit of nitrate-vulnerable zone regulations. However, David believed the reduced opportunity for leaching of inputs offered by an organic farming system would reduce the potential for the vulnerable zone regulations to restrict his practices. In this instance, David’s decision to convert from a conventional system was driven by market dynamics and anticipated constraints caused by nitrate vulnerable zone regulation, but his decision to convert farmland from conventional to organic status was driven by the fortuitous availability of organic
land and availability of the Common Agricultural Policy’s organic conversion subsidy.

Overall, this section illuminates how the processes that catalyse, support, and lead up to transformations in understanding and management of agroecosystem fertility are not linear. This section shows how the agricultural policy landscape catalyses and enables the conversion of farmland to organic status. In one instance the EU Nitrates Directive catalyses a shift away from a conventional agricultural system, whilst the Common Agricultural Policy’s organic conversion subsidies fortuitously creates a window of opportunity for the conversion of farmland from conventional to organic status. However, decisions to convert land to organic status compete against alternative viable options. Windows of opportunity incentivise and enable decisions to convert farmland to organic status. Individuals express common and differentiated reasons for seizing on the windows of opportunity, and make these decisions at different moments in time.

6.4 Anticipating uncertainty

A resilience perspective on change embraces notions of uncertainty and surprise as key dimensions of change across multiple scales of a social-ecological system (Berkes et al., 2003). Sections 6.2 and 6.3 analyse how conversions of members’ farmland to organic status that precede their transformations in understanding and management of agroecosystem fertility, are catalysed and driven by a diverse range of forces of change and trigger events in the external system that create a sense of uncertainty at the scale of the farm. Sections 6.2 and 6.3 identify that the forces of change and trigger events are experienced differently by members, and that windows of opportunity to convert farmland to organic status are seized on at different times. These findings present a complex, and non-linear picture of the historical events leading up to members’ transformations in understanding and management of agroecosystem fertility. This section analyses evidence from the participatory scenario planning workshop to consider how members understand their future capacities to address surprise and uncertainty in the external system.
The preceding section identifies how Charlie desired a fundamental change that would allow him to disconnect from the yield maximising approach that was driving self-defeating decisions in his conventional agroecosystem. Decisions to convert farmland from conventional to organic status resulted in shifts in how all members connected to the uncertain external forces of change that triggered their decisions to convert from their conventional systems. For example, organic certification meant that members were no longer able to use chemical fertilisers and therefore broke connections to the volatile and upward trend of the prices of externally sourced chemical inputs. The processes of self-organisation and social learning identified in chapter four, combined with the innovative practices identified in chapter five, enabled members to break their dependence on advisory services from agents tied to agribusiness corporations, and created a belief that the risk of major animal disease events were significantly minimised. However, members expressed uncertainty in how future external forces of change would interact with change in their agroecosystems.

Members identified a broad range of external forces of change that were expected to manifest in uncertain ways across social and ecological domains. The power of global corporate companies and climate change were identified as the two most uncertain external forces of change. For example, Adam expressed fear that the interest of Monsanto in, and potential trade-marking of, biological inputs such as mycorrhizal fungi would negatively affect his capacities to source innovative and cost-effective means of managing fertility in his agroecosystem. Dan extrapolated from historical experiences to suggest that climate change would increase the intensity of rainfall on his farm.

_Well, climate change, being on a farm that gets sixty-five inches of rain a year, I'm just thinking that in twenty years’ time it’ll be raining even more. In the last twenty years our rain intensity has increased. We do get more rain but it’s more intense over the last 20 years. So if that continues I think that could be quite detrimental to our farm._ [Dan]

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4 Monsanto ([http://www.monsanto.com/pages/default.aspx](http://www.monsanto.com/pages/default.aspx)) is one of the world’s largest producers of seeds and associated technologies
Changes to the Common Agricultural Policy, interest rates, population growth and agricultural commodity markets were identified as other major uncertain forces of external change that would influence members’ capacities to manage change in their agroecosystems. Members expected an increasing sense of volatility of change in the external system to be a key determinant of their capacities to manage change.

Change will come, but how quickly none of us knows. [Jack]

...everything’s happening so much quicker. We’re so much more connected. When things go wrong they go wrong more quickly and worse. [Toby]

The increasing volatility of change was understood to be driven by increasingly complex connections between major external forces of change. However, members expressed a sense of familiarity with volatility in external systems; volatility was recognised as a defining feature of farming, irrespective of conventional or organic certification.

I think as farmers we’re used to volatility in a way. Going and sorting problems. We see problems every day, it’s just a different one. You don’t know what’s coming round the corner. [Charlie]

Volatility was not considered constant or fixed to specific dynamics. Indeed, Charlie believed that the complexity of change in the external system meant that a reduction in volatility in one aspect of the external system would result in an increase in volatility in another aspect. Volatile dynamics of change were understood to create challenges for effective planning and decision-making, yet members expressed an optimistic sense of empowerment in their capacities to at the very least adapt to the volatile forces of change. The sense of optimism and empowerment was particularly evident in the selection of scenarios during the participatory scenario planning workshop. Members opted not to select the most negative and potentially adverse scenario of increased climate change and increased power of global corporate companies. Indeed, the three selected scenarios were given the optimistic and positive names of ‘Carbon bulldog’, ‘Rose
tinted illusionists’ and ‘Future’s good’. These names imply a sense of confidence and optimism regarding the extent to which members believed they were capable of addressing and managing uncertain external forces of change. Toby was convinced in his beliefs that external forces of change would only impact change on the farm if he wilfully allowed it to.

There may not be any change at all. If you choose you can control it. [Toby]

Toby’s sense of empowerment represents the extreme end of the scale of the group’s optimism but illustrates how the expressions of confidence articulate a distinct sense of capacity to manage change.

The Common Agricultural Policy was widely agreed to be an external force of change that would cause abrupt and continual change on members’ farms.

The biggest shock you’ll get to the system is all of a sudden there’s a policy change….It’s a very dangerous area to be in really where things are policy driven. [Brian]

However, members expressed concern that their limited opportunities to participate in the development of the Common Agricultural Policy offered them little capacity to address the policies that governed their agricultural practices.

You can’t beat it, you’ve got to try and do what they want and try get that premium whilst it’s there. [Tony]

These comments emphasise the extent to which members felt they did not have the ability to influence changes to the Common Agricultural Policy that so heavily influenced their agricultural practices. Processes of adaptive governance would address this issue by enabling decision-making to occur at multiple scales and level, and by striking a balance between centralised and decentralised control (Folke et al., 2005). Members would be able to participate through voluntary processes of self-organisation that link networks and actors across multiple scales and levels (Olsson et al., 2006). These important and participatory
processes of governance are absent in the Common Agricultural Policy, as further demonstrated in section 1.2, yet would offer a means of extending past the specific and narrow consultations that characterise the current process of governance.

Members were, however, more optimistic towards the extent to which the processes of social learning and engagements with key individuals identified in chapter four, and innovative practices identified in chapter five, enabled them to anticipate and adapt to future changes in the Common Agricultural Policy. The advanced nature of members’ knowledge and practices created a belief that they would be able to anticipate and adapt to change before its impacts could be felt severely. For example, members believed their current practices already met the ‘greening’ requirements proposed for future change in the Common Agricultural Policy that governed practices and subsidies within the British agricultural community (Defra, 2015b).

… we’re already doing it before it’s coming into policy. [Brian]

The distinct sense of optimism, confidence and empowerment in capacities to adapt to changes in the Common Agricultural Policy are equally exemplified in members’ reflections on their capacities to adapt to market forces that determine the prices they receive for their products. The globalised and complex nature of markets was understood to drive volatility in milk and meat prices. The powerful role of buyers such as supermarkets and abattoirs added an additional layer of complexity to the price members received for their products. For example, Toby expressed frustration at the control of abattoirs over the meat grading system that determined the price he received for the meat he produced. Grading systems determine the quality of meat for customers such as supermarkets and wholesale purchasers and, therefore, determine the price received by the member. The outcomes of many grading decisions were considered unfair but Toby expressed a perceived inability to change grading decisions and the systems that they emerge from. Toby expressed concern that if he raised complaints about a grading decision he might damage valuable relationships with the abattoir that his farm relied on for its income. He did, however, reflect optimistically on the extent to which he felt empowered to adapt to the situation and therefore increase
the likelihood of receiving better grading of his produce. Adaptive measures included improving the quality of breeding stock, installing a weighbridge that would provide the member with reliable evidence of the likely grading, or even removing the need for grading by developing independent markets for his produce. Whilst these adaptations had not yet been enacted by Toby, he understood and believed in his capacities to make decisions and pursue actions that would improve his situation. The expression of confidence in capacities to adapt draws a parallel with the preceding example of capacities to adapt to changes in the Common Agricultural Policy; in both instances members contribute to the resilience of the social-ecological system through social learning and changes to farm practices, that enhance their capacity to respond to perturbations and changes in external forces.

Members who operated dairy systems were equally optimistic towards their capacities to adapt to change driven by their customers. Contracts with customers such as supermarkets and milk cooperatives determine the price a member receives for each unit of milk to a specified standard. If the quality of milk specified in contracts is not achieved, then members are penalised and receive a lower price per unit of milk. Members did not believe they could address the power of supermarkets and cooperatives over the price they received for their milk. However, they did express confidence in their capacities to marginally improve their situations by negotiating improved contracts with alternative supermarkets or cooperatives to that which they were currently contracted. An improved milk price, derived through a new contract, would, however, increase the required quality of milk and therefore necessitate further adaptations to practices and farm infrastructure.

*I've got to change the system and invest money in the parlour and different things to be able to hit the standards that they require.* [Tony]

Whilst additional financial investment and change in practices were not necessarily desired, Tony expressed distinct confidence in his capabilities to pursue the adaptations that would allow him to achieve the improved milk price.
This section identifies optimistic and confident reflections on capacities to adapt and respond to changes in the Common Agricultural Policy and market dynamics. In each instance, members identify the external force as driving negative change. Change in the external system was not, however, identified as negative in all circumstances. For example, Tom believed that a growing global population would result in increased demand for food from limited resources. Brian expressed belief that the challenge of producing more food from fewer resources would likely improve the status of the farming community in global society.

_I think that could actually put farmers back as maybe not flavour number one but slightly higher up the pecking order than we are now._

[Brian]

Members also believed that converting their farmland to organic status placed them in a strong position to seize on favourable shifts in consumer dietary preferences towards healthier products. Members placed distinct emphasis in their belief that the increased health of their soils contributed to healthier livestock products and, ultimately, a healthier human.

_.....the thoughts of those people, what they want, what they eat, will be driving what farmers produce._ [Jack]

Members believed that the fundamental shifts in understanding and management of agroecosystem fertility identified in section 4.2 enabled them to respond to increasing consumer awareness of the dangers of consuming livestock products whose production systems included routine use of antibiotics. The medicinal benefits of the innovation of herbal leys, as identified in section 5.2, illustrates how members’ sought to minimise use of medicines in their agroecosystems. Increased scrutiny of the environmental impacts of livestock production systems was expected to drive a culture amongst some sections of society whereby regular consumption of low quality meat would be swapped for lower consumption of high quality meat. Members’ confidence in the nutritional content and environmental integrity of their products meant they believed consumers would favour their products over others. Social media was identified as a key
force of change that would increase the speed of change of preferences but equally allow members to connect to changes in consumer demands.

In summary, this section identifies how conversions from conventional to organic farming systems involve changes in how individuals connect to and understand external forces of change. Conversions enabled members to break or reduce the extent to which they were affected by particular external forces of change, yet did not insulate members from the uncertain dynamics of other drivers of change such as the Common Agricultural Policy, dietary preferences, population change, prices received for products. In these instances, it is the volatility of uncertainty that represents the greatest challenge for members. The section identifies a clear sense of confidence and belief that the processes of self-organisation, social learning and innovative practices identified in chapters four and five respectively, build capacities to anticipate and adapt to the volatile dynamics of external change. Whilst members are able to anticipate uncertainty, their actions are adaptive and bounded; that is, the evidence presented in this section does not suggest that members expressed capacity to address the forces of change that caused uncertain dynamics of change. It is to this concern that I turn in the following section.

6.5 Shaping alternative futures

Transformations involve imagining and creating alternative futures that challenge deep-rooted beliefs and structures (Bahadur and Tanner, 2012; Brown et al., 2013; O’Brien, 2012). The following section analyses evidence from the participatory scenario planning workshop to explore how members recognise their ambition and capacities to shape desirable alternative futures. I explore how capacities to shape alternative futures interact with change across multiple scales of a social-ecological system, and elaborate on the key factors that act to constrain these capacities. The preceding section identifies that conversions of farmland from conventional to organic status resulted in renegotiation of connections to many external forces of change. Members took large strides to shift away from their conformance to the yield maximising approach that permeated conventional farming systems. However, the strong sense of belief and confidence identified in the preceding section fostered an ambition and
perceived capacity to scale out their transformations in understanding and agroecosystem fertility to the wider social-ecological system. Such change could be pursued by sharing and potentially stimulating transformations in understanding and management of agroecosystem fertility amongst their conventional peers.

The extent to which members desired and believed in their capacities to stimulate these proximal and wider transformations in understanding and management of agroecosystem fertility was, however, differentiated within the group. Toby believed that a gang mentality within the conventional community meant that it would be difficult for members of TVOG alone to break the entrenched and rigid beliefs that his conventional peers held towards his transformation. Other members believed that transformational change within the conventional farming community would only be achieved if the government or levy organisations such as the Beef and Lamb, or Dairy subsidiaries of the Agriculture and Horticulture Development Board promoted and incentivised transformations in understanding and management of agroecosystem fertility. The Beef and Lamb, and Dairy subsidiaries of the Agriculture and Horticulture Development Board were identified as playing instrumental roles in change due to the expectations farmers place in the levy contributions that fund it. Brian stated that the Agriculture and Horticulture Development Board receives a levy contribution from the sale of each unit of produce and reinvests it into research and development for the benefit of the wider farming community. Farmers place high levels of trust in the Agriculture and Horticulture Development Board’s research and guidance, that it offers in return for the levy contributions. For example, Brian believed that a wide scale shift to the social-ecological innovation of mob grazing, that I analyse in section 5.3.3, would not happen until the Agriculture and Horticulture Development Board demonstrated the practice’s efficacy as a mainstream and viable grazing system. These observations suggest that transformations in understanding and management of agroecosystem fertility amongst the conventional farming community would need to be driven by institutional forces that the conventional farming community are more accepting of and familiar with.

Other members expressed a greater degree of confidence in their capacities to catalyse transformations in understanding and management of agroecosystem
fertility amongst their peers. Education and learning were identified as key capacities through which the transformations could be catalysed.

...we can't change the way that farming is going. The majority. But we can try and educate them. That's the only thing I would say, but we're not going to change it. [Toby]

Members expressed strong belief that if change started from the grassroots upwards then it would hold significantly more traction in the external system.

...put a domino against a slightly bigger domino, against a bigger tower block and the little domino can make the tower block fall over. It's just a sequence of events. Little acorns grow big trees, big oaks trees. [Brian]

However, a number of members believed their capacities to stimulate transformations in understanding and management of agroecosystem fertility amongst their peers were limited as their conversions to organic systems meant they now operated within a niche that created boundaries between themselves and their conventional counterparts.

You may have seen the light but you're in the minority. [Toby]

We're still in that niche. We're still in that 5%. [Tony]

Members’ capacities to share their fundamentally changed understanding of agroecosystem dynamics were commonly limited by their conventional peers’ relatively low understanding of, and critical perceptions towards, the efficacy of their transformed management practices. Tony highlighted how he could speak to his conventional counterparts about the price and utility of chemical fertilisers, yet would not be able to discuss viable agroecological alternatives that he believed would reduce his peers’ financial costs. Members’ attempts to transform their conventional peers’ understanding and acceptance of their conversions commonly resulted in converse outcomes to those they hoped for. Instead of building stronger relationships with their peers, members were commonly subject
to marginalising comments that reinforced their niche status amongst their conventional counterparts.

Adam says I talked to so and so about mycorrhizal fungi. I said yep, did they switch off? You know, because you can tell when people aren’t engaging as they don’t look you in the eye anymore. They say “That’s alright. You go and sort yourself out with the blokes in the white jacket”. [Brian]

The sense of empowerment and optimism identified in the preceding section commonly enabled members to discount the marginalising comments of their peers. Humour and metaphors used by the group reflect a strong sense of belief amongst members that their conversions provided them with a life that could not be achieved through conventional systems.

…we’re looking at it in a holistic way. Looking outside of the box. Everybody may think that we’re off our trolleys but we laugh a lot and say every village could have an idiot so we just carry on. [Adam]

But we’re in that process, you know, that transition now. So, you know, if we’re perceived to be nutters then ok, so be it. I’m not going to lose sleep over it. [Brian]

One member stated that he had become so frustrated at his conventional peers’ lack of willingness to understand and accept his conversion, that he would rather stop attempting to address the marginalising constraints, than invest more energy in a potentially unfruitful process of change. Despite differentiated perceptions of capacity to catalyse transformations in understanding and management of agroecosystem fertility amongst their conventional peers, members’ reflections suggest additional signals of transformative learning that align with the signals analysed in section 4.4. Mezirow (1997) proposes that transformative learning should enable more inclusivity, autonomy in thinking, and critical reflection around assumptions and biases towards other cultures. Viewed through this lens, members’ transitions from positions of marginalised outsiders with little desire to reengage with conventional agricultural systems, to ones of thought leaders in
agroecosystem fertility whose knowledge would be desired by the conventional agricultural community, suggests that the process resulted in outcomes for members that increased their autonomy and inclusivity in the external system. When considered in conjunction with the findings of section 4.4., these insights highlight how a resilience lens enables analysis of transformative learning as a process that builds capacities to address change across multiple scales. In this instance, transformative learning builds capacities to manage change at the scale of the agroecosystem by challenging pre-existing assumptions on the dynamics of agroecosystem fertility, and also enables members to address change in the external system through processes that build inclusivity and autonomy in their relationships with their conventional peers.

During my engagements with TVOG the group reflected on whether it should change its name from Tamar Valley Organics Group to Tamar Valley Biological Group. The change in name was proposed as it more accurately reflected the group’s shift in learning from solely organic to biological farming systems. However, a number of members expressed concerns that changes to TVOG’s name would potentially act as a constraining factor on the group’s collective capacity to catalyse transformations in understanding and management of agroecosystem fertility amongst their peers. Changing TVOG’s name was feared to minimise the group’s capacities to attract new members, and to minimise the likelihood of gaining acceptance within the wider conventional farming community. Although organic systems accounted for only 3.2% of utilised agricultural land in the UK in 2014 (Defra, 2015c), the wide recognition of organic systems meant that actors could more easily establish what TVOG represented. Biological systems are, however, less well recognised and do not experience the same level of certification or recognition in the marketplace. The group therefore decided to incorporate both ‘organic’ and ‘biological’ into its name to ensure that its internal identity could still be reflected in an identity that the wider community would be more likely to understand and accept.

The analysis presented in this section identifies differentiated ambitions and perceived capacities to scale out their transformations in understanding and agroecosystem fertility to the wider social-ecological system. This section also establishes that members’ conventional peers’ understanding and acceptance of
their transformations marginalise capacities for similar transformations to permeate into the external social-ecological system. The remainder of this section analyses the activities that members believed enabled them to scale out their transformations in understanding and management of agroecosystem fertility. Members optimistically believed that hosting learning events provided them with a distinct opportunity to simultaneously share their understanding of agroecosystem fertility, and increase their acceptance within the conventional farming community.

...a lot of people are surprised and are coming away and thinking perhaps they aren’t such idiots, such idiots of the village. [Brian]

...there are people who come here and go away thinking, yeah, he must be doing something right. [David]

In section 4.3.1 I identify how processes of inter-group social learning contribute to capacities to manage agroecosystem fertility by enabling members to assess the efficacy of a system or practice in a situated and similar environment to that of their own agroecosystem. Members used the same processes to educate individuals unconnected to the group. For example, Will hosted a learning event that demonstrated the benefits of applying mycorrhizal fungi to seeds before they are sown. Will emphasised how surprised he had been that none of the near one hundred participants could demonstrate a strong understanding of the practices he was sharing. Will accepted that he could not be sure what influence the event would have on the event’s participants, but did believe that he had offered participants the opportunity to learn of mycorrhizal fungi through the same useful process that led to his adoption of the practice.

Adam hosted a soil carbon workshop in partnership with the Farm Carbon Cutting Toolkit5. The event convened speakers from academic, third sector, and commercial organisations who could inform and guide participants on best practice and the latest advances in understanding of the importance of soil carbon. The workshop was attended by around forty members of the farming community.

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5 Farm Carbon Cutting Toolkit (http://farmcarbontoolkit.org/) is a not for profit organisation that provides practical advice to farmers on how to reduce their carbon emissions.
community and took the format of presentations on soil carbon, discussions focused on innovative technologies that reduce disruption of soil carbon such as a sub-soiler that simultaneously sows seeds, and study of the quality of the farm’s soils. Adam believed that hosting events was unlikely to cause immediate change, but could stimulate processes of thought and discussion at individual and collective levels of the conventional community that may ultimately catalyse transformations in understanding and management of agroecosystem fertility in the external social-ecological system.

Members expressed distinct belief that their conversions had benefits way beyond the scale of their farms and the learning events that contributed to change amongst their conventional peers. This belief was most evident in members’ reflections on their perceived capacities to address and minimise the impacts of climate change. Climate change is identified as a highly uncertain external force of change in section 6.4. Capacities to address climate change were pursued through agroecological practices that were understood to sequester greenhouse gases and thereby reduce the impacts of climate change. Although members understood that they could make only small contributions, the optimism and belief expressed towards these capacities was striking.

During the participatory scenario planning workshop members buoyantly presented a scenario in which revenues from a proposed tax on large properties would be reinvested into subsidies that incentivised carbon sequestrating land management practices. Furthermore, land valuation would change from a value based on subsidies and inheritance tax, to a value based on capacity to sequester carbon. The innovative practices of mob grazing and herbal leys that I analyse in chapter five were believed to sequestrate nitrogen and carbon dioxide from the atmosphere and thereby contribute to a net reduction in greenhouse gases emitted from members’ agroecosystems.

...because we’ve got higher organic matter we’re capturing carbon so hopefully we’ll be able to reduce the amount of carbon going into the atmosphere by having this particular system. So it’s thinking downstream of what’s happening here. [Brian]
Members also understood that their efforts to address climate change had cross-scale implications for their acceptance within the wider conventional farming community.

...because we're aware of increasing soil carbon we'll probably be seen to be leaders rather than followers. It'll probably become the norm rather than being seen to be eccentric. Not being idiots in the village anymore and it will become just the norm. [Brian]

Members’ belief in their latent capacity for leadership illuminates a distinct sense of confidence and aspiration that their roles in their systems would change from ones of proximal and marginalised actors, to critical agents of change. This informal form of recognition of the changes made by members to their farming systems was complemented by a belief that linking their carbon sequestrating practices to global carbon markets would result in formalised recognition of their activities. My engagements with the group occurred at a time when members were exploring means of reliably quantifying any carbon sequestration in their agroecosystems. Soilgener8ion, a limited company, was created to act as an institutional vehicle through which TVOG members hoped they could trade their sequestered carbon with local organisations that sought to offset their carbon emissions. The income derived through Soilgener8ion would only be small yet it would represent formal recognition that the group’s conversions to organically certified farmland have benefits far wider than the increased capacities to manage agroecosystem fertility on their farms. Members’ desire to link their activities to carbon markets presents two further insights of interest. A desire to generate income from carbon sequestrating agroecological practices substantiates my claims in section 6.4, in which I identify the importance of diversity to building capacities to manage change. Furthermore, the desire to link to carbon markets, which are commonly volatile and uncertain (The World Bank, 2015), represents an active and wilful ambition by members to connect to other uncertain forces of external change.

In summary, this section identifies distinct ambition and perceived capacity to address external forces of change. The cross-scale nature of these capacities is manifest in members’ desires to stimulate transformations in understanding and
management of agroecosystem fertility in the external social-ecological system through more proximal transformations amongst their conventional peers, and desires to link agroecological practices to formal global carbon markets. Capacities to address change in the external system are constrained by members’ peers’ low levels of understanding and acceptance of the group’s transformations in understanding and management of agroecosystem fertility, and by perceptions of niche identity. The section also analyses the complex nature of transformations by identifying individual differences in ambitions and capacities to address external forces of change.

6.6 Summary

The introduction to this chapter illuminates how a resilience understanding of capacity for transformations is notably lacking at the scale of the individual and collective. The empirical data presented in this chapter addresses this considerable gap by examining how individual and collective capacities for transformation relate to change in the external social-ecological system. The chapter illuminates how trigger events, driven by disempowering external forces of change, catalyse decisions to shift away from conventional farming systems. Individuals experience different and common trigger events at different rates and at different times. These trigger events manifest across different temporal and spatial scales; some are fast and abrupt, whilst others are slower and incremental. It is the cumulative effects of these fast and slow trigger events that drive decisions to shift from conventional farming systems.

Transformations in understanding and management of agroecosystem fertility are not linear processes of change. A decision to shift from conventional systems does not automatically lead to a decision to convert to an organic farming system. Decisions to convert farmland to organic status compete with other viable alternative options. Windows of opportunity, enabled by the Common Agricultural Policy’s organic conversion subsidies, enhance capacities for transformation in understanding and management of agroecosystem fertility by financially incentivising decisions to convert farmland to organic status. Transformations in understanding and management of agroecosystem fertility result in a shift in how individuals connect and relate to change in the external system. Volatility of
change in the external system is identified as a major threat to capacities to manage change at the scale of the agroecosystem. Optimism, confidence and belief play core determining roles in capacities to adapt to volatile external forces of change. Diversity builds adaptive capacity as it presents individuals with multiple viable options in response to change in the external system.

This chapter makes a key contribution to resilience literature by illuminating how individuals aspire to pursue the alternative visions for the future that lie at the heart of transformational change. Individuals express different levels of ambition and capacity to catalyse transformations in understanding and management of agroecosystem fertility across scales. The chapter identifies desire for informal and formal recognition that the processes of self-organisation, social learning and innovative practices, identified in chapters four and five respectively, offer benefits across much wider scales than that of members’ agroecosystems. Capacities to stimulate transformational change in the external social-ecological system are, however, constrained by limited and marginalising levels of understanding and acceptance of members’ transformations in understanding and management of agroecosystem fertility. The following chapter synthesises the findings of this chapter in conjunction with the findings of chapters four and five.
7 Multiple dimensions of capacity for transformation

Transformation extends past conservative notions of adaptive change to consider how alternative, more radical forms of change can be pursued (O’Brien, 2012). This thesis contributes to an understanding of transformation by conducting an exploratory analysis of the key resilience characteristics of transformations in social-ecological systems. The three preceding empirical chapters address this aim by analysing empirical data on transformations at different scales. Chapter four analyses processes of self-organisation and social learning across the scales of the individual, collective, and international shadow networks. Chapter five analyses the role of innovation in building capacity to manage change at the scale of the agroecosystem. Chapter six analyses change across and between the scale of the individual and the external system. Viewed as a sum, the empirical chapters present an account of transformation that goes beyond the typical focus of resilience studies on the implications of change for the wider social-ecological system.

The action research practice and analytical resilience methodology applied in this thesis enabled the research questions to act as the launch pad for an exploratory process of research into the distinct resilience characteristics of transformations in social-ecological systems. The rich narratives from reflective interviews, analysis of individual mental models, and deliberation from the participatory scenario planning workshop, provided me with multiple windows into different dimensions of transformations. This chapter begins by presenting a summary of how the preceding empirical chapters have addressed the key research questions. The chapter then advances by analysing and synthesising the critical findings that emerge from analysis of empirical data in chapters four, five and six. The chapter also provides critical reflections on the extent to which the process of analytical resilience addresses the action research quality choice points of participation and partnership, actionability, and significance. Critical reflections analyse how this thesis operationalises and contributes to our conceptual understanding of innovation, resilience, transformation, and the relationship between them. The chapter ends by concluding on the critical insights presented in this thesis.
7.1 Summary of main findings

This section presents the critical findings from chapters four, five and six that address the four key research questions.

**What roles do key individuals play in building capacity for transformation?**

In addressing the first research question, the thesis analyses how key individuals contribute to capacities for transformation in understanding and management of agroecosystem fertility through processes of self-organisation and social learning across different temporal and spatial scales. Facilitators build capacities for transformation by developing a unifying vision and goals for learning; create structure and process for learning activities; integrate scientific and experiential knowledge; seize on specific moments for learning to cause abrupt shifts in understanding; and, present the group with access to a wide network of other key individuals. A sub-group of key individuals within TVOG’s membership inspire, motivate, build confidence and challenge assumptions of the wider group. Shadow networks of pioneer key individuals, situated across local to international scales, build capacities by contributing international agroecological knowledge that introduces alternative perspectives and ideas on the dynamics of agroecosystem fertility. Individual capacities for transformation in understanding and management of agroecosystem fertility are not built by the same key individuals, at the same time, in the same space. That is, each member’s capacity for transformation in understanding and management of agroecosystem fertility involves combinations of contributions from the same and different key individuals over different temporal scales. It is the cumulative effects of these differentiated interactions that build individual capacities for transformation.

**Are feedbacks recognised across the temporal and spatial scales of a social-ecological system?**

In addressing the second research question, this thesis identifies twenty-nine feedback loops in causal link diagrams of seven members’ mental models. I identify distinct differences in the number of feedback loops identified between Brian, the group’s facilitator, and the remaining six members, all of whom are
farmers. This observation draws similarities with literature that analyses differences between expert and non-expert mental models, in which experts demonstrate higher levels of scientific and theoretical understanding of concepts in comparison to non-experts. All identified feedback loops are comprised entirely of environmental concepts, and all contain interventions enacted at the scale of the agroecosystem. This observation can be explained by three key insights. Firstly, members’ advanced knowledge and daily management of agroecosystems means they are more likely to identify environmental feedback loops than those that contain a mix of environmental and social concepts, or those that are totally comprised of social concepts. Secondly, members express a situated capacity to manage feedbacks through practices and interventions at the scale of their agroecosystems. Thirdly, the process of eliciting mental models, including the location and focus of questions on grazing systems and agroecosystem fertility, may have increased the likelihood of eliciting feedback loops containing only environmental concepts.

Can we identify social-ecological innovation?

The thesis identifies signals of social-ecological innovation. Mob grazing identifies as a social-ecological innovation due to two key observations. Firstly, mob grazing identifies as an innovative practice as it counters mainstream understanding of how to manage agroecosystem fertility. Secondly, mob grazing directly influences components and processes in feedback loops with effects across social and ecological domains in causal loop diagrams of two members’ mental models. Mob grazing is adopted for different purposes, and at differing scales, within TVOG’s membership. The limited adoption of mob grazing within TVOG illuminates concerns around the efficacy and risk of social-ecological innovation. Social-ecological innovation threatens desires for stability despite the large scale shifts to organically certified farmland previously undertaken by members. This contradictory observation is reflected on in greater depth in section 7.4.
How do individuals understand their capacities to shape change in external systems?

Transformations in understanding and management of agroecosystem fertility result in a shift in how individuals connect and relate to change in the external system. The external system simultaneously enables and constrains capacities for change across different temporal and special scales. Volatility of change in the external system is identified as a major threat to capacities to manage change at the scale of the agroecosystem. Optimism, confidence and belief play core determining roles in capacities to adapt to volatile external forces of change. Diversity builds capacities to manage change as it presents individuals with multiple viable options in response to change in the external system. Individuals express different levels of aspiration and capacity to contribute to change that manifests across scales, and across social and ecological domains. The chapter identifies desire for informal and formal recognition that the processes of self-organisation, social learning and innovative practices, as identified in chapters four and five respectively, offer benefits across much wider scales than those of members’ agroecosystems. Capacities to address change in the external system are, however, constrained by limited and marginalising levels of understanding and acceptance of members’ activities. Frustrations at limited capacities to shape change in the external system are contradictorily countered by conscious decisions to actively disconnect from external forces. This contradiction is analysed in greater depth in section 7.4.

As noted throughout this thesis, the four research questions that guide this thesis acted as a launch pad for a wider exploratory process of research. The following sections move beyond the research questions to synthesise critical findings that inform the resilience understanding of transformations in social-ecological systems.
7.2 Identifying transformations

Transformations involve fundamental shifts from one state, function, form or location to another (Brown et al., 2013; Marshall et al., 2012; Nelson et al., 2007; Olsson et al., 2014). Throughout this thesis I have been particularly cautious of what change identifies and analyses as transformation. The targeted approach is informed by two key observations that emerge from the review of literature presented in chapter two; firstly, interpretations of what is transformed, and whether a transformation has even occurred at all, are commonly vague and ambiguous (Brown et al., 2013); and, secondly, identifying transformational change is “dependent on being explicit about scale.” (Marshall et al., 2012: 034022). Chapter four identifies two specific transformations. Transformation is identified as a fundamental shift in understanding of agroecosystem fertility. This finding draws an accord with Pelling (2011), who suggests that transformations involve shifts in perceptions and understanding of the world in one or a number of people. Transformation is additionally identified as a fundamental shift in management of agroecosystem fertility. This thesis illuminates the intertwined and reciprocal nature of the two identified transformations. For example, section 4.4 analyses how transformations in understanding are demonstrated through profound shifts from chemical to biological conceptualisation of flows of resources necessary for fertility. Fertility in conventional farming systems was understood as flows of nitrogen, phosphorous and potash that were managed through application of externally sourced chemical inputs. The soil was perceived as a medium to grow crops in, with little endogenous fertility building capacity. Soil biology, soil carbon and soil organic matter were unrecognised or poorly understood in conventional farming systems, but were subsequently recognised as the keystones of fertility in organic farming systems.

The identification of intertwined transformations in understanding and management of agroecosystem fertility illustrates how transformations are enmeshed within much broader and dynamic processes of change across multiple scales. However, the fundamental shifts in understanding and management of agroecosystem fertility are not the only profound change that could be construed as transformation. Chapter four analyses processes of self-organisation that lead to social learning around agroecosystem fertility. The shifts
from independent to collective forms of organisation, and shifts from individual learning to social learning, raise questions about the extent to which the formation of TVOG could be interpreted as a transformation in its own right. However, when considered in conjunction with the identified and analysed transformations in understanding and management of agroecosystem fertility, I interpret the formation of TVOG as a manifestation of capacity for transformation. The process of self-organisation that leads to the formation of TVOG enables and builds capacity for the transformations in understanding and management of agroecosystem fertility. The formation of TVOG is one part of a much wider and linked process of change that manifests across multiple scales and multiple domains. These cross-scale issues represent a key contribution of this thesis, and are analysed further in my synthesis of social-ecological innovation in the following section.

7.3 Social-ecological innovation, risk, and stability

As I identify in chapter two, social-ecological innovation focuses analysis on the social and ecological dynamics of potentially transformative innovations (Olsson and Galaz, 2013; Pereira et al., 2015). This thesis contributes to an understanding of social-ecological innovation through empirical analysis of the innovative practice of mob grazing. In section 5.3 I identify mob grazing as social-ecological innovation due to its innovative nature, and its capacity to influence the behaviour of feedback loops that have effects across social and ecological domains. These findings suggest signals of social-ecological innovation. However, the processes of social learning and individual experimentation analysed in chapters four and five in which mob grazing is tested and deliberated are more akin to those of adaptive management. For example, adaptive management is enacted through a learning by doing approach (Walters and Holling, 1990), as demonstrated by members’ reflections on the learning around, and continual adaptation of, mob grazing as a tool to manage dynamic change in agroecosystems.

Adaptive management involves processes of social learning that provide individuals and groups with a safe space in which they can test and experiment with novel options without threatening desired trajectories of change (Béné et al.
The safe space is mirrored by the collaborative and supportive culture of TVOG’s learning, and differing scales of implementation of the practice on individual members’ farms. Members who implement mob grazing identify the practice as a tool that enables them to pursue their ambitions and goals for their farms. The reflections of members who do not implement mob grazing do, however, present some interesting insights into cross-scale dimensions of risk and stability. The latter group identifies mob grazing as a threat to the stability that they desired, following their conversions of farmland from conventional to organic status. Viewed through a resilience lens, the conversions represent shifts to a new basin of attraction, and a new set of conditions that represent the stability domain (Folke, 2006; Walker et al., 2004). Mob grazing embodies a distinct risk to capacities to establish and act within the new stability domain. Other practices are prioritised over mob grazing as they are perceived to enhance capacities to actively manage change within the desired stability domain (Gunderson, 1999). The desire to establish stability is equally evident in the dependence some members placed in advisory services from tied agribusiness consultants. At a superficial level, members’ desire for stability seemingly runs counter to the giant leap into the dark caused by the conversion of farmland from conventional to organic status. However, when analysed in conjunction with the multiple accounts of transformation presented in this thesis, it becomes apparent that the contradictory statements are explained by dynamic interplay between small and large changes across different scales. In this context, members express the dynamic interplay between persistence, adaptation and transformation through articulations of stability. It is to the critical theme of cross-scale interplay that the remainder of this thesis now turns.

7.4 Capacity and cross-scale interplay

The analysis presented in this thesis identifies a broad array of the characteristics of capacities to manage change at different scales. Characteristics of adaptive capacities identified across the empirical chapters include enhancing social-ecological memory, dealing with uncertainty, responding to and managing feedbacks, and combining experimental and experiential knowledge (Fazey et al., 2006; Folke et al., 2003 and 2005). Capacity for transformation is characterised by a preparedness to contribute to building social networks and
social capital, leadership, proactivity, creating new visions and goals, and a sense of unity that acknowledges and accepts differing perceptions (Apgar 2015; Wilson et al., 2013). These characteristics ally with members’ desire to build and contribute to agroecological knowledge networks, the facilitative role of Brian in creating a shared vision for learning, and the sense of solidarity within the group that allowed members to share different and at times conflicting perceptions of change. Capacity for transformation can also be qualified by the extent to which capacities address underlying causes of vulnerability (Béné et al., 2015). In this context, the processes of self-organisation and social learning analysed in chapter four address uncertainties in understanding of agroecosystem fertility identified in section 4.2, and profound individual vulnerability to external forces of change identified in section 6.2. However, processes of self-organisation and social learning more commonly identify as characteristics of adaptive capacities (Folke et al., 2005; Reed et al., 2010). Furthermore, and as identified in chapter four, the roles of key individuals in building capacity for transformation do not distinctly differ from those roles associated with contributing to adaptive capacities. These findings lead me to agree with Marshall et al. (2012), who assert that attempting to draw a line between characteristics of adaptive and transformative capacities is a rather arbitrary pursuit. This thesis informs an understanding of capacities and transformation in a much more nuanced and sophisticated way than any delineation might reflect.

The findings presented so far in this thesis provide partial insights into transformation and its associated capacities, but do not illuminate the whole. Synthesis of the partial insights elaborates an understanding of transformation as a complex set of changes characterised by dynamic cross-scale interplay. Such a conceptualisation of transformation draws parallels with Bergström and Dekker’s (2015) framing of resilience as fractal, and existing across and between multiple scales. By embracing an understanding of cross-scale interplay, this thesis identifies that transformations in understanding and management of agroecosystem fertility involve a complex and dynamic set of interrelated changes. Panarchy suggests that the resilience of a social-ecological system is influenced by interplay across and between dynamics of change at scales above and below the focal scale (Holling et al., 2002; Walker et al., 2004). Transformations at smaller scales draw on resilience at larger scales (Folke et
For example, cross-scale interplay is particularly manifest across and between individual and collective scales. In section 4.3 I identify how individual uncertainty in understanding of agroecosystem fertility catalyses collective processes of self-organisation and social learning. Social learning is characterised by interplay between inter-group learning, and learning across wider shadow networks of pioneer key individuals who contribute new ideas and build the knowledge of members. Transformative learning presents an additional lens that highlights the interrelated nature of changes across scales, in this instance the challenging of assumptions on the dynamics of agroecosystem fertility, and increased autonomy and inclusivity in the external system. It is the capacity for self-organisation and social learning at collective scales that builds capacity for the transformations in individual understanding and management of agroecosystem fertility.

Section 6.2 analyses how individual decisions to convert from conventional farming systems are driven by the effects of external forces of change such as the yield maximising approach, volatile prices of fertilisers and prices received for products, animal disease events, and tied advisory services. A resilience interpretation of the effects of the external forces suggests that members are forced into rigidity traps (Carpenter and Brock, 2008). Members slow their continued progression into the trap through incremental adjustments to their practices, yet the external system constrains capacities to pursue effective and desirable outcomes. Individual feelings of frustration and disempowerment accord with the untenable and undesirable states that characterise transformations (Brown et al., 2013; Marshall et al., 2012; Nelson et al., 2007; Olsson et al., 2014). The cross-scale lens on transformation illuminates a seemingly contradictory process of change in which the external system acts as both a constraint and an enabler of capacities for transformation in understanding and management of agroecosystem fertility. Windows of opportunity such as Common Agricultural Policy organic conversion subsidies and the unexpected availability of organic farmland provide members with the financial buffers they require to break their connections to the disempowering external forces of change. It is through transformations in understanding and management of agroecosystem fertility that members escape their rigidity traps.
My analysis of cross-scale interplay has so far illustrated how change in the external system catalyses and facilitates transformations in understanding and management of agroecosystem fertility. These transformations, and the associated changes in capacity, contribute to resilience at the scale of the farm. Panarchy suggests that transformations at smaller scales cascade upwards to influence resilience at larger scales (Holling et al., 2002). Applying this cross-scale lens to the analysis presented in the empirical chapters suggests that individuals express an understanding and belief that their actions build resilience at larger scales of the social-ecological system. Chapter six analyses how members express clear confidence in their capacities to either disconnect from, or adapt to, the effects of different external forces of change. For example, members no longer relied on chemical fertilisers and their associated advice for fertility in their agroecosystems. In other instances, members were still subject to volatile changes in, and lack of control over, the prices they received for their products, yet felt confident that their transformations in understanding and management of agroecosystem fertility enhanced their capacities to adapt to the change. The desire to disconnect from drivers of change is, however, seemingly contradicted by members’ desire and belief in their capacities to change the external system and thereby build its resilience. In 6.4 I identify a sense of self-efficacy whereby members felt that whilst their actions may not have a substantial impact on external forces of change, they still contributed towards a much greater sense of change in the external system. For example, section 6.5 analyses how individual capacities to address the yield maximising approach are enacted through education and relationships with their conventional peers. I also analyse how perceived capacities to minimise the impacts of climate change are enacted through innovative practices such as herbal leys and mob grazing that are understood to sequestrate greenhouse gases. These examples illustrate how transformations at smaller scales build the resilience of the external system through interrelated changes in different capacities at different scales.

In summary, this thesis contributes to the resilience understanding of transformation by illuminating dynamic interplay across and between the scales of the individual to the external system. Transformations are shaped by and contribute to resilience across the scales of the individual, collective and wider system. By embracing the presence of cross-scale interplay, future studies of
transformations will be better equipped to understand how transformations relate to resilience at the specific focal scale of interest.

7.5 Reflections on action research practice

I have been fortunate to experience both moments of inspiration and difficulty in many different measures throughout the three years of research that supports this thesis. The action research practice, analytical resilience methodology, and research activities applied in this study are a key contributing factor to these experiences. This section reflects on the extent to which this thesis identifies as an action research project. My concern is one of quality, and I therefore address the action research choice points for quality (Bradbury Huang, 2010) that are most relevant to this thesis.

I begin this section by critically evaluating the extent to which this research project was able to address the choice point of participation. Participation relates to the extent to which participants are able to shape and analyse the research activities that comprise an action research project (Bradbury Huang, 2010). In chapter three I illuminate how the research process that guides this thesis was adapted to fit the practical needs and interests of participants. By engaging with members as an outsider to the group (McArdle, 2008), I was not initially fully aware of the group’s needs and concerns towards the research. The processes of relationship-building that preceded the formal research activities allowed me to identify that my initial plans to use the learning histories process would place too much constraint on participating members’ available resources, and did not connect to their desires for my research. I therefore decided to include only the reflective interviews aspect of the learning histories process. The outcome of this decision meant that members’ capacities to participate fully in the process of research were significantly constrained. For example, members did not act as co-researchers, nor was a learning history narrative developed and used to reflect on and embed the learning that occurred through members’ interactions with TVOG. The adaptive and iterative nature of this process of research ensured that alternative methods such as the mental models interviews and participatory scenario planning workshop could be used to triangulate and validate findings, and equally increase opportunities for co-construction and participation.
However, by not sufficiently addressing the action research quality choice point of participation to the extent that I had first hoped, it is necessary for me to critically question the extent to which this thesis continues to be identified as a process of action research. I address this concern by analysing this thesis against Bradbury Huang’s (2010) quality choice points of actionability and significance.

To recap, actionability is the “extent to which the project provides new ideas that guide action in response to need”, and significance is “The extent to which the insights in the manuscript are significant in content and process. By significant we mean having meaning and relevance beyond their immediate context in support of the flourishing of persons, communities, and the wider ecology.” (Bradbury Huang, 2010: 98). In section 3.4 I identify that my role as a social scientist, coupled with constraints on time and resources on this study, meant that I could not easily contribute to the improvements in agroecological practice that members desired. Furthermore, I arrived as an outsider with my own set of theoretical and practical ambitions for the study. These different challenges left me wondering how exactly this process of research might address issues of actionability and significance.

As identified in chapter three, members’ initial concerns for this research related to their desires for their individual and collective experiences to be shared more widely within the farming community. See sections 6.4 and 7.4 for analytical discussion of members’ perceived capacities to pursue this particular desire. This was a particularly challenging concern to connect to. The process of research that guides this thesis is inward facing, working only with members of TVOG, yet members’ concerns reflected a desire to be outward facing. However, I understood that my role as a researcher, and preceding experiences within the agricultural community, provided me with access to resources, skills and relationships that could address these concerns and thereby contribute to significance and actionability of this process of research. However, these capacities relate to my engagements with TVOG more broadly, and go beyond the actionability and significance of the research activities or resilience lens applied in this thesis. Following my attendance of the Oxford Real Farming Conference with members of TVOG in January 2014, Adam and Brian asked me to write articles for the Cornish and Devon Post newspaper, and South West
Farmer magazine. The articles publicised the group’s belief in the benefits of attending the conference, and the extent to which they believed other members of the wider farming community could benefit from participating in the conference. Adam and Brian were unlikely to be able to write the articles due to their own pressures on time and resources. My ability to build the group’s capacities to share their stories more widely was also reflected in the group’s participation in the filming of a movie titled ‘Soil Carbon Cowboys 2’ that aimed to explore farmer experiences with mob grazing systems. Peter Byck, the director and producer of the film, and Professor of Practice at Arizona State University, learned of my engagements with TVOG and contacted me to see if any of the group would be interested in participating in the movie. Adam and Charlie participated in filming during August 2014. The film is expected to be released within the next year.

The examples of newspaper articles and filming illustrate how this research addresses issues of actionability and significance through third person reflection around TVOG’s experiences. As identified in section 6.5, members of TVOG expressed a strong desire to quantify the extent to which their practices sequestrated greenhouse gases, and thereby gained formal recognition for the processes of change they had undertaken. Whilst this was not a task I could lead, I understood that I could act as an agent of change for the group by advocating their desires to quantify their impacts on greenhouse gases with particular individuals within my own institution who held the knowledge and resources necessary to conduct the research. An individual within the University of Exeter’s Research and Knowledge Transfer team was aware of the group’s practices and established a project between Charlie and a member of faculty. The project, still ongoing at the time of submitting this thesis, aims to measure the flux of greenhouses gases on areas of pasture that have been subject to different grazing practices. My role was one of advocate; I do not take responsibility for creating the project but believe my interactions within my institution provided information and catalysed the research project.

The examples provided so far illuminate how I addressed issues of significance and actionability through small contributions that extended beyond the boundaries of specific research activities. However, it is also important to reflect critically on the extent to which the research activities and resilience, as an
analytical lens, addressed the choice points of significance and actionability. My initial engagements with TVOG coincided with a difficult economic environment for the group that resulted in a reduction in available funding for new learning events from previously reliable sources such as the Duchy College. Adam and Brian were particularly keen for me to publish my contributions to an understanding of resilience and transformation in peer reviewed journals. Publication of findings is particularly important as the papers can be used to substantiate future grant bids that will support the group’s activities. This is one ambition that I aim to fulfil shortly.

Charlie informed me that the research process, and the participatory scenario planning workshop in particular, acted as a catalyst for raising questions and issues that addressed uncertain individual and collective concerns. For example, issues of intergenerational succession and capacities to build stability by collaborating and connecting to consumer preferences were brought to the fore through discussion of notions of uncertainty in the external system. These issues are not commonly discussed during TVOG learning events. The temporal nature of the process of research means that this thesis cannot track the extent to which using resilience as an analytical lens leads to concrete action in the future. However, Charlie’s reflections suggest that the deliberation around resilience concepts can have immediate impacts that may contribute to larger processes of change at later dates.

A number of members recounted how previous engagements with survey-based research left them feeling as though they could not express their true concerns and experiences. In contrast, the same group of members reflected on how the narrative nature of reflective interviews, and freedom to select the location for all interviews, enabled them to communicate their experiences in ways that were much more relevant to them. These observations accord with Glandon (2015), whose role as a resilience practitioner leads him to suggest that narratives have an increased level of meaning for participants when they construct resilience in their own terms. The level of meaning and freedom enabled by narratives is also understood to elicit a broader understanding of resilience characteristics than particular methodologies or analytical lenses may afford.
Brian was more pragmatic in his reflections and viewed the research process as a particularly useful vehicle for maintaining group cohesion during a time when funding for learning activities was minimal.

Thanks for your support over the last couple of years, it helped to keep TVOG(+B) strong despite not having any funding available to it! [Brian]

The feedback was gratifying on a personal level as I had developed strong relationships with members throughout the course of the research process. Furthermore, Brian’s comments can be interpreted in a way that suggests resilience ideas and concepts embedded in action research practice can build capacities to manage change by contributing to group cohesiveness across current and future temporal scales.

In summary, this thesis provides a critical account of the challenges and limitations of applying action research practice to resilience analysis. The flexible yet systematic research process identifies as action research as it addresses concerns specifically relating to actionability and significance of research. In sections 6.4, 6.5 and 7.4 I analyse how participating members express a desire and capacity to address external forces of change, and contribute to a much wider sense of change in the external system. The theme of cross-scale interplay that characterises and influences members’ capacities is manifest equally in the actionability and significance of this thesis. The examples presented in this section illustrate how members were able to use this process of research to share their experiences and beliefs more widely, and thereby go beyond the inwards facing research activities to contribute to change in the external system. Resilience ideas and concepts enabled members to deliberate over concerns that were of significance to their future oriented capacities to manage change. The cross-scale nature of the significance and actionability of this process of research can, therefore, be understood as contributing to resilience at the scales of the individual, collective and wider system.
7.6 Critical reflections on innovation, resilience, and transformation

The resilience lens applied in this thesis analyses innovation at the scale of the agroecosystem. I address innovation in general terms, through the lens of social-ecological innovation, and through discussion of adaptive management. These multiple dimensions of innovation highlight the centrality of innovation and novelty to the resilience understanding of transformation in social-ecological systems. Social-ecological innovation is operationalised by analysing causal link diagrams of individual mental models for innovations that influence the behaviour of feedback loops with effects across social and ecological domains. The cognitive lens and associated process of converting mental models into causal-link diagrams represents a novel and rigorous means of analysing social-ecological feedback loops and social-ecological innovation. However, as I identify in section 5.3.2, the process used to convert mental models concepts and functional linkages into causal-link diagrams meant that members’ implicit thinking was not adequately reflected in the causal-link diagrams. I therefore annotated my interpretation of members’ implicit thinking by using dotted lines in Figures 5.11 and 5.12. In both instances the dotted lines relate to the effects of identified feedback loops on social components of the constructed social-ecological systems.

By employing an approach that addresses cognitive and implicit dimensions of members’ thinking this thesis presents a more holistic understanding of how social-ecological innovation and social-ecological feedbacks can be analysed and understood. However, the approach employed in this thesis also highlights the difficulty of interpreting social-ecological innovation as a concept that integrates social-ecological feedback loops at its core. Without the inclusion of members’ implicit thinking, mob grazing may not identify as social-ecological innovation as it would only enhance capacities to influence feedback effects across ecological domains. Yet, in spite of these limitations and the multiple interpretations of social-ecological innovation presented in section 2.3.4, understanding social-ecological innovation through the lens of social-ecological feedbacks provides resilience scholars with an alternative lens to analyse how individuals understand their capacities to manage change across scales.
This thesis makes an additional contribution to the emergent understanding of social-ecological innovation by suggesting social-ecological innovations may not in themselves be transformative. Mob grazing, the example of social-ecological innovation analysed in this thesis, is adopted after members’ transformations in understanding and management of agroecosystem fertility. Whilst social-ecological innovation enhances capacities to address feedback effects across social and ecological domains, these changes are not in themselves transformational. Instead, social-ecological innovation is one component of a process of changes in capacity within which transformations are situated.

The multi-scalar, action research approach adopted in this thesis has enabled me to develop a rich and nuanced understanding of how resilience concepts can be used to understand and develop capacity across and between scales. This thesis elaborates an understanding of resilience as a deeply personal journey that develops with associated narratives of change. Members’ reflections from reflective interviews and the participatory scenario planning workshop give insight into emotional and human dimensions of change such as bereavement, confidence, efficacy, optimism, and marginalisation. Factors such as these are commonly absent in resilience studies yet their influence on how resilience is understood, and changes, are distinct. The emergent approach applied in this thesis gives agency to key protagonists and antagonists in a social-ecological system, and elicits a rich understanding of how key resilience concepts manifest across scales, such as how protagonists and antagonists relate to uncertainty and surprise in a wider social-ecological system. The grounded approach applied in this thesis enables a less deterministic understanding of resilience across scales; that is, rather than pre-determining the resilience concepts of interest to the study, participants are able to reflect on resilience concepts that have meaning and relevance to their lives.

The importance of meaning and relevance of resilience concepts was equally evident in my analysis of transformation. In section 7.4 I consider how processes of social learning could be interpreted as transformation, yet argue that they are instead one element of a dynamic process characterised by cross-scale interplay within which transformations in understanding and management of agroecosystem fertility are enmeshed. Interpreting transformation as profound
shifts in understanding and management of agroecosystem relied on an understanding of transformation as profound change from one state, function, form or location to another (Brown et al., 2013; Brown, 2014; Marshall et al., 2012; Nelson et al., 2007; Olsson et al., 2014). However, the highly interpretive nature of transformation meant that analysis involved the application and testing of different resilience concepts that had relevance to members’ experiences. For example, transformation is understood as a process involving the crossing of critical thresholds when a social-ecological system’s current state is no longer viable (Béné et al., 2013; Folke et al., 2010). However, I experienced difficulty in identifying precisely what constitutes the crossing of a threshold at the scale of the individual. In section 6.2 I analyse how members of TVOG shifted from conventional to organically certified systems due to the untenable nature of the external social-ecological system. During reflective interviews and the participatory scenario planning workshop members of TVOG expressed belief that should their future as organic farmers become unfeasible then they would consider returning to conventional grazing with the benefit of what they had learned and experienced throughout the processes that built capacity for their transformations in understanding and management of agroecosystem fertility. These reflections offer a critical insight into what is understood as transformation. Even if the shift from conventional to organic farming systems could be reversed, members could employ their enhanced understanding of soil fertility and associated practices within a conventional approach. The profound shift in understanding of agroecosystem fertility therefore identifies as the most critical of the transformations analysed in this thesis.

In summary, this thesis informs future processes of analytical resilience as it highlights the highly interpretive nature of transformation, and challenges involved in applying resilience concepts to processes of individual and collective change. This thesis suggests that a more nuanced and considered form of analytical resilience can have meaning and relevance for research and participants. The engaged form of analytical resilience applied in this thesis presents an understanding of resilience as an ongoing, continual narrative of shifts in capacity to address changes at particular scales. Transformation and social-ecological innovation are interrelated but not interdependent, yet both
contribute to individual and collective capacities to pursue a desirable narrative of resilience.

7.7 Conclusions

Conventional agriculture is a major driving force of global environmental change (Bennet et al., 2015; Rockström et al., 2009). There are calls for agriculture’s current pathway to be transformed across scales (Bennet et al. 2015; Jiggins 2014), yet understanding of transformation lacks empirical evidence and analytical rigour across scales. This thesis addresses this gap by applying a resilience lens to investigate the conversion of farmland from conventional to organic status as transformations in social-ecological systems.

This thesis presents a multi-layered narrative account of change in which different capacities change in particular ways, at different scales, over different periods of time. It is through processes of self-organisation and social learning, facilitated and shaped by interactions with key individuals across different temporal and spatial scales, that individuals build capacities for transformation in understanding and management of agroecosystem fertility. By being specific about the scale at which transformations occur, this thesis has attempted to disentangle the much broader processes of change in capacities within which transformations in understanding and management of agroecosystem fertility are enmeshed. Innovation contributes to capacities to manage change at specific scales yet equally presents risk to desires for stability. These dynamic and interrelated changes illustrate the complex nature of transformations in social-ecological systems.

My experience with action research practice has enabled me to understand that research can have significance and outcomes for participants that extend beyond the neatly defined boundaries of research activities. Critically, however, by bringing elements of action research practice into resilience analysis I have been able to facilitate the adaptive and grounded process of research necessary to explore the subtleties inherent in transformations. Transformations are not just one stepwise or linear process of change; they are fragmented and messy, and comprise of multiple, interrelated changes. It is the way in which these changes
work with each other, or more specifically their cross-scale interplay, that provide a more informed understanding of the multi-dimensional nature of transformations in social-ecological systems.
Appendix 1 – Reflective interview protocol

1. Context and Purpose of Research

Thank you for offering your time to this research. I’d like to begin by recapping on the context and purpose of this research. My research is exploring how groups of land managers innovate together in response to environmental change. I am particularly interested in the practice of mob grazing and the people that have implemented it on their farms.

The first stage of my research will involve a number of individual interviews and group workshops which will be used to develop a ‘learning history’. The learning history is a document that reflects participants individual and shared experiences related to mob grazing. It recounts the experiences in a narrative form – it is written for and about the research participants. The document can be used as a means for participants to reflect on their own experiences, the group’s shared experiences and as a tool to support future activities. Secondly, and only with your permission, the document can be shared with external parties to act as a tool in their future learning and innovation.

During this interview we will create a timeline that charts your most significant experiences that relate to mob grazing. I will explain what I mean by ‘significant experiences’ in a moment. It’s important that you feel at ease to recount your own experiences of what has happened. Towards the end of the interview we will explore the social relationships that were significant to the experiences you talk about. We will use a matrix to help us explore who was involved, what their role was and how important they were to your experiences.

I hope this brief summary has given sufficient background to my research and what I hope we will do in the next couple of hours. Before we proceed to discussing your rights to confidentiality and anonymity do you have any questions?
Guarantees of confidentiality and anonymity

I’ll now run through your guarantees of confidentiality and anonymity and what they mean in practice. Please feel free to ask questions at any point.

- Before I advise you of guarantees of confidentiality and anonymity I need to let you know that everything you say during this interview is potentially usable in the learning history document.

- However, all quotes that I hope to use in the learning history will be validated with you before the learning history is published. You will have the opportunity to correct errors and amplify comments.

- Additionally, only quotes that you confirm are true and that can be published will be included in the learning history.

- You have a right to anonymity throughout the research. I will only use your name and attribute information from our discussions if you confirm you are happy for me to do so.

- The learning history will be shared first inside, then outside of the group of research participants. If you would prefer your identity to be made anonymous in either version then please let me know.

- I need to gain your permission to digitally audio record the interview. The recording provides more of a guarantee of accuracy in the learning history document. It also ensures you will be heard, speaking your own voice, in the document. Once the interview is complete I will transfer the audio recording to an encrypted computer at my university. I will then delete the recording from the digital recorder to ensure the only copy that exists is the encrypted one.

- To summarise, nothing from this interview will be repeated with your name attached, and nothing will be shown to anyone besides those on the
learning history team before you have a chance to approve it. The learning history team includes my three supervisors – Prof Katrina Brown, Prof Robbie McDonald and Dr Patricia Gaya. I am happy to supply their contact details.

If you are happy to proceed with the interview on the ground rules just covered could I please ask you to sign two copies of the form. One copy is for you to keep and the other copy is for me to keep in a secure, locked location at university.

Do you have any questions before we proceed with the interview activities?

Participant Information

I’d like to collect some personal information before we start the interview.

<table>
<thead>
<tr>
<th>Name</th>
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<tbody>
<tr>
<td>Year of birth</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>Interview site</td>
<td></td>
</tr>
</tbody>
</table>

Definition of Mob Grazing

I’d like to start by clarifying my understanding of mob grazing with you. I understand mob grazing to be the management of a grazing unit, grazed by a relatively large number of animals at a high stocking density for a short time period.

- To what extent does your understanding of mob grazing approximate with my definition?

Reflective Interview Introduction

I have produced a blank timeline [present timeline to participant] that we will use to guide us through the interview. As we discussed earlier, I want to explore your most significant experiences that relate to mob grazing. As I ask you questions I
will annotate the timeline with some of the key points and events from your interview. If you would find it useful to annotate the timeline instead of me or together with me then please feel free to do so. I have pre-prepared a few questions that I would like to ask you but expect the interview to feel more like a conversation than a formal interview.
Significant Experiences

Earlier I mentioned that I am interested in your experiences that relate to mob grazing. I would now like you to spend a couple of minutes to consider which of your experiences of mob grazing are most significant to you. By significant experience I mean any activity, event or outcome, anywhere, with anyone, that you were personally involved in:

- that reveals critical aspects or lessons from your experiences of mob grazing.
- that was out of the ordinary or much different than what would have typically occurred.

I’ve printed off the definition for you so that you are able to refer to it throughout the interview.

[Place significant experience document on table]

Would you like a couple of minutes to think about your most significant experiences that relate to your grazing system? The experiences need not be restricted to on-farm experiences - they can be anywhere, with anyone doing anything.

Now that you have considered the most significant experiences, can you start by telling me which one really springs to mind?

[Interviewer must now ask probing questions that support participant in their reflections. To aid story telling the interviewer’s questions should be guided by questions using Labov’s (1972) narrative structure below. Interviewer to annotate timeline as the participant recounts the experience. Annotations should include elements of the abstract and orientation. Participant able to annotate if she/he prefers]
<table>
<thead>
<tr>
<th>Narrative Structure</th>
<th>Questions</th>
<th>Asked?</th>
</tr>
</thead>
</table>
| Abstract            | How did it begin?  
                          | What happened?    
                          | What kinds of things are you thinking of?  
                          | Can you give me an example?  |        |
| Orientation         | Who/what does it involve?  
                          | When?         
                          | Where?     
                          | What did you see?  
                          | What did you hear? |        |
| Complicating Action | Then what happened? |        |
| Resolution          | What finally happened? |        |
| Evaluation          | Why did this happen? So what?    
                          | Is this something you thought at the time?  
                          | Why?    
                          | What led you to say that (conclusion or assumption)? |        |
| Coda                | What makes this particular experience significant to you?  
                          | What does it mean?  
                          | How did you feel?  
                          | What did you make of…….? |        |
| Action/alternative focus | In retrospect, what could have been done differently?  
                          | Why did the alternative not happen? |        |
| Follow-up           | Earlier you said ............  
                          | What were your expectations at the start?  
                          | Why?    
                          | Did you change your views or attitudes?  
                          | What surprised you the most about…...? |        |
What other experiences of mob grazing come to mind?

[Interviewer must now repeat the guiding questions in the table above until the participant feels she/he has covered all of the significant experiences]

2. Most Important Experience

Reflecting on all of the experiences we've discussed today, what is the single most important one to you? Why?

3. Significant individuals

You mentioned a number of people during the interview. I would now like us to explore the actors you perceive to have played important roles in your experiences. By ‘actors’ I mean any person, group or organisation. We will do this exercise twice, at two of the significant experiences on the timeline. This will allow me to explore any changes to group dynamics. As with the timeline, please feel free to write the answers into the matrix yourself or together with me.

[Interviewer ensures timeline is visible to participant and offers pens. Interviewer uses the ‘Asked columns in table below to ensure questions have been covered.]
Question 1st? 2nd?

What significant experience have you chosen? Why?

Can you name five important actors who played significant roles in this experience?

How would you describe each actor’s role at this point on the timeline?

How would you describe the type of relationship you held?

What type of information did you exchange?

Why was this person, group or organisation important at this point? How important?

[Interviewer annotates matrix with the details. If the participant believes that there were less or more than five then continue the discussion until the participant feels they have completed their list.]

4. Repeat significant individual questions

I would now like us to do the same but for a different significant experience. [Interviewer repeats social network questions from stage 10 above]

Interview Close

We’re at the end of the interview now. However, there is always a chance my list of questions may not have reflected everything you wanted to, or could have said. So:

- Is there anything you would add to what has been discussed so far? Anything that needs to be said?

- Are there questions I should have asked?

- Is there anything else you’d like to say?
Participant Details for Quote Checking and Invitation to Future Workshop

- How should I reach you for quote checking?
- Can I call if there are questions or clarifications that come up later?

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<thead>
<tr>
<th>Name</th>
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<td>Address</td>
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<td>Telephone</td>
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<tr>
<td>Email</td>
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<tr>
<td>Times unavailable for quote checking</td>
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CONSENT FORM

I have been fully informed about the aims and purposes of the project.

I understand that:

there is no compulsion for me to participate in this research project and, if I do choose to participate, I may at any stage withdraw my participation and may also request that my data be destroyed

I have the right to refuse permission for the publication of any information about me

any information which I give will be used solely for the purposes of this research project, which may include publications or academic conference or seminar presentations

if applicable, the information, which I give, may be shared between any of the other researcher(s) participating in this project in an anonymised form

all information I give will be treated as confidential

the researcher(s) will make every effort to preserve my anonymity

the interview will be digitally recorded. The researcher(s) will make every effort to ensure the data is stored securely and used only for the purposes of this research project.

.................................................................
(Signature of participant )  (Date)

.................................................................
(Printed name of participant)
One copy of this form will be kept by the participant; a second copy will be kept by the researcher(s)

Contact phone number of researcher(s): 07811 185 985

If you have any concerns about the project that you would like to discuss, please contact:

Prof Katrina Brown - e: Katrina.brown@exeter.ac.uk t: +44 (0) 1326 255903
Prof Robbie McDonald – e: r.mcdonald@exeter.ac.uk t: +44 (0) 1326 255720

* when research takes place in a school, the right to withdraw from the research does NOT usually mean that pupils or students may withdraw from lessons in which the research takes place

Data Protection Act: The University of Exeter is a data collector and is registered with the Office of the Data Protection Commissioner as required to do under the Data Protection Act 1998. The information you provide will be used for research purposes and will be processed in accordance with the University’s registration and current data protection legislation. Data will be confidential to the researcher(s) and will not be disclosed to any unauthorised third parties without further agreement by the participant. Reports based on the data will be in anonymised form.
Appendix 2 – Mental Models Interview Protocol

Participant: ___________________________ Date: __________
Venue: ________________________________

Place Questions
As I mentioned in my earlier email, I asked whether you could consider a location for the interview that would enable us to best explore your understanding of your grazing system.

- Have you selected a particular place?
- Why have you selected this place for the interview?
- Is there anything particularly different about this place that caused you to select it over others?

System Questions
We’re now going to explore how you think about your grazing system. I have some fixed questions but will also ask additional questions depending on your responses. You will also have the opportunity to draw a picture or diagram too; it’s not a compulsory activity but may help you with some of my questions. If you can, please try to speak or draw in general terms. This is not a test of your knowledge so do not worry if you cannot answer some of the questions. Feel free to ask me to clarify anything you’re unsure of.

1. Can you very briefly describe your grazing system to me please?

2. Thinking about your farm can you explain to me, either orally or by picture or diagram, how your grazing system affects soil quality?
3. Are there any other things that are affected by your grazing system?

4. Are there any things that affect your grazing system?

5. Is the system you have described influenced by anything away from your farm?

6. Does your system influence anything away from your farm?

7. Does anything else come to mind?

<table>
<thead>
<tr>
<th>Oral - Qs 2, 3, 4 and 5 (for use with Picture or Diagram)</th>
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<tbody>
<tr>
<td>o Does anything else come to mind?</td>
</tr>
<tr>
<td>o What happens then?</td>
</tr>
<tr>
<td>o Are there any flow-on effects? Are any of the things linked?</td>
</tr>
<tr>
<td>o Why do you think……..(happens)?</td>
</tr>
<tr>
<td>o What happens if…….?</td>
</tr>
<tr>
<td>o What does……..do? What role does ……. play? So the ……. does this ……. ?</td>
</tr>
<tr>
<td>o Does ……. rely on any other &lt;thing, component, process&gt;?</td>
</tr>
<tr>
<td>o Does this amplify or reduce change?</td>
</tr>
<tr>
<td>o At what rate does……..change?</td>
</tr>
<tr>
<td>o How frequently does……..change?</td>
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<tr>
<td>o Where does ……. happen?</td>
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<table>
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<tr>
<th>Picture or Diagram – Qs 2, 3, 4 and 5</th>
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</thead>
<tbody>
<tr>
<td>If you’d like to draw a picture or diagram then you can use words, pictures or a combination of both.</td>
</tr>
<tr>
<td>o What is happening in the picture?</td>
</tr>
</tbody>
</table>

8. What critical things can cause significant change to the way your system functions?

9. What would cause you to significantly change your current system?
<p>| | |</p>
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<td></td>
<td></td>
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<tr>
<td>o What are they?</td>
<td>o Why are they critical?</td>
</tr>
<tr>
<td>o What happens if they change?</td>
<td>o How do they change?</td>
</tr>
<tr>
<td>o Are there any cascading or flow-on effects?</td>
<td>o What causes/restricts the change?</td>
</tr>
<tr>
<td>o What causes these limits/thresholds to be passed?</td>
<td>o Can you reduce/increase the likelihood of these limits/thresholds being passed? How?</td>
</tr>
<tr>
<td>o How do you respond when limits are passed?</td>
<td>o Does anything else come to mind?</td>
</tr>
<tr>
<td>o At what rate does this happen?</td>
<td>o How frequently does this happen?</td>
</tr>
<tr>
<td>o Where does this happen?</td>
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</tbody>
</table>

10. How would you describe your role in the system you’ve described?

11. Which of the things/components/processes that you’ve described do you change or influence?

12. Conversely, which of the things/components/processes that you’ve described influence your actions?

<p>| | |</p>
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<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>o How? Why?</td>
<td>o Why do you describe your role that way?</td>
</tr>
<tr>
<td>o How do you respond to change in …..?</td>
<td>o To what extent do you/they cause change?</td>
</tr>
<tr>
<td>o At what rate does this change happen?</td>
<td>o How frequently does this change happen?</td>
</tr>
<tr>
<td>o Where does change happen?</td>
<td></td>
</tr>
</tbody>
</table>
Conclusion

13. Is there anything you feel we have not discussed today that should be included?
Appendix 3 – Participatory scenario planning workshop protocol

Stage 1 – Setting the Scene - 10 minutes

- Fire safety
- Audio and photographs ok? Just say if want anything redacted or photo not to be taken
- Food – 7:45

- Introduce scenario planning
- Recap on research so far
- Introduce workshop activities
- Set ground rules

Stage 2 – Future driving forces of change – 10 minutes (20 minutes gone by end of this stage)

“We’re now going to take a step into the future and consider what might be the driving forces that determine change on your farms in 15-20 years’ time. Will you still be working or hoping to retire? What will the main driving forces of change be? What new driving forces are likely or possible? Working together, I’d like you all to consider what you think those driving forces of change might be and record them onto the post-its provided. Try not to extrapolate from those that you experience today - driving forces are dynamic and may change significantly. Don’t hesitate to shout out if you have an idea and do feel free to write as there are plenty of pens and post-its.”

“What do we mean by ‘driving force of change’? Any natural or human-induced factor that directly or indirectly causes a change to your farm.”

[10 minutes - Participants to write drivers of change onto post-its and place them onto table]

Stage 3- : Importance and Uncertainty – 25 minutes (45 minutes gone by end of stage)
“The next exercise is for you to all rank how important you think each driving force will be to your grazing system in twenty years' time. Working together, can you agree the relative importance of the driving forces to your farms in 20 years’ time. Don’t worry if you can’t agree on specific positions, we’re more concerned with the general picture.”

[10 minutes for participants to rank driving forces.]

“Now that you’ve ranked the driving forces, I’d like you to consider how you expect the driving forces to develop over the next twenty years. Will the driving force be better or increase? Will it be worse or decrease? Or will it be highly uncertain? Whilst I know none of us have a crystal ball to predict what will happen try to go with your gut instinct. This time round I’d like you all to use these blank post-its and place one each for each driving force of change. Don’t worry about what the rest of the group are thinking, just go with what you feel.”

<table>
<thead>
<tr>
<th>Importance</th>
<th>Driving Force</th>
<th>Development of Driver</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Better/More</td>
</tr>
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<td>1</td>
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<td>5</td>
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<tr>
<td>Etc</td>
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</table>

[10 minutes. Once post-its placed in categories then count numbers to identify whether driving force will be better/more, uncertain, or worse/less. If equal spread of post-its across each category then driving force classified as uncertain. Take photo of sheet]

“Why did you decide on their positions? Might any of them cause surprises or shocks?”

Stage 4 – Create starting point for scenarios using 2x2 matrix – 10 minutes (55 minutes gone by end of stage)
“We’re now moving closer to the scenario planning exercise. Before we begin that activity we need to create some foundations for each scenario based on what the most uncertain driving forces of change will be. We need to select two to begin with but you’ll be able to draw on the remaining stages of the activity so don’t worry if you think something’s being left out. We’re going to plot the driving forces against each other and see if we can generate some feasible scenarios to start with”

[Select the two driving forces of change with highest counts for uncertainty from previous exercise and plot on pre-printed matrix. Add scenarios A, B, C and D from left to right.]

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>D</td>
</tr>
</tbody>
</table>

“This matrix gives some potential scenarios for the driving forces of change. Do you think these uncertain driving forces of change that have been selected give feasible scenarios to start with? If not, which ones should we include? Remember, these are only starting points and you’ll be able to draw on the other driving forces as the activity progresses.”

[If change required then ask participants to agree on which ones should be used and plot new matrix scenarios A, B, C and D from left to right]

“We’re now going to work together in smaller groups and, using one of the scenarios we just created as a foundation, start to flesh out broader stories of what your farms might be like in 20 years' time. For this exercise you’ll work in smaller groups and consider just one of the scenarios in the matrix.”

[Split participants by giving number and then directing to table for each number. Depending on number of participants aim for 3-4 groups of 3-4 people so can use...
one scenario each. If cannot form four groups then ask participants to select the scenario that they would like to work with]

Stage 5 – Creating Scenario Narratives – 20 minutes (1hr 15 mins gone by end of stage)

“In your groups I’d like you create some stories based on the starting points we created. Don’t restrict the stories to just the starting points – include any of the other driving forces of change that we discussed earlier. Remember, we’re interested in how these dynamic, non-linear driving forces of change will impact your grazing system in 20 years’ time. Try to create stories that are feasible and potentially realistic. I’d also like you to come up with a name for your scenario. I’ve printed a list of questions that should help you think about the future and I’ll come round to help you. Once you’ve created your stories you’ll be asked to present it back to the rest of the group so it’s important at least one of you writes down the scenario as you go. You’ll have 20 minutes for this exercise and don’t hesitate to shout if you get stuck.”

[Provide participants with flip chart paper and pens. Groups facilitated by two facilitators]
Use the scenario base lines as your starting points but add any other combination of drivers that you think will make a feasible and plausible story of what might happen in 20 years' time.

Drivers may be completely different in the future, full of non-linear dynamics and surprises.

- What driving forces of change will be most important in 15-20 years?
- What will be happening away from your farms?
- To what extent does change happen away from your farm?
- Will what happens away from your farms influence what you do?
- Do you expect there to be any shocks or surprises?
- How do you deal with uncertainty in change away from your farm?
- How do you feel about uncertainty?

We're interested in what might happen on your farm and away from it.

- What will your farms and grazing systems be like?
- What will you be using your land for? Will it still be farmed? Who will be managing it?
- What driving forces will determine your decision making?

You may or may not feel like you will have choices in the future.

- Where do you have a choice about the future?
- What can or can't you influence or control?
- What will your needs be? What will society's needs be?
- Is there anything you might do that has a positive or negative repercussion at a later point?
- Is there anything that results from your actions and feeds back to influence you or the wider system at a later point?

You may want to turn your choices into actions.

- What new opportunities does the future present?
- What can you start to plan for now? How?
Stage 6 – Present and discuss scenarios – 20-30 minutes (1hr 45mins gone by end of stage)

“I’d now like each group to fed back on the story they created”

[2-3 minutes to present and 5 minutes of discussion. Prompt each group if struggling to present story. After each scenario is presented ask participants:
  • How do you feel about this scenario? Does it make sense?
  • What aspects of the story can you control? What can’t you control?
  • What could you monitor to see if this story is actually occurring?
  • Are there any opportunities for you that come out of this scenario?

Stage 7 – Likelihood and desirability of scenarios – 10 minutes (1hr 55 mins gone by end of stage)

[Ask for scenarios and stick to wall if able to. If not then leave scenarios with participants.]

“Final exercise now. Having created and discussed the scenarios I’d like you all to consider which the most desirable future is but also which is the most likely. They can be the same or different – it’s up to you. Place a yellow post-it on the most desirable and red post-it on the most likely”

[Hand participants post-its and count once post-its placed on scenarios]

“It looks like ….. is the most likely and ….. is the most desirable. I’d like to ask you then why scenario …. Is the most likely? What about it makes it seem like it might happen?
“You’ve selected scenario ..... as the most desirable. What can you do now to make the future more like this desirable one?”
Close

Thank participants for contributions. Did they enjoy it? How useful could some of what we’ve discussed be for your futures?
Appendix 4 – Feedback loops identified in causal loop diagrams of members’ mental models

One feedback loop identified in causal loop diagram of David’s mental model

Loop Number 1 of length 2
- Pasture Growth
- Cattle Stocking Ratio
- Daily Grazing Management Activities
One feedback loop identified in causal loop diagram of Toby’s mental model

Loop Number 1 of length 1

- Effectiveness of Grazing System
- Extremity of Dry Conditions
One feedback loop identified in causal loop diagram of Roy’s mental model

Loop Number 1 of length 1

- Control of Undesirable Plants
- Use of Chemical Pesticides
Two feedback loops identified in causal loop diagram of Dan’s mental model

Loop Number 1 of length 2
- Use of External Purchased Inputs
- Pasture Growth
- Cattle Stocking Ratio

Loop Number 2 of length 3
- Use of External Purchased Inputs
- Soil Nutrient Levels
- Pasture Growth
- Cattle Stocking Ratio
Three feedback loops identified in causal loop diagram of Adam’s mental model

Loop Number 1 of length 1
- Soil Biology
- Soil Organic Matter

Loop Number 2 of length 1
- Soil Biology
- Soil Aerobic Conditions

Loop Number 3 of length 1
- Soil Biology
- Mechanical Intervention in Soil
Four feedback loops identified in causal loop diagram of Eddie’s mental model

Loop Number 1 of length 1
- Soil Condition
- Soil Drainage

Loop Number 2 of length 1
- Soil Condition
- Poaching

Loop Number 3 of length 1
- Daily Grazing Management Activities
- Poaching

Loop Number 3 of length 2
- Soil Condition
- Poaching
- Daily Grazing Management Activities
Seventeen feedback loops identified in causal loop diagram of Brian’s mental model

Loop Number 1 of length 1
- Soil Organic Matter
- Soil Biology
Loop Number 2 of length 2
- Soil Organic Matter
- Soil Condition
- Soil Biology
Loop Number 3 of length 2
- Soil Organic Matter
- Soil Condition
- Soil Air Mass
Loop Number 4 of length 2

- Soil Organic Matter
- Soil Biology
- Soil Drainage
Loop Number 5 of length 3

- Soil Organic Matter
- Soil Condition
- Soil Air Mass
- Soil Biology
Loop Number 6 of length 3

- Soil Organic Matter
- Soil Condition
- Soil Biology
- Soil Drainage
Loop Number 7 of length 4

- Soil Organic Matter
- Soil Condition
- Soil Air Mass
- Soil Biology
- Soil Drainage
Loop Number 8 of length 5
- Soil Organic Matter
- Soil Resilience
- Extremity of Weather Conditions
- Interval Between Grazings
- Pasture Growth
- Root Activity
Loop Number 9 of length 5

- Soil Organic Matter
- Soil Biology
- Soil Drainage
- Soil Moisture Content
- Soil Condition
- Soil Air Mass
Loop Number 10 of length 6

- Soil Organic Matter
- Soil Resilience
- Extremity of Weather Conditions
- Interval Between Grazings
- Pasture Growth
- Root Activity
- Soil Drainage
Loop Number 11 of length 6

- Soil Organic Matter
- Soil Resilience
- Extremity of Weather Conditions
- Interval Between Grazings
- Pasture Growth
- Root Activity
- Composting Manure
Loop Number 12 of length 6

- Soil Organic Matter
- Soil Resilience
- Extremity of Weather Conditions
- Interval Between Grazings
- Pasture Growth
- Root Activity
- Soil Biology
Loop Number 13 of length 7

- Soil Organic Matter
- Soil Resilience
- Extremity of Weather Conditions
- Interval Between Grazings
- Pasture Growth
- Root Activity
- Soil Biology
- Soil Drainage
Loop Number 14 of length 9

- Soil Organic Matter
- Soil Resilience
- Extremity of Weather Conditions
- Interval Between Grazings
- Pasture Growth
- Root Activity
- Soil Drainage
- Soil Moisture Content
- Soil Condition
- Soil Air Mass
Loop Number 15 of length 9

- Soil Organic Matter
- Soil Resilience
- Extremity of Weather Conditions
- Interval Between Grazings
- Pasture Growth
- Root Activity
- Soil Drainage
- Soil Moisture Content
- Soil Condition
- Soil Biology
Loop Number 16 of length 10

- Soil Organic Matter
- Soil Resilience
- Extremity of Weather Conditions
- Interval Between Grazings
- Pasture Growth
- Root Activity
- Soil Biology
- Soil Drainage
- Soil Moisture Content
- Soil Condition
- Soil Air Mass
Loop Number 17 of length 10

- Soil Organic Matter
- Soil Resilience
- Extremity of Weather Conditions
- Interval Between Grazings
- Pasture Growth
- Root Activity
- Soil Drainage
- Soil Moisture Content
- Soil Condition
- Soil Air Mass
- Soil Biology

Soil Biology A
Pasture Growth 7
Root Activity 7
Soil Condition 8
Soil Organic Matter F
Soil Drainage 8
Interval Between Grazings 7
Soil Resilience 7
Extremity of Weather Conditions 6
Root Activity 7
Soil Air Mass 5
Soil Condition 9
Soil Moisture Content 3
Soil Drainage 8

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**Appendix 5 - Interventions identified in feedback loops**

<table>
<thead>
<tr>
<th>Interventions identified in feedback loops</th>
<th>Description of intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle stocking ratio</td>
<td>Decision by member that influences the density of cattle on a particular unit of land.</td>
</tr>
<tr>
<td>Interval between grazing</td>
<td>Decision that influences the period of time between which cattle are allowed to graze the same piece of land.</td>
</tr>
<tr>
<td>Use of chemical pesticides</td>
<td>Use of chemical pesticides that reduce the presence of undesirable plants and animals.</td>
</tr>
<tr>
<td>Use of external purchased inputs</td>
<td>Use of organic inputs that originate away from the farm such as whey, green waste, compost and forage.</td>
</tr>
<tr>
<td>Mechanical intervention in soil</td>
<td>Interventions such as ploughing or re-seeding.</td>
</tr>
<tr>
<td>Daily grazing management activities</td>
<td>Activities such as moving fences or milking cattle</td>
</tr>
<tr>
<td>Composting manure</td>
<td>Process that promotes the availability of slow release nutrients when applied to land as organic fertiliser.</td>
</tr>
</tbody>
</table>
9 Bibliography


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