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"Marginal land" for energy crops: Exploring definitions and embedded assumptions

O.K. Shortall [a,b,*]

[a] Centre for Applied Bioethics, University of Nottingham, Sutton Bonington Campus Loughborough, Leics LE12 5RD, United Kingdom
[b] Danish Centre for Bioethics and Risk Assessment, University of Copenhagen, Rolighedsvej 25, 1958 Frederiksberg C, Denmark

HIGHLIGHTS

- Qualitative methods were used to explore definitions of the term "marginal land".
- Three definitions were identified.
- Two definitions focus on overcoming biomass land use controversies.
- One definition predicts what land will be used for growing biomass.
- Definitions contain problematic assumptions.

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ABSTRACT

The idea of using less productive or "marginal land" for energy crops is promoted as a way to overcome the previous land use controversies faced by biofuels. It is argued that marginal land use would not compete with food production, is widely available and would incur fewer environmental impacts. This term is notoriously vague however, as are the details of how marginal land use for energy crops would work in practice.

This paper explores definitions of the term "marginal land" in academic, consultancy, NGO, government and industry documents in the UK. It identifies three separate definitions of the term: land unsuitable for food production; ambiguous lower quality land; and economically marginal land. It probes these definitions further by exploring the technical, normative and political assumptions embedded within them. It finds that the first two definitions are normatively motivated: this land *should* be used to overcome controversies and the latter definition is predictive: this land is *likely* to be used. It is important that the different advantages, disadvantages and implications of the definitions are spelled out so definitions are not conflated to create unrealistic expectations about the role of marginal land in overcoming biofuels land use controversies.

1. Introduction

Growing energy crops on "marginal land" is seen as a way of ensuring that biomass production involves an acceptable and sustainable use of land (Reijnders, 2009; International Energy Agency, 2010).[1]

The production of biomass on agricultural land has raised a number of interrelated controversies. Competition for land between biofuels and food crops is seen as one of the causes of food price spikes that occurred in 2007 and 2008, leading many to conclude that biofuels production was unethical: the so called "food versus fuel" controversy (McMichael, 2010; Mol, 2010; Ribeiro, 2013). There is the issue of the direct and indirect destruction of natural lands and land with high carbon stocks resulting in the release of carbon emissions (Nuffield Council on Bioethics, 2011; Gamborg et al., 2012). Indirect Land Use Change (iLUC) is the use of agricultural land that displaces food production and causes natural land elsewhere in the world to be cultivated for food instead – indirectly leading to the use of natural land. An influential paper by Searchinger et al. (2008) stated that greenhouse gas emissions from biofuels production could be significantly *higher* than those

* Corresponding author at: Centre for Applied Bioethics, University of Nottingham, Sutton Bonington Campus Loughborough, Leics LE12 5RD, United Kingdom. Tel.: +44 785 698 1530.
E-mail address: stxos4@nottingham.ac.uk

[1] This paper will use the term biomass to refer to any organic material that is used in energy production, whether for heat, power or transport fuel. The use of biomass in transport fuel will be referred to as biofuels. Most of the land use controversy surrounding biomass production has thus far been concerned with biofuels for transport so this paper will focus on biofuels in particular.

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of fossil fuel use once emissions from indirect land use change were factored in. Similar papers calculating the indirect effects of biofuels production followed (Melillo et al., 2009). The sheer scale of the land use required to meet targets has also raised doubts about biofuels, with some pointing out that they would have a large impact on the agricultural sector and a relatively small impact on the energy sector (FAO, 2008).

This paper will refer to these factors together as the land use issue or controversy. The use of marginal land is cited as a way of overcoming land use controversies because, as the UK government states in the 2009 Renewable Energy Strategy: "Use of this [marginal] land will reduce the risk of competition with existing food crop production, and help ensure that any associated land use change does not have a significant impact on the anticipated greenhouse gas savings or pose any other significant detrimental environmental impact" (HM Government, 2009 p. 114). The production of biofuels from wastes and residues is seen as another way of dealing with these issues, as well as the production of both animal feed and biofuels from food crops (Ozdemir et al., 2009; Drax Group plc, 2011).

The idea of putting "marginal land" in areas where farming is currently unprofitable to a more productive use while meeting energy goals is an appealing one. Energy could be locally grown, produced with few inputs, not compete with food production and give farmers an additional income (Schubert et al., 2008). Some controversy surrounds the idea of using marginal land however (The Gaia Foundation et al., 2008). Two prominent questions relate to what "marginal land" actually means and how claims about marginal land would be put into practice.

These questions are worth asking because of the rhetorical force of the concept of marginal land in debates about biomass, particularly biofuels for transport. Hype about future technologies can be used to raise expectations and tap into cultural expectations of scientific progress leading to societal progress (Brown, 2003). Talk of marginal land could be seen to raise expectations about the production of abundant, sustainable biomass. The concept marginal land has not made its way into UK or EU biomass policy as yet but we can ask whether it will in the future. Will the idea that using marginal land can circumvent iLUC lead to more favourable treatment of non-food energy crops in EU policy? How will the marginal land issue influence perceptions of non-food based energy crops and the land issues they raise?

This paper will focus on the question of what "marginal land" actually means. It will use qualitative social sciences methods to identify different definitions of marginal land in a selection of academic, industry, government and civil society (including NGO) documents in the UK. It seeks to highlight the ethically relevant values and assumptions embedded within these definitions and suggests challenges to these assumptions. Three different definitions of marginal land will be presented: (i) land not fit for food production, (ii) ambiguous lower quality land and (iii) "economically marginal land". It will highlight technical assumptions about where and under what conditions it will be possible to grow energy crops, political assumptions about the feasibility of implementing land use strategies and normative assumptions about how much food production should be displaced and the acceptability of displacing environmental "uses" of land. We will see that definitions (i) and (ii) have a normative motivation: energy crops *should* be grown on this land to avoid further land use issues and definition (iii) has a practical motivation: energy crops are *likely* to be grown on this land. It is important that the different advantages, disadvantages and implications of the definitions are spelled out so that definitions are not conflated to create unrealistic expectations about the role of marginal land in combating biofuels land use controversies.

2. Background

This paper focuses on the use of marginal land for biomass production, regardless of whether it is used in biofuels for transport, heat or power applications. The concept of marginal land in the UK is often tied up with the production of perennial energy crops such as willow and miscanthus because it is suggested that they do not need to be grown on prime land (Nuffield Council on Bioethics, 2011). A relatively small quantity of perennial energy crops are currently grown in the UK for heat and power production (DEFRA, 2012). The production of liquid biofuels from these feedstocks is not yet undertaken commercially because of technical and/or economic challenges (Nuffield Council on Bioethics, 2011).[2] The majority of biofuels currently come from wastes such as used cooking oil or food crops (Department for Transport, 2012).

Before the land use controversies and criticisms of biofuels outlined in the introduction became widespread, marginal land was not widely promoted in the UK as somewhere suitable for energy crop production. In fact, quite the opposite, in one instance unproductive land is framed as marginal for energy crops. An academic document in 2005 estimating the amount of land available for perennial energy crops production in Scotland states that ideally crops should not be planted on "marginally suitable land" because yields would not be significant and production would unlikely be profitable (Andersen et al., 2005). The term refers to "land with low yield potential and/or severe harvesting conditions" (p. 74). This definition is echoed in a report written by the Royal Commission on Environmental Pollution (RCEP 2004) in 2004. The report led to the establishment of the Biomass Task Force and the publication of the UK Biomass Strategy in 2007.[3] The report contains no references to the problems of direct and indirect land use change and only refers to "marginality" in the following context: "Farmers currently see willow as a marginal crop and will make use of subsidies by planting on set-aside land. The land chosen for set-aside is often the lowest quality land and this could also result in reduced yields" (p. 11). Here the term "marginal" is used to signify that farmers do not regard willow as an important crop and as such it risks being put on the least productive land resulting in the lowest yields. The potential association of biomass production with "marginal land" or as a "marginal crop" is seen as a hindrance to its development in the UK. We can see that this changes after the height of the controversies in 2007 and 2008 when marginal land is promoted as land where energy production should take place.

The term marginal land is part of a family of related labels used to characterise the type of land that is promoted for biofuels production such as idle, unused, suitable, free, spare, abandoned, under-used, set aside, degraded, fallow, additional, appropriate, under-utilised land. The definitions of these terms are also ambiguous and fluid and there are many interesting conceptual issues raised, particularly in relation to the linguistic negotiation of "free" and "unused" land. A preliminary study done by Slade et al. (2010), as part of a large UK Energy Research Council (UKERC) funded project into potential biomass resources, gives an exposition of the work previously undertaken in estimating biomass potential and the different classifications of what counts as "available" land. For the sake of simplicity and conceptual neatness this paper will restrict the analysis to marginal land.

[2] It is stated that certain conversion pathways for producing biofuels from non-food feedstocks do not face technical challenge, only economic challenges and indeed production of ethanol from lignocellulosic materials is currently in commercial production to a limited extent (Rødsrud et al., 2012). Other technologies are seen to face technical challenges also.

[3] This was superseded by the UK Bioenergy Strategy in 2012.

The rationale for using biomass within the EU comes from the EU Renewable Energy Directive (RED) 2009/28/EC set a target of 20% renewable energy within the EU by 2020, with individual targets for member states, and each state to supply 10% of transport energy from renewable sources, of which a proportion will come from biomass. At present, there are restrictions on the types of land biomass for biofuels and bioliquids can be grown on. Article 17 states that in order to count towards renewable energy targets biofuels cannot be grown on land designated for nature protection purposes, forest land, highly biodiverse grassland, or land with high carbon stock including wetlands and peatland. This was transposed into UK law by the Renewables Obligation (Amendment) Order 2011. In addition the order states that "degraded" land which was not in agricultural use in January 2008 and is either severely degraded or contaminated will receive a carbon sequestration bonus. The recent EC proposal on biofuels states that these measures may be changed because they may not be suitable in their current form and will need to be integrated into other measures to minimise emissions from land-use change (European Comission, 2012).

The proposal from the European Commission suggests that the contribution of food based biofuels will be limited to 5% of EU transport energy, half of the target for transport energy from renewable sources set out in the RED. Member states will also have to report on the iLUC factors of the feedstocks used. Feedstocks originating from oil, cereal and sugar crops will be assigned specific iLUC factors and all other feedstocks, including perennial energy crops or "lignocellulosic feedstocks", will be assigned a factor of zero. Advanced biofuels which do not compete with food production will also be weighted more heavily towards meeting the target than biofuels from food crops.

Much of the previous work on marginal land undertaken by social scientists and NGOs has focused on marginal land in the global South. Many people have pointed to implicit biases and value-based assumptions within land categorisations (Borras and Franco, 2010; Franco et al., 2010; Brara, 1992; Nalepa and Bauer, 2012). In different ways they point to the distance between abstract categorisations of land types and the situation on the ground, as well as the effects this can have on different interest groups. More details of previous work on marginal land will feature in the analysis in Section 4. Many of the documents analysed focused in particular on marginal land in the UK, especially the government and academic documents, making this the primary focus of this paper. However most of the NGO documents referred to marginal land in a global context and the term is also used more widely in many of the government and academic documents to refer to marginal land in general, whether it is in a UK context or elsewhere. Thus previous social sciences work on marginal land in the global South can be considered relevant to many of the documents. It will be made clear in the analysis when marginal land is being discussed in a UK or global context. This paper will build on previous analysis by providing an in depth analysis of different definitions of marginal land and how they are used in a UK context.

3. Methods

The work undertaken here aims to explore how assumptions and values are embedded within language. Goffman (1974) states that frames are principles of organisation we use to structure our experience of the social world and frame analysis is a way of investigating this organisation. Previous examples of work of this type within the field of agriculture and the environment include Elliot (2009) who considers case studies of how the choice of language in scientific research can have ethically relevant consequences by affecting the future direction of scientific research, altering public awareness or attention to environmental problems, affecting the attitudes of key decision makers and changing the burden of proof required to make decisions on environmental issues. Braiser (2002) conducts a method called "depth hermeneutics" to consider how agricultural interest groups used linguistic strategies to advocate certain policy positions or bolster their own political position around the formation of the Federal Agricultural Improvement Reform Act 1996 in the USA. Larson (2011) considers scientific metaphors that are used to speak about the natural world. He explores their implications for sustainability and suggests that we could formulate metaphors for the natural world with values more rooted in sustainability. He states "By framing our relationship to an abstract entity in a specific way, such a metaphor contributes to a particular way of being and acting in the world" (p. 16). Cacciatore et al. (2012) demonstrate how the framing of issues surrounding biofuels can influence how the public perceive them: the public respond differently to questions about biofuels depending on whether they are called "ethanol" or "biofuels".

The documents for this analysis were chosen over a period of a year and three months as part of a larger project exploring how land use and production methods of perennial energy crops for biomass energy are framed by important actors within the sector. The aim of the selection process was to identify documents that may be considered influential and important in debates about land use for bioenergy production in the UK. They were chosen if they came from prominent organisations or individuals involved in the bioenergy sector, and/or were published in peer reviewed journals, and discuss marginal land and other types of land use for energy crop production. Documents were identified through keyword searches in journal databases, through citations in other documents, through browsing websites and through references to documents obtained at conferences.

Academic and consultancy documents that estimate the potential biomass resource available from perennial energy crops and crop residues for energy production in the UK were chosen. Government documents that express aspects of the government's strategy on bioenergy and significant reports about bioenergy commissioned by the government were picked. Documents by influential campaigning NGOs in the UK who have been outspoken on the biofuels issue were sought and influential reports by groups such as CAT, Nuffield Council on Bioethics and Royal Society. Industry documents from the main energy providers and suppliers in the UK, companies prominent in developing biofuels and organisations representing the UK biomass energy and renewable energy industries were sought. Documents which deal with matters relating to sustainability and land use and the origins of biomass were considered relevant.

Sixty documents were originally amassed, which were searched for the terms "land" and "marginal land". The number of references to land was recorded and the document was skimmed to see if the types of land that should be used for energy crop production were discussed in depth. Any documents with references to "marginal land" were retained. Based on this selection process the documents were narrowed down to 35 and these documents were analysed. These documents are listed in Appendix A.

The analysis in this paper mainly consisted of thematic analysis which focused on the themes and issues that emerged from the documents, analysing how the language was used and the arguments that were made (Bryman, 2001). This was carried out by reading the documents in detail and making notes in tables designed for the analysis. Questions were asked of the documents including: how does the document view the use of marginal land for energy crop production? How is marginal land defined? How

does the definition compare to that used in other documents? What claims are made about the potential for marginal land use to overcome land use controversies raised by biofuels? What assumptions are embedded within these definitions and how could these assumptions be challenged?

4. Analysis

4.1. Definition 1: Land unsuitable for food production

The first definition classifies marginal land as land where food production cannot take place because the land is not productive enough. This definition appears in two of the documents. Appendix B shows the documents that use each definition. The Gallagher Review, commissioned by the UK government in response to controversies raised by biofuels in order to explore their indirect effects, define marginal land as: "• Land unsuited for food production, e.g. with poor soils or harsh weather environments; and • Areas that have been degraded, e.g. through deforestation"(Renewable Fuels Agency, 2008 p. 33). We find a similar definition in the report on the ethics of biofuels by the Nuffield Council on Bioethics (2011) "[…] there is no agreed definition for marginal land; however, it has been commonly used to refer either to land that is unsuitable for food agriculture or land that has a low carbon stock. (p. 172). We can see that this definition exemplifies the original logic behind the idea of using marginal land for biofuels: it will help overcome controversies around the use of land for biofuels, including iLUC. There are several assumptions embedded within this definition and the use it is put to.

4.1.1. Assumption 1: Significant amounts of marginal land exist

The first assumption is a practical assumption that sufficient quantities of this land exist in the UK and/or abroad to produce a substantial amount of biofuels crops. Several people have questioned this assumption in the UK context. Booth et al. (2009) – a report funded by the Department of Energy and Climate Change and managed by the National Non-Food Crop Centre – state:

> "The basic premise recommended by Gallagher, 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. Unlike the situation in Brazil or Southern Africa there is very little underutilised agriculturally productive land in the UK" (p. 113).

This assumption about the existence of marginal land has also been questioned by NGOs and academcis in the context of the global South. Young (1999) states that certain estimates of spare land that could be used to address hunger in developing countries are unrealistic and unhelpful as they significantly overestimate the amount of cultivatable land, underestimate current cultivation of land and do not take sufficient account of other uses of that land. Franco et al. (2010) and Borras and Franco (2010) point out that even when it is not farmed, marginal land is often used for another purpose, such as gathering firewood, and the people who use it often lack the political power to defend this use. Similarly, Brara (1992) points to the dissonance between local people and the government on the question of degraded pasture land in India. The local people still use the land for grazing whereas it is classed wasteland according to the government's scientific definition. Christian Aid (2009) reiterate this point stating "One person's marginal land is another's vital grazing territory" (p. 26). Franco et al. (2010) and Borras and Franco (2010) also question the normative assumptions embedded in the definitions stating that the terms "marginal" or "degraded" land can be used to implicitly normalise past degradation of land, and to represent the land and its current uses as less important than those of "prime land". Action Aid (2010) also state that communities would often dispute the existence of marginal land and risk being displaced.

Others have highlighted the important environmental functions of that land, in addition to the social functions, and question the acceptability of displacing these. In the context of the global South the RSPB (n.d.) point out that "marginal land" could provide important habitats for wildlife. The Gaia Foundation et al. (2008) make the same point about EU countries stating that policies to use previously set aside land and marginal land for biofuels production have had negative impacts on biodiversity, soils and water quality through increased intensification.

4.1.2. Assumption 2. Production Is possible on marginal land

The notion of marginal land as land unsuitable for food production also contains technical and economic assumptions that production will be possible and economically feasible on this land. This is presented as a cautionary footnote within the Gallagher Review itself: "The potential for use of marginal land should not be overstated since whilst crops can grow in difficult conditions, the yield performance may be poor" (RFA 2008 p. 37). Others take this argument further and see it as a reason for dismissing the use of the term "marginal land" altogether. Such arguments are often based on previous experience with jatropha in the global South.[4] Ariza-Montobbio et al. (2010) seek to debunk the idea that marginal land is suitable for the crop jatropha in India. They state that growing jatropha under poor agricultural conditions with few inputs yields leads to low, uneconomical yields. This point has also been raised by NGOs (Action Aid, 2010; The Gaia Foundation et al., 2008). Doubts of this kind have been raised about the potential to grow perennial energy crops on this land in the UK, as some have pointed out that small yields have been obtained on less productive land (Sherrington et al., 2008; SEERAD, 2006).

Many have pointed to the potential of advanced plant breeding techniques, such as genetic modification, to improve yields of perennial energy crops on marginal lands by making crops resistant to pests and disease and decreasing their nutrient and water requirements (Karp et al., 2009; Karp et al., 2011). Others claim that such technological promises are problematic and are a way of raising expectations about two as yet largely unproven technologies: genetic modification and second generation biofuels (Levidow & Paul, 2008). We will briefly revisit the role of technology and promises of technological innovation in the next section and the conclusion.

4.1.3. Assumption 3. Production can be targeted to marginal land

This definition also contains market and/or policy assumptions that production can be targeted to this type of land alone, in either the UK or the global South, provided it exists and if production is feasible on it. If there is no policy framework to ensure this land is used then the term arguably has little impact and there is nothing to stop companies using better land to obtain higher yields (Nalepa and Bauer, 2012). The Gallagher Review again highlights the difficulty such a policy would involve: "A framework to prevent biofuels causing land-use change has been proposed but is challenging and will take time to develop" (RFA 2008 p. 14). At present there are instruments in the UK which regulate the change in agricultural land use. A farmer wishing to grow willow above a certain threshold of land area on agricultural land may need to undergo an Environmental Impact Assessment (EIA) (Natural England, 2009). As mentioned in the background there

[4] Jatropha is a non-food crop with oil rich seeds that can be used to produce biodiesel. It is grown in parts of Asia, Africa and South America.

are land use restrictions within the RED. If this definition of marginal land is taken forward, will suppliers of biofuels be required to assess whether the land was used for food production in the past? The practical feasibility as well as the will to implement such constraints, in addition to the ones already in place, remains to be seen.

4.2. Definition 2: Ambiguous lower quality land

The second definition identified in the literature is that of lower quality agricultural land. This can be seen as a weaker version of the first definition: it is not land that is necessarily *unsuitable* for food production but where food production is less productive. This is another normatively motivated definition: this land *should* be used to overcome land controversies. Since this use of the term "marginal land" is vague and ambiguous it may not be correct to call it a "definition" as such, but more of a loose category of terms. This version of marginal land appears in 7 of the documents, although it should be noted that the 3 NGO documents do not advocate the use of this land, but rather comment on the idea of using it.

We can see the use of this type of term in a report on the sustainability of biomass by Drax power station (2011). The report states that "Biomass for electricity generation is typically sourced from discarded forestry and agricultural residues, and some purpose grown energy crops which can be grown on marginal or low grade land" (p. 2). The phrase "marginal or lower grade land" suggests some equivalence between these two terms. Later the report states that use of marginal land is one of the options in ensuring that biomass production does not displace food production. "For example, the biomass sourced by Drax is typically agricultural residues, such as straw, forestry residues, such as tree tops and bark, and energy crops grown on marginal land, none of which displace food production" (p. 17). This suggests a somewhat stronger definition of marginal land is being used, as land where food production currently does not take place.

A report on biofuels by the Royal Society uses the term in a similar way. It states that plant breeding could enhance the suitability of dedicated energy crops for processing into biofuels, reduce their environmental impacts and enable "the plant species to be cultivated on marginal land of low agricultural or biodiversity value […]" (p. 8). On page 46 they state that this would reduce the amount of productive land diverted away from food production. Bauen et al. (2010) similarly define marginal land as grade 5 arable land in the UK: lower quality agricultural land where food production may currently be taking place. SEERAD (2006) discusses the production of perennial energy crops on "[…] marginal agricultural lands, where other arable crops are less successful" (p. 18). They state there is a potential to use this land but yields may be lower.

4.2.1. Assumptions. As above

This definition can be seen to involve many the same assumptions as the previous definition: that this type of land exists in the quantities estimated; that biofuels production is possible on it; that production can be targeted to this type of land alone; and that use of this type of land will lead to less significant and therefore acceptable impacts on food production and sustainability than the use of prime land. These assumptions can all be challenged as they were for the other definition.

4.3. Definition 3. "Economically marginal land"

The third definition identified in the literature refers to "economically marginal land". This definition can be seen to circumvent some of the challenges to the previous definitions that production would not be feasible and that this type of land does not exist. This definition however is based on the concept of marginal land within economics and can be seen to differ in normatively significant ways from the previous definition. This definition appears in 3 of the documents.

Turley et al. (2010) use this definition and outline it in opposition to that given in the Gallagher Review:

> "Marginal land is more commonly defined as land where cost effective agricultural production is not possible under a given set of conditions" (p. 7).

Turley et al. (2010) is a report written by academics and consultants commissioned by the UK Department for the Environment, Fisheries and Rural Affairs (DEFRA) to estimate the amount of idle and marginal land in the UK available for energy crop production. The report models the amount of arable land "of marginal profitability"; fallow arable land; and grassland with low stocking rates; as well as certain types of non-agricultural land available for both arable and perennial energy crop production. The arable land identified as economically marginal is grades 3 and 4 land under the MAFF land classification (Ministry of Agriculture Fisheries and Food, 1988). This classification is based on the physical, climatic and fertility characteristics of the land, with grade 1 being the most productive and grade 5 the least.

This definition is also found in a report on biomass by the Committee on Climate Change—a statutory body established under the UK 2008 Climate Change Act to advise the government on setting and meeting carbon targets. It estimates the amount of land that is either "not required or not suitable for arable crop production" globally that could be used for biomass production (Committee on Climate Change, 2011 p. 17). Within this there are different subcategories of land, including marginal land: "areas where cost-effective production is not possible, under given conditions (e.g. soil productivity), cultivation techniques, agriculture policies, as well as macroeconomic and legal conditions" (p. 17).

Similarly to the first two definitions, the classification "economically marginal land" is based on the land's agricultural productivity, however it has a different meaning. The concept of "marginality" in economics refers to a small increase or decrease in the stock of something one owns. As Peterson and Galbraith (1932) state "In terms of the physical grade of land the economic margin is *at the 'poorest' land which can be 'remuneratively' operated 'under given price, cost, and other conditions'*" (p. 296 italics in original). Economically marginal land for willow would be the lowest quality land that could be used for production under a given set of price conditions for inputs and the product. This land could be different for other energy crops and if the economic conditions were different. Turley et al. modelled different commodity prices and found that grades 3 and 4 arable and grassland could be used more profitably for energy crop production than for arable crops, making it the economically marginal land. As Turley et al. (2010) state "Less productive land is closer to the break-even economic margin and this is reflective of land where significant change in use is most likely to be observed".

While the first two definitions of marginal land can be seen as normatively motivated concept – energy production *should only* take place on land unsuitable for food production, this second definition can be seen as more of a predictive concept – given a set of economic conditions this is the land that is *likely* to change use to energy crop production. Nalepa and Bauer (2012) advocate the use of this concept of marginal land as more realistic and useful than a static definition of marginal land based on the land's fertility. "Thus, the 'marginality' of a land parcel can only be determined in reference to the particular economic opportunities offered by the array of land use choices available locally at that moment and cannot be determined by analysing land suitability for a single productive use" (p. 415).

4.3.1. Assumption 1. Using economically marginal land will reduce impacts of energy crops

The assumption made within this definition is that the use of "economically marginal land" for biofuels would help overcome land use controversies. Turley et al. (2010) state that the aim of their study is: "[…] to identify potential 'idle' and marginal land areas where expansion of biomass production is possible without incurring significant impacts on sustainability and competing with food production" (p. 2). We can also return to the statement about marginal land from the UK Renewable Energy Strategy quoted in the background section: "Use of this [marginal] land will reduce the risk of competition with existing food crop production, and help ensure that any associated land use change does not have a significant impact on the anticipated greenhouse gas savings or pose any other significant detrimental environmental impact" (HM Government, 2009 p. 114). What the quote is actual referring to is "economically marginal land" in the UK.

Here we can see that the assertion about marginal land is somewhat watered down. It is not stated that use of economically marginal land will lead to *no* conflict with food production or incur *any* sustainability impacts, but that it will not lead to *significant* impacts and will *reduce the risk* of competition with food production. We can see that this weaker formulation of why "economically marginal land" should be used matches the less explicitly normative orientation of the concept and the fact that it involves displacement of some food production.

Here it could be pointed out that what counts as a "significant impact" on food production or sustainability is a value judgment. Using grades 3 and 4 land would lead to displacement of food production. Why is this level of food displacement or sustainability impacts acceptable? What alternative scenario is the level of impacts being compared to? The purpose of this paper is not to criticise this value judgment and to state that *no* food production should be displaced but simply to point out that this *is* a value judgment. We could also point out that labelling this level of impact as "not significant" is somewhat arbitrary given that the analysis is primarily practical, based on the land that is *likely* to change use, rather than explicitly normative. The authors may wish to defend the displacement of this level of food production or environmental impacts, given the benefits accrued, but this should be done on explicitly normative grounds, recognising the trade offs (Gamborg et al., 2012).

HM Government appear to use the concepts of "marginal land" and "land of currently marginal economic production value" interchangeably, which could confuse the reader (2009 p. 114). We can ask whether the concept of economically marginal land adds any extra normative dimension to the debate about biomass production. Turley et al. (2010) model the same type of land as Booth et al. (2009) who disavow the concept of marginal land altogether.

4.3.2. Assumption 2. Economically marginal land includes grassland

The second assumption is about the acceptability of using grassland for energy crop production. As we saw, grassland was included in the economically marginal land modelled by Turley et al. (2010). Thus under this view, use of grassland in the UK can help to avoid significant sustainability issues and conflicts with food production resulting from the use of biomass. Others have raised doubts about the use of grassland for energy crops because of the resulting soil carbon emissions. Booth et al. (2009) estimate that converting grassland to willow production would result in a net carbon deficit when the foregone emissions from replacing coal with biomass are compared to the soil carbon loss from converting grassland. A report on the carbon saving credentials of biomass by the Environment Agency (2009) views displacement of food production onto permanent grassland *as* indirect land use change: "However, if demand for land to produce energy crops rises and leads to the displacement of other crops, the indirect effect may be to shift production of these crops onto permanent grassland, causing the same problem" (p. 6). Thus while Turley et al. (2010) view less productive grassland as a type of economically marginal land whose use could help overcome food versus fuel and environmental problems, the Environment Agency view it as land that could fall foul of iLUC. This points to further ambiguities in the concepts of marginal land and iLUC and highlights that decisions about what land should be used for production and what land should be spared from production because of its environmental credentials are not uniform and clear cut.

4.3.3. Assumption 3. Technology will make up the shortfall in food production

The technical assumption is also made that if food production is displaced on this "economically marginal land" then yield increases on the remaining land will make up the shortfall. "Use of the proposed areas of uncropped and economically marginal land for biomass production will involve changes to habitats and intensification of agriculture" (Turley et al., 2010 p. 70). It is widely stated that increases in crop yields will free up land. As Slade et al. (2010) state "If technological improvements increased crop yields, or population decreased, or diets changed and the consumption of meat was reduced, then at least in theory, surplus land would become available" (p. 16). The assumptions embedded within this claim would require more time to unpack and are beyond the scope of this paper but for now we could point out that such claims about technology use freeing up land go beyond the original logic of using "marginal land" to overcome land use controversies. The idea that marginal land use will not compete with food production is different from the idea that yield increases will make up for any shortfall in food production. If the latter idea is used to shore up arguments about the use of "economically marginal land" this is because economically marginal land is not marginal land as it was originally conceived.

5. Conclusions

This paper considered how marginal land is framed within academic, NGO, industry and government discourse within the UK. We saw that the three definitions of marginal land identified share the feature of being less productive land. Where they differ is whether or not the land is suitable for food production and whether the concept has an explicitly economic or normative rationale. Originally the "marginality" of land or energy crops themselves was seen as something to be avoided or overcome in order to develop perennial energy crop production in the UK. After the land use controversies around biomass the idea of "marginal land" for biomass production was embraced by government, industry and others to circumvent their negative environmental and social impacts. This is a normative conception of marginal land: this land *should* be used to overcome land use issues. The idea of using "economically marginal" land can, in turn, be seen to overcome the problems with using very poor, unproductive land. This is a predictive conception of marginal land: this land is *likely* to be used because of economic circumstances.

This paper pointed out that if marginal land follows the original logic of overcoming land use controversies by using land unsuitable for food production, then many arguments have been made against the feasibility of its use for biofuels production. If the use of this land could in theory overcome land use controversies then many have argued it would not work in practice. If on the other hand marginal land is defined in a more practical sense: as more productive "economically marginal" agricultural land, then it can be pointed out that this does not follow the original logic of using marginal land to circumvent land use controversies. Whether or not use of this land would lead to lesser impacts and why these

impacts are more acceptable is somewhat hazy. At this point some appeal to technology either to argue that production could be feasible on marginal land in the future, or that yield increases could make up a shortfall in food production. These technological arguments may become increasingly important in the future and more work could be done exploring the value judgements and assumptions embedded within such claims.

Both the discursive force of arguments about marginal land and their more readily visible effects on policy and land use should be borne mind in the future. We can see the difficult discursive work undertaken in painting a type of land that is abundant, free, accessible and where production is feasible for biofuels production. It is important to be clear about exactly what type of land is being referred to. It is often difficult to pinpoint if definitions are being conflated because the term is often used in a vague and nondescript way, as we saw in definition two, with similarly nondescript claims being made on its behalf. We saw that normative and predictive definitions were potentially conflated in HM Government (2009) which changed between "marginal" and "economically marginal" land. The distinction between "marginal" and "economically marginal" land should not be fudged in order to paint a rosier picture of biomass' future by unrealistically increasing expectations about their production and decreasing expectations about their impacts. The terms should also not be confused in order to argue that if lignocellulosic feedstocks become commercially viable for biofuels production they should retain an iLUC factor of zero under EC regulation, or should continue to weighted more heavily towards meeting targets.

As a final point it is also worth noting that some voices in the debate have already moved beyond the term "marginal land" because of doubts about the rhetorical emptiness of the concept. In a review examining the potential land demand of second generation energy crops. Valentine et al. (2012) state "We have avoided the use of the term 'marginal lands' in view of the objections raised by the African Biodiversity Network and others (2008)" (p. 5). However they appear to make similar arguments to those highlighted above but use the term "so-called marginal land". They state that it is important to take into account the fact that "Energy crops are deep rooted perennials which may be more economic than food crops on so-called marginal lands or on agriculturally degraded and abandoned lands […]" (p. 11). They use the term "so-called marginal land" to distance their claims from the controversies surrounding marginal land, but the argument remains the same. The argument that there is a type of land available in sufficient quantities to overcome the land use controversies around bioenergy can be made independently of the concept "marginal land".

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Appendix A. Documents analysed.

Academic documents	ADAS, 2008. Addressing the land use issues for non-food crops, in response to increasing fuel and energy generation opportunities. ADAS, Hereford. AEA, 2008. UK and Global Bioenergy Resource—Final Report. AEA, Oxfordshire Andersen, R.S., Towers, W., Smith, P., 2005. Assessing the potential for biomass energy to contribute to Scotland's renewable energy needs. Biomass and Bioenergy 29, 73–82. Aylott, M.J., Casella, E., Tubby, I., Street, N.R., Smith, P., Taylor, G., 2007. Yield rotation and spatial supply of bioenergy poplar and willow short-rotation coppice in the UK. New Phytologist 178, 358–370. Bauen, A.W., Dunnett, A.J., Richter, G.M., Dailey, A.G., Aylott, M., Casella, E., Taylor, G., 2010. Bioresource Technology 101, 8132–8143. Booth, E., Walker, R., Bell, J., McCracken, C., Curry, J., Knight, B., Smith, J., Biddle, A., 2009. An analysis of the potential impact on UK agriculture and the environment of meeting renewable feedstock demands. DECC and NNFCC. Copeland, J., Turley, D., 2008. National and regional supply and demand for agricultural straw in Great Britain. NNFCC, York. Haughton, A.J., Bond, A.J., Lovett A.A., Dockerty, T., Sunnenberg, G., Clark, S.J., Bohan, D.A., Sage, R.S., Mallott, M.D., Mallott, V.E., Cunningham, M.D., Riche, A.B., Shield, I.F., Finch, F.W., Turner, M.T., Karp, A., 2009. A novel, integrated approach to assessing social, economic and environmental implications of changing rural land-use: a case study of perennial energy crops. Journal of Applied Ecology 46, 315–322. Lovett, A., Sunnenberg, G.M., Richter, G.M., Dailey, A.G., Riche, A.B., Karp, A., 2009. Land use implications of increased biomass production identified by GIS-based sustainability and yield mapping for miscanthus in England 2, 17–28. Rowe, R.L., Street, N.R., Taylor, G., 2009. Identifying potential environmental impacts of large scale deployment of dedicated perennial energy crops in the UK. Renewable and Sustainable Energy Reviews 13, 271–290. Slade, R., Bauen, A., Gross, R., 2010. The UK bioenergy resource base to 2050: estimates and assumptions, and uncertainties. Imperial Centre for Energy Policy and Technology. Turley, D., Taylor, M., Laybourn, R., Hughes, J., Kilpatrick, J., Procter, C., Wilson, L., Edgington, P., 2010. Assessment of the availability of marginal or idle land for bioenergy crop production in England and Wales. Food and Environment Research Agency.
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	Forestry Commission Scotland (2007) Biomass Action Plan for Scotland. Scottish Executive, Edinburgh.
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	Renewable Fuels Agency (2008). The Gallagher review of the indirect effects of biofuels production. Renewable Fuels Agency, London.
	SEERAD (2006) Review of greenhouse gas life cycle emissions, air pollution impacts and economics of biomass production and consumption in Scotland. Scottish Executive, Edinburgh.
NGO	Action Aid (2010). Meals per gallon: the impact of industrial biofuels on people and global hunger. Action Aid, London
	Biofuelwatch (2009) Biomass and Biofuels in the Renewable Energy Directive. Biofuelwatch, Edinburgh.
	Centre for Alternative Technology (2010) Zero carbon Britain 2030: A new energy strategy. The second report of the zero carbon Britain project. Centre for Alternative Technology, Llwyngwern.
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	Nuffield Council on Bioethics (2011) Biofuels: ethical issues. Nuffield Council on Bioethics, London.
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	Royal Society (2008) Sustainable biofuels: Prospects and Challenges. Royal Society, London.
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	RSPB (n.d.) A cool approach to biofuels. RSPB, Sandy.
	WWF (2008) WWF Position Paper on Bioenergy. WWF, London.
Industry	Drax (2011a) Biomass: The fourth energy source. Drax, Selby.
	Drax (2011b) Sustainability policy for biomass. Drax, Selby.
	REA (2010) Renewable Energy Industry Roadmap UK. REA, London.

Appendix B. Instances of definitions appearing in documents analysed.

Definition of marginal land	Document	Quotation
Definition 1: Land unsuitable for food production.	Nuffield Council on Bioethics (2011) Biofuels: Ethical Issues. Nuffield Council on Bioethics, London.	"[…] land that is unsuitable for food agriculture or land that has a low carbon stock" (p. 172).
	Renewable Fuels Agency (2008) The Gallagher review of the indirect effects of biofuels production. Renewable Fuels Agency, London.	"• Land unsuited for food production, e.g. with poor soils or harsh weather environments; and • Areas that have been degraded, e.g. through deforestation"(p. 33).
Definition 2: Ambiguous lower quality land.	Action Aid (2010) Meals per gallon: The impact of industrial biofuels on people and global hunger. Action Aid, London	"So-called marginal land" "[…] semi-arid areas; on poor soils with limited water resources […]" (p. 22).
	Bauen, A.W., Dunnett, A.J., Richter, G.M., Dailey, A.G., Aylott, M., Casella, E., Taylor, G., 2010 Bioresource Technology 101. 8132–8143.	Grade 5 arable land under MAFF land classifications.
	Christian Aid (2009) Growing pains: the possibilities and problems of biofuels. Christian Aid, London.	"[…] poor quality land that is difficult to cultivate […]" (p. 2)
	Drax (2011a) Biomass: The fourth energy source. Drax, Selby.	"[…] marginal or low grade land." (p. 2).
	Royal Society (2008) Sustainable biofuels: Prospects and Challenges. Royal Society, London.	"[…] land of low agricultural or biodiversity value […]" (p. 8)
	RSPB (n.d.) A cool approach to biofuels. RSPB, Sandy.	"[…] 'marginal' or 'degraded' land […]" (p. 6)
	SEERAD (2006) Review of greenhouse gas life cycle emissions, air pollution impacts and economics of biomass production and consumption in Scotland. Scottish Executive, Edinburgh.	"[…] marginal agricultural lands, where other arable crops are less successful" (p. 18)
Definition 3: Economically marginal land.	Committee on Climate Change (2011) Global and UK Bioenergy Supply Scenarios. Committee on Climate Change, London.	"[…] areas where cost-effective production is not possible, under given conditions (e.g. soil productivity), cultivation techniques, agriculture policies, as well as macro-economic and legal conditions" (p. 17).
	HM Government (2009) The UK Renewable Energy Strategy. HM Government, Surrey.	"[…] land of currently marginal economic production value in England and Wales that could potentially be used to grow energy crops" (p. 114)

Turley, D., Taylor, M., Laybourn, R., Hughes, J., Kilpatrick, J., Procter, C., Wilson, L., Edgington, P., 2010. Assessment of the availability of marginal or idle land for bioenergy crop production in England and Wales. Food and Environment Research Agency.	"[…] land where cost effective agricultural production is not possible under a given set of conditions" (p. 7).

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