Supergen Bioenergy

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Workshop Report: Land use decision-making for biomass deployment, bridging the gap between national scale targets and field scale decisions.

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The Supergen Bioenergy Hub works with academia, industry, government and societal stakeholders to develop sustainable bioenergy systems that support the UK's transition to an affordable, resilient, low-carbon energy future.

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Executive Summary

The workshop brought together 74 attendees representing stakeholders from academia, industry (including biomass suppliers, agricultural consultancies, and end-users), NGOs and government (with representation from the England, Scotland and Welsh governments). Attendees contributed comments and recommendation on three questions relating to land suitability, barriers to growth of the sector, and tools needed to support stakeholder decisions around deployment.

Criteria for identifying suitable land for sustainable perennial bioenergy crop deployment

Economic criteria were identified as a primary consideration in predicting where landowners would be willing to deploy perennial biomass crops. Criteria should favour sites where biomass crops are economically competitive with alternative food and non-food land use options. Criteria should favour sites with minimal transport distance to end-user, and critically, distance to biomass agronomic contractors due to the costs associated with transporting specialised harvest and planting machinery. The monetisation of environmental criteria could alter biomass crop economic performance and deployment patterns. Comments on farm diversification noted the need to consider the contribution of biomass crops to the farm as a whole.

Environmental criteria were seen as particularly important by academics, government and NGO stakeholders. Biodiversity and crop carbon balance were highlighted as particularly important environmental criteria. Biodiversity criteria should aim to both prevent harm to vulnerable species and promote, and potentially reward, biodiversity friendly planting. Criteria should select sites with a net C gain, including but not restricted to soil C, and taking into account the potential alternative land use. Unknowns, which may hamper the development of effective criteria, were highlighted, including impacts of the scale of planting on biodiversity, and impact on pest and water resources for neighbouring crops.

Social criteria are important in landowner's decision-making processes and the community acceptance of land-use change. Criteria should avoid land with high community value,

factoring in how and if the community is currently utilising the land, including visual amenity and valuation. Criteria based on the potential to contribute to the creation of local jobs or wealth are desirable. Criteria that incorporate cultural ties to the land and a landscape's historical past would help to improve the prediction of the acceptability of land use change to biomass crops.

Attendees at the workshop also noted that Marginality was viewed by some stakeholders as a poor term that should not be used, whilst other highlighted additional land area for which the term should be expanded to include.

Barriers to the sustainable growth of the UK energy crop sector

Societal barriers were identified by stakeholders as a barrier to growth of the sector. A lack of communication regarding the benefits associates with energy crops was seen as the key people barrier, linked to the negative perception of the crops with the general public and farming community. Developing partnerships between industry, NGO, policy and academia, were seen as key in tackling many barriers.

Economics are a primary barrier to perennial biomass crop deployment, a combination of factors (markets, flexibility, cash flow) make biomass crops less economically attractive and they are perceived as having a higher economic risk than alternative land use options. Comments suggested overcoming these economic barriers will require long term solutions to stimulate both supply and demand

Policy barriers were identified as hindering development of the sector. The lack of synergy across government is a key barrier, with biomass crops requiring better integration into land-use, energy and net zero policies all of which sit in different departments. Instability of biomass policy was also a key barrier with past changes in policy leaving a negative legacy. Participants identified a current lack of capacity (machinery, planting material and skills) to allow large scale planting as one of a number of technical barriers. Other technical barriers included absence of independent advice and decision support tools, these will be key in the

recruitment of new growers and end users to grow the sector. There was also an identified need, for assurances as to the environmental impacts of large-scale planting.

Tools to identify suitable land at a range of scales (from whole landscape to individual fields)

Attendees noted that tools need to be available to address questions at a range of scales determined by stakeholders. Larger scale modelling (e.g. 1km^2 and larger) were seen as appropriate for broader policy decisions. Strong emphasis on the need for field scale or even sub field scale modelling to support deployment (< 5 m). Heterogeneity at field scale and smaller can be problematic in terms of conclusions from larger scale models. There is a need for clearer quantification of uncertainty to improve understanding outside of the modelling community.

Stakeholders identified three modelling tools that are needed in order to identify suitable land and encourage take-up of dedicated bioenergy crops. Firstly, predictive multi-crop productivity and economic models to guide on farm crop choice. Secondly, predictive models to provide guidance on wider benefits of planting bioenergy crops for biodiversity and ecosystem services, particularly if these will be linked to payments for public goods. Thirdly, integrative models are needed to bring together existing disparate data sources to support farm and wider land management.

There was consensus that models can play an important role in the decision-making process particularly through facilitating discussion among stakeholders. Comments around functionality noted that models must be accessible and easily interpretable across all users, and that integration with existing well know tools is desirable (e.g. MAGIC maps). Co-design with range stakeholder was noted as essential to ensure legitimacy and accuracy. To this end participants emphasised that models have a role only as part of a wider process that involves land managers and other stakeholders.

Conclusion

This workshop has highlighted that there are substantial barriers and knowledge gaps around the practical deployment of dedicated biomass crops at scales envisaged in energy policy. To realise the benefits that could accrue from an emerging bioeconomy investment needs to be made in addressing practical challenges and the needs for information at the farm scale.

Introduction

Background

There has been considerable debate as to where in the UK landscape perennial biomass crops should be located, how much suitable land is available, and what barriers exist that may prevent biomass crop deployment or alter its spatial distribution. A range of analysis and models have been developed that use factors such as soil carbon stocks, crop yields, policy drivers, biodiversity and ecosystem services, current food production to identifying potential deployment strategies. However, perennial biomass crop deployment in the UK still remains relatively small-scale, and well below the levels predicted to be required by the Committee on Climate Change (CCC) and others in order for the UK to meet its net zero targets. Selecting criteria to use within models to identify suitable land, especially around the definition of marginality, has also proved to be complex, resulting in inconsistencies between approaches. Even where a definition can be agreed upon the criteria and processes used to categorise land parcels as suitable for biomass crop deployment within models translating these criteria to farm or field scale is challenging. With a renewed focus on biomass crop deployment resulting from the recent Net Zero Strategy: Building Back Greener, and the forthcoming Biomass Strategy, it is important to ensure that all stakeholders have a voice in addressing challenges around biomass crops. These include (i) defining what land should be considered as suitable for biomass crop deployment; (ii) identifying barriers that prevent the sustainable growth of the UK energy crop sector and steps needed to overcome them; (iii) how modelling approaches can be utilised to support the identification of suitable land. In this workshop, we brought together stakeholders from Government, Industry, NGOs and academia to explore these challenges, covering the criteria used to select land as suitable for perennial biomass crops, the identification of barriers, and an assessment of what tools are available or needed to support land-use decision-making for biomass crop deployment.

Outcomes

This workshop supports the Supergen bioenergy Hub's aim to work with academia, industry, government and societal stakeholders to develop sustainable bioenergy systems that support

the UK's transition to an affordable, resilient, low-carbon energy future, through three key outcomes.

- Improve our ability to predict UK biomass crop deployment patterns by identifying and prioritising criteria for the selection of suitable land based on the values and knowledge of the stakeholders.
- Support the removal of barriers to biomass crop deployment, by identifying key barriers and stimulating dialogue between industry, academia and policy.
  Support the land use decisions needed to achieve sustainable biomass crop deployment, by identifying available tools and research needs.

Outline of workshop

The workshop was held online on Friday, 14 January 2022, between 10:00 am and 12 pm. There were 74 attendees representing a broad spectrum of stakeholders from academia, industry (including biomass suppliers, end-users and agricultural consultancies), NGOs government (with representation from the English, Scottish and Welsh governments). The workshop was split into three sessions covering criteria, barriers, and modelling tools. To support open discussion each session began with a short talk available here[1]. Attendees were then split into small breakout groups (no more than 10 people) where, based on their knowledge and experience of the sector, stakeholders were asked to use online whiteboards (Mural-boards) to record their responds (as virtual post-it-notes) to the questions below.

Session questions

- Where should biomass crops be located, what criteria should be used to identify suitable land?
- What are the barriers to the sustainable growth of the UK energy crop sector?
- What tools are available or are needed to support landowners and policymakers to identify suitable land at a range of scales (from whole landscape to individual fields)?

There were seven breakout groups, each facilitated by a member of the Supergen Bioenergy Hub team, and with access to their own group Mural board (separate board for each session question). The discussions within the breakout rooms were conducted under Chatham House

[1]https://www.supergen-bioenergy.net/news/workshop-report-published-on-land-use-decision-making-for-biomass-deployment/

rules, thus attendees were encouraged to record on the boards any comments they wish to be used within the workshop report. The aim was to gather the full spectrum of opinions present within the breakout groups, thus the facilitators made it clear that it was not necessary to reach a consensus for a point to be added to the board. The boards also remained accessible until the Monday following the Friday event to allow attendees time to add any additional points, although editing of the boards was blocked.

Polls

For the sessions related to criteria and barriers the points on the Mural boards were collated across all the breakout groups and presented as a poll to the attendees during the workshop. Attendees were asked to select what they felt were the most important criteria and barrier. After the workshop, following feedback from the attendees that there is often a combination of equally important factors which need to be considered, a modified version of the poll was sent out via email. In this version, individuals were able to select their top five criteria and barriers, with this poll sent to all those who had registered for the workshop, including those who are not able to attend on the day.

Analysis

Following the workshop all comments and points on the Mural boards were collated and transferred to a excel sheets including data on the identity of the author. With individual attendees identified by stakeholder type (Academia, Government, Industry, NGO, Research Council, and Undisclosed). Comments from all boards were grouped into themes through an iterative process between the facilitators.

This approach allowed us to both explore the common themes across the breakout groups and any differences or similarities in the nature of the points made by different stakeholders. Although it must be recognised that linking comments to stakeholder type will include a margin of error as comments made by one individual may in fact represent a consensus from the break-out group as a whole, and as the breakout groups were randomly assigned each group

contained a mix of stakeholder types. However, we still feel this approach provides useful insights. For transparency copies of all comments are available in the appendix.

Attendance

74 individuals participated in the workshop. Academia, Industry and Government, were equally represented, although it should be noted that the Supergen organisers are also drawn from academia (Figure 1). A smaller number of NGOs and research council representative attended and five individuals did not provide information of their associations. Academics included individuals involved in modelling, social science, engineering and natural sciences, whilst the government-included representatives from the Scottish, Welsh and Westminster government departments. Whilst industry attendees spanned individuals involved in planting and supply of biomass, trade bodies, agricultural consultancies and end-users. NGOs included representation from environmental and farming NGOs.

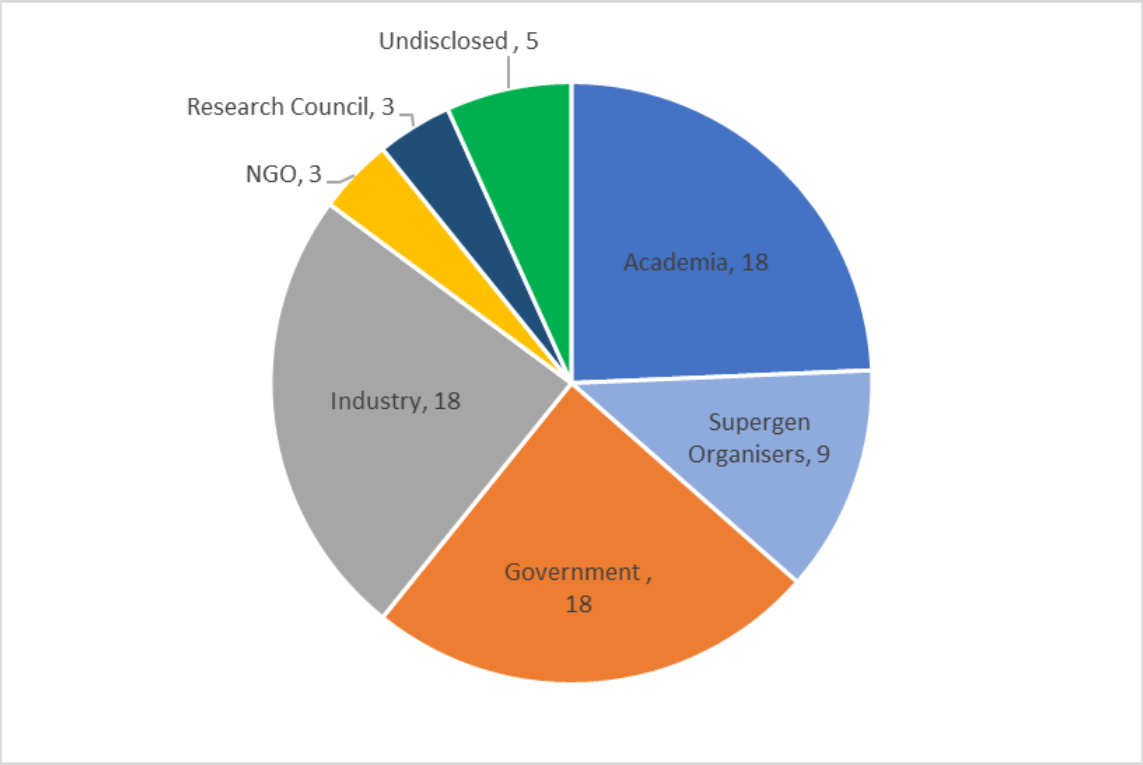

Figure 1: Number of workshop attendees broken down by stakeholder type

Criteria for identifying suitable land for sustainable perennial bioenergy crop deployment

Workshop participants were put into breakout rooms and asked to discuss criteria for defining land suitability for perennial biomass crop deployment. They were encouraged to think about criteria falling under the board headings of economic, environmental, social, or other, and specifically about criteria that could practically be applied, e.g. criteria such as minimum plot of 10 ha rather than just “size of plot”.

Comments across all seven-breakout room Mural boards were grouped into common themes, Comments covered twenty-five themes. These are listed in Figure 2, which shows the number of individual comments made in relation to each theme broken down by stakeholder group and with five top themes selected within the polls marked with asterisk. Some participants made general points around the definition of marginal land and crop management and these were categorised as other. A full list of the comments is provided in the Appendix. There were a small number of unclassified comments, most of which were more generalized points not directly related to criteria or were instead referring to barriers (and were repeated in the second session).

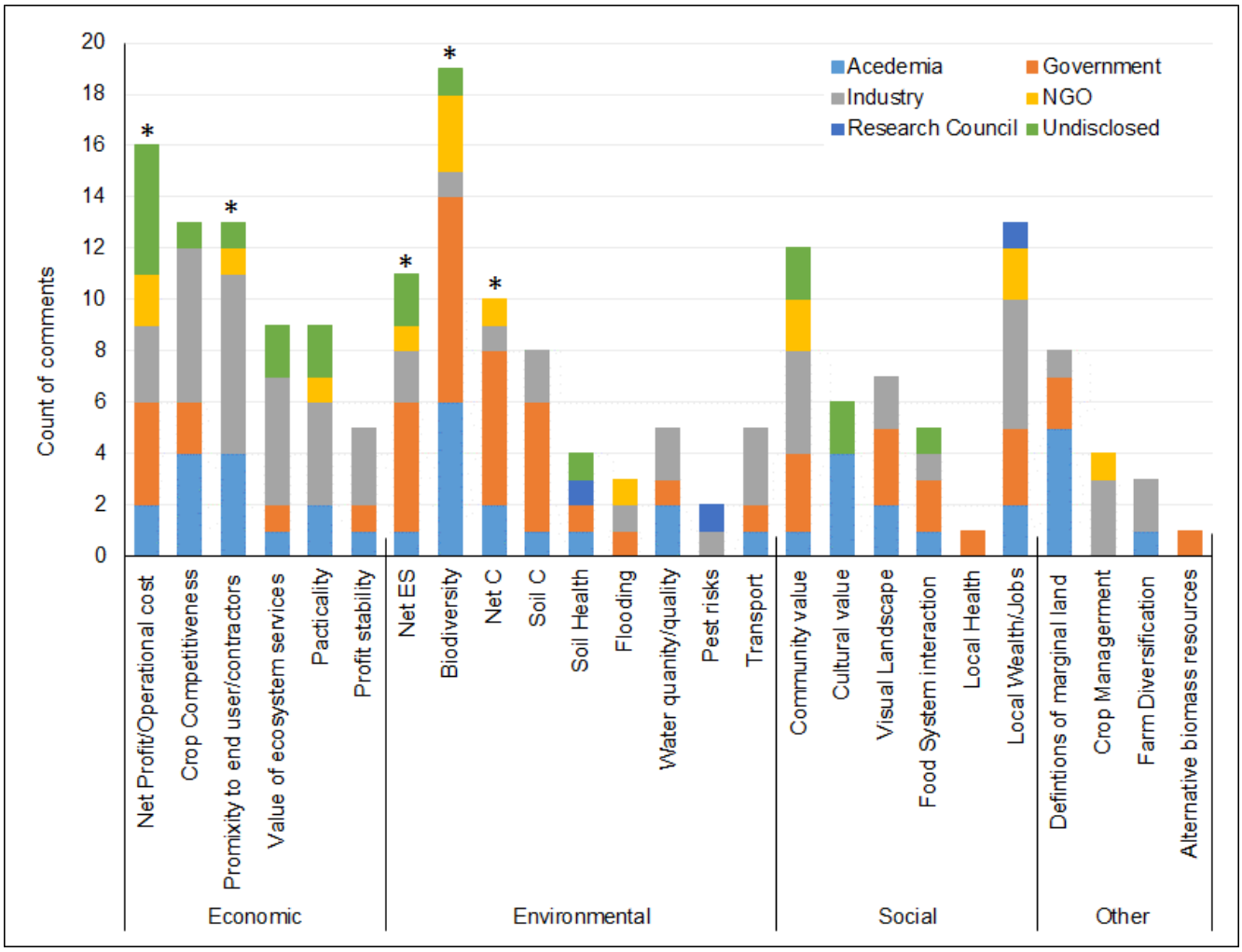

Figure 2: Count of the number of individual stakeholder comments related to criteria for the selection of land suitable for biomass crop deployment. Demonstrating the breakdown of the themes identified and the contribution by the stakeholder groups. Asterisks indicate top 5 barriers as selected in the combined polls. The asterisks indicate the themes linked to the top five criteria selected within the combined polls conducted both during and after the event.

Economic criteria for perennial biomass crop deployment

In both the polls and discussions participants were clear that economic criteria were the primary consideration for landowners. This was put simply in one comment: "*Whatever crop is grown* [it] *must make the grower profit - or it won't happen!*". Criteria for the selection of land should identify land where biomass crops will turn a **net profit**, with all **operational costs** (such as agronomic inputs, establishment, labour, harvesting, processing) balanced by yields. Participants highlighted this also need to be considered in the context of the relative economic **competitiveness of biomass crops**. Landowners will prioritise selection of land where profits

from bioenergy crops exceed those of alternative food or non-food land use options. Interestingly it was noted that this competition currently effectively excludes the lower value perennial biomass crops from competing with food crops on productive high-grade agricultural land (assuming there are no other constraints). Illustrated in the comment, "*Food crops will (should?) take priority over energy crops due to greater profitability, so economic criteria are less important than socio-economic for where to grow these energy crops*".

Several comments identified **proximity to the end-users/contractors** as key criteria. This again links to net profit because transport costs impact profits for both end users and landowners. Proximity to contractors is a key issue in profitability for land-owners due to the high transports cost associated with the transport of the specialised contract machinery needed to plant and harvest perennial biomass crops. One comment also highlighted how transport costs to end users can directly influence the economically acceptable scale/ yield threshold for planting in any given area, "*Minimal land size/yield* [is] *dictated by transport capacity.* [required] *Yield should relate to transport to end user to reduce cost. e.g. half wagon loads cost same as full*".

There were also a number of comments made which suggested that monetarising the **value of ecosystem services** may alter the land selected for bioenergy crop deployment. With comments highlighting that such payments would make planting on poorer land more likely and allow planting of smaller fields, for example: *"PEC [Perennial energy crops] need to make farmers money - either by producing high yields from goodish land or from getting paid from providing environmental benefits. Expecting them to plant on poor land without any incentives is not likely […]".*

Participants also noted some fundamental **practical** issues that will make some areas unsuitable for bioenergy crop deployment, including: accessibility for machinery; workability of the land; the amount of land available; and the abiotic conditions (e.g. water availability). Linked to this were comments on **profit stability**, which noted the need to consider the potential impact of potential future changes in biomass yield (due to climate change), crop price, and location of end-user markets.

Summary

- Industry stakeholders identified economic criteria as the primary consideration for predicting where landowners would deploy perennial biomass crops.
- Comments suggested:
    - Criteria should favour sites where biomass crops are not just profitable but are economically competitive with alternative food and non-food land use options.
    - Criteria should favour sites with minimal transport distance to end-user and distance to biomass agronomic contractors, due to the costs associated with transporting specialised harvest and planting machinery.
    - The monetisation of environmental criteria could alter biomass crop economic performance and deployment patterns.

Environmental criteria for perennial biomass crop deployment

Comments on environmental criteria were dominated by stakeholders from academia, government, and NGOs. The overall tone of the comments focused on the desire for selection criteria that balance positive and negative impacts, or as one comment put it "*Can we identify "Goldilock Zones" where biomass crops create maximum benefit and minimum disbenefit?*".

Whilst a range of environmental criteria were discussed, the ones that were the focus of the most comments were: impacts on biodiversity; net carbon balance; and soil carbon. Biodiversity and net carbon were also selected as key criteria in the poll. Comments on **biodiversity** noted the need for criteria that will prevent planting on habitats depended upon by species of conservation concern, but also criteria that promote planting in areas or in ways that will result in biodiversity gain. For example, using the cover provided by perennial biomass crops to extend existing wildlife corridors as suggested in the comment "*Aggregation with wildlife corridors*". Unknowns that may hamper the development of effective criteria were also highlighted, for example: "*How do the crops impact landscape permeability for different species*" and "*Some aspects of env*[ironment] *(e.g. biodiversity) impact may depend on unknown factors e.g. what is influence of biomass planting on distribution/ abundance/ activity of generalist predators that could impact on wader [wading bird] populations*".

Comments on **soil carbon** focused on the need for criteria to exclude high carbon and peat soils. However, comments within the **net carbon** suggested that criteria that simply exclude certain soil types might result in missed opportunities. Rather, it was suggested that criteria related to the crops carbon balance should take a whole life cycle approach including consideration of the "*Carbon storage potential of land if not used for bioenergy crops*". As one comment noted, with appropriate crop management this may render even the use of peatlands acceptable: *"Conventional perennial energy crops should not be grown on peat soils, but paludiculture (wet farming) perennial bioenergy crops offer the opportunity to solve multiple environmental issues, including reducing GHG emissions from peatlands*."

Comments on **soil health, flooding,** and **water quality** were dominated by the potential for positive impacts, such as flood mitigation and the treatment of contaminated soils. With the suggestion that criteria could help to maximise these through targeting crop planting in appropriate areas. Although comments did note the need to consider small scale impacts, for both water and other environmental factors, for example *"*[biomass crops] s*hould not adversely impact on neighbouring crops - i.e excessive water use or providing a haven for pest species*".

Proximity to end-users was mentioned although in this case, unlike within the economic criteria, in relation to minimising emissions from **transport.** This was the one theme within the environmental criteria where industry stakeholders provided the majority of the comments.

Summary

- Environmental criteria were seen as particularly important by stakeholders from academia, government and NGOs.
- Biodiversity and crop carbon balance were highlighted as particularly important environmental criteria, with comments suggesting:
    - Biodiversity criteria should aim to both prevent harm to vulnerable species and promote, and potentially reward, biodiversity friendly planting.
    - Criteria should select sites, which will provide a beneficial net carbon balance, taking into account the potential carbon cost/offsetting of alternative land use options.
- Unknowns that may hamper the development of effective criteria were highlighted, this included the response of biodiversity to different scales of planting and, the impacts on neighbouring crops with regards to pests and water resources.

Social criteria for perennial biomass crop deployment

Comments on **community value** highlighted the importance of understanding how the community is currently interacting with different land parcels. Comments noted the need to consider the current "*leisure value of land*" and impacts on *"Footpaths & access improvements*", and made clear that land for biomass crop should not displace community activities. **Visual** impacts were also noted as a key part of this local community value, but with additional wider societal implications, especially in tourist areas. As one comment explained "*visual impacts [are] to be expected from growing 3m+ ECs* [energy crops that reach over 3m in height]". It was highlighted in the discussion that such impacts are subjective and whether these are viewed as negative or positive will depend on the scale and location of planting. Setting criteria for visual impacts therefore may require direct community engagement.

It was noted that communities will also respond more positively to biomass crops if they can contribute directly to the creation of **local jobs** and/or **wealth**, with comments highlighting links to governments "*levelling up"* agenda and a "*just rural transition*". Thus, selection criteria that predict the potential for local job creation are desirable.

Comments regarding **cultural value** noted the importance of landowners and communities cultural links to the land, and the potential negative impacts of land use change on cultural identity e.g. "*loss of identity as food grower*". Whilst difficult to quantify within broad criteria, it was highlighted that cultural value may also support the identification of suitable land for biomass crop deployment through an understanding of the historic context. As explained in one comment: "*historical land use; if it's previously been used for fibre crops (e.g. historical hemp, flax) there's a much better chance of acceptability*".

Comments related to **food systems interactions** broaden the discussion, moving away from the direct consideration of criteria for land-use selection onto discussions of the wider interactions between biomass cropping and food. Comments noted the connections between land availability and diet ("*Availability of marginal land will require reduction in livestock numbers and change in diet from society*") and the potential for international impacts of changing UK land use ("*off-shoring food production*"). This highlights the links between

bioenergy production and the much wider, and extremely important, debate regarding the UK's overall land-use policy, but is not one the biomass community can answer alone.

Summary

- Social criteria influence landowner's decision-making processes and the level of community acceptance of land-use change to biomass crops.
- Comments suggested:
    - Criteria should avoid land with high community value, factoring in how and if the community is currently utilising the land, including visual amenity and valuation.
    - Criteria based on the potential to contribute to the creation of local jobs or wealth are desirable
    - Criteria that incorporate cultural ties to the land and a landscape's historical past would help to improve the prediction of the acceptability of land use change to biomass crops.

Other criteria for perennial biomass crop deployment

A number of comments focused on the **definition of marginal land**. Comments noted that the term could be insulting, for example "*please stop insulting farmers by referring to their land as marginal! Suitable for biomass crop is a much less loaded term than any of the abandoned/idle/waste/marginal type terms".* Others noted that the term itself is ambiguous depending on the current situation and individual perspective, *"[...] it changes every year as farming subsidies reduce, so economically marginal is a very moveable concept*" and "*'Marginal' is a perspectival term. […]* ". Further comments suggested the term should be expanded to include non-agricultural marginal lands, or land that would become marginal in the future, for example: "*Areas that will become unsuitable in future i.e. low lying coastal zones*". Given that marginality is often defined based on collection of underpinning criteria and is by nature based on human perception and presupposition, a term should be used that accurately portrays that what is being measured is the suitability for perennial energy crops. Such a change in term may also be more amenable to encompassing the social factors, which were noted as important criteria within this discussion but do not easily align with current the concepts of marginality.

Comments on **crop management** highlighted that within field crop management is often not factored into criteria for the selection of suitable land but may alter the outcomes. This will be

particularly the case for environmental criteria as noted in the comment, "*What kind of plantings? Species and configuration? This will determine compatibility with and influence on environmental features and benefits".* With comments on **farm diversification** drawing attention that criteria will also need to consider how bioenergy crops will interact with other aspects of the farm business, as this will also influence where the crops are deployed. One comment highlighted the need to ensure discussions of UK perennial biomass don't exclude more novel biomass sources such as bracken which may have a role in the future bio-economy.

There were a small number of unclassified comments. Many of these were related to, and were repeated, in the following discussion of barriers however they are included in the appendix for full transparency.

Summary

- Marginality was view by some stakeholders as a poor term should not be used, whilst other highlighted the need to expand the term to include additional land areas.
- The potential for within field crop management to alter outcomes was highlighted, especially for environmental impacts including biodiversity.
- Comments on farm diversification noted the need to consider the contribution of biomass crops to the farm as a whole.

Barriers to the sustainable growth of the UK energy crop sector

Participants were put into breakout rooms and asked to identify barriers for the UK sector under four subheadings, people, economic, policy and technical. As with the discussion on land selection criteria, comments across all seven Mural boards were grouped into common themes. Comments made during these discussions covered twenty-three themes. Figure 3 gives a tally of the number of individual comments made related to each theme, broken down into stakeholder groups and with five top themes selected within the polls marked with asterisk. A full list of the comments is provided in the Appendix.

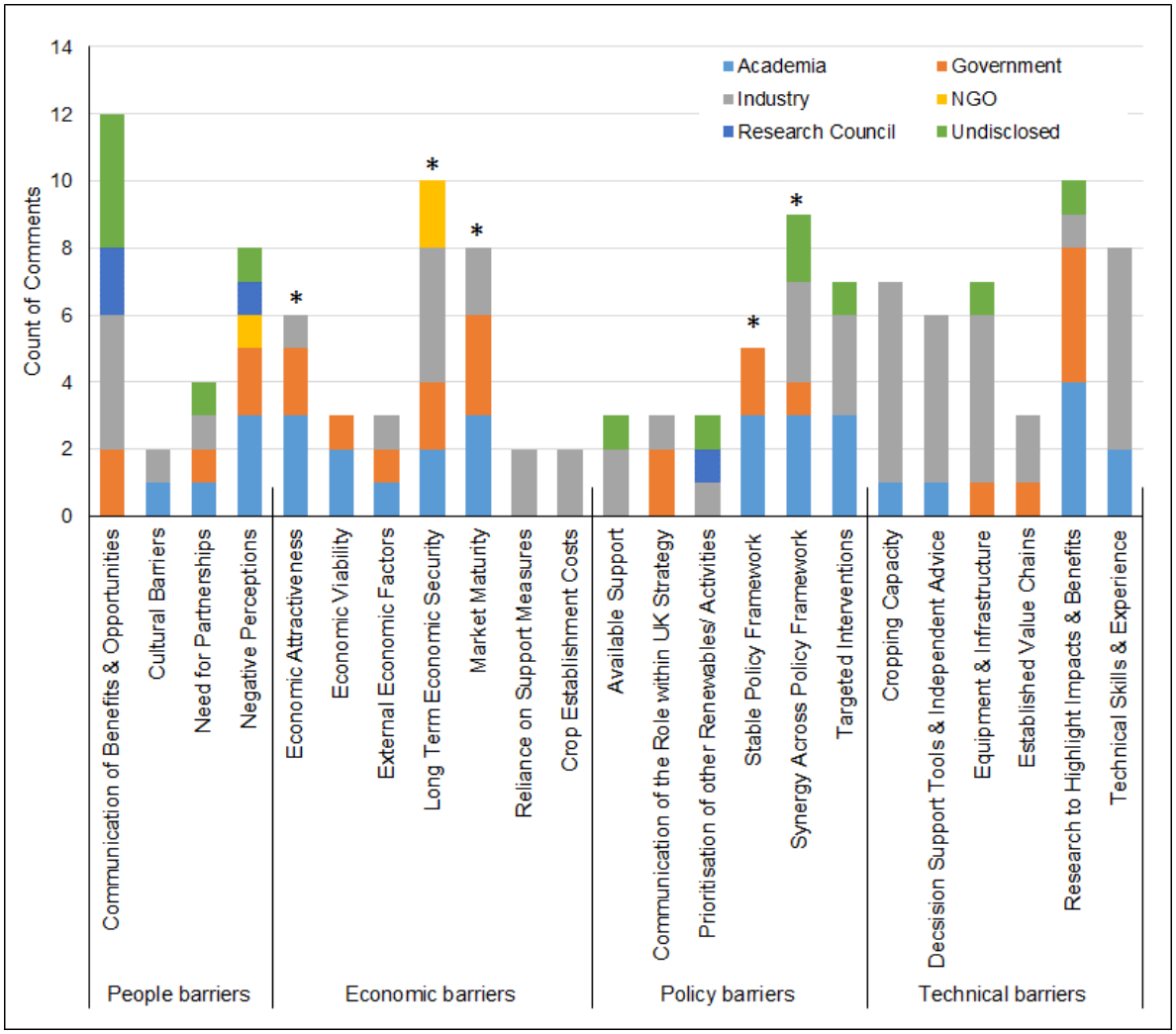

Figure 3: Count of the number of individual stakeholder comments identified as preventing the sustainable growth of the UK energy crop sector. Demonstrating the breakdown of the themes identified within each category and the stakeholder group. Asterisks indicate top 5 barriers as selected in the combined polls.

People Barriers to the sustainable growth of the UK energy sector

Although not selected within the polls, the most common comments were on **communication of the benefits and opportunities of energy crops.** Comments in this theme, and related comments on the **negative perceptions** of biomass, identified a limited understanding of biomass crops among the farming community, the general public, and some policy makers, and suggested a need to improve communication. This was summed up by the comment "*Bioenergy/ biomass community need to tell their story better particularly on complex issues like carbon cycling - how biomass contributes to short and long-term carbon cycle*"". Issues with language were also noted, especially the use of the term marginal. This term is used in many reports and strategies to describe land suitable for perennial biomass crop deployment, but as one comment noted "*farmers don't consider their land to be marginal!*".

Partnerships between community, industry, government, academia, and specialist energy crop groups, were suggested as a solution to a number of barriers. Participants suggested that partnerships could provide the information, skills, equipment, finances, and certainties required to build a sustainable energy crop sector. However, a more targeted approach may be needed for some of the cultural barriers identified, including the predominantly older farming community being less attracted to the novel and long-term nature of biomass crops, and the substantial change in practices required for livestock farmers to switch to growing energy crops.

Summary

- Participants identified negative perceptions and lack of knowledge about biomass crops within the general public's and farming community as key people barriers.
- Comments suggested:
    - A need for improved communication of the benefits associates with energy crops, with clear accessible messaging.
    - The need for partnerships between industry, NGO, government, and academia, to provide information and support to farming communities

The Economic Barriers to the sustainable growth of the UK energy sector

Participants identified economics as a primary barrier to perennial biomass crop deployment. Seven themes emerged that play a part in influencing the economic barriers to biomass crop deployment. Of these seven **long term economic security** received the most comments and was selected as a key barrier in the poll. As commented: "*Planting energy crops is a long-term commitment so certainty over who you are selling to, for how long and at what price is crucial*". However, it was felt that currently there are limited guarantees around if and how the demand for biomass crops will develop and what the price will be. Long term contracts and clear statements from industry and policy on long-term utilization of biomass, and were seen potential solutions, together with the diversification and expansion of the biomass market as picked up within comments on **market maturity.** The UK biomass market currently being in its infancy added to the perception of economic risk. Difficulties in triggering market development were highlighted in comments regarding **reliance on support measures.** Comments highlighted that to be successful any support mechanisms would need to support supply and demand, summed up by the comment "*Must address both supporting supply (feedstocks) and supporting demand [..] since only very specialist subset of society can provide demand*.". However, participants also noted that support mechanisms do not guarantee development of the sector: *"The industry wrongly expects a support mechanism to stimulate a market – why"*.

Comments on **economic attractiveness, economic viability,** and **crop establishment cost** highlighted various aspects of the same underlying barrier. Namely, that where the economics (including impact on business flexibility, economic risk, and cash flow) of an energy crop proposal are not competitive with that of other agriculture or alternative land use activities, it is highly unlikely land managers will choose to produce energy crops. Simply put in one comment "*Other agriculture is far better supported and more profitable*". With comments on **external economic factors** highlighting that competition with imported biomass will also factor in landowner decision making. Reducing establishment cost and mechanisms to level out cash flow may assist in these challenges, but only if there is confidence in the development of a strong biomass market or guaranteed long-term demand.

Summary

- Participant identified economics as a primary barrier to perennial biomass crop deployment
- Comments highlight a combination of factors which need to be overcome and suggested:
    - The development of long-term solutions to reduce perceived higher economic risk than alternative land use options.
    - The need for solutions or interventions that stimulate both supply and demand, tackling issues with market maturity, on farm cash flow and flexibility.

The Policy Barriers to the sustainable growth of the UK energy sector

Workshop participants identified lack of **synergy across policy framework** as a key barrier. Industry, academic, and even government stakeholders made comments associated with this theme. Here, and in related comments on the need for **stable policy frameworks**, participants raised concerns over; (i) the lack of a integration of biomass crops into new land-use and energy policy; (ii) the "*Complexity of departmental responsibilities*" with improved communication needed between departments, and (iii) the negative impacts of fluctuating biomass policy. Strongly integrated policy was seen as critical in providing industry confidence, but there is also a negative policy legacy that needs to be overcome. As one participant commented "*So much damage done to the sector by poor or in-complete policy*.".

Limited confidences in government policy was also notable in comments relating to the **communication of the role (of energy crops) within UK strategy,** and **prioritisation of other renewables/ activities.** Participants noted the need for better communication as to the expected role of biomass crops in achieving a range of government targets such as preserving natural landscape and Net Zero. There is uncertainty around the relative role of biomass crops in comparison to other renewables (wind, solar), and how any potential rewards for achieving targets could be administered, as shown by this comment: "*Natural capital policies, who owns value from biomass crops e.g. carbon etc"*.

Targeted Interventions were mentioned by stakeholders from academia and industry, and were felt necessary in order to overcome the large number of barriers currently facing biomass

crops. As one participant stated, "*Would anyone seriously consider growing energy crops for purely economic reasons, given the barriers discussed?*". Participants noted interventions should encompass the different stages of the value chains, for example, rewarding delivery of environmental objectives, support for testing novel biomass crops, and stimulating the market with suggestion of the need for "*a strike price for biomass* [derived] *energy*" from UK grown energy crops.

Difficulties in accessing policy information and support schemes (**availability of support**) where highlighted by industry stakeholders. Illustrated by the comment "*None of the Defra agents know about Miscanthus (willow is mentioned) - need advice! Hard to understand payments schemes, support etc".* Increased information would empower potential producers to make choices about energy crops with full knowledge of the link to broader strategy.

Summary

- Participants across all groups identified the lack of synergy across government policy is a key barrier, with comments suggesting:
    - Biomass crops integrate into land-use, energy, and net zero policies, thus they require improved communication pathways across government departments.
    - Improved communication is also need to ensure a stable policy framework, as past policy changes have left a negative legacy.

The Technical Barriers to the sustainable growth of the UK energy sector

Participants from academia, government, and to a lesser extent industry identified the need for **research to highlight impacts and benefits** of energy crops. Comments focused on the need for research outputs addressing the impacts and benefits (on GHG, yields, biodiversity, air quality) of the UK producing and utilizing energy crops at scale and across different landscapes (e.g "*Uncertainty around large scale environmental impacts i.e. biodiversity.*"). The industry comments focused more on recognizing/proving benefits, whilst government and academic comments focused on "reducing uncertainty". This may reflect the type and level of risk each group faces when taking actions that will influence bioenergy crop deployment.

The majority of the remaining comments in this category were contributed by industrial stakeholders and highlighted the technical challenge of scaling up biomass crop deployment. Participants highlighted current limits on the supply of planting material, the availability of bespoke **equipment** needed to produce, harvest, transport, and convert biomass crops efficiently and economically, and **infrastructure** needs. This included comments on crop storage, for example "[need for] *Sufficient and suitable on-site and offsite storage for baled crop*"**.** Comments on the **decision support tools and independent advice** reflected on the need for independent advice to empower land managers to make informed decisions about whether energy crops are appropriate for their circumstances and crop agronomy. There were also comments on **establishing value chains**, which covered the separate issue of the need to explore the match between feedstock composition to onward transportation and conversion technologies, something that will increase in importance as the bio-economy develops.

Summary

- Participants identified a current lack of capacity (machinery, planting material and skills) and knowledge gaps that are hampering large scale planting.
- Comments suggested:
    - There is need for the provision of a trusted source for independent advice and the development of new decision support tools, to support new growers and end users.
    - There a research need to remove uncertainty over the environmental impacts; especially of large-scale planting.

Tools to identify suitable land at a range of scales (from whole landscape to individual fields)

Workshop participants were put into breakout rooms and asked to discuss the following four questions/ points:

- What scale do we need tools to work at? and how accurate do they need to be?
- What output do we need (yield, environmental)?
- Do we need detailed models at all? Or just criteria of where not to plant?
- Examples of tools/models currently used or in development.

These questions were design to help guide model development by exploring stakeholder needs, and to raise the profile of any models currently available which can provide support in land use decision making for biomass crop deployment. Figure 4 gives a count of the number of individual comments made related to each question, grouped into common themes and broken down by stakeholder groups.

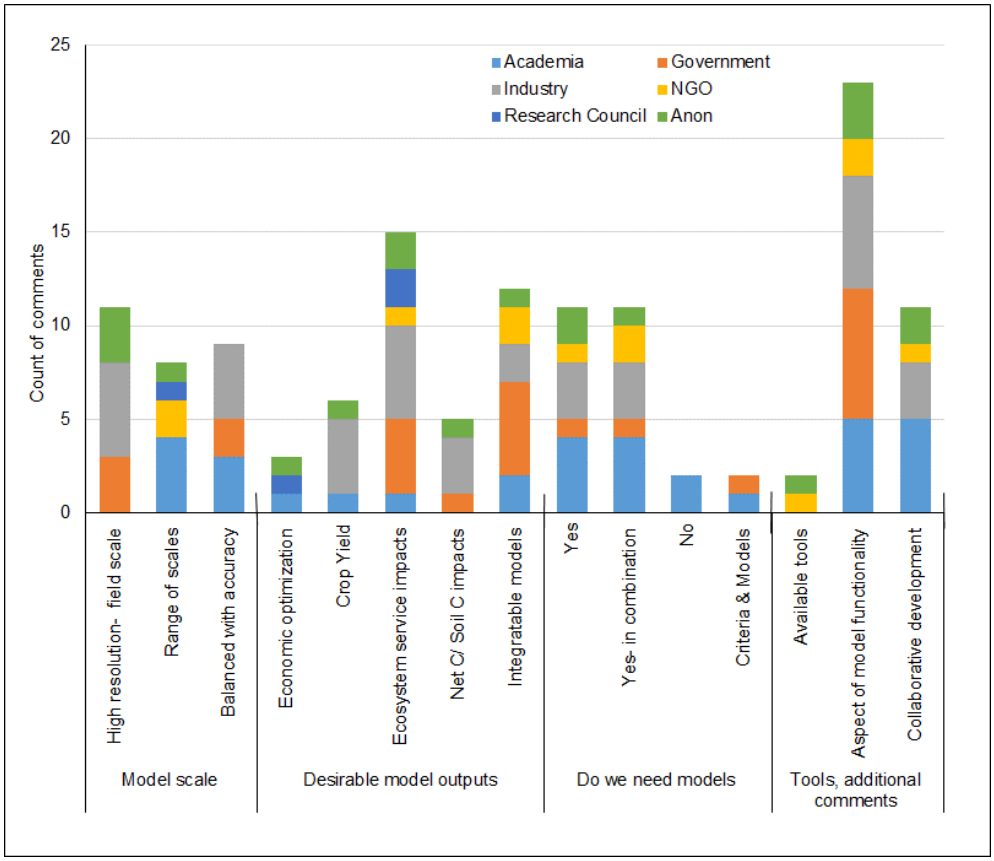

Figure 3: Count of the number of individual stakeholder comments related to modelling tools needed or available to support deployment of UK energy crop sector. Comments are grouped into themes and by stakeholder group.

What scale do we need tools to work at and how accurate do they need to be?

Comments covered three themes, the need for models covering a **range of scales** dependent on the questions being addressed, calls for **high-resolution** (field scale or smaller) models (primarily to support land-owner decision making), and concerns or comments on model **accuracy** and the constraints of available data.

Models with coarse spatial resolution (e.g. 1km^2 or greater) were identified as being appropriate for strategic decision making and prioritisation at national/regional scale. A concern participants had with such models is that they may not accurately reflect important parameters such as attainable yields, as the relatively coarse scale at which they operate does not capture considerable variation that can be found at field scale within the UK. As noted by one attendee "*I think [there] can be a misunderstanding between how variable fields in the UK actually are*!"

Within the workshop emphasis was placed on the need for models that could inform planning by landowners and managers at farm scales – it was suggested that models at scales of 1m^2 to 5 m^2 are needed and would be appropriate. The requirement for such data is driven by in field variability and desire by farmers to better utilize existing land. As noted by one attendee "*some farmers will look at not planting whole fields of biomass, instead doing small sections, e.g. to square off an awkwardly shaped field to make it easier to farm for conventional crops*". The suggestion that land not profitable food production will play an important role in future deployment strategies, also increases the need for a greater spatial resolution as it is likely that in these areas realised yields will be more variable.

Participants noted that the scale at which models can operate is often constrained by the limits of the spatial data that is put into them i.e. limits of remote sensing capability. Properly calibrated models will be critical to build farmer confidence however, as noted in the comments, this can be challenging due to the quality of available data. For example, it was noted there is a 20-30% difference between trial crop yields, the bases of many models, and

commercial yields. To improve the calibration process a number of workshop participants identified the opportunity to link the modelling community with practitioners, for example "*farmers should be able to input ground truthing data to the model, e.g. if they have done soil testing recently*". Correctly managed such feedback could support model development.

Summary

- Participants noted that tools need to be available to address questions at a range of scales determined by stakeholders.
    - Larger scale modelling (e.g. 1km^2 and larger) were seen as appropriate for broader policy decisions.
    - Strong emphasis on the need for field scale or even sub field scale modelling to support deployment (< 5 m)
- Comments also noted the need for clearer quantification of uncertainty to improve understanding outside of the modelling community. This is particularly the case when land-owners are interpreting the conclusion of larger scale models as heterogeneity at field scale and smaller can be problematic in terms of applying conclusions from larger scale models.

What outputs do we need from models?

Comments from participants draw a distinction between data models that predict or provide guidance on outcomes, and **integrative models** that bring together data from multiple sources providing a one-stop-shop for information.

Comments on the outputs of data models highlighted the importance of models for gaining insight into factors that are of direct relevance to farm management. **Yield** and **economic** performance were highlighted, with a requirement to bring together information on yields of biomass for a given area, and contextualise this in terms of counterfactual crop production, operational information, and production constraints. For example: "*It is useful to know what yield could be generated from a given area of land. ideally this would be against other land-use options*".

Outputs on environmental impacts (**ecosystem services**, **net zero**, and **soil carbon**) drew the most comments. Carbon dynamics of agricultural systems relating to both above and below

ground changes were highlighted, with understanding of such dynamics being of particular importance in linking agriculture with carbon markets. As noted in the comments "*Carbon assessments are going to be important as potential carbon markets take off*". Speaking to wider issues of sustainability and questions around public money for public goods, participant identified additional modelling needs relating to non-carbon environmental impacts, with particular notes on biodiversity, water resources, soil improvement, and flood mitigation. One participant noted that "*models could potentially inform and assist compliance with higher levels under ELMS standards (assuming the emergence of such policy measures)",* whilst another noted role for modelling in defining biodiversity impact with regards to habitat connectivity "*Habitat Fragmentation impacts and gains*". Such model will require relative high-resolution modeling (field scale).

There were many uses identified for integrative models, most prominently to inform farm business decisions. For example, it was suggested that mapping end use markets and access to contractors or facilitating equipment sharing among farmers would be useful. Participants noted such model should support integration with subsidy and planning processing, with one comment highlighting "*should be able to produce products that could be used in planning [..] for example subsidy maps vs croft registrations vs planning applications vs title deeds. all have different mapping requirements, processes and systems which do not speak to each other*". Such data could be linked through standard datasets such as OS maps and data available through Defra MAGIC map tool.

There was recognition of the important role that both types of models will have in realising goals for sustainable production of biomass. Ultimately the outputs of models should allow practitioners to consider multiple 'land use options' and build a jigsaw that incorporates multiple management options such as those for food, fuel and wider biodiversity and ecosystem service benefits. There does however need to be recognitions that modelling results should not rule out on-the-ground decisions that diverge from their recommendations.

Summary

- Participants identified three key model output requirements:
    - Predictive multi-crop productivity and economic models to guide on farm crop choice between land use options.
    - Predictive models to provide guidance on wider benefits of planting bioenergy crops for biodiversity and ecosystem services, particularly if these will be linked to payments for public goods.
    - Integrative models to bring together existing disparate data sources to support farm and wider land management choices.

Do we need detailed models at all? Or just criteria of where not to plant?

Participants were positive about the value of models but comments emphasised that whilst model have an important role they should only form part of the decision process. As explained by one participant "*model outputs are used in the context of a decision-making process that also uses local knowledge and common sense*" with the land manager having a critical role in the decision-making process. As previously discussed, it was noted that data driven models can suffer from issues around generalisation – hence the emphasis on engagement with local stakeholders who will know the specifics of local landscape. Allied to this there was recognition that models cannot incorporate all the factors that need to be considered in the decision-making process. As noted by one participant *" [users] need to remain aware of all the things that a model will never tell you (e.g. the Economics of Biodiversity [TEEB] report emphasising the stuff that is priceless, or hard to pin down, or impossible to measure)"*. Indeed, while existing biodiversity models tend to focus on pollinators given the economic benefits, biodiversity in the round is priceless and impossible to measure and therefore cannot be readily integrated into models to support decision making.

Models were also seen as having value in providing an independent assessment of the potential for expansion of the biomass sector, and for feeding into independent advice to the land manager. As put by one participant, "*Yes as a good model will enable better understanding and increase potential expansion of the industry. It is not enough to rely on commercial organisations that may over inflate yields and potential income".*

There were a few more negative comments, and these provide useful insights. Comments that supported the use of criteria did not dismiss the value of models, rather they highlighted the value of using criteria in conjunction with models to aid accessibility, *"Written criteria (or summaries of lessons learned from using models) are often more accessible to end users than detailed models that they may not be able to run themselves"* . This issue of accessibility was also a common feature in comments supporting the use of models, as unless model are user friendly and open access they are unlikely to have the intend impacts. The other negative comment questioned not if models had value, but rather if modelling capability is actually a current barrier to biomass crop deployment, and stated "*it's very academic to think that of all the things that might overcome barriers, models is the thing to start with!"* and *"early stage development more focused on where not to plant. Detailed models are not that valuable".*

Summary

- There was consensus that models can play an important role in the decision-making process particularly through facilitating discussion among stakeholders.
- Participant emphasised that models have a role only as part of a wider process that involves land managers and other stakeholders.

Examples of tools/models currently used or in development

Participants noted very few **available tools**, with only the "BIOPLAT-EU WebGIS tool" mentioned, although it was acknowledged that Department for Business, Energy & Industrial Strategy (BEIS) and others are currently funding model development. The discussion therefore naturally expanded to cover desirable **functionality** within and future models, model legitimacy, and equality of the input of different stakeholders during model development.

Comments on model functionality reiterated some of the points made already regarding desirable outputs, the need to ensure model are accessible, but also noted the value enabling model integration. There was interest in enabling links to both private business models, e.g. "*Open source for all these tools, so they can be integrated into business decisions, and tools business want to develop to support supply chain decisions" ,* and to government tools and

infrastructure mapping, *"Farmers/ land managers are used to these tools (in particular defra MAGIC maps) [..] - good to integrate with these".*

Concerns over model accuracy and legitimacy were raised, with comment noting that inaccuracies or mistrust of models can cause rather than overcome barriers "*we need to remember that models can actually increase barriers to adoption (e.g. a farmer dismissing a statement because it's based on a model and not real life, or simply doesn't reflect their lived experience)"*. Engagement or even **collaborative design** with relevant stakeholders was mentioned in a number of comments to over-come this issues. Such engagement could improve accuracy "*Any models should be underpinned by independent yield data from bioenergy crops. When used as a decision support tool implications of getting this wrong are big and could skew outcomes. More harm than good could be done if this is not got right".* In addition, as no model can ever be 100% accurate engagement is also critical to ensure understanding. One participant asked "*is there a need for dialogue between modelers and growers to understand some of the nuances around generalisations?".*

Summary

- Participants noted that few tools are currently available but a number are under development.
- Comments noted that
    - Models must be accessible and easily interpretable across all users, and that integration with existing well know tools is desirable (e.g. MAGIC maps)
    - Co-design and development of models with stakeholders is recommended to ensure legitimacy and accuracy. Allowing access to field data and up to date management practices and input of modelling functionality and usability.

Conclusion

The workshop aims were to:

1. Improve our ability to predict and guide UK biomass crop deployment patterns by identifying and prioritising criteria for selection of suitable land based on the values and knowledge of the stakeholder.
2. Support the removal of barriers to biomass crop deployment, by identifying key barriers and stimulating dialogue between industry, academia and policy which can move towards solutions.
3. Support land use decisions making needed to achieve sustainable biomass crop deployment by identifying available tools and research needs.

The workshop identified a large number of criteria for defining whether land was suitable for deployment of energy crops, and provided an indication of priority across and within different stakeholder groups. Many of the criteria highlighted have already been incorporated within tools designed to predict available land(2), although often not in combination. Social factors, especially the more complex concepts such as cultural and community value are often notable by their absence, with competition between different land-use options including non-food ones also more limited. Improvement of these models will require a greater degree of engagement with all stakeholder groups, and the models themselves will need to remain flexible in order to incorporate changes the political and economic framework.

We identified barriers affecting every aspect of the bioenergy supply chain. Tackling these will be challenging however, at least regarding the barriers related to policy these were recognised by all stakeholders, which is the first step in developing solutions. Participants themselves suggested the formation of partnerships between academics, industry, government, and NGOs in order to tackle barriers, especially those related to the communication of bioenergy crop benefits and lack of skills and independent sources of information. The Supergen Bioenergy Hub already has a role in such partnerships, and there has recently been funding for the development of new partnerships as part of the recent awards under the BEIS Biomass Feedstock Innovation Programme[3].

[2] Marginal lands: Concept, classification criteria and management (supergen-bioenergy.net https://www.supergen-bioenergy.net/wp-content/uploads/2021/09/Marginal-Land-Report.pdf)
[3] https://www.gov.uk/government/publications/apply-for-the-biomass-feedstocks-innovation-programme.

Models were seen as valuable in helping to guide and support land use decision making. Two scale of models were identified, broader (1km^2) scale for support planning and policy, and fine field scale to support individual landowners land use planning. There are already examples of the broader scale models including the Energy Technologies Institute's (ETI) Biomass Value Chain[4] and the Addressing the Valuation of Energy & Nature Together (ADVENT) NEV model[5], both of which use underlying datasets at 1 km^2 resolution, and which are used to address broad policy questions about potential feedstock availability to meet net zero targets. Participants identified both a gap and a need for models that could provide guidance around bioenergy crops at farm and field scales. Developing such models is challenging due to the high-resolution input data required. However, this challenge may however be surmountable through partnership between academics and landowners and this was something the workshop participants were keen to see develop. The workshop also highlighted the complexity of issues around bioenergy deployment, which include biophysical, social, economic, and political factors, acting across multiple spatial and temporal scales. This means that no definitive model could ever be developed, and local knowledge and engagement will always have a critical role.

This workshop has highlighted that there are substantial barriers and knowledge gaps around the practical deployment of dedicated biomass crops at scales envisaged in energy policy. In order to realise the benefits that could accrue from an emerging bioeconomy, investment needs to be made in addressing practical challenges and the needs for information at the farm scale.

[4] https://doi.org/10.5286/UKERC.EDC.000025
[5] https://ukerc.ac.uk/research/advent/

Appendix: All comments

Session 1: Criteria all comments
Economic criteria
Net profit/operational cost “inputs costs including labour” “Establishment Cost” “what is the minimum viable size of field to make biomass worthwhile” “Probably a minimum planted area, but preferably not too prescriptive” “Needs to take into account the cost of harvesting and processing” “Needs to take into account the cost of harvesting and processing (duplicated as two points)” “Need to work out the minimum crop yield to make it worthwhile - taking into account possible degradation of land over time” “Yield Potential from land” “Whatever crop is grown must make the grower profit - or it won't happen!” “Required inputs. i.e. fertiliser treatments etc.” “PECs need to make farmers money ” “Doesn't impact someone's livelihood negatively ” “Provides potential for additional revenue stream to land owner” “clear business case for farmers / growers” "yield based using climate drivers and edaphic constraints” “Bioenergy crop yield”
Crop competitiveness “Food crops will (should?) take priority over energy crops due to greater profitability, so economic criteria are less important than socio-economic for where to grow these energy crops” “In general avoid Grade 1-2 LCA (but note that there is areas in this that are not suitable for high grade arable production) a yield threshold approach would effectively 'set' and economic threshold by proxy ” “Need to assess how much it is better to use particular land for biomass rather than other uses.” “What is the alternative - i.e. how productive for food crops” “How can economics of energy crops compete with other uses ” “Comparative crop economics - if higher GM than existing GM ? ” “what is the counterfactual land use? Is land best considered as more of a venn diagram where there are multiple cropping options for some land and fewer options for other land types” “Doesn't disrupt other higher value land use options” “Foregone agricultural production” “Use of land [currently use] for food cropping should be unsustainable as an economic activity where the quality of the land is being sustained.” “Energy per area of land used” “find land best suited for type of biomass” “Avoid high value land - grade 1-2 especially should be avoided”
Proximity to the end user/contractors “Sensible location or for on farm use to minimise transport”

“Locate plantings close as possible to end use” “Location of field site to where biomass will be used” “nearby market” “Proximity to contractor a key current economic consideration (transporting crop specific harvester / planting machinery) is a consideration / cost currently for growers – away from contractors” “proximity to end market; this is key to both the economics and also the social acceptability” “Proximity to end user” “Duplicated two points: transport costs” “Access to markets. Haulage cost is significant. More support for new markets in remote areas ” “Close to end user for both business and domestic” “Proximity to other suitable bioenergy crop locations (i.e. clustering of crop locations)” “Minimal land size/yield dictated by transport capacity. Yield should relate to transport to end user to reduce cost. e.g. half wagon loads cost same as full” “Proximity to demand/offtake points ”
Value of ecosystem services “Should include both direct financial returns and also carbon and ecosystem benefit valuation” “PECs need to make farmers money - either by producing high yields from goodish land or from getting paid from providing environmental benefits. Expecting them to plant on poor land without any incentives is not likely. In any poll I have ever conducted the economics come out top for growers. If we want farmers to plant en masse they need to make money from it -one way or another.” “Potential Inclusion in ELMS payments” “Low Green Premium to make self sustaining and not grant dependent” “Net output of land after carbon inputs are "priced" correctly” "“Field Size - Whilst large plantations are economic and efficient to establish, smaller areas (that could be hand planted) could utilise awkward, unproductive areas on farm and benefit on-farm biodiversity” “In some cases growing energy crops on marginal land could be to stabilize in some way. Yields may not be such an important criteria but I guess the economics need considering from other aspects, such as cost of erosion on otherwise unmanaged/unvegetated ground, or land that is a pollution hazard, which could be mitigated through planted energy crops that may have some harvest value even though poorly yielding.” “Small fields when combined with integrated delivery of outcomes” “Carbon Sequestration how to value, ie cash or contribution to net carbon targets, ditto on bio-diversity enhancement”
Practicality “Temperature sensitivity for certain species” “Marginal land may be more difficult to harvest from” “How much land is available per location” “Accessibility of the field site (for planting, harvest time etc...)” “Ease of harvesting and transport costs” “Access to land for machinery” “Slope” “Feasibility of current or close to upcoming machinery to harvest crop efficiently” “Land needs to be suitable for growing that crop type - i.e. climate, slope, edaphic quality.”
Profit stability

“Long term crops remove farmer flexibility for year on year management” “End use market stability is critical along with market price” “Consider impact of overseas imports on biomass price” “Income for farmers. Stability over time” “Suitability to current and future climate”
Environmental criteria
Net ecosystem service “Air, Water and Soil quality” “Avoid growing crops which require high pesticide or fertiliser inputs” “Ideally shouldn't just be a question of risk assessment to elements of biodiversity or env factors - if plantings could also deliver environmental benefits (e.g. for biodiversity, water management etc) then opportunities assessment also appropriate” “There can be benefits from crops and these have not been recognised previously” “There are areas of the UK that have several needs that could be met or assisted by perennial energy crops e .g. flood issues, water quality issues, low forest cover, high off gas, fuel poverty, need for pollination services etc. These areas should be targeted as Perennial Energy Crops can help meet dual needs. Areas include the SW, Herefordshire and Worcestershire, Cumbria, North east. PECS could make a profound effect in these areas both environmentally and socially.” “land where there may be wider benefits beyond yield of biomass (e.g. ecosystem services)” “Ecosystem service being delivered” “what is the land already being used for? ” “Areas needed for NbS (nature base solution) delivery” “Can we identify "Goldilock Zones" where biomass crops create maximum benefit and minimum dis-benefit?”
Biodiversity “Need to take into account how biodiversity is affected.” “Biodiversity benefits v impacts” “Biodiversity protections” “Land with high levels of high biodiversity should be excluded, or particular protected species/ ecological significance” “presence/location of biomass crops shouldn't decrease the survival or breeding opportunities of species of conservation concern.” “Protected land (i.e. SSSIs)” “Avoid habite expansion zones” “Avoid all Semi natural habitat” “Protect or improve biodiversity” “Biodiversity benefits v impacts” “How do the crops impact landscape permeability for different species” “Pollination / biodiversity value” “Ability to actively enhance biodiversity” “Biomass fits in with the ecosystem - fits with exisiting flora and fauna” “Aggregation with wildlife corridors”

“Protect or improve biodiversity” “Some aspects of env (e.g. biodiversity) impact may depend on unknown factors e.g. what is influence of biomass planting on distribution/abundance/activity of generalist predators that could impact on wader populations” “Biodiversity benefits increased in Bio energy crop delivery” “Issue of cumulative impacts - distribution of biomass plantings may be important”
Net carbon “Land is key to determining the GHG performance of energy crop/ bioenergy projects” “Conventional perennial energy crops should not be grown on peat soils, but paludiculture (wet farming) perennial bioenergy crops offer the opportunity to solve multiply environmental issues, including reducing GHG emissions from peatlands.” "“GHG benefit, constraints mapping in GIS is obvious first pass, removing regulatory constraints ”" “Need to consider whole life cycle impacts as marginal land may require increased inputs to deliver economic returns and have higher GHG and other negative environmental externalities” “Contribution to UK's carbon budget (CB6)” “Whole system is net positive” “Foregone carbon sequestration” “Carbon storage potential of land if not used for bioenergy crops” “Growing the crop must be possible in a carbon negative scheme. i.e. outputs outweigh inputs” “Land with low carbon”
Soil carbon “Peat soils should be avoided where possible” “Soil carbon doesn't decrease significantly” “anticipated carbon stock changes” “Ability of biomass crops to increase soil carbon stocks” “What is the opportunity to increase soil carbon?” “Avoid Peatlands” “Avoid High carbon organic- mineral soils (shallow peats)” “Avoid permanent grassland which may cause net C loss - G Crane”
Soil health “Contamination” “Soil health / need for bioremediation” “Land Contamination levels” “potential for soil stabilisation”
Flooding “Potential for ecosystem services such as Flood management” “Impact on water basins - flooding mitigation or reverse. (I live in an area subject to flooding....” “Flood risk management”
Water quality/quantity “Water use and water availability essential” “water quality protection opportunity”

"Impacts on water quality" "Should not adversely impact on neighbouring crops - i.e excessive water use or providing a haven for pest species"
Pest risk "introduction of alien/invasive species" "Should not adversely impact on neighbouring crops - i.e excessive water use or providing a haven for pest species "
Transport "Proximity to point of use or conversion for positive energy balance" "Useful if the crop is near the end user" "Crop distance to end user to reduce overall LCA emissions of feedstock" "Carbon Neutral - energy crops should be grow as close to use as possible. " "Proximity of end use technologies. Distance and mode of travel to end use to be able to build cradle-to-grave Life-cycle analysis"
Social criteria
Community value "Ownership / other natural capital. amenity value" "Can the land be used for something else" "Yes - very much agree with the point to the left here - answers to many questions about where to put biomass depend on various aspects of multi-functionality - Point to the left was "Can the land be used for something else"" "Important recreational space" "Footpaths & access improvements" "leisure value of land" "Effects on neighbouring fields, or facilities" "should be land not needed for community activities" "if in community should have benefit - green spaces within urban areas" "Recreational resource to local and urban communities"
Cultural value "Ridge & furrow areas" "impact on farming family livelihood, labour, succession plans" "cultural value of land" "loss of identity as food grower" "cultural acceptability and local context" "historical land use; if it's previously been used for fibre crops (e.g. historical hemp, flax) there's a much better chance of acceptability" "Changing crops can loosen cultural links to the past and distance people from earlier cultural practices that are no longer visable in the landscape"
Visual landscape "landscape impact" "Visual changes to landscapes that communities may not find acceptable" "landscape impacts (social impacts as well as environmental)" "Visual impacts to be expected from growing 3m+ ECs"

“Account should be taken of landscape impacts” “Consider the visual impact and possible effect on tourism etc” “Inappropriate landscape planting”
Food system interactions “Off shoring food production” “Food impact? Why is this statement not pointed at Maize for AD, or wheat for ethanol?” “Availability of marginal land will require reduction in livestock numbers and change in diet from society” “what are the benefits / issues about swapping from biomass to food or vice versa” “societal- impact on food production”
Local health “Effect on local population health/wellbeing - some kind of social index used to quantify this?”
Local wealth/jobs “Job creation” “Effect on local economy growth (£ per year contribution to local economy)” “Local employment opportunities (no of new jobs)” “prioritise local food and local energy markets” “levelling-up - need for 'just rural transition' in climate change and agricultural policy” “new farm income streams for less favoured areas (uplands)” “impact on rural economy- jobs offered/lost” “Creation of new jobs by supporting new industries” “employment opportunities for locals, trainee apprenticeship opportunitie ” “Quantity of local, skilled jobs produced” “Community benefit. Direct and indirect wealth creation locally” “What is the impact on the local rural economy and landscape” “leveling up”
Other
Definitions of marginal land “this is going to be hard as it changes every year as farming subsidies reduce, so economically marginal is a very moveable concept” “Areas where CC adaptation will need be ” “Areas that will become unsuitable in future i.e. low lying coastal zones” “Target non-agricultural marginal lands (see Mellor et al 2021 https://doi.org/10.1016/j.rser.2020.110220” “Marginal' is a perspectival term. A curlew defines urban settlements as marginal land; an arable farmer defines uplands as marginal land. A suburban human resident defines a disused industrial site as marginal land; a common lizard defines that same site as a refuge and the only place their population can cling on” “Use Derelict Underutilised Neglected (DUN) land as a Nature Based Solution to dereliction” “Remove marginal land as a definition and criteria”

"Please stop insulting farmers by referring to their land as marginal! Suitable for biomass crop is a much less loaded term than any of the abandoned/idle/waste/marginal type terms"
Crop management "What kind of plantings? Species and configuration? This will determine compatability with and influence on environmental features and benefits." "utilising best technology to minimise land use" "Field design best practice" "Agronmic challenges to overcome"
Farm diversification "land diversification opportunity" ""Farmers grow energy crops for different reasons. Such as farm diversification income Reduced inputs and workload completed to food crops."" "Provides alternative for farm diversification - also not likely to be whole farm conversion"
Alternative biomass resource "Don't we have plenty of perennial crop biomass in the form of bracken?"
Unclassified comments
"market to sell the biomass to?" "How can encourage planting of energy crops when delay on any financial returns" "Need available end market - i.e. need to have a customer for the crop" "Lack of information for growers on energy crops (miscanthus not on defra search engine) - grower / land user" "use of spatial decision making of land use constraints will meet the major criteria required" "Skills & Knowledge of famers to produce crops (and willingness)" "What does Defra think about Miscanthus! - Miscanthus grower - grower / land user" "Land Management" "Land use changes" "Environmental NGOs need to get on board rather than just see PECs as -ve. They should embrace the positives. It is as though their view is a worst case scenario view. Done well there could be checks and balances put in place to make sure than the upscale of these crops is done sustainably and benefits biodiversity." "altituse" may refer too alternative use "Counterfactual land use with comparable metrics and criteria"

Session 2: Barriers, all comments
People barriers
Communication of Benefits & Opportunities "Lack of awareness of benefits of biomass use versus counterfactuals (i.e. to displace fossil based products)" "Public perception of energy crops is tied to BECCS (and hence Oil & Gas w/CCS). The 2020 Climate Assembly highlighted this." "Educating people on value of biomass crops, to defend food vs fuel arguments." "Farmer acceptance of change / need for change." "Explicit ability to combine energy crops with environmental benefits." "Lack of visibility and level playing field compared to food crops and trees." "Environmental considerations." "Public perception about changing land use." "People equate bioenergy with wood pellets not bioenergy crops, fuels etc." "People don't recognise the other uses of biomass - non energy, concrete, materials etc." "Bioenergy/ biomass community need to tell their story better particularly on complex issues like carbon cycling - how biomass contributes to short and long-term carbon cycle." "Need more simplified diagrams on carbon cycles and how it affects them."
Cultural Barriers "Cultural background - a livestock farmer is in a completely different industry compared to arable compared to dairy." "Average UK famer age is 58(?), this will likely impact their appetite to take on the risk required to grow energy crops."
Need for Partnerships "Lack of farmer networks to share best practice." "Role of industry in helping to de-risking establishment activities. There are good examples of industry end users working with farmers in producing biomass crops." "We need to get environmental NGOs seeing the benefits. It's been us and them for way too long. They need to get on side and see that there are benefits to be gained for biodiversity, in particular for pollinators and bird life." "Need more intermediaries."
Negative Perceptions "Lack of trust." "Researchers (need to stop) referring to people's farms as marginal." "Farmer identity - many will regard themselves as food producers and this is a key internal motivation." "A view that biomass has no role in future energy supply." "Recent failure of (the) energy crops scheme undermining confidence (also could be a policy barrier)." "Opposition of many key environmental campaigners to bioenergy." "social acceptability." "View that bioenergy has had its day - stop lobby in opposition."

Economic barriers
Crop Establishment Costs "Costs to establish energy crops perceived as high compared to annual crops." "Insufficient machinery = high costs." "High establishment costs and lack of incentives."
Economic Attractiveness "BAU based on short term profit cycles, doesn't build influence on willingness diversify." "(there are potential) Effects on land value." "Land managers often focused on primary business." "(too much) Uncertainty on the return on Investment." "(unattractive) Return rates." "Desire for continued flexibility and unattractive economics don't challenge this"
Economic Viability "Other agriculture is far better supported and more profitable." "Land valuation (both real and perceived), economic impacts of continued BAU in GHG terms is not factored in." "How can energy crops compete with existing uses."
External Economic Factors "Demand for biomass is at least 10 times higher than UK supply. So we need to consider the economics of importing biomass as the counterfactual to producing our own." "Relative cost of imported biomass vs domestically produced. Need to demonstrate benefits of domestic production." "Market price impacted by overseas imports."
Long Term Economic Security "Need long-term stable markets for bioenergy crops (de-risking for farmers)." "Long term contacts." "Long term returns on changes to farming system." "Long-term risk associated with bioenergy crops. Lack of confidence." "Scale up limited as protagonists can only make investment decisions based on markets, income potential or incentives. The lack of this means that people are taking a very tentative approach when we need people to be able to be confident that their investment is sensible." "Planting energy crops is a long-term commitment so certainty over who you are selling to, for how long and at what price is crucial." "Policies need to genuinely mitigate risk - for RHI, income is guaranteed for several years but not sure if this is true for bioenergy crops, which involve a commitment of several years by the farmer - policy memory of farmers planting energy crops for facilities that ceased trading." "Conditions & duration of tenancy agreed." "Sale prices need to be index linked because of crop longevity to provide security in investment." "Energy crops are long term investments, ~15y – the normal 'risk appetite' for farmers is based on a year on year decision basis"

Market Maturity “No actual markets in locality.” “Must address both supporting supply (feedstocks) and supporting demand (farmers) since only very specialist subset of society can provide demand.” “Supply-demand is a chicken-egg problem. Not sure how impasse can be broken…” “Markets!” “No existing market or indication of when and what market will look like.” “Uncertainty over what the demand will be in future and what crop will be required.” “Where energy crops can be used will impact on economic value = market size is low or in its infancy, causes concern” “Wide variety of end uses, cause confusion and low quantity making markets uneconomic.”
Reliance on Support Measures “Ensure markets and crops both get equal support at the right time to make sure both ends of market work.” “The industry wrongly expects a support mechanism to stimulate a market – why.”
Policy barriers
Available support “None of the Defra agents know about miscanthus (willow is mentioned) - need advice! Hard to understand payments schemes, support etc.” “Very hard to find support - what land demands, how to manage it etc.” “Uncertainty about what the options are at the moment.”
Communication of the role within UK Strategy “Unclear direction on how net zero will be achieved, people need more detail.” “Perceptions in flexibility of future land use.” “Natural capital policies, who owns value from biomass crops (e.g. carbon etc).”
Prioritisation of other renewables/activities “Countryside stewardship is more familiar and 'safer'.” “Preserving natural landscapes with cultural or other values.” “(It’s unclear) whether other renewable energy (e.g solar) are better economical prospects in terms of land use etc.”
Stable policy framework “So much damage done to the sector by poor or in-complete policy.” “Statements needed about long term policy particularly given the failure of other schemes in the past, and also the derating that we have seen in incentive schemes for other renewables (e.g. RHI, FIT).” “Start (ECS), stop (2007), start (Net Zero) policies have not helped.” “Uncertainty in ELMs payments and scheme options.” “To much change in policy means many will wait until more stable environment.”

Synergies across policy framework

"Classification of land use type (forestry species in agriculture currently fall under the forestry compliance system which is complex)."
"Complexity of ultimate departmental responsibility."
"Parity needed with schemes such as England Woodland Creation Offer - which pays 100% of establishment costs and an ongoing £300/ha annual payment."
"Lack of harmonisation around soil carbon credits. Building clarity here could incentivise bioenergy crop production in the context of carbon credits/offsetting markets."
"Lack of alignment between DEFRA and BEIS."
"Lack of joined policy across departments (e.g. BEIS want biomass, but not talking to DEFRA)."
"Previous Energy Crops Scheme was complicated and enabled applications to be blocked under planning rules - height of crop, visibility etc."
"Complexity of departmental responsibilities - whose remit is this under? Need agreement as it is a cross departmental area."
"Poor integration (Defra-BEIS)."

Targeted interventions

"Would anyone seriously consider growing energy crops for purely economic reasons, given the barriers discussed?"
"Needs market interventions (e.g a strike price for biomass energy content...)."
"In England no mention of energy crops in ELM. Need for them to be on the 'menu' so they are an option for land managers."
"Need for a scheme to ensure environmental benefits are rewarded."
"Where are perennial energy crops in the ELMs discussion? Conspicuous by their absence. Unfortunately, this is like leaving a key part of your toolkit back in the shed! Really needs to be prioritised as perennial energy crops can deliver results for the environment fast."
"Get more unmanaged woodlands into management."
"Support for novel biomass crops in new policies."
"Land managers need to have energy crops recognised within things like ELMs - not got parity with other crops."

Technical barriers

Cropping capacity

"Multiplication capacity (needed) for establishing new plantations."
"(Lack of) Speed/ access of rhizome production."
"(There is a) Disease risk when scaling PEC production."
"Need to address UK seed/rhizome supply from nurseries."
"Slow planting and labour intense."
"Getting beyond the issue of "native" plants. Biomass perennial energy crops have been bred so they do the job really well. Some are non-native but then so are many food crops. Perennial energy crops that have been bred for high productivity will do a job far better and quicker than a native."
"(Lack of) Availability of feedstock."

Decision support tools and independent advice

"Ability/confidence of land managers to identify suitable locations on their holdings."
"Need decision support tools that provide good, independent information and outputs."
"(need to shift) Annual crop rather than perennial crop mindset."
"Mixed messages - variety choices, species choices - can be confusing at such early stage."
"Lack of independent advice."
"Perennial energy crops considered low/ zero input. Lack of agronomic info to boost yields."

Equipment and infrastructure

"Lack of supply chain infrastructure, undermines confidence in consistent demand for producers to invest."
"(need) Long term storage options."
"(need) Sufficient and suitable on-site and offsite storage for baled crop."
"Field size, road access (issues)."
"(need) Equipment suitable for difficult to access land."
"On farm equipment - likely to require contractors or specialist machinery."
"(need) Mechanised / automated harvesting at scale?"

Establishing value chains

"(Need support for) Next stage processing requirements."
"Incompatibility with existing power plants."
"(Questions about) Compositional suitability for certain end uses."

Research to highlight impacts and benefits

"Current lack of drivers to ramp down agricultural GHG (which would open the door for bioenergy crops)."
"Credibility. We seem to have a lot of strategies and statements, which are all just words. The lack of assessment of contributions to emissions reductions that any policy will make renders them virtually meaningless, because it means the policy is easy to pull back from based on a whim."
"Understanding environmental impacts in different landscapes."
"Uncertainty around large scale environmental impacts (i.e. biodiversity)."
"Environmental impacts not known."
"Misunderstanding land management practices and lack of understanding of co benefits of multiple land uses."
"Concern about air quality implications at end use."
"Long term impact on land quality."
"Limited data on long term potential of new crop varieties."
"Recognition/ understanding of the potential benefits - better for biodiversity etc - is this recognised by policy makers?"

Technical skills and experience

"Stop / start nature of the sector in some regions has let to depletion of knowledge & skills."
"Knowledge about removing crops."
"Lack of energy crop knowledge in farming community."
"Training programmes for agronomists to ensure they know about biomass crops."
"People skill sets are in very low quantity - training required."
"Across industry skill sets need to be developed - not just leading supply companies."
"Agronomic experience."
"Switch from annual cropping is unfamiliar."

Session 3: Tools -all comments
Q1. Model scale
High resolution – field scale "As small scale as possible 5x5 m of the e-planners sounds ideal" "Farm and field scale, down to 5m resolution to match yield maps" "Field level is needed, as some farmers will look at not planting whole fields of biomass instead doing small sections, e.g. to square off an awkwardly shaped field to make it easier to farm for conventional crops" "Even at 1ha scale there will be large actual variations in field" "Ideally they should be sub-field level. This would allow the land-owner to identify areas of their fields that are not as productive within the arable rotation" "Should be usable by farmers and small holders of just a few ha" "accurate to 1m" "Small scale tools would be very useful for land managers particularly when there is less general information on these crops " "Smaller scale model important for making decisions about where to put crops in small pockets on existing land / agriculture" "There is a real need for more information for growers" "Maybe we need greater accuracy in some areas, i.e. the more marginal the site the more variable the yield is likely to be"
Range of scales- depending on question "I think that both national scale and local scale (and possible intermediate scales!) are useful. National scale really important in guiding strategic decision-making and prioritisation. Local really important in guiding decision-making by land owners and managers" "Useful for regional spatial land use planning; less useful at level of individual fields, depending upon quality and fine scale of farm data available" "But don't let perfect be the enemy of the good... the accuracy of the model depends on what it's used for; if it's being used as part of a payment scheme for example it needs a different level of accuracy compared to if it's being used to measure overall benefits for strategic policy level 1km down to 250m/5m, for user tools" "Scale must be relevant to the scale at which affected processes operate. Since many processes will be affected and these typically operate at different spatial and temporal scales it almost always the case that we must have predictions across multiple spatio-temporal scales in order to make well-informed decisions." "Tools will be needed at different spatial scales to answer different questions" "We need short, medium and large-scale models for different needs" "Hybrid - this is all areas with potential, these are small areas that should be high quality"

Balance with Accuracy

"Yield models based on 10k ha extrapolated to the whole UK make me uneasy. Widespread trials required."
"I think can be a misunderstanding between how variable fields in the UK actually are!"
"Accurate as the data allows"
"Best if based on trial data and real commercial data as there is often a 20-30% difference in reality. Farmers need to make decisions based on real information as far as possible as this way they will be making an investment with their eyes open."
"The models need to be far more refined with regards the factors they take into account farmers should be able to input ground truthing data to the model, e.g. if they have done soil testing recently"
"Top down models can only give (very) general indicative result, while bottom-up are necessarily small-scale due to data required (as CEH example)"
"There are many species whose responses to landscape change are still not well modelled due to limitations in our spatial datasets to capture and represent their needs, i.e. there are some consequences models currently cannot give you reliable information on."
"The scale at which models can operate is often constrained by the scale of spatial data input into them which is often constrained by remote sensing capabilities."

Q2. Desirable model outputs/functions

Economic Optimization

"Economic benefits"
"Economic scenarios illustrating economic effects of making a choice in landuse, likely investment"
"Economic focus useful for farmers (can help choose optimal crop choice too)"

Crop yield

"Yield"
"Yield figures for SRC, miscanthus and SRF based on yield trials and commercial experience. AFBI are leading the EnviroCrops project as part of the BEIS BFI competition. We are looking to augment models with grower information This will help farmers make economic decisions based on real figures."
"It is useful to know what yield could be generated from a given area of land. ideally this would be against other land-use options"
"Yield, decision support (operational information), identifying constraints, economics"
"Estimated Yield"
"Models to aid farmer confidence in crops would be useful, e.g. independent verification of yield potentials"

Ecosystem service impacts (sectioned into ES type)
Net ES “Ecosystem benefits” “Models could potentially inform and assist compliance with higher levels under ELMS standards (assuming the emergence of such policy measures) “ “An estimate of the scale of land use change and environmental impacts” “Environmental benefits” “Capture the co-benefits” Biodiversity “Habitat Fragmentation impacts and gains” “Biodiversity benefit” “Broader biodiversity benefits beyond pollinators” “Pollination benefits of PECs - in particular SRC willow and SRF eucalyptus” “Biodiversity impact” Water/flooding “Water impact” “Flood mitigation benefits of hydraulic roughness of willows and Miscanthus” “Perhaps some measure of flooding abatement” Other “Social benefits” “Soil improvement”
Net C/ soil C impacts “Potential C saving and cost” “Carbon dynamics of system - above and below ground changes” “Carbon assessments are going to be important as potential carbon markets take off” “Carbon Sequestration” “Would be good to know current soil carbon figures. This may help farmers who are looking to plant PECs and then trade the carbon sequestered.”

Integrated models

"Will also be useful, in many circumstances, to use model outputs and guidance from multiple sources (e.g. planning tools used by forest industry and regulators)"
"Needs to be able to relate and interact with the subsidy process"
"Constraint mapping has been a useful output in the past"
"Should be able to produce products that could be used in planning (e.g. use OS map underlay), for example subsidy maps vs croft registrations vs planning applications vs title deeds. all have different mapping requirements, processes and systems which do not speak to each other"
"Put in multiple 'land use options' to build a jigsaw and future look at the farm.. would include wind turbine addition vs hight limit of forestry nearby if they wanted to install it
Intergration with Defra MAGIC layers"
"Mapping end use markets and contractors could be useful. Facilitating equipment sharing could be useful"
"Distance to end use to be economically and environmentally sustainable"
"Spatial data can be useful to show achievable potential"
"Integrated delivery where you cross over 2 or 3 benefits and look where they align well"
"Numbers on potential biomass availability - and categorised by risk profile. So amount of land easily availability with low risk vs amount availability at higher risk."

Q.3 Do we need models

Yes

"Yes as a good model will enable better understanding and increase potential expansion of the industry. It is not enough to rely on commercial organisations that may over inflate yields and potential income"
"Good models but also spatial data outputs that are open data - so freely used by end users"
"I think the models are going to be very helpful - if we just have criteria, it will be almost impossible to ensure that interpretation of these is consistent between places, people and land uses"
"We need both to help people visualise unforeseen consequences that may be due to processes outside of their own experience."
"For integration with agriculture, modelling water quality and air quality protection "Could" be a useful aid for where to plant"
"Tool to help prioritise areas that could allow quick win? Help with proof of concept"
"Modelling will be important where integrating with agriculture to make sure get best benefits"
"Useful if enabling and they help avoid deployment where outcomes will be bad"
"They can be useful to direct policy"
"Yes more detailed modelling can feed into useful independent advice for landowners/ farmers"
"Detailed models more likely to influence inclusion in ELMS"

Yes in combination “Information to inform decision making but we should not allow models to make the decision for us since there are always factors that any given model does not account for.” “Really important that model outputs are used in the context of a decision-making process that also uses local knowledge and common sense!” “Models and DST can prompt conversations, rather than offer prescriptions” “Outputs must be accompanied with qualifications that emphasise that outputs should not rule out on-the-ground decisions that diverge from their recommendations due to place-specific deviations that are not incorporated in the modelling” “Yes - BUT, by supporting actual field work - not replacing it!” “Often the decision of to plant or not is down to the farmer. With the exception of areas where there are already limits on what the can and cannot do already. The key factor is ensuring crop profitability, so models are more need to ensure end users are in vicinity of crops.” “Need to exercise caution in making value judgements. IMHO there are relatively few places "where not to plant", more on technical grounds (unsuitable soils or local climate, unprofitability) than any hard-and-fast land use criteria.” “Models have a place but they need to be based on reality rather than large-scale generalisations” “Potentially valuable for prioritisation and proof of concept” “Need to remain aware of all the things that a model will never tell you (e.g. the Economics of Biodiversity report emphasising the stuff that is priceless, or hard to pin down, or impossible to measure)” “We shouldn't underestimate the role of the land manager as a decision maker”
No “It's very academic to think that of all the things that might overcome barriers, models is the thing to start with!” “Early stage development more focused on where not to plant. Detailed models are not that valuable”
Need both criteria and models “We need models and good guidance and criteria” “Written criteria (or summaries of lessons learned from using models) are often more accessible to end users than detailed models that they may not be able to run themselves.”
Available Tools and additional comments
Available tools “BIOPLAT-EU WebGIS tool” “BEIS is already supporting some trial decision support tools”

Aspects of model functionality

"Models are not good at capturing real life occurrences or unexpected events"
"These tools are always just part of the solution. Not the definitive answer."
"These tools will always contain some level of uncertainty but they can help to feed into wider discussions. Decisions need to be made now based on currently available data"
"The Exeter work presented – did not have habitats or ecosystem in it so quite limited non-market aspects"
"Exeter work does not seem to account for topography"
"The national model was taking in properties of 1 km squares - but not considering wider landscape impacts (including but not restricted to cumulative impact issues)"
"Look at where delivery will benefit biodiversity"
"Ecosystem services come from functional ecosystems Map the former to understand the latter. Not as we normally do the map[ping]"
"Mapping red and amber list birds and where planting PECs could help their populations"
"We also need to be able to make and guide decisions about the nature of biomass planting - not just where, but what is planted, and aspects of configuration and management?"
"If fine-scaled land use models were available, it would be useful to include functions such as connectivity, nature recovery networks, wildlife corridors, etc."
"Integrate into tools such as e-planner"
"Existing or planned customers markets"
"Details of farmers locally or regionally who have implemented the changes Champions"
"Include wider bioenergy infrastructure and networks - e.g. is there a bioenergy plant of haulier that could support the producer? or is there nobody around for 100s of miles?"
"Model predictions can only ever represent the expected conditions for a given site and must always be accompanied by on-the-ground observations of place-specific deviations from the expected norm."
"How to understand impacts of large projected deployments when it is happening at a scale not done before. "
"Would be interesting to see if suitability models could be overlaid with infrastructure mapping - additional data of appropriateness of land near relevant offtakers"
"Note aware Nigel Cornwall is possibly working on relevant mapping that could sink up"
"Open source for all these tools, so they can be integrated into business decisions, and tools business want to develop to support supply chain decisions"
"Models shouldn't be overcomplicated and should be set up in a user-friendly way. Need user experience expertise as well as modelling expertise."
"Farmers/ land managers are used to these tools (in particular Defra MAGIC maps) which also highlight areas where uplift money would be given - good to integrate with these"
"Needs to be easy and intuitive for farmers with no training"
"It is difficult to link models at different spatial scales (local, regional, national). Decision-making is made at multiple different levels"

Collaborative development

“Any models should be underpinned by independent yield data from bioenergy crops.”
“When used as a decision support tool implications of getting this wrong are big and could skew outcomes. More harm than good could be done if this is not got right”
“Models should clearly state the sources for their data”
“Is there a need for dialogue between modellers and growers to understand some of the nuances around generalisations?”
“We need more actual field trials around the country in different farming situations
Opportunities for those who use the models (farmers etc.) to give feedback, input local knowledge, which can inform future versions of the model would be good.”
“Outputs should be considered inline with data requirements of regulators or planning authorities. This could ensure users are able to get the exact data they need to present to regulators”
“Important to ground-truth models against real-world examples”
“The validity of a model depends on who is backing it; a commercial company can model whatever they like but it doesn't necessarily relate to what will happen on farm. Most farmers are used to this though.”
“we need to remember that models can actually increase barriers to adoption (e.g. a farmer dismissing a statement because it's based on a model and not real life, or simply doesn't reflect their lived experience).”
“Very different models needed for different user groups; a farmer might want one type of model but the neighboring community would be judging the acceptability of a change by completely different criteria”
“Co-design with users, importance of knowledge outreach (training)”