Where did the marginal land go? Farmers perspectives on marginal land and its implications for adoption of dedicated energy crops

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Abstract

Dedicated energy crops such as miscanthus and short rotation coppice willow were expected by UK policy and academic modelling to be deployed across large swaths of UK marginal lands in response to farm and market level incentives, delivering on bioenergy policy objectives. Yet, this never materialised. This article examines a previously unanalysed component of this policy failure by comparing and contrasting policy and farmer perspectives on marginal land as a suitable site for energy crops.

Drawing on qualitative interviews with 32 livestock, arable and mixed farmers in England this research suggests that the policy framing of energy crops on marginal land to resolve sustainability controversies, was translated by the farming community into 'energy crops are *for* marginal land'. This acted as a multifaceted barrier to dedicated energy crops due to complex interactions between farmers' personal and cultural values, on-farm practices, technologies, regulations and market developments. Farmers, never considered their land marginal *enough*, consequently this policy framing invoked considerable resistance. This highlights the importance of embedding understandings of farmers' cultural values, on-farm practices, technological change, and tensions between different bodies of regulation when articulating new policy initiatives and the way in which policy narratives translate into practical settings.

Keywords

Farming, Attitudes, Marginal Land, Energy Crops, Bioenergy

Highlights

- Modelling marginal land as a static category doesn't reflect farmer understandings.
- Farmers proud of their land, do not consider it marginal *enough* for energy crops.
- Farmer identified marginal land considered marginal for energy crop cultivation.
- Emerging opportunities for energy crops due to rise in resistant weed species.
- Understand farmer values and on-farm realities to improve policy communication.

1 Introduction

Cultivating dedicated energy crops such as miscanthus and short rotation coppice willow on marginal land has been consistently cited as an attractive means of achieving sustainable bioenergy and lignocellulosic biofuels feedstock production in academic and policy literature in the UK. However, in many instances the expectation that dedicated energy crops would find a willing home on UK marginal lands has remained just that. Expectations put forward in UK policy (DEFRA, et al., 2007; HM Government, 2009; DECC, et al., 2012) and academic research (Haughton, et al., 2009; Lovett, et al., 2009; Turley, et al., 2010) identified considerable tracts of marginal land in the UK. Furthermore, policy modelling identified price thresholds at which dedicated energy crops were presumed to become highly lucrative for farmers (DEFRA, et al., 2007; DECC, et al., 2012). While the Energy Crops scheme (2000 – 2013), provided 50% establishment grants to reduce the high up-front establishment costs perceived to be a barrier to cultivation. With these farm level and market incentives in place, alongside expectations of large tracks of suitable land, energy crops were anticipated to undergo rapid expansion in numerous policy documents throughout the early 2000s (Biomass Task Force., 2005; DEFRA, et al., 2007; DECC, et al., 2012). In practice farmers have not planted significant quantities of miscanthus or SRC willow in the UK. Planted acreage has instead declined since 2009 from an already low base (DEFRA, 2013).

This raises the important question, why, despite a long period of dedicated farm level and market level incentives, alongside explicit policy support for energy crops and bioenergy, did energy crops fail to meet expectations. The limited array of social science research on dedicated energy crop adoption has, to date, primarily focused on on-farm experiences with the crops, and farmer attitudes to this new cropping system. In the process, they have highlighted practical on-farm barriers, economic barriers (Sherrington, et al., 2008; Sherrington & Moran, 2010; Convery, et al., 2012) and broader industry failures (Adams & Lindegaard, 2016) as underpinning farmer apathy to dedicated energy crops. This small body of literature provides a number of key insights; however, it has not examined an unstudied component for understanding the failure of dedicated energy crops. Farmer perspectives on marginal land, and its implications for their attitudes towards dedicated energy crops.

To answer this empirical question, the paper draws on literature from the sociology of modelling, which has explored, in a variety of contexts, the way in which modelling practices construct an inevitably selective reading of and gaze upon the world (Leach & Scoones, 2013; Morgan, 2009; Kruse, 2012). In particular, aiming to link these insights to a rich body of rural sociology that has focused on farmers values, behaviour, culture and practices (Burton, 2004; Burton, et al., 2008; Convery, et al., 2012; Morris & Potter, 1995) as a means of addressing a knowledge gap regarding farmer attitudes towards the concept of marginal land in the context of understanding (non)adoption of dedicated energy crops in the UK. Following this work, the analysis examines farmer values, practices, and perspectives towards energy crops but shifts focus to place emphasis on examining the disjuncture between marginal land as outlined in policy and academic modelling, and on-farm understandings, opposed to just focusing on the energy crops per se. This is an understudied area of social science research regarding energy crops specifically, and how farmers value land more broadly, and the implications this has for land use and management decisions.

Previous work specifically on marginal land has focused on examining policy assumptions (Shortall, 2013) or has focused on marginal land in the global south. Much of this work has highlighted the implicit value-based assumptions within formal policy land categorisations (Borras Jr & Franco, 2010; Franco, et al., 2010). Although adopting different approaches they touch upon the distance between abstract policy categorisations of land and on ground realities. This paper explicitly examines these realities in the context of UK farmers.

Drawing on 32 qualitative seated and farm walk style interviews with arable, mixed and livestock farmers from the North West, Humberside and East Midlands conducted in 2012-2013 the analysis will highlight three key themes. Firstly, that farmers have considerable pride in their land holding which impacts on its use and management. Second, marginal land was deemed marginal by farmers, and thus its uses inflexible. Third, land quality emerges from complex arrangements of on-farm practices, regulations and relationships with other farmers and contractors. The article will examine the implications for energy crops of each of these themes in turn. Finally, this article will examine how these findings are important for future modelling and policy engaging with land management and use.

2 Marginal land: Policy Origins

The contemporary discussion on using marginal land to grow perennial energy crops for bioenergy and lignocellulosic biofuels is the most current point in a long and shifting history of debate about how to utilise marginal lands to solve socio-economic or environmental conundrums. The establishment of the Forestry Commission to co-ordinate domestic timber production following the First World War would eventually result in large quantities of the uplands and marginal land being converted to coniferous plantations (Forestry Commission, 2015). However, post-Second World War experiences with prolonged rationing meant marginal land was later called upon to provide more than just timber but cattle and sheep (Ellison, 1953). This suggests long-standing tensions over using marginal land and competition between forestry and agricultural uses. Additionally, the use of marginal land for growing perennial crops utilised in energy systems is not a particularly novel one. In the 1980s, McElroy and Dawson (1986) discussed the potential to use marginal land in Ireland for growing short rotation coppice to fuel rural bioenergy facilities and possibly lignocellulosic ethanol production. Although this potential did not come to fruition. The multitude of possible uses of so called marginal land is suggestive of the elastic nature of marginal land as a concept (HM Government, 2009).

Using marginal land to meet government objectives received renewed impetus with the publication of the Gallagher Review (RFA, 2008). Again, in the context of biofuels, but unlike the earlier work of McElroy and Dawson (1986) who focused on lignocellulosic fuels, in response to concerns over the indirect impacts of first generation biofuels. As the report notes, policy must ensure "agricultural expansion to produce biofuel feedstock is directed towards suitable idle or marginal land ..." (RFA, 2008, p. 7). This claim tackles the problem of potential negative consequences from land use change, due to expansion of cropping, or the use of prime existing agricultural lands for energy (Nuffield Council on Bioethics, 2011), through shifting policy attention to the prospects of utilising underused, marginal or perhaps spare lands. The use of marginal land was not however limited solely to meeting the needs of first generation biofuels. Marginal lands became a key site onto which anticipated future dedicated energy crops for lignocellulosic biofuels and bioenergy would be grown more broadly (see HM Government, 2009)

These claims have not been without detractors, with authors such as Booth et al. (2009, p. 113) arguing "The basic premise recommended by the Gallagher Review, that biofuel crop production should be segmented to appropriate idle or marginal land, is unlikely to stand up as a viable option when put to close scrutiny". Likewise, the premise of the Gallagher Review also signals a shift from early policy documents. Most notably the Royal Commission for Environmental Pollution (Royal Commission for Environmental Pollution, 2004) report, *Biomass as a Renewable Resource* which noted that energy crops grown on "the lowest quality land … could also result in reduced yields." (p.

11). Here marginal land is a problem impeding high yields (Shortall, 2013). However, the claims made within the Gallagher Review have taken a position of prominence. This was most notable in the UK Renewable Energy Strategy (HM Government, 2009) in which marginal land was claimed to reduce food versus fuel conflict risk and negative environmental consequences of greenhouse gas emissions due to indirect or direct land use change. However, simply stating the providence of using marginal land is insufficient. Its potential availability, location and thus the attainability of using marginal land requires further work mapping out this marginal land.

3 Mapping Marginal Land: Assumptions and Expectations

In the context of UK energy policy, Shortall (2013) conducted a study that aimed to tease out the embedded assumptions relating to the framing of marginal land. This identified three main policy framings: first, land unsuitable for food production; second, ambiguously defined lower quality land; and third, economically marginal land. For Shortall (2013), the first two definitions relate to lower quality agricultural land that is not suitable for food production. Several normative assumptions are contained within this definition. Principal among these assumptions is that a significant amount of marginal land is available for productive cultivation and that energy crops can be targeted to this land. Modelling has been an important aspect in legitimising these assumptions. The third definition, economically marginal land, defines the marginality of land on the basis of its break-even economic margin (Turley et al, 2010). This break-even point is contingent on the set of dominant agricultural practices and market conditions within which the land is utilised. Many of these assumptions are implicitly and explicitly embedded within the modelling efforts informing UK policy on energy crops and marginal land.

Mapping studies such as Haughton et al. (2009), Lovett et al. (2009), conducted as part of the RELU programme, and Turley et al. (2010), directly commissioned by DECC and undertaken by the Food and Environment Research Agency[1] (FERA) in conjunction with ADAS (see DEFRA, 2009) have been highly influential, informing policy (such as HM Government, 2009) and later modelling with regards to marginal land in the UK (such as Smith, et al., 2014). These studies aim to define marginal land from a cartographic perspective and utilise geographic information systems (GIS) mapping to determine the spatial availability of marginal land for energy crops.

The nature of this approach gives justifiable prominence to biophysical categories that are deemed important in determining land quality, and can be displayed in the form of a map. A consistent indicator drawn upon to facilitate the task of assessing the marginality of land is the Agricultural Land Classification (ALC) scheme which ranks land based on its productive capacity for cropping which is then reproduced in a map format. Grades 1 to 3a are considered the most valuable and versatile lands whilst Grades 3b to 5 are considered moderate to very poor (Natural England, 2012). It is this later group of grades 3b to 5 that are usually considered of marginal quality. However, the ALC scheme frames land as a productive resource for crops. Prime arable land is synonymous with quality land in this definition. This obscures the many uses for land in agricultural systems which will be detailed later in this paper.

With this as a starting point, land is then excluded on the basis of eleven ‘planting constraints’. Whilst this terminology conjures up assumptions regarding biophysical and practical constraints on cultivation it includes a number of ‘social’ (i.e., culturally important and/or legally protected landscapes) factors. These relate mainly to the aesthetic impact of growing new crops (particularly miscanthus) in certain landscapes (Turley et al, 2010) and the perception of public resistance being generated by energy crops disrupting these landscapes. This framing means that the exclusion criteria developed by Lovett et al. (2009) (and used by Turley et al. 2010) focuses primarily on legally protected cultural heritage landscapes (ancient monuments etc.), Areas of Outstanding Natural Beauty (AONBs) and National Parks

[1] FERA is an executive research agency of DEFRA.

The final set of assumptions relates to the way in which barriers are formulated on the basis of these mapping activities. Turley et al. (2010, p. 7) note that “the area identified represents the maximum possible area; the actual area available will depend on policy developments, economic circumstances, social trends, ecological factors, and logistical limitations and is likely to be much smaller”. Policy development relates to the uncertainty surrounding continued fiscal support provided directly to dedicated crops and the biofuel/bioenergy sector, economic considerations relate to farm-gate prices of energy crops versus alternative cultivations, whereas ecological factors and logistical limitations deal with the biophysical properties of the land, its slope, nutritional properties, water availability, climate, distance to infrastructure and end users. This ignores the numerous interactions and relations that are important in the creation of on-farm barriers to adoption such as historically rooted trajectories of farm development, the maximisation of existing farm enterprises to the land holding, and the practices and values that inform how land is valued by farmers which will be explored in this paper.

These mapping exercises create a situation in which a seemingly dormant resource, ‘marginal land’, is poised for exploitation to deliver beneficial outcomes without the negative consequences associated with first generation biofuels. This leaves further work to be done in the form of modelling how this marginal land will be unlocked and barriers to energy crop cultivation overcome. An activity undertaken elsewhere in policy, for instance the UK Bioenergy Strategy (DECC, et al., 2012) which expects significant uptake of SRC willow (between 0.93 and 2.42 Mha) and miscanthus (between 0.72 and 2.80 Mha) if gross margins on the crops reach £241/ha and £526/ha respectively.

In summation key assumptions within policy and policy modelling are as follows. Land quality is characterised by its biophysical properties. Quality is synonymous with its suitability to arable agricultural practices. On-farm barriers relate primarily to logistical and economic constraints. Cultural and heritage considerations shape suitability of land. These assumptions will be compared and contrasted with the findings of farmer interviews in section 5.

4 Methodology

Famers were sampled and contacted through the use of the Yellow Pages. The Yellow Pages has been used previously in farm surveys as a means of sampling participants (see Morris & Potter, 1995; Holloway & Ilbery, 1996; Morris, et al., 2000; Tsouvalis, et al., 2000) and accessing farmer contact information (see Warren, et al., 2016). Nonetheless it is not without criticism. Burton and Wilson (1999) argue that it favours the identification of commercially driven farms as well as more established farming families, excluding less-commercial or 'life-style' farmers. In the context of producing a representative sample of the farming community this was deemed potentially problematic (Burton and Wilson, 1999). This study was primarily aimed at accessing commercial farmers. In this context the Yellow Pages was justified due to its accessibility, the ability to use postcode searches and no financial barrier to entry.

Given the large potential participant pool arising from the UK farming community the sampling strategy was narrowed to three geographical areas the selection of which is justified below. The use of geographical boundaries as a means of bounding the study and ensuring a more manageable quantity of potential participants has been widely used within the agricultural studies literature. The areas chosen below were selected on the basis of their proximity to existing or expected biofuel and bioenergy production infrastructure, the convenience of accessing farmers in these areas, and that these areas were assumed to be suitable for the adoption of the new technologies and practices under study. In light of these considerations the following three areas were chosen from which to sample farmers: Humberside, Cambridgeshire and Lancashire.

Humberside and Cambridgeshire were chosen due to the placement of a first-generation biofuel and a bioenergy facility, respectively within these counties. Lancashire was chosen due to the geographic concentration of grade 3b-5 land which is considered to be marginal in UK bioenergy modelling and policy.

The choice of these three geographic areas was combined with the participant search strategy through the use of post code searches within the Yellow Pages database of farmers in the selected areas. Initial searches identified over 1500 potential addresses. 150 farmers were selected from a master lists of farm addresses identified in a postcode search by using a random number generator on a calculator. This totalled 50 farmers for each area.

32 farmers responded positively to the request for interview. Of the farmer's interviewed, 14 operated livestock enterprises, 14 arable and four mixed.

Interviews were analysed through thematic analysis of the interview notes and transcribed interviews. This provided a flexible means of analysis, enabling a qualitatively rich and detailed account of the data (Braun & Clarke, 2006). Themes, a specific set of patterns within the data, can refer to something that is directly observable, repetition of a topic, or something implicit and requires interpretative analysis into the meanings and values within the data (Joffe & Yardley, 2004). However, thematic analysis has no agreed upon protocols (Braun & Clarke, 2006; Bryman, 2012; Vaismoradi, et al., 2013). The following section therefore outlines how thematic analysis was applied in the context of this article.

Each transcript was given an initial pass which identified key themes in each interview, coding important sections of text. An initial list of codes and quotes was consolidated through amalgamation of thematically similar codes and removal of repetition. The transcripts were then given a second read to ensure that the new coding captured the content and emphasis of the selected quotes. Each code document consisted of a number of quotes linked to each code and short analysis notes. This article focuses only on those relevant to the topic of marginal land and energy crops. The results of this analysis are presented below.

5 Results and Analysis

5.1 Marginal land, a solution and a barrier

Food versus fuel was a central reference point for farmers discussing marginal land. Flowing from this, farmers overwhelmingly agreed with policy framings that energy crops on marginal land was suitable solution to food versus fuel conflicts and land use change concerns. This agreement was based on their own prioritisations of how land should be used. Good land should be prioritised for food, whereas the use of poor land for growing biofuel and bioenergy products was less of a problem. This is highlighted in the following quotes drawn from farmers operating livestock, mixed and arable enterprises respectively:

> L02: … if it is good land then it's for producing food.
>
> …
>
> A02: using a bi-product is one thing, but when you actually put grade 1 and grade 2 aside [for] non-food crops … it's not something that you want to erm, probably rush into.
>
> …
>
> M04: I don't agree with this … you know land, good farming [land] out of production to go into energy.

This is initially suggestive that the framing of marginal land as a site for energy crops finds certain synergies with how farmers value land. Amongst a small number of the farmers, the objection to the use of good agricultural land for energy crops was linked to the suitability or desirability of cultivating marginal or poor land in its stead. An arable farmer highlights this linkage:

> A08: I am a bit against producing biofuels and things off good land that can feed people, if they can … make use of poor land well that's fine … that's a sensible thing to do …

However, the definition of marginal land was often left ambiguous in the context of this discussion about shifting energy feedstocks from 'good' to 'poor' land. A major implication of the connection between energy crops, particularly willow, and marginal land was that farmers persistently framed energy crops as specifically *for* marginal land, as follows:

RH: Have you ever considered dedicated energy crops at all ... miscanthus or short rotation willow?

A03: No I haven't, as I say, all our land is in decent twig[2] and you can only be doing that for land that isn't very good for productivity really.

…

RH: [I]s there much information provided on miscanthus and SRC willow?

A05: No … I don't have any of my guys interested in that basically because we are not on marginal land …

Although farmers favoured the use of poor land for energy crops in general terms, in the context of their own farms this became a major barrier.

Farmers take understandable pride in their land and its management in existing systems. Consequently, this translates into farmers never considering *their* land to be sufficiently marginal to justify energy crops.

A09: It never struck me as fitting our farming systems; it's all such good arable land it seems such a shame to grow second rate crops really.

Energy crops being suitable for poorer land, rather than being a source of attraction mean farmers consider the crops to be second rate. Equally, this was not something restricted to arable farmers. As previously noted Grade 3b to 5 lands are categorised in modelling as marginal land. These grades capture most of the UK's permanent and temporary improved and unimproved grasslands. Although

[2] Twig is understood as meaning condition

in the ALC quality is synonymous with arable land, the managers and owners of this land were no less proud of their land and its quality than arable farmers, framing it as prime grassland.

RH: So have you ever considered erm, growing any energy crops at all?

L05ii: But that one tends to be a crop for poorer land doesn't it, and we haven't got any poor land, it's all.

L05i: Well it would grow willow.

L05ii: Anything will grow willow but you don't put willow on stuff like this.

Therefore, whilst all farmers consider some of their land to be of poorer quality than other parts of the holding, in all but one interview where the farmer had considered growing energy crops, it was never marginal *enough.* This acted as a means to justify why these crops would not be grown on the farm, despite considering poorer land as a suitable site for energy crops. In summary, although supportive of the use of marginal land for energy crops, land suitable for this use was routinely externalised outside their own holdings. When situated within the context of the farmer's values and connection to their land, 'marginal land for energy crops' caused significant resistance to adoption.

Important to understanding this is the symbolic value attached to land by farmers. As Burton (Burton, 2004; Burton, et al., 2008; Burton, 2012) notes, the look of crops and land conveys symbolic value, communicating to the wider farming community the quality of the land holding and importantly the farmer's skill in managing it. It is notable that during farm walks farmers consistently showed the parts of the farm they were most proud of, whilst on numerous occasions literally pointing to poorer fields, for instance with a more prolific weed problem from afar.

A01: This is the best. I have brought you to my best field

…

A02: I am not going to show you my black grass.

It is therefore important to reflect on the symbolic implications of growing an energy crop particularly when they are routinely framed as being for marginal land. The unwritten subtext to this is that by growing these crops the farmer is admitting that their land is itself second rate.

5.2 Marginal land is marginal

In contrast to policy claims that marginal land is a suitable and attractive site for energy crops, where it was identified during farm interviews, farmers more closely reflected the earlier concerns of the RCEP (2004). Several noted that cultivation on marginal land had the potential to deliver marginal yields and therefore poor returns. The anticipation of poor returns was not the only major concern. Cultivating marginal land was faced with a number of difficulties, for instance its steepness or propensity to flood or become waterlogged. Heavier clay soils were most likely to be implicated, as was the case for two farmers, the first an arable farmer, the second a livestock farmer:

A07: … if I had a go it would be right down at the bottom corner of the farm where it is a little bit prone … [to] flooding, very heavy land I think I would struggle to get it started off, once you got it going it would be OK. A good year you know you'd probably get it established whereas nine times out of ten you would have a big bare patch same as what there is now you know.

…

L04: No no, we haven't, basically I wouldn't, our land is very heavy clay land and if you were to start running about it on big machines then you are going to make an awful mess of the land, so it's a non-starter on here. … a lot of the fields are quite undulating, so it is not easy to plough.

These cases represent how marginal land exists as an on-farm reality, not as a malleable resource but as difficult or risky to manage in the ways required for establishing energy crops. Complications that are not guaranteed to be captured by mapping. The quote from A07 documents land that was high quality land, cultivated as part of a larger field producing combinable crops. But was considered by the farmer as marginal due to persistent flooding and therefore a high risk of crop failure. This risk remained and was not negated by energy crops. L04 is referring to permanent grassland, which would fall into marginal land as a modelled category. Although suitable for livestock grazing, in this case sheep and a small beef suckler herd, the soil type and land topography meant this land was marginal for crop cultivation and deemed unsuitable for energy crops. In both these cases marginal land is not made more viable through energy crop production. Furthermore, modelling these logistical barriers as price negotiable obscures the risk and work that would be required to establish the crops on these particular sites.

5.3 Absence of spare land

The notion that land is spare or otherwise idle was entirely absent from farmers' discussion of land and the land market in their area. Indeed, the opposite was consistently expressed, particularly in the North West amongst livestock farmers. In these circumstances land was already firmly embedded within existing management regimes and the farm enterprise had been maximised around the restraints of the available land. The notion of land being taken up for energy crops would therefore require a reconfiguration of the farm enterprise. The following quotes are all from livestock farmers asked if they had ever considered planting energy crops on their land:

> L12: No cause we do not have the land, we only have enough land to be able to keep the animals that we have got so it's just a waste of time even thinking, contemplating anything else, wouldn't be so bad if we had lots of land and thought we could do a bit of that and a bit of that but we haven't.

…

> L11: No, no, no, no, you mean taking some land up? As I said before we needed the land to feed the cows.

…

L02: … we haven’t enough land available to turn into any of these energy crops.

The response from L11 was particularly memorable due to the incredulous look on the farmer’s face at the suggestion of taking up land for something that did not feed directly into the dairy and calf rearing enterprise. However, this was not restricted to livestock farmers. Arable farmers also maximised their current cropping activities on their land holding, although this was sometimes disrupted:

A07: 534 acres, there is about 524 that goes through the combine. We grow two wheats, barley and then rape and the little bit missing this time is because of wet weather [flooding had left a part of a field originally sown with wheat fallow] and we’ve an electric cable going across the farm [requiring significant works rendering some land unworkable until the construction was finished].

Therefore, the notion of spare land was entirely absent from interviews. Furthermore, it is also absent from discussions of land in the wider farming literature. The rise in land rental values and purchase prices is suggestive of a highly competitive market for land both for agricultural and non-agricultural uses, although as of 2016 this has started to subside (Daneshkhu, 2016). This is likely indicative of a mature land market and agricultural system which was noted by Booth et al. (2009) to be the main cause for questioning assumptions about availability of marginal lands.

5.4 Producing land quality

The technical assessment of marginal land contained within the modelling and policy literature obscures the way in which marginal land as an on-farm category is produced through the interaction of numerous factors. Although these factors are often related to physical characteristics of the land - its steepness, soil type, and propensity to flood - how that land is made marginal requires encounters with other policies, such as set-aside, as well as technologies and practices. It is through the frictions that occur during these convergences that land is made marginal in certain instances. The consequence is that lands which may have previously been economically and practically viable to cultivate is made marginal under a number of evolving conditions. Upgrades to machinery being a recurring theme.

> A03: We've got [a bit of land] that is just plenty steep enough to farm, … That's been aggravated because I got a bigger sprayer two years ago and its dodgy on the hillside. [the land is cultivated for wheat and the farmer is considering an alternative venture, Christmas trees]

> A05: … we have taken [land] out of production for ELS [Entry Level Stewardship scheme] and such because we have been aware of buffer zones for water courses but these have been areas where they are difficult to get vehicles in.

In these instances, the trend for large farm machinery means that certain parts of fields are no longer accessible, or in the case of A03, safe to cultivate. This follows from a general trend towards increased economies of scale and larger machines. For example, the Claas Protector combine harvester produced between 1968 to 1972 had a header width of between 2.6m and 3m depending on the header variant (Harvestop, 2014i). In comparison, the Claas Lexion 740, the smallest of the Lexion series currently in production, has a header width of between 7.5m and 9m (Harvestop, 2014ii). This is to say nothing of the changes to the tractor in terms of increased size and horsepower which has implications for the size of tractor led machinery that can now be operated.

The increased capacity and output of machinery comes with additional cost and time implications relating to its set up and running requirements. As one farmer noted, this meant that smaller fields were not commercially viable to cultivate with crops, not because they could not grow a good crop but because the cost and time involved in harvesting was now prohibitive:

A05: Combines are a high capacity machine and we have like a one and a half acre paddock, by the time we have put the header on, driven round the outside and taken it off again, it's half a day gone and it's not cost effective.

Previously, these pressures have favoured a trend towards large field sizes and larger farms (DEFRA, 2012) due to the requirement to achieve certain economies of scale to produce the conditions in which new larger machines become efficient. Despite regional variations (linked to specialisation), increased average field size has been an enduring development of post-war agricultural change. For example, between 1945 and 1994, in pastoral areas such as Somerset, field size increased from 5.5ha to 9.5 ha. During the same timeframe, in areas such as Cambridgeshire where arable specialisation diminished requirements for boundaries to secure livestock, field size expanded from 6.5ha to 16ha (Robinson & Sutherland, 2002). However, emerging landscape and environmental concerns regarding the rapid loss of hedgerows, saw the inception of hedgerow regulations in 1997, creating new barriers to boundary removal (Natural England, 2014) and this trend has been arrested with field size and boundaries having stabilised (Gallent, et al., 2015).

The field referred to by A05 was bounded by a hedgerow. Although this was not explicitly mentioned as *the* reason for maintaining the field, hedgerow regulations have in many cases removed the capacity of farmers to easily merge these fields into larger land parcels and this was likely a factor. In these instances, marginal land is produced through the everchanging encounters between a field, the machinery required to manage it and government regulation. Consequently, in this example a small field has become economically marginal to cultivate and harvest as the core enterprise has moved towards greater economies of scale.

This may provide a window of opportunity for energy crops. With smaller fields marginalised within the context of the core farm enterprise it creates room for energy crops to be cultivated on these smaller fields. A low input crop that sidesteps the cost-prohibitive nature of managing a smaller area might become attractive in this context, although, it would still rely upon appropriately sized machinery to ensure cultivation is practically and economically worthwhile.

Additionally, a potentially significant and emerging means through which land is made economically marginal relates to pesticide resistant weeds such as blackgrass which is an arable weed species increasingly difficult to control through chemical means (HGCA & AHDB, 2014). Several farmers, discussed blackgrass as a major challenge to continuing commercially viable cultivation of land with annual crops such as wheat, OSR and barley. Blackgrass can have a significant impact on yield whilst also contaminating the harvested crop leading to buyer rejections. Problems controlling grass weed populations were an emerging factor influencing some farmers to explore alternative production methods and crops as combinable crops became economically marginal. In these contexts, Miscanthus or SRC willow might offer a viable means of controlling blackgrass given its vigour and height, although whether these developments spurs adoption is yet to be seen.

Therefore, marginal land is not a static on-farm category and might shift once more to viability depending on future changes to practices or on farm technologies.

5.5 Marginalising energy crops

Farmers often positioned energy crops as distracting from the core enterprise and thus being marginal to the trajectory of the farm business. Many of the interviewed farmers when asked about planting energy crops preferred the idea of a small area as a test plot, but this is not without implications. This downside relates to the feasibility of only putting a small portion of the farm into a new venture. Economically and practically, the cultivation of a small portion of the farm in a different way might undermine the core enterprise, especially if it causes redundancy of existing farm infrastructure, diminishes the value of sunk investments, changes the configuration of the farm or crop rotations, and causing disruptions to current management regimes.

An additional consideration is that on farm marginal land is often embedded into existing systems of farm management and revenue creation. The most repeated example of this observed during the farm walks was the now replaced ELS agri-environmental scheme[3]. In this way, small parcels of marginal land scattered around the farm can be made productive through enrolment in government schemes which are often tailored to ensure minimal disruption to the main farm enterprise.

Furthermore, larger plots of marginal land, particularly in the context of conventional arable cultivation, saw preferred uses that involved the development of more flexible alternative enterprise, often through relationships with other farmers. Alternatives observed during the interviews and farm walks included small livestock enterprises, rental to the equine trade or neighbouring farmers, production of hay for pet and equine markets, and an off-road motorbike course. As of 2014, roughly 55% of the UK agricultural area was within voluntary agri-environmental schemes (DEFRA, 2014i), whilst nationally 57% of farms have diversified their activities in some way to provide additional economic opportunities (NFU, 2015).

Therefore, the deployment of energy crops on a farm's marginal land might disrupt existing uses that are produced through the ability of farmers to connect their land into a range of different regulatory, agricultural and non-agricultural options for use. Dedicated energy crops may be attractive from the energy production perspective, offering opportunities for larger production scales at greater geographic densities than equivalent residues for instance. But in the context of any one farm energy crops were likely to be a marginal component of the business.

6 Conclusion and Policy Implications

The academic and UK policy modelling that aims to elucidate the availability of marginal land for bioenergy policy requirements has been based on cartographic exercises that has placed mappable biophysical properties and social factors such as National Parks, as the key factors influencing the

[3] During the time period within which interviews were conducted the ELS scheme was in a process of transition towards being replaced by a new Countryside Stewardship scheme. This process appears to be causing significant resistance from the farming community at present with reduced uptake. However, given that the previous ELS scheme had many agri-environmental options that required only small plots of land or interventions that were at the margins of intensive systems, it is unlikely to translate into significant opportunities for energy crops.

identification of marginal land available for energy crops. This paper highlights the frailty of static understandings of marginal land, and the disjuncture between modelling approaches and on-farm understandings of marginal land. Future modelling approaches must therefore be cognisant of these alternative understandings and their implications on model construction and its findings.

Static definitions of land do not reflect its real-world management by farmers. The evidence presented has demonstrated that on-farm conceptions of marginal land are fluid and subject to change as the farm enterprise, infrastructure and machinery change over time, as well as practical problems with resistance. These evolutions hold the possibility of making land marginal or conversely improving agricultural output. Notable practices influencing this are the upgrading of machinery in scale, and the development of resistance problems amongst important weed species.

Furthermore, the previous work that has aimed to examine the practical, economic and cultural barriers to dedicated energy crop deployment by farmers has not engaged with the concept of marginal land as a multifaceted barrier to dedicated energy crops. The novel findings presented in the article demonstrate the complex nature of interactions between farmers cultural values and perspectives, on-farm practices, technologies, regulations and market developments. These findings therefore add to the understandings of energy crop policy failure in the UK. In particular, as this paper has shown, a policy framing of energy crops on marginal land to resolve sustainability controversies, was translated by the farming community into ‘energy crops are *for* marginal land’. Farmers, never considered their land marginal *enough*, consequently this policy framing invoked considerable resistance. This is as much an issue of communication as of misunderstanding. This highlights the importance of embedding understandings of farmers cultural values when articulating policy initiatives and the way in which policy narratives translate into practical settings.

From a bioenergy policy and industry perspective, this paper identified two main requirements. Firstly, ensuring that food and energy policies align with farmer understandings and values regarding their land and its use. Otherwise, envisaged policy futures and the way they frame particular resources, will not resonate with key stakeholders. As presented here, this disjuncture between academic and policy understandings of marginal land and farmer values and understandings has generated unnecessary resistance to energy crops. Secondly, policy needs to consider energy crops as just one of many existing and established land use choices. Farmers have a large number of options, many tried and tested, with which to utilise their marginal land. Thirdly, marginal land is not static and therefore emerging situations, such as blackgrass resistance, may produce future opportunities for energy crop establishment, particularly if crops are positioned and can be shown to be a means of managing blackgrass whilst generating income. There is a policy and industry role to be played in facilitating these changes to how energy crops are framed and presented to the farming community.

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