Agroecological break-out: legumes, crop diversification and the regenerative futures of UK agriculture

Abstract

This paper reviews the shifting fate of legumes in UK agriculture. Legumes were once a common part of crop rotations, providing food and feed, while enhancing soil fertility and enabling pest control. During the 20th century, UK arable management became predicated on minimally diverse crop rotations, dependent on artificial fertilisers and pesticides. Legumes were locked out of food and farming. Existing research has identified the drivers of this lock-in. Whilst this intensive model increased crop yields, there are growing concerns around its greenhouse gas emissions and impacts on soil health and biodiversity. In response, there is a resurgence of interest in legumes as a solution to these problems, as part of a wider shift towards agroecological management. This analysis draws on interviews with different actors in the UK agricultural sector to present a Multi-Level Perspective analysis of the drivers and characteristics of this transition - what we term agroecological break-out. It describes how macro-level economic changes (a growing market for plant-based proteins) and political transitions (a focus on public goods subsidisation) are combining with shifting agricultural attitudes (such as concerns around soil health, and the prioritisation of multi-annual profitability over annual yields) to increase the attractiveness of crop diversification and legume cropping. These changes open space for micro-level innovations by private, public, and civil society actors to disrupt the meso-level status quo of minimally diverse crop rotations. The conclusion maps the different forms and trajectories of this break-out and reflects on their implications for the future of food and farming in the UK.

Keywords

Agroecology; Regenerative Agriculture; Legumes; Sustainable Agriculture; Crop Rotations; Transition Theory

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1. Introduction

In his autobiography *English Pastoral*, the celebrity shepherd James Rebanks captures the dramatic changes that have taken place in UK agriculture since the Second World War (Rebanks 2020). His book covers the experience of three generations of his family managing two farms in the Lake District: one a marginal upland farm, the second a more fertile lowland holding. On the lowland farm, the family reluctantly try to keep up with their neighbours who are moving away from a low-intensity and labour-intensive model of mixed agriculture towards a more specialised, mechanised and agrochemical model of intensive livestock production. He marvels at the incredible yield gains this shift enabled, while bemoaning the ecological, economic and social harms it inflicted upon the landscape and the farming community. Jobs were lost, habitats and species disappeared, and soils ran off in angry, swollen rivers.

The upland farm had avoided intensification and, although it was uneconomic, Rebanks finds a landscape in much better health: richer in plants, birds and earthworms. Informed by a cast of ecologists and agronomists, he experiments with different animal breeds, forage varieties, restrains from using pesticides and fertilisers, and plants scrub and wild plants to recreate traditional farmed landscapes. With this book, Rebanks joins a growing cohort of farmers and practitioners (e.g., Montgomery 2017, Brown 2018, Tree, 2018) offering their perspectives on how agroecological or regenerative methods might be used to remedy the social and environmental crises associated with intensive agriculture; messages being broadcast by high-budget documentaries, like Netflix's *Kiss the Ground* documentary (Tickell and Tickell 2020) to new audiences.

For those versed in rural studies, the book is describing the Green Revolution. A 'socio-ecological transition' through which British (and wider European) agriculture became 'locked-in' to a model of intensive commodity agriculture, 'locking-out' low intensity cropping regimes, and mixed livestock-arable management. Rebanks inherits a rare example of a farm that resisted these trends, and now finds himself as an emerging spokesperson for those seeking to 'break-out' from the modern orthodoxy in pursuit of more sustainable farming futures. In this paper, we develop this lexicon to explore the character, significance, and consequences of what Duru *et al.* (2015) term the 'agroecological transition' that is underway in the food and farming sector. We do this by applying Geels' (2005, 2006) Multi-Level Perspective (MLP) to the study of farm management. We develop the literature that has focussed on the path dependency of contemporary agricultural practices, departing from Duru *et al.*'s terminology to outline the idea of 'agroecological break-out'. We argue that although the existing literature helps us to understand the historical roots of current agricultural management practices, and the reasons why change might be hard to bring about, it has had less to say about the winds of change that are already in the air. We use MLP, which was developed to understand the conditions needed for one technological regime to be replaced by another, to theorise this transition.

We use the term agroecological break-out to capture the characteristics of an emergent agricultural paradigm (one that places great emphasis on the revitalisation of ecosystems and the synergies between different crop types and land uses), as well as the various social, cultural, environmental and economic forces that are precipitating change. Our specific focus is on arable crop diversity and the shifting place afforded legumes in the arable activities of English farmers. We use these topics, though, to reflect on broader questions relating to crises in intensive agricultural management and changing agricultural norms.

The following two sections represent the review portion of the paper. We first trace how legumes became a casualty of the processes of agricultural intensification: getting locked-out of the UK farming landscape. We then describe the repercussions of agricultural intensification and specialisation, framing it as a case of environmental 'blowback' (Wallace and Wallace 2015) - the negative impacts generated by the excessive application of modern modes of managing life. After this review, we provide an account of the MLP framework we use to structure our analysis and a description of how this theory maps onto agroecological break-out. We then describe the methods used to produce this study. The subsequent sections contain the main analysis in which we explore the enthusiasm for legume production and consumption in England. In conclusion, we reflect on the significance of this potential regime change, acknowledging the long history of past hopes for break-out, and raise some broader questions about the possible trajectories of UK agriculture's agroecological future.

2. Review: Legumes and agricultural lock-in

The legume family covers a diverse set of plants with different agronomic and dietary characteristics. Some are grown for their seeds which, after drying, are called pulses. Notable examples include beans, peas, lentils. Others, like soya, are harvested in their green state. A further group like alfalfa, clover and vetch are grown as cover crops[1] or as forage for grazing. Legumes are valued as a component of crop rotations due to their ability to fix nitrogen from the air into the soil (Hirsch *et al.* 2001), thus improving soil fertility and reducing the quantity of organic or mineral fertiliser needed to maintain yields (Gan *et al.* 2015). They have long played a role in UK agriculture. The Romans used them in Britain in a three-course rotation from the 1st century AD. The Norfolk four course rotation (wheat, turnips, barley and a legume-grass ley[2]) was popularised in the 17th century. By the end of the 19th century, cropping cycles were up to eight years long and included fodder crops (such as kohlrabi and turnips), fallow, grass-legume leys, oats, beans, peas, wheat, barley and rape (Knox *et al.* 2011). Crop rotations created a diverse food and feed supply that was resilient in the face of individual crop failure. Rotations enhanced crop yields, enabled pest control by preventing the build of crop specific pests and improved provisioning for pollinators (Rusch *et al.* 2013, Gurr *et al.* 2013, Lin 2011).

Agricultural historians and sociologists have identified a series of interconnected political, economic, technical, and cultural processes that led to the simplification of crop rotations and the demise of legumes. The most insightful subset of this literature has come from scholars applying ideas of lock-in and path dependency to the subject of agricultural management (Vanloqueren and Baret 2009, Koukkanen *et al*. 2016, Magrini *et al.* 2016, Maynard *et al.* 2018). The concepts are used to explain instances in which some widely used technology is popular not necessarily because it is the best available but because it has become embedded in the praxis of its user group or because it benefitted from an early-mover advantage (David 1985, Arthur 1994). This means that even when a technology has proven financial, environmental or social disadvantages relative to an alternative, there may be a cultural or economic inertia keeping it in place. Social capital, co-evolved technologies, knowledge economies and user habits crystallise around the technology, making alternatives seem worse performing, alien, risky or otherwise incompatible with the socio-technical network within which it would have to operate. We can distil the insights from the literature applying these

[1] Cover crops are those grown to avoid having uncovered soil, to reduce erosion and to improve soil fertility.
[2] A ley is a temporary grass or grass-legume mix which enables the integration of livestock grazing into arable cultivation.

ideas to the study of legumes and agricultural management practices into three central factors: i) political developments in agricultural support; ii) technological developments in cultivars, fertilisers, and pesticides; and iii) socio-psychological changes in agricultural knowledge and social norms.

First, in response to the threat of food shortages, financial support was offered to scale-up European agricultural productivity after the Second World War. Capital investment was provided to farmers to procure new technologies to increase output, and price guarantees were offered for agricultural commodities to incentivise production (Lefebvre *et al.* 2012). Farmers sought economies of scale by increasing the size of their fields (through the removal of field boundaries), their farm holdings (by concentrating land in a smaller number of larger farms), and their farm machinery (de Roest *et al.* 2018). They also increased the application rates of chemical inputs and adopted more specialised systems by separating livestock from arable management. This expansion coincided with the liberalisation in the trade of global agricultural commodities. Regions like Europe intensified the production of the agricultural goods most suited to its climate and land type, creating territorial specialisation in commodity production (Foley *et al.* 2005, Campi *et al.* 2020). It also opened the European market to cheap imported feed products from the US and, more recently South America, impacting livestock management by reducing the need to rely on local or on-farm supplies of grazing land or feed crops (Coffey *et al.* 2016).

These structural changes in support coincided with the second major driver – innovations in agricultural technology. High yielding crop cultivars were developed to be used in tandem with new chemical pesticides and synthetic mineral fertilisers. A select few crops that were most amenable to intensification in a European context benefited from this targeted development. They included wheat, barley, rye grass, and oilseed rape (OSR). The narrow focus of this Green Revolution has, for example, driven a ~4-fold increase in wheat and barley yields since the 1940s whilst pea and bean yields have remained static. As the production of agricultural chemicals and cultivars was refined, so the application of those technologies became cheaper and more productive. This drew more farmers into a high-input high-output model. The changes are a form of what Altieri and Farrell (2018) term input substitution. New agricultural products (artificial fertilisers and pesticides most importantly) were used to undertake the work of pest control and fertilisation, reducing the need to rely on crop rotations, grass-leys and fallowing.

Finally, agricultural expertise shifted to support the production of the cereals and grass varieties dominating European agricultural hectarage. Farmers became expert, over the course of a generation, at managing highly productive, input dependent and minimally diverse rotations of wheat, barley, and OSR. The minor crops needed for diverse rotations were then further isolated from the agendas of agricultural extension services (Vanloqueren and Baret 2009); an exclusion visible in the paucity of choice for legume cultivars relative to wheat or rye grass varieties (see the Agricultural and Horticulture Development Board's 'Recommended List' for reference). In rural communities, what constitutes a 'good farmer' was refigured to celebrate the productivist manager (Burton 2004), creating a normative position to which others aspire, and against which laggards or those adhering to alternative models are judged (Burton *et al.* 2008).

These three drivers (economic and political, technological, and socio-psychological) operate in a self-reinforcing relationship, locking farmers in to intensive and minimally diverse crop rotations (Magrini *et al.* 2016, Meynard 2016). As research improved the performance of the

crops assigned to European intensification, the relative performance of the minor crops (like legumes) decreased (Vanloqueren and Baret 2009). These improvements then attracted more farmers (and farmland) into an intensive model to keep up with market conditions being shaped by highly productive and efficient modes of production (Meynard *et al.* 2018), thus channelling further research investment towards certain crops and away from others (Vanloqueren and Baret 2009, Magrini *et al*. 2016).

Reading across this literature, the concern is that even as this model comes to a point of crisis, and good reasons become apparent for moving towards alternatives, there are major socio-cultural, technical and economic barriers to change. While this work helps document the history of this lock-in, it has had much less to say about how and why agricultural transitions might be emerging to counter the problem, and what different forms they might take. But before turning to these futures, we must attend to the crises to which they respond.

3. Review: Blowback and crises

The demise of crop rotations and the widespread intensification, specialisation and simplification of agriculture has come at substantial environmental and social cost (Bowler 1986, Donald *et al.* 2006, Rusch, *et al.* 2016). Four interlinking impacts stand out: biodiversity loss, soil health degradation, greenhouse gas (GHG) emissions and climate change, and water nitrification.

First, the simplification of land use and the intensification of management (particularly through the use of broad-spectrum pesticides) has squeezed out farmland biodiversity, especially pollinators like bees and butterflies (Kleijn *et al.* 2009, Flohre *et al.* 2011, Emmerson *et al.* 2016). In a meta-analysis of the relevant literature, Chopin *et al.* (2019) describes the consistently high impact agricultural systems of different types are having on biodiversity populations around the world. Second, soil tilling and the excessive use of pesticides, vermicides and fertilisers have significantly degraded the quality of European soil, Virto *et al.* 2015), the various lifeforms to which it plays host (Tsiafouli *et al.* 2015) and its ability to store water, manage flood risk and preserve fertility (Panagos *et al.* 2016). The UK Environment Agency (2019) estimates that two million hectares of soil are at risk of degradation or erosion, which is estimated to cost £1.2 billion annually.

Third, there is a growing awareness of the GHG emissions of modern agricultural management, with food and farming producing around a quarter of global GHG emissions (Poore and Nemecek 2018). Emissions from ruminant systems are estimated to account for 14% of global emissions (Gerber *et al.* 2013), whilst the shift to imported feed crops is a major driver of deforestation in the tropics (Fraanje and Garnett 2020). Fertiliser application accounts for over a half of UK agriculture's non-carbon GHG emissions (Defra 2009) and the energy used in its production contributes around 1% of the UK's total emissions (Audsley *et al.* 2009). Finally, water nitrification, caused chiefly by excessive application nitrogen fertilisers (organic or synthetic) and its entry into water systems via run-off and leeching, is undermining the ecological health of water systems (Moss 2007, Yousaf *et al.* 2021), with knock-on effects on the GHG emission rates of riparian and wetland landscapes (Hefting *et al.* 2013). Nitrification also impacts on soil fertility, crop yields and soil biodiversity (Beeckman *et al.* 2018).

Taken together, this catalogue of consequences provides a clear example of what Robert and Roderick Wallace (2015) describe as blowback – the unintended yet violent repercussions the non-human world is issuing in response to the expansion of human activity, the unsustainable

use of the world's resources, and the pace with which planetary boundaries are being approached. These are crises that are emerging from within the intensities of the modern UK (and global) agricultural systems as a consequence of the ways in which these undermine the diversity and resilience of farmed landscapes and the health of the plants and animals of which it is comprised (cf Guthman 2019; Hinchliffe *et al.* 2017; Lorimer 2020). Theorists of socio-ecological transition point to the ontological significance of such moments of crisis for driving system change. In his conceptualisation of the 'adaptive cycle' of resilience, Holling (2001) points to the importance of such 'destabilising events' in the collapse of stable socio-ecological regimes, noting how they open opportunities for reorganisation, regeneration, and renewal. Stephanie Wakefield (2018) develops this analysis to argue that the current environmental crisis is rich in political possibility, driving experimentation towards radical modes of ecological break-out. Seen in this way, we can figure these crises in modern agriculture as catalysing new forces with a building momentum towards political and ecological change.

4. Theoretical framework: Agroecological break-out

Transition theorists are interested in how systems change from one organisational structure or technology to another (Wilson 2007). For our analysis of agricultural paradigms and the shifting place afforded to legumes in crop diversification strategies, we turn to this transition theory literature and draw on Geels' (2002, 2005, 2006) MLP framework. MLP seeks to grapple with the sociological questions concerning the relationship between social structure, socio-technical systems, and individual agency. It argues that transitions emerge from interactions between actors and processes on three different levels: the *meso*, the *micro*, and the *macro*. In this MLP framework, the meso-level describes the dominant paradigm or socio-technological regime. More than just a specific technology, the meso-level regime is "the rule-set or grammar embedded in a complex of engineering practices, production process technologies, product characteristics, skills and procedures, ways of handling relevant artefacts and persons, ways of defining problems" (Geels 2006, p. 171). In the context of our analysis, the meso-level consists of the agricultural model of minimally diverse rotations whose products are sold as fungible commodities into agricultural commodity markets and whose practices are underpinned by public subsidy and R&D orientated around high yields and high application rates of fertilisers and pesticides (Meynard *et al.* 2013, Meynard *et al.* 2018).

Transition theorists are especially interested in micro-level innovation niches: safe spaces created by individuals, firms, or research groups in which new technologies are shielded from a competitive marketplace by public and/or private support, such that they can be nurtured and improved by their developers and users. Examples of such innovation niches that we detail below include crop diversification through legume cropping, intercropping and the use of catch crops; spaces being opened up by research firms, agronomists, public research investment and farm benchmark groups developing more agroecological modes of farming. Both the micro-and the meso-levels exist within an over-arching *macro*-level. Geels sometimes refers to this as the socio-technical landscape: the "wider exogenous environment that affect[s] sociotechnical development" (Geels 2005, p. 451). The 'landscape' term is used to stress the durability and hardness of its character, the way it is subject to gradual development such that it cannot be redesigned at will, and the manner in which it creates "gradients" (Geels 2002, p. 1261) that make actions that are compatible with the meso-level regime easier to take than those that do not (Geels 2002, 2005). These 'gradients' are closely linked to the phenomenon of lock-in as described by David (1985) and Arthur (1994). In our

case study, the macro-level includes the policies, technologies, consumer preferences, social norms and farming identities that determine the selection of certain agricultural practices over others, including those that are responsible for the lock-in of minimally diverse rotations and the exclusion of legumes in farm management.

In this MLP framework, regime change occurs when changes in the macro-level permit innovations from the micro-level to establish themselves at the meso-level, displacing existing practices and technologies. Periods of macro-level flux – caused by the sort of blowback or crisis we describe above – reconfigure the competitive space in which micro- and meso-level technologies compete. We use MLP to help address deficiencies in the literature on legume lock-in reviewed above, which has tended to focus on how different forces *act on* individuals in the food system, without considering the extent to which groups of actors have agency to initiate change, and the evidence that transition might already be underway.

The uptake of agroecological practices is the regime change we are interested in. Although variation exists in the way that the term agroecology is used (Wezel *et al.* 2009), as well as related terms like regenerative agriculture (Newton *et al.* 2020), we use it to refer to its central agronomic and environmental principles. Namely, the restoration of agroecosystems, particularly farmland biodiversity, soil quality and water health – all of which have important functions for agricultural productivity – achieved through the reduction or removal of artificial agricultural chemical application and the diversification of land use and cropping practices (Altieri 2018). In the MLP model, agroecology is an alternative agricultural-technological paradigm – a micro-level niche – that is looking to unsettle the dominant meso-level regime. Its proliferation is being frustrated by the competitive advantage of the intensive model, particularly with regards agricultural productivity, and the socio-technical network that has developed around it. For its advocates, however, destabilisation on the macro-level, caused by the environmental and social ills associated with the contemporary food system, is highlighting the inadequacies of the current meso-level regime and creating an opportune moment for a regime change. As we discuss below, this destabilisation is influencing policy and consumer behaviours (also on the macro-level) which are in turn reconfiguring the competitive landscape on which agroecological innovation and meso-level conventional agricultural production systems are competing.

Centred on this agroecological model, we use the term agroecological break-out to refer to the proliferation of the movement's attendant agricultural principles and practices, *and also* the conditions that are helping it gain traction amongst a broader cohort of actors in the food system. The term covers: the micro-level innovation of agricultural practices (the farmer groups, research bodies and consultancies experimenting with rotations and legume cropping, legume cultivars, grass-arable rotations, no-tillage etc.); the potential ascension of those practices from the micro- to the meso-level; and all of the commercial, environmental, political and cultural shifts occurring in the macro-level that are making that change possible. Figure 2, below, is a modified version of the 'adaptive cycle' from Wakefield (2020, p. 22) that draws together the agricultural focus of this study, the MLP framework we use and the adaptation cycle of Wakefield (2008) and Holling (2001). We return to Wakefield and her work on the creative back loop at the end of the paper.

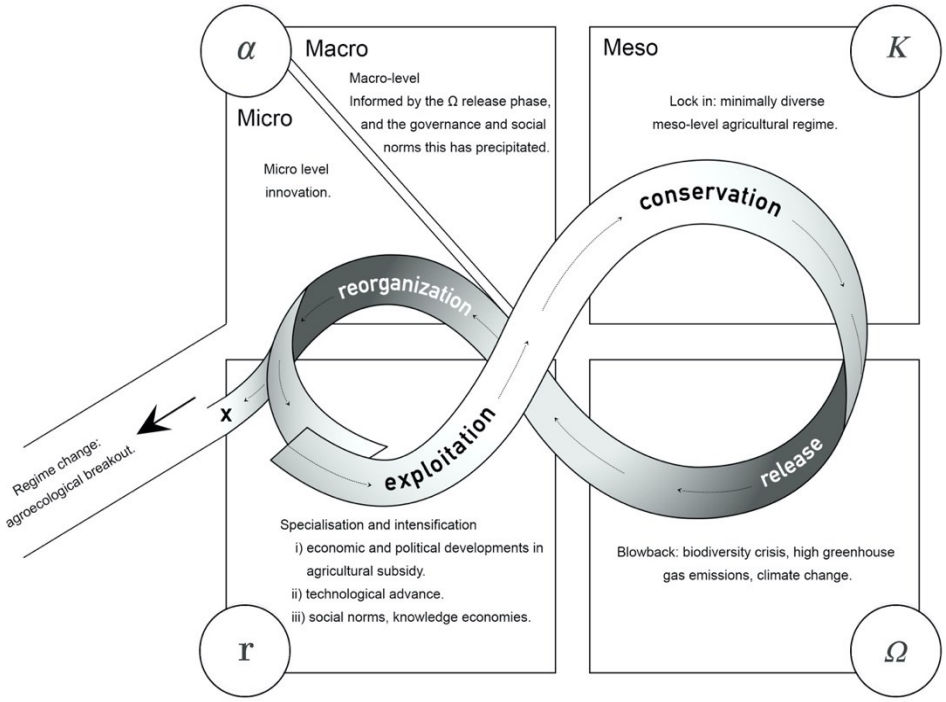

Figure 2 – Modified and annotated version of Wakefield's (2020) adaptive cycle, itself based on Gunderson and Holling (2002). The period of exploitation (r) corresponds to the intensification and specialisation of agriculture. The conservation period (K) is the meso-level agricultural regime of minimally diverse crop rotations and specialist farm systems: the status quo locked in regime in the UK. Blow back in the form of biodiversity decline and climate change has precipitated a period of release (Ω) that is unsettling the lock-in. This destabilisation is creating the conditions for a period of reorganisation (α); the primary site of analysis for this paper. New macro-level conditions (social norms, political and economic conditions, consumer preferences etc.) inspired by the environmental blow back in the Ω phase are creating fertile ground in which new micro-level innovation niches are thriving. The combination of the release (Ω) and reorganisation (α) phases – the creative back loop – are creating an environment in which micro-level innovation is developing into a new regime (x): a process we describe as agroecological break-out.

5. Methods and materials

The paper takes England as its unit of analysis. Owing to their shared agricultural, cultural and economic traits, however, the findings we present here have relevance for the rest of UK and other parts of the EU. The research is predicated on in-depth, semi-structured interviews with 23 individuals occupying different up-stream positions in the food system. All interviews took place between May and August 2020 and, due to the UK Covid-19 lockdown, all were conducted by phone or videocall. Interviews lasted around 90 minutes each. Of the 23 interviews, 13 were with commercial farmers, and 10 with people from organisations at other relevant up-stream points in the industry. A wide range of actors – farmers, farm advisors, seed merchants, agronomists and so on – have important perspectives on the lock-in and break-out of agricultural practices, hence the reason for the heterogenous interview sample.

For the cohort of farmer interviewees, a snowball sampling methodology was used. Only commercial, non-Organic holdings of at least 200ha were included. This was to ensure the research was accessing the farms and farmers most exposed to the pressures that have precipitated the move towards minimally diverse and intensive production systems, and to identify the forces, desires or anxieties that might be pushing them towards break-out. To sustain a focus on the use of legumes in crop rotations, the methodology only permitted farmers to be interviewed if they had an arable or mixed land use portfolio. Interview schedules focussed on their agricultural management practices, and the various economic, cultural and ideological factors shaping their decision-making processes. As with the paper more generally, legumes were used as a lens through which more general issues of agricultural intensification and paradigm change were accessed and so, where appropriate, topics beyond the particular case of legume cropping were also covered.

Geographically, the research was confined to the counties of Gloucestershire, Herefordshire and Worcestershire. The area was selected as one with a coherent local agricultural identity, with many actors in the industry (contractors, agronomists) using the three counties to delimit their area of professional activity. This facilitated the snowball referral system and allowed for an in-depth snapshot of one specific agricultural region. The area is also one in which livestock, arable and mixed farming units are all well represented (Defra 2018). The strong arable potential of the area meant farmers could reflect on the (un)attractiveness embodied in different cropping practices, and the existence of a robust livestock sector meant there would also be potential for farmers to reflect on the plausibility of developing local or on-farm feed supply-chains.

Due to the element of control ceded with a snowball methodology, the geographical limits of the research method were not perfectly observed. This outcome was not perceived as problematic for the research, and those interviewees' contributions were used for the purpose of this analysis. All farmer interviewees have been anonymised with attributable references removed. Figure 2 shows this case study area, and the rough location of the three outliers.

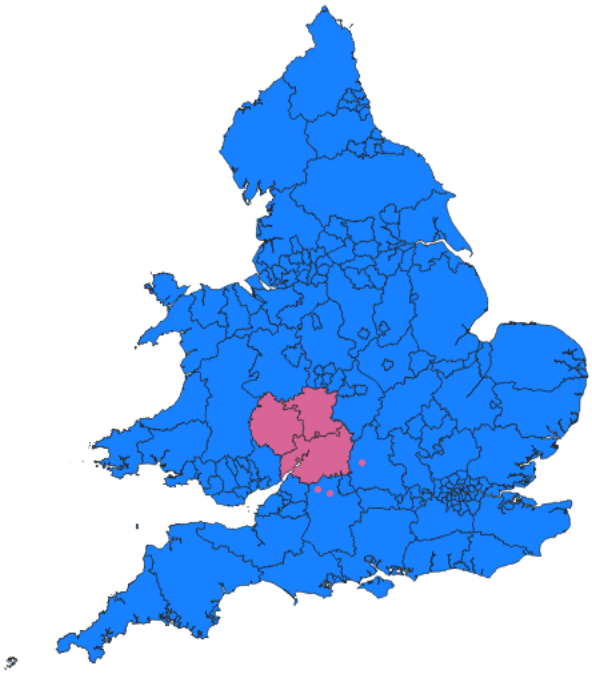

Figure 1 - Case study map

For the other interviewees, a more purposive methodology was employed. Where appropriate (agronomists, merchants) interviewees were restricted to the same three counties area as the farmer cohort. For others (industry bodies, agronomy researchers) the research was limited nationally. The spread of interviews was designed to capture those working at multiple different up-stream points in the industry, all of whom were able to speak to different aspects of cropping decisions. This included industry bodies (PGRO, Pulses UK), agronomists (from Hutchinson's), a seed merchant (Cotswold Seeds), a legume processor and general agricultural merchant (Askew and Barrett Pulses), a legume agronomy researcher (James Wallace of IAR), and two specialist organisations developing UK markets for legume crops, both of whom grew legumes commercially, contracted other farmers to grow legume crops and offered agronomic consultancy for their respective areas of expertise (Soya UK and Hodmedod's). The interview schedule focussed on the topics directly relevant to their area of expertise and activity, as well as a more general reflection on the topics of agricultural intensification, agricultural sustainability and crop rotations.

The methodology was approved by the research ethics board of the authors' University. For both groups of interviewees, the project details were discussed by phone and/or email, and their informed consent given ahead of each interview. The non-farming cohort of interviewees, whose names and affiliations are preserved in the write-up of the paper, were given editorial oversight over their respective contributions. Once collected, interviews were transcribed and subsequently analysed using the NVivo software package. The data analysis process was deductive, with a pre-determined set of nodes used to analyse target themes. These nodes were designed to reflect the MLP framework on which the paper is based.

In the sections that follow, we first review a set of macro-level changes in UK agriculture, before describing how these enable agroecological micro-level innovations to break-out and become established at the meso-level.

5.1 Macro-level changes

Our interviewees identified a range of changes that are occurring at the macro-level to reconfigure competitive conditions for legumes so that micro-level innovations might outperform incumbent approaches and overcome the lock-in that keeps meso-level regimes *in situ.* In the analysis that follows we group these under three thematic headings: i) subsidies and regulations; ii) research, knowledge and norms; and iii) consumer demand. These three themes roughly correspond to the three drivers that lock farmers into systems of simplified arable management, that were described in section 3.

Subsidies and regulations

The 2020 departure of the UK from the EU (Brexit) has opened political space for a new regime of agricultural subsidies, tariffs and regulations. One central plank of this regime is the Environmental Land Management Scheme (ELMS), which is set to redirect agricultural subsidies towards the provision of 'public goods' (Houses of Parliament 2019), including a range of environmental services such as biodiversity, soil health and GHG mitigation (Bateman and Balmford 2018). Anticipated changes to the subsidy regime are exerting their influence over farming attitudes and behaviours (Cusworth and Dodsworth 2021). Here

farmers were reflecting on and experimenting with the merits of different soil management and crop diversification practices. One farmer, for example, noted the advantages that his no-till and six-way rotation practices would have in a subsidy landscape that rewarded responsible carbon management:

> I'm hoping that when the ELMS is published, there is a whole raft of environmental measures encouraging long-term leys and carbon sequestration and all that. I'd be well up for it.

Lewis Cottey from Pulses UK spoke directly about how a quasi-market that internalises GHG externalities could offer a windfall for legume production:

> We talk a lot about the carbon offsetting. I think a good way would be to look at what the carbon cost of these products that we produce are. If you look at pulses, they require no artificial fertilisers and have a relatively low carbon balance compared to a lot of other commodities that are grown.

Likewise, James Wallace an agronomy researcher and consultant, explained that the:

> Inclusion of pulse crops in arable rotations provides a basis for a more sustainable system of farming through their nitrogen fixation. Pulse crops in the rotation can provide the public goods desired by government.

Interviewees reported how the pressure to consider the GHG implications of their farm practices extended beyond the specifics of post-Brexit agricultural policy design. Asked about the recent declaration by the UK National Farmers Union that British agriculture would be net-zero by 2040 (NFU 2020), one farmer made some broader predictions about the production and marketing of agricultural commodities:

> Everything's doable, you've just got to set your mind to it. We're looking at going into any new schemes to pay us [for reducing emissions]. I mean give it time and it'll be a marketing requirement – but we are already ticking that box.

Their predictions are well founded. A number of the largest buyers in the UK such as Arla (2019), Waitrose (2008) and Tesco (2019), have made high-profile announcements that their agricultural sourcing policies are being redesigned around emissions reductions and the delivery of environmental public goods. Participants noted how these anticipated shifts in agricultural subsidies and the governance of emissions are already reshaping the relative value of incumbent meso-level cropping practices and crop diversification techniques.

Other political interventions are having more targeted effects on the macro-level landscape within which different cropping practices compete. The 2013 ban on neonicotinoid dressings – motivated by their adverse effects on pollinators – has reduced the reliability of OSR, encouraging farmers to look elsewhere for a break-crop (Scott and Bilsborrow 2018). OSR is a highly productive crop, harvested for its oil for food processing and biofuels, and for its meal for use in feed products. OSR cropping has caused environmental concern for some time (Lane 1983) due to its GHG (Walter *et al.* 2015) and biodiversity impacts (Budge *et al.* 2015). It has become a central force in the short crop rotations that characterise intensive arable production: rape-wheat-wheat or rape-wheat-barley (Hilton *et al.* 2013, Sieling and Christen 2015, Meynard *et al.* 2013).

As a result of the neonicotinoid ban, OSR has become riskier and more vulnerable to disease. Mainstream agricultural media outlets have begun promoting legume cropping as a break-crop alternative (FWI 2020, Farmers Guardian 2020). This motivation was expressed keenly amongst interviewees after a cabbage stem flea beetle outbreak (the sort that previously permitted pesticide products would have protected against) destroyed the 2019 UK OSR crop (CPM 2020). When asked whether he had a legume crop, one farm manager explained that:

> We do this spring for the first time in a long time. Reason being is that we are struggling to grow OSR because of the ban on neonicotinoids.

Interventions such as the neonicotinoids ruling, the UK's ELM scheme and the EU's broader ambitions to reduce fertiliser and pesticide use by 50% by 2030 (European Commission 2020) can be understood as macro-level responses to the growing understanding of the negative environmental externalities associated with an input-dependent agricultural model.

Research, knowledge and norms

A second set of macro-level changes relate to three new research agendas that are emerging in response to an awareness of environmental crises and the need for more sustainable arable management techniques (Sherwood and Uphoff 2000, Beillouin *et al. 2019*). In the first there is a growing research interest in legume performance, protein crops, and crop diversification. Across Europe public funding is flowing towards projects dedicated to developing crop diversification practices (such as ReMIX), and legume performance (Legumes Translated, LEGVALUE, LegumePlus and LEGATO). In certain Member States these research projects are supported by targeted subsidies for protein crop cultivation (see the 2017 European Strategy for the Promotion of Protein Crops, for example), which has driven the rapid expansion of soya in Romania, Italy and Bulgaria in recent years. UK universities and industrial partners continue to participate in many of these research projects.

Second, UK agricultural research centres are refining crop diversification and other agroecological practices to reduce environmental impacts without foregoing productivity (e.g. MacLaren *et al.* 2019, Whitmore and Schroder 2007). Vanloqueren and Baret (2009 p.979) compare bibliometric values to demonstrate the primacy of agricultural research predicated around biotechnology and genetic engineering over those looking into agroecological methods. In using their same search terms but across a contemporary time period, we found that research developing agroecological farming methods has gained ground on the research using more technological solutions. Five times as many agroecological research articles were published during the 14 years from 2007-2020 as were published during 20-year window between 1987-2006 that they use. Interviewees evidenced how the environmental, agricultural and economic potential of these methods are becoming established in agricultural knowledge systems. They explained how intercropping, catch crops, and the use of interactions between crop varieties in sequential rotation are becoming accepted with multifunctional agricultural objectives in mind. For example, Sam Lane (from the seed merchants Cotswold Seeds) explains how:

> The cost of fertiliser is more a factor than it used to be and we're finding it in watercourses and all that sort of thing, where it was thrown about quite readily… farmers in the last ten years have started to question it, and have said, 'do we need to

> use as much or can we get away with a lower rate, so we can make a cost saving that way?' Or 'can we utilise legumes… to try and fix nitrogen for us?'

Restricting the nitrogen cycle to smaller territorial areas is an important lever in improving the sustainability of modern farming (Fields 2004, IDDRI 2018). Managers are being induced to reduce application rates through the use of leguminous nitrogen fixation and other break-crops like oats via the financial savings such practices represent for the farm.

Crop diversification is understood to offer other economic advantages for a farm business. In describing the rationale for having a wide crop rotation, leguminous cover crops and re-introducing livestock onto the farm for grass ley rotations one farmer interviewee explains that:

> We've always had some beans, some vining peas. It's part of our rotation. It helps reduce disease. Weed control's easier with different crops. Insect control, too.

Participants explained that these shifts run deeper than short term concerns with farm profitability, extending to long-term concerns around soil health: the third significant field of new research. For example, one farming interviewee describes his motivations for expanding his crop rotation:

> [It's about] trying to improve the soil … It needs to go back to old traditional farming because we've messed all the soils up with intensive agriculture… You can't solve everything with a can of something.

The growing research base and industry concern about soil health has driven a dramatic rise in the profile of sustainable soil management in the last ten years. The UN declared 2015 International Year of Soils (followed by 2016 as the Year of the Pulse). Defra's (2018) 'A Green Future' 25-year plan established dedicated targets for the uptake of sustainable soil management practices. Since 2017, the Farmers Weekly (the UK's largest farming news outlet) has been running annual 'Soil in Practice' conventions to spread knowledge and best practice across the sector. There is a growing awareness in the industry of the need to be attentive to soil management which has enabled the spread of communities of practice for soil (Krzywoszynska 2019a) even where such activities are not being adequately facilitated by government bodies (Ingram and Mills 2019). New groups, such as the Soil Care Network (started in 2017), Agricology (started in 2015) and the Farm Carbon Toolkit (started in 2009) have emerged as intermediaries between soil scientists and land managers. Numerous farmer-led groups have been created to spread ideas and experiences relating to sustainable soil management (Thomas *et al.* 2020).

Farmers' first-hand experiences with soil erosion (Boardman *et al*. 2017) and yield plateaus (FWI 2015, Krzywoszynska 2019b) has given the research on the links between soil health and land use intensity greater traction amongst farmers than research on other agri-environmental issues, like GHG emissions (Ricart *et al.* 2019, Hyland *et al*. 2015). As one farmed explained:

> There's more knowledge about how important the soil is. There's also a little bit of scaremongering, saying, 'In twenty years' time we won't be able to grow anything.' That's slightly bullshit, but it's got the people's attention, which is important.

Taken together these changes in attitudes and norms around soil health and arable management are part of the more general shift in agricultural values that is reported in the literature. Exposure to agri-environmental initiatives (Riley 2016, Cusworth 2020), the coupling of financial and environmental performance (Sutherland 2013, Cusworth and Dodsworth 2021), and the dissonance of being regarded as environmental polluters by the public (McGuire *et al*. 2013) have driven the integration of multifunctional objectives into farming identities. These changes are important in the context of this study as they place greater emphasis on the soil health and pest-control benefits of diverse rotations, on the cost of fertiliser relative to commodity prices, and on the profitability of having a legume crop in rotation.

Consumer demand

The exclusion of legumes from arable management is largely due to their poor yielding performance, and the low price they attract relative to their costs of production (Meynard *et al.* 2013). But there are emerging signs that macro-level changes in consumer demand might change their profitability. The UK market for plant-based products grew by 40% in 2019 to £816m (Mintel 2020), with one in four consumers regularly buying plant-based meat and dairy alternatives (AHDB 2018) due to ethical and environmental concerns (Jallinoja *et al.* 2019). There was a 13.5% year-on-year increase in the number of new products designed around plant-based proteins in Europe between 2007-17, with the UK as the single biggest contributor (Euvepro 2019). The changing composition of these products is also significant. In 2007, protein derived from peas and soy were in 1% and 29% of those products. By 2017, this had increased to 12% and 33% respectively – with much of that share being taken away from wheat and other cereals (Euvepro 2019). In Europe, these food marketing and food consumption trends are having upstream impacts on the viability of including legumes in more diverse crop rotations. As one farmer prosaically put it:

> You know, these vegans want something to eat, so the market's there!

This rising demand is also creating feedback loops upstream from the consumers in the practices of food marketing and food processing. Interviewees explained how macro-level societal anxieties around the links between food and environment damage are driving changes in the profitability of production practices and commodities for a farm business. Josiah Meldrum from Hodmedod's – a small company producing novel (lentils, chickpeas) and heritage (fava beans, peas) legumes in the UK – suggested that the emerging market for pea protein isolates in food processing may tempt more farmers into legume production. This market for fungible commodities will, importantly, also be better able to draw in farmers who do not have the ability to create the direct-to-market wholefood model he favours. Milan Shah from Pulses UK explained that the rising demand for plant-based proteins and legumes was also being propelled by other dietary shifts, including the growing popularity of gluten free ingredients. Legumes thus represent an intersection for those whose diets are being shaped by different allergenic, environmental and ethical concerns.

Participants' responses are supported by research investigating the potential application of legumes in health-food snacks, breads, flours, pastas and meat-analogue products. (Bousala *et al.* 2017, Boye *et al.* 2010, Noorfarahzilah *et al.* 2014). Roger Vickers of PGRO (the trade body for pulse and legume production in the UK) argued that it is versatility of legumes that represents the greatest opportunity for growing production:

> I think that the future is not in the consumption of whole peas. It will be something of a health-by-stealth issue and the constituent parts of peas or beans will be used in convenience food processing. You'll have the protein and starch and fibre being used as your raw ingredients as constituent parts in burgers or flours or milkshakes or whatever.

Agricultural market analyses from the US (Lakkakula *et al.* 2017), Europe (CBI 2019, Schneider 2002), and the UK (de Souza Monteiro *et al.* 2017) make healthy predictions for plant-based protein crops, and legume crops in particular. The global market for pea protein is, for example, expected to rise from $1bn in 2019 to $1.6bn in 2029 (Market Insider 2019). The diversity of marketing and processing opportunities manifest in legumes represent important macro-level shifts that stand to increase the economic viability of legume cropping for human consumption markets as a micro-level innovation.

5.2 Micro-scale changes

The multi-level account of transition suggests that although these macro-level shifts will reshape the competitive environment, incubated spaces are needed at the micro-level in which innovations can develop to change the meso-level status quo. In this section we identify three important examples of these incubating spaces in which cropping legumes and crop diversification strategies are being made competitive and attractive to potential upstream actors. We focus on the role played by: i) new companies; ii) benchmarking groups; and iii) regenerative agriculture groups.

New companies

Important innovations are coming from companies nurturing the development of crop varieties beyond those prevalent to intensive European arable management. One example is Hodmedod's, who have created an innovation niche for legumes. Josiah Meldum describes their work and reflects on the subsequent diffusion of their expertise:

> We work with a core of organic and regenerative farmers, but we're always keen to encourage any farmer that wants to effect change on their farm, to offer them a route to market that allows them to continue doing that positive work [diversifying with crop rotations]. Things have changed a lot in the last five years. One of the biggest farming landowners in the UK wants to talk to us about where their farming business is going over the next few years. And that's tens of thousands of hectares of land that we could potentially engage with [to grow the lentils, chickpeas and other novel crops].

Although the genetic development of new legume cultivars is outside of their technical, financial and ideological remit, Hodmedod's experience of sowing, cultivating and harvesting are improving the performance of their flagship crops. This expertise helps address the concerns of bigger agricultural players around soil health, crop rotations and input application rates, lowering the barriers to entry for other individuals wanting to diversify their crop rotations through novel legume crops. The story of Soya UK – a company set up to develop soya production, processing and marketing potential in the UK – offers a similar example. Dramatic rises in soya price have combined with developments in crop varieties more suited to the UK climate (the product of micro-level innovation through collaboration with plant breeders in Kiev). This is making the cultivation of soya a more

attractive prospect for other upstream actors, attracting the attention of farmers looking to diversify their rotations with a cropping legume. Taken together, these examples represent archetypal transitions in which macro-level changes permit an insulated innovation niche to disrupt the meso-level incumbent regime through buy-in from other actors in the system.

Benchmarking groups

Half of the farmers interviewed in the research were involved in a benchmarking group, a figure close to the national average. Benchmarking groups involve farmers gathering to make peer-to-peer comparisons and evaluations of their application rates, yields, and cropping practices. These groups typically originate in concerns around best business practice and farm profitability, but in benchmarking farm business performance, farmers may also find ways of enhancing their environmental performance (Dolman *et al.* 2014, Eip-agri 2017) as there are many instances where good business practice and good environmental management intersect (Lotjonon and Ollikainen 2017, Preissel *et al.* 2015). Farmer participation in benchmarking groups has grown rapidly in recent years, up from around a third in 2008 (FWI 2018) and a tenth in 2004 (Whitehead 2009, FCC 2007).

Research suggests that more established benchmarking groups offer good opportunities for members to fold in their own sustainability objectives, particularly where those efforts are remunerated through certification or agri-environment schemes, or where they have clear economic co-benefits (Jack 2009). Benchmarking groups become more ambitious as they become established: moving from single-issue crisis management (say, dealing with an endemic local pest) towards the development of a more coherent socio-political or environmental worldview and theory of change (Pretty and Ward 2001).

Our farming interviewees extend these findings in the context of crop diversification and legume cropping. Participants explained how an awareness of new subsidy regimes and concerns about long-term soil health and fertility are directing benchmarking activities towards crop diversification and minimising expensive inputs. For example, one farmer explained how his participation in a benchmarking group led him to plant a bean break-crop after critically interrogating the business sense of having an input-dependent oil seed rape crop:

> I mean OSR – very high risk, very high impact, with all the nitrogen, a lot of spray, all up front. Fast-forward and you get a beetle that'll eat the crops and you can't do anything about it. Why have that risk in your business?

While the benchmarking service used by another farmer combined measurements of soil organic matter, risk of soil erosion, soil fertility, yield, optimal input levels and profitability as a matter of course. He explained how a growing awareness of these metrics helped recalibrate his farm management:

> They analyse soil and provide a report at the end of the year detailing an extensive analysis of the soil, grain and the crop and marry it all together. You're talking about soil and rotations - it comes across as a soil health index. They measure organic matter, oxygen, how much soil microbial action, things like that…
>
> *So you can fine-tune what you're doing?*

> Yeah absolutely… they look at your soil and your other inputs and see whether there's any correlations between them and whether there are potential tweaks you can do to make it more efficient and more profitable for the future.

Benchmarking groups offer another example of a micro-scale innovation niche in which transformative practices are incubated such that they emerge as the macro-level context changes.

Regenerative agriculture

Growing concerns around soil health have driven the emergence of a network of micro-level innovation groups dedicated to growing the regenerative agriculture movement in the UK. Regenerative agriculture looks to repair soil health through the reinvigoration of the natural interactions between plants, animals and organisms on which crop growth relies (Rickards and Kearnes 2020) and to reduce inputs of agricultural pesticides and fertilisers (Burgess *et al.* 2019). Researchers are beginning to document the spread of bottom-up innovation and farmer-to-farmer knowledge exchange around soil care and other regenerative principles (Krzywoszynska 2019a, MacMillan and Benton 2014) – insights corroborated via private communications with individuals in the movement. Several of the farming interviewees spoke to these topics and were optimistic about the prominence regenerative agriculture might come to have in UK farming. One farmer, for example, explained how he was frustrated by the parochialism of his local benchmarking group and had very recently begun to engage with group of regenerative farmers online:

> Everyone [in the local benchmarking group] was obsessed with yield, which is basically pub talk. But I had a greater focus on margins… And a lot of these people on the [regenerative agriculture] forum, you can just pick the phone up and just speak to them, and they say "Yeah, come along to the farm."

Through his gradual interaction with these groups, which coincided with his taking managerial charge of the holding from his father, he transitioned his farm from a conventional arable operation to an articulation of his new regenerative ideals. Describing his crop rotation, he explains that:

> Legumes naturally fix nitrogen, so provide nitrogen for my following wheat. So, I'm getting off the artificial bandwagon there. We grow a lot of cover crops, so we'll grow six, seven, eight-way cover crops, just to get some variety into the soil.

Social media has come to play a key role in facilitating such farmer-to-farmer knowledge transfer, particularly in the context of soil management (Skaalsveen *et al.* 2020, Mills *et al.* 2019). The digital de-localisation of these groups enables new individuals to be brought into contact with regenerative agriculture and sustainable soil management principles, creating innovation niches in which the knowledge and experience of reconciling long-term soil health, productivity and financial viability are shared. As these groups become better attended, and as an increasingly large cohort of farmers contribute to their knowledge-exchange platforms, the competitivity and practicability of their management practices improve accordingly.

The economic rationale behind the growing numbers involved in regenerative agriculture (Kassam *et al.* 2009) and, relatedly, no-till management (Marandole et al 2019, Derpsch *et al.*

2010) are discussed elsewhere in the literature. An analysis of the messages in our participants' regenerative agriculture groups reveals an evenly spread emphasis on yield and sustainability. This focus on productivity and a less-than-puritanical approach to chemical inputs (where a reduction of inputs is sought rather than their total removal) marks a departure from similar food movements – like organics – that look to reject the logics of intensification and industrialisation more fully. Although organic management practices have been subject to a degree of mainstreaming (Sutherland 2013, Kjelsden and Ingemann 2010), the focus on profitability and yield may allow regenerative agricultural techniques to gain traction amongst a broader group of bigger or less politically engaged farmers.

6. The futures of agroecological break-out

We opened this paper with a short review of the *English Pastoral*. If we circle back, we can see how Rebanks' autobiography fits with the analysis we have offered in this paper. He traces the multiple drivers that locked him and his neighbours into an intensive, simplified and specialised agricultural model. Writing from the Cumbrian landscape, he identifies the negative social and environmental consequences of these changes; the blowback creating new imperatives to change agricultural practice. These imperatives are manifest in a range of macro-level political, economic and social changes, including new subsidy regimes, new research agendas, and shifts in consumer demand. Rebanks articulates anxieties in the industry about soil health and long-term farm profitability, which are destabilising the prevalent modern model premised on intensive management and minimal diversity. Revised calculations of farm business profitability are, in part, being shaped by a changing policy and subsidy structure predicated on the delivery of public goods and the tightening of agri-environmental regulations. Rebanks and his wife are a single farm incarnation of the type of micro-level innovation that is disrupting the status quo. Similar experiments are being incubated by private firms, publicly funded research consortia, farm benchmarking and farmer-to-farmer knowledge exchange groups. These actors nurture alternative approaches and facilitate the processes of agroecological break-out that challenge the incumbent meso-level regime.

To conclude, we reflect on the different trajectories that this break-out might follow and identify some of the tensions between the different redemptive visions of the agroecological English Pastoral that are coming into focus. Three central differences stand out. The first relates to the depth of ecological commitment future agricultural regimes might embody, and their different epistemological cultures. Duru *et al.* (2015) offer a conceptual framework for understanding agroecological transitions, sketching a typology of profiles that a transition might assume in response to political destabilisation. At one extreme they describe a light green regime of ecological modernisation based on green technology, input efficiencies, and regulatory compliance. At the other extreme is a deeper green, biodiversity-based model, based on a more profound integration of ecological principles into agricultural management.

The evidence provided by our empirical analysis cautiously suggests that UK agriculture is on a trajectory towards this latter model. Interest is being turned towards the integration of ecological principles into agricultural practice, with actors from across the food system recognising the importance of entangled, complex natural processes (especially in soils) that need to be cared for if food production is to remain politically and environmentally sustainable (Krzywoszynska 2019a). But the robustness of these agroecological principles remains unclear. Kearnes and Rickards (2020) have identified an epistemological ambiguity in the emerging regenerative agriculture movement – an ambiguity manifest in

agroecological movements more generally – that speaks to the different ways in which ecological principles might be integrated. They document how a holistic, even mystical, focus on environmental forces can be replaced by a modernistic and reductionist set of knowledge and management practices more amenable to the audit cultures of environmental reporting and the technological infrastructure of modern farming.

Conversations with the research participants reveal the speed with which this epistemological metamorphosis can take place. Whilst our interviewees were knowledgeable and motivated by the need to integrate ecological principles into their practice, they did so under the proviso that it would measurably improve farm profitability and/or their farm's natural capital. Modernistic epistemic practices have thus become an entry point for the adoption of agroecological practices, not an *a priori* incompatibility. These ways of knowing are particularly important in the context of the growing interest in market-based solutions to agri-environmental issues like climate change, biodiversity and water pollution (Lockie 2020), and the attendant need to demonstrate the additional environmental value that some financing has secured (McVittie *et al.* 2018). Does the dilution of agroecology's epistemological practice foreshadow (or even precipitate) an erosion of its ecological commitments? In the case of legumes, these different possibilities have direct implications. Whilst legumes might get enrolled in a more attentive and care-full agricultural regime, representative of the reinvigoration of traditional crop rotations and maligned food and feed stuffs, they might similarly get absorbed into an intensive agricultural model interested in ecological health only insofar as it tracks farm business performance or helps navigate to environmental regulation. The agricultural sector's proclivity for scale, fungible commodity goods, and tight profit margins could well combine with a political agenda increasingly focused on market-based solutions to environmental problems (carbon credits, ecosystem services, natural capital) to shape the plausibility of these alternate futures (cf. Oviatt 2019).

Second, trajectories for agroecological break-out differ according to the political and economic futures they enable. The light green future of ecological modernisation improves the environmental footprint of agriculture whilst largely preserving the political economic status quo. Here agroecological principles become mainstreamed in a food system characterised by a relatively small number of farmers, owning sizable land holdings, and dependent on high tech and highly automated production systems. They receive small margins, employ few people, and have limited contact with their distant consumers. Legumes become cheap and are sold as bulk commodities; generic protein that is to be incorporated into processed food stuffs, which are sold at a premium in supermarkets. Power in this future food system remains downstream of those producing the legumes, shared amongst marketers, processors and retailers. A contrasting political economy is offered by the deeper green trajectory. Here, the rise of more politically engaged food movements increases the power of the farmer by shortening supply chains and encouraging consumers to purchase whole food legumes over processed protein meat and dairy simulacra. This model of legume production-consumption requires more labour and thus creates more agricultural jobs, keeping people in rural communities. It offers a model of food sovereignty that shifts power in the food system to those at either end of the modern supply chain, helping producers and consumers achieve a more equitable distribution of the benefits of food and farming.

Both of these trajectories were envisioned by our interviewees. Some were optimistic about the food processing malleability of legumes ('health by stealth'), and their large-scale application in products targeted at consumers with different allergenic, environmental and health driven diets. For others, legumes' long-standing role in the UK food system grounded

compelling revivalist stories; gaining traction amongst producers who recognise them as familiar and uncontentious features of the agricultural landscape (most of the farming interviewees seemed to remember their grandfather planting a crop of peas), and consumers interested in ideas of tradition, locality and historicity. Legumes, in this light might function as a sort of 'boundary object' (Star and Griesemer 1989) between conservative farmers and those involved in radical food politics: a distinctly unnoteworthy and unradical entry-point into sustainable agroecological futures.

How such stories will compete with the well-resourced marketing campaigns of alternative protein companies like Impossible Foods, Huel and others producing products based on legume-derived proteins is unclear. Whilst there may be a growing market for whole-foods, farmers markets and direct-to-consumer enterprises (perhaps being amplified by the Covid pandemic (Cattivelli and Rusciano 2020)), it is the burgeoning market for processed vegetarian, vegan and/or gluten-free products we see as having a more determining influence on the uptake of legumes and the diversification of cropping regimes. Manufacturers and retailers of legume-based processed foods are already beginning to seize on stories of radical social and environmental change (Hippea, Perform, The Mighty Pea are some examples), but only insofar as they incrementally improve the environmental performance of upstream commodity production, rather than overhaul the food system more fully (cf Clay et al 2020). Insights from market reports, as well as anecdotal evidence from our research interviewees, indicate that the market for health, 'free-from' and convenience products using processed legumes have a greater potential to shape the agricultural sector over, say, the market for unprocessed beans, peas and other legumes. Whichever ends up having greater sway in the food system, it is clear that legumes are being enrolled into a wide (even conflicting) variety of modern/traditional, whole/unprocessed food futures (Cusworth *et al.* 2021).

Third and finally, there are tensions between the roles that are afforded livestock (and thus meat and dairy) in the different agroecological futures of the English pastoral. Livestock occupy a unique place in agroecological theory and practice (FAO 2018). They enable greater land use heterogeneity through the use of rotational grass-leys and the production of crops for animal feed. They are valued for the production of fertilising manure (Bonaudo *et al.* 2014). Some figure livestock as analogue keystone species that can replicate the ecological functions of creatures now extinct from temperate European landscapes such as the aurochs (cow), tarpan (horse), bison and boar (Lorimer 2020). In the context of more recent historical baselines, livestock, like those on Rebanks' farm, are seen as occupying an important role in traditional (and thus well-adjusted) mixed agricultural management (Ryschawy *et al.* 2013). Through their grazing, ground disturbance and excreta, the presence of livestock is also claimed to dramatically increase soil carbon sequestration (Rowntree *et al.* 2020). Agroecology thus creates a rationale for the continued and central role of livestock in the food system (FAO 2018). Amongst the interviewees, and in farming communities more generally (NFU Cymru 2020), there is excitement about the creation of a pro-environmental space for livestock agriculture. The valorisation of livestock, however, creates a tension between those that conceive of livestock as environmental allies, and those looking to minimise the presence of livestock due to their GHG emissions, water use, and land use inefficiencies. The emergence of a fledgling 'veganics' movement (vegan, organic) that deploys agroecological principles but without using livestock evidences the diverse trajectories this sort of contestation can create. We expect these tensions to become more visible as voices celebrating or decrying the positive or detrimental environmental impact of livestock farming continue to intensify.

There is, of course, no need for an agricultural transition, like the agroecological break-out we describe, to assume a singular profile or trajectory. The potential for an agricultural transition to follow divergent – even antithetical – pathways is well documented (Winter 2003, Dupuis and Goodman 2005, Lockie 2009). Even in the region that we studied in this paper, different farmers are integrating ecological principles into their practices to varying degrees and in different ways. It is clear that we are seeing diffracted and diffuse responses to the mounting evidence of crisis in the modern food system. Different actors at different points in food supply chain are being swept up in the same rupture or 'release' (Wakefield 2018); they are entering a creative 'back loop' – the release (Ω) and reorganisation (α) phases described in Figure 2, above - interrogating old frameworks, habits and priorities and refashioning new ones in the search for more appropriate systems. Consumers, food processors, policy makers, farmers, food marketers, food processors and researchers are responding to the injunction that the food system needs to be made more sustainable. In this messy and creative process, the resilience of the UK food system is emerging from an experimental and uncertain set of process that merit further social science enquiry.

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