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RESEARCH ARTICLE

An assessment of policies to promote perennial energy crop and woodland planting

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Abstract

If the UK is to meet its target of reducing greenhouse gas (GHG) emissions to net zero by 2050, significant land-use change will be required. More woodland will have to be created and more perennial energy crops (PECs) will need to be grown. Land will also be required for food production, habitat restoration, and for new settlements. Government intervention will be required if landowners are to deliver this transition in land use. This research identified 43 policies that had been proposed for delivering increased planting of PECs and new woodlands. Their desirability, feasibility and potential effectiveness were assessed by a panel of experts using a policy Delphi method. Results showed that the most important was a comprehensive land-use policy, which will have to be delivered by the post-Brexit, Environmental Land Management (ELM) scheme in the UK. PEC cultivation could be most effectively encouraged by delivering investment or incentives to electricity generators at the top of the supply chain. Woodland creation requires support from attractive, well-administered grants to replace annual farm income. Educational and informational policies are also needed to breakdown the divisions between the farming and forestry sectors, and to overcome reluctance of landowners and farmers to grow non-food crops.

Author summary

If the UK is to meet its target of net zero by 2050, then more woodland will have to be planted to store carbon. Perennial energy crops such as willow and miscanthus grass will be needed for bioenergy with carbon capture and storage (burning woody crops to generate electricity and then capturing the carbon dioxide produced). The land needed for trees and energy crops could also be used for farming, for restoring wildlife habitats and for new buildings. New government policies are needed to persuade landowners and farmers to change the way they use their land. In this research we found 43 policies which could increase planting of trees and energy crops and then we discussed them with experts, to understand how effective they could be. We found that having a single policy to control rural land use is vital. The best way to encourage farmers to plant perennial energy crops is to financially incentivise the companies who generate electricity, so that they can pay farmers a competitive price for the crops. Woodland creation can be encouraged by offering financially attractive grants that are easy to apply for. Farmers and landowners also

need more information about planting woods and growing non-food crops to help overcome their reluctance to change the way they manage their land. Our findings will help governments to design effective policies to deliver sustainable changes to land use.

Introduction

If the UK is to hit the target of net zero greenhouse gas emissions by 2050 there will need to be significant changes to land use. The need for tree planting is well recognised, but land will be also needed to grow the biomass feedstocks for bioenergy with carbon capture and storage (BECCS) which is recommended by both the Intergovernmental Panel on Climate Change (IPCC) [1] and the UK Climate Change Committee (CCC) [2]. The CCC is the independent body which advises the UK government on GHG emissions reduction and adaptation to climate change [3]. Bioenergy (without carbon capture and storage) already makes a significant contribution to the decarbonisation of energy generation in the UK (delivering 29% of renewable electricity and 71% of renewable heat in 2020) but much of this is generated from imported wood pellets [4].

The CCC has identified a number of routes to net zero by 2050. These require the deep decarbonisation of all sectors, using a wide range of technologies and societal changes [5]. The Committee proposes significant woodland creation, increased cultivation of perennial energy crops (PECs), and peatland restoration; all of which require significant changes to land-use [2]. The CCC also proposes that less land is used for ruminant livestock (mainly cattle and sheep), consistent with their recommendation of a 35% reduction in meat consumption by 2050, and 20% reduction in consumption of dairy products by 2030 to improve health [6,7]. Landowners and farmers must be willing to change the use of their land if these net zero targets are to be met. This research considered two scenarios constructed by the CCC, *Further Ambition* and *Speculative* [2], and the more ambitious ESC *Clockwork* scenario [8], covering a range of levels of ambition. The PEC and woodland targets for these scenarios are shown in Table 1. The CCC has since announced four more scenarios [9] including the ambitious *Tailwind* which reaches net zero in the mid-2040s and increases tree planting to 70 kha from 2035, and the new central scenario, the *Balanced* Scenario, with the same energy crop and woodland cover targets as *Further Ambition*. In the last decade the areas of miscanthus and willow grown in the UK have remained level at around 8 kha and 2 kha respectively [10] and the area of trees planted in the UK has not exceeded 14 kha [11]. The targets in the CCC scenarios are therefore clearly challenging.

In the UK miscanthus and short rotation coppice (SRC) willow are the most commonly grown PECs. They can be processed by gasification or pyrolysis but are usually combusted to generate electricity and/or heat. Miscanthus rhizomes produce tall stems which can be harvested annually in winter from two–three years after planting for 10 to 15 years (or longer), are resistant to cold weather, require little fertiliser, and can grow on poor quality land that would otherwise be uneconomic or unsuitable for food crops [12,13]. Using miscanthus to replace fossil fuel can significantly reduce GHG emissions reductions [14], even without CCS. SRC,

Table 1. Land-use changes in UK by 2050 from three net zero scenarios.

Scenario	New trees planted by 2050 (kha)	Energy crops planted by 2050 (kha)	Agroforestry
CCC Further Ambition	900	700	10% of arable and 10% of temporary and permanent pasture
CCC Speculative	1,500	1,200	10% of arable and 10% of temporary and permanent pasture
ESC Clockwork	900	1,400	None specified

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usually willow or poplar in the UK, can be grown as a perennial crop. Willow takes up to four years to establish and can then be coppiced every three years [15] for 22 to 30 years [13], to produce biomass. Willow can fix carbon in soils, improve biodiversity [16–18], control flooding, and increase soil stability [19,20].

Cultivation of PECs was supported by Energy Crops Schemes from 2000 to 2013, which were under-subscribed [21,22]. Infrastructure grants were available from 2005 to 2009, EU grants were payable from 1992 to 2008 for growing energy crops on set-aside land, and from 2003 to 2009 energy crops received *Energy Aid Payments*, mainly for oil seed rape [23,24]. These schemes failed to deliver significant planting, and by providing subsidies based on planted area, they did not encourage careful husbandry, and poor establishment and low yields resulted [24]. Although no planting grants are currently available, land planted with miscanthus is eligible for some payments from the Sustainable Farming Incentive (SFI) scheme (a part of the ELM scheme) e.g. payments can be received for using no insecticides on a miscanthus crop [25,26]. The 2012 UK Government bioenergy strategy recognised the role of bioenergy in decarbonisation, and the benefits of energy crops (including preventing soil erosion, and improving biodiversity and fuel security) [27]. However, no policies to support PECs specifically resulted from this or from the 2023 biomass strategy [28]. The announcement by BEIS of biomass innovation funding [29] is an indication of Government support for the sector, and the commitment by Drax (the largest UK generator of electricity from biomass) to sourcing more biomass from the UK, and their partnership with the NFU to encourage farmers to grow PECs [30], is another development that could stimulate more planting.

Creating woodland, for timber production or carbon sequestration, also delivers increased biodiversity, flood control, recreational space, and improved air quality [31]. Sustainable woodland management, as specified by the UK Forest Standard [31], will produce sustainable woodfuel, especially from broadleaved trees which may not produce useable timber. Woodfuel can deliver meaningful GHG reductions if taken from sawmill waste, from thinnings, or produced from low carbon soils which would otherwise remain unused [32].

UK woodland cover has increased from a low of 5% in 1919 [33] to 13% in 2023 [11]. Planting peaked at over 40 kha annually during the 1970s, mainly conifer plantations in Scotland with the Forestry Commission planting significant areas of nationally-owned forests [33]. Planting dropped from the mid-1970s when tax advantages for conifers were removed, but some recovery in England was achieved in the early 1990s supported by the Woodland Creation Grant, and the Farm Woodland Scheme provided income-foregone payments. Planting in England declined again under the 2007 English Woodland Grant Scheme and fell to 0.7 kha per year in 2015 when the Countryside Stewardship Grant Scheme was introduced [34]. The Government set the target of 6.2 kha per annum by 2030 as a part of their 25-year Environment Plan [35]. Other UK targets for 2030 have been proposed e.g. 40 kha per annum by the World Wide Fund for Nature and by Confor (the trade association for the UK forestry industry) [36], 48 kha per annum by the Woodland Trust [37] and 100 kha per annum by Friends of the Earth [36]: all significantly above current planting levels. The Government's current UK target is 30 kha per annum [38], with 7 kha per annum in England [39]. The English target is viewed as unfeasible in the short-term because of constrained sapling supplies and a lack of interest and skills from landowners [40]. In the year 2022–23, 3.13 kha of woodland were created in England and 12.96 kha in the UK with government support [11].

The Forestry Commission has comprehensive summaries of grants offered for woodland creation [41,42]. Expansion of the nation's forests is encouraged through leasehold agreements between Forestry England and owners of land suitable for afforestation [43], and the Plant Your Future initiative [44] aims to encouraging farmers to plant trees. Woodland owners also qualify for tax benefits [45,46].

There are many barriers to both PEC adoption and woodland creation in the UK. Although PECs are promoted for poor or marginal land [47], diversification of farm incomes [48,49] and as low maintenance crops [15,50] with a positive impact on GHG emissions [50], planting is discouraged by the many economic barriers including high planting costs, the delay before income is generated [15,21,49,51,52], and the high prices of cereals, especially wheat [49,50]. Committing land to PECs for 15 to 20 years is a risk for farmers who may be reluctant to change existing farming practices, traditions and landscapes, or to be the first farmer locally to adopt a new technology [53], and may be concerned about losing flexibility in their farm strategy [54]. Other barriers include the absence of a consistent UK energy crop policy [23,48], a lack of knowledge among farmers [53,55,56], negative perceptions of energy crops by the general public [57] and concerns around long-term land-use change [58]. Technical issues were found with winter harvesting in early years [21,59,60], but McCormick and Kåberger [55] argue that none of the key barriers are technical. Although farmers support reducing carbon emissions and reliance on fossil fuels, they also require crops to be economically viable [48,53,61]. Failure of the ARBRE project (a PEC-fuelled gasification power station in the 1990s [24,62,63]), reduced the confidence of UK energy crop growers [23,64]. Lindegaard [22], ADAS [65] and McCalmont [14] all describe a '*chicken and egg*' problem: farmers will not plant PECs without a market, but there will be no investment in generation plant without a supply. McCalmont [14] recommends top down intervention and policy stability to ensure planting of miscanthus. Slow uptake of PECs is not restricted to the UK and need for policy intervention throughout Europe has been recognised [66].

Although the Government incentivises woodland creation, uptake has been disappointing. Most planting will have to be carried out on privately owned land, and the volume of woodland planting depends on the attitudes and objectives of landowners [67]. As there is no compulsion for a landowner to plant [34], woodland creation must be economically advantageous to landowners as well as being environmentally beneficial [68]. Planting can be complicated further when land is held by tenants [69,70]. The Countryside Stewardship Scheme which delivers incentives has been described as '*not fit for purpose*', bureaucratic and overly complex [71, p. 3]. Incentives for woodland creation need to cover initial planting, and some or all of the income foregone from agricultural activities, but because the payback from forestry is over a long term it may never be economic on poor land [34,72–74]. The cultural division between forestry and farming can also constrain woodland creation, with some farmers holding negative opinions of forestry, and the permanent land-use changes required. They view forestry as bad for the landscape and food production [69,72,75,76], and fear that planting trees will reduce the value of their land [68]. The availability of suitable land is another significant constraint [68], and it is possible that much suitable land has already been used, leaving only less productive land or land suitable for other uses, such as arable farming [77]. Restrictions on species mix, which prioritise native broadleaved trees [31,78] to deliver environmental benefits [79,80], are deterring some planting [68]. The limited capacity of nurseries to scale up the supply of young trees is also a constraint and it may take years for new grant schemes to deliver planting [34].

UK bioenergy was first supported by the *Non-Fossil Fuel Obligation* and then by the *Renewables Obligation Scheme* [63,81] which supported large generators for 20 years, and was open to entrants from 2002 to 2017 [23,82]. The *Contracts for Difference* scheme [83] is now the main support for large generators of renewable power, including dedicated biomass with CHP [84]. From 2010, feed-in tariff (FIT) payments were made for 20 years to small-scale generators of electricity [85] but this scheme closed to new entrants in 2019 [86]. Although there is not currently a mechanism for rewarding the negative emissions from BECCS, following consultation [87], DESNZ is designing a reward mechanism for greenhouse gas removals based on a

contract for difference model [88]. Biomass combustion has faced opposition from pressure groups [89] and environmental charities [90,91] and Drax recently received widespread criticism for felling protected forests [92]. Public support for bioenergy has lagged behind other renewable technologies. Members of the public in the CCC Climate Assembly rated it as significantly less desirable than offshore wind and solar power, while 99% were in favour of tree planting and only 42% supported growing biomass for BECCS [93,94].

Although some incentives have been effective in encouraging bioenergy generation and use, incentives to promote PECs in the UK have failed. Woodland creation in England has also fallen short of targets, leaving the UK dependent on imported biomass. New policies will be needed to persuade landowners to adopt PECs and woodland creation at large scale, rather than continuing to produce food or to opt for habitat restoration. Carbon pricing is not expected to be enough to deliver climate change mitigation and significant government intervention will be needed [95,96], preferably clearly signalled by governments [97,98] to deliver fair policies which allocate risk to the parties best placed to bear them [96]. Following the departure of the UK from the EU (Brexit), the UK is implementing its Environmental Land Management scheme covering agriculture and forestry. Between 2021 and 2027, this will replace the EU Common Agricultural Policy payments made to those with land at their disposal, with payments for environmental services: rewarding sustainable practices on farms and encouraging local cooperation on larger scale projects such as flood management and forest creation [99]. This period of transition, when public and media sentiment is generally supportive of GHG emissions reduction, presents a policy window [100] during which significant change could be implemented. PECs and woodland creation could benefit from this window and also from the recent global focus on energy prices and security following the Russian invasion of Ukraine. However, there are already signs that the UK government will prioritise food production and security over environmental land-use schemes [101].

Many policies have been proposed to overcome the barriers to PEC and woodland adoption by advocates for the farming and forestry industries, researchers, and government bodies. Some proposals cover all types of land-use change [2,8,102–105]; others focus on PECs [22], or woodland [34,37,106–108]. More recently the need for a framework to deliver balanced land-use has been advocated [109], and the need for collaboration to deliver dedicated biomass cultivation has been identified [110]. Although many organisations and academics have proposed policies, there has been nothing published on their potential effectiveness in delivering desired land-use change in the face of competition for land from food production, expansion of settlements, and restoration of valuable habitats. This research fills that gap by assessing potentially suitable policies and recommending the policies which could be most effective in delivering the significant land-use transition needed to allow the UK to reach net zero by 2050.

Methods

Policies with potential to deliver increased PEC or woodland planting were identified and then assessed using a policy Delphi. Delphi is a forecasting, analysis, and decision-making method used to gather opinions on complex problems from groups of experts [111,112], based on the theory that a group of experts will produce better predictions or decisions than individuals. The key characteristics of a traditional Delphi include: anonymity, the use of a panel of participants with in-depth knowledge who do not meet each other, at least two rounds of structured dialogue or consultation, the emergence of consensus, and the use of a knowledgeable facilitator or research team, [113–115]. The use of frequency distributions to identify patterns of opinion has also been identified as a core feature [113].

The *policy Dephi* variant defined by Turoff, can analyse policy options [112], and deliver opinions to policy makers [116]. A policy Delphi usually has three rounds [117], often gathering policy ideas or issues in round one, rating them in round two and presenting the ratings for review in round three [118]. If the policy options are gathered by the facilitator, only two rounds of consultation are needed [118] and this approach was taken here.

Policies for assessment were identified from searching academic and grey literature for proposals from pressure groups, charities, government bodies, and academics. These authors carried out previous research on the adoption of PECs and creation of woodland in the UK, interviewing farmers, landowners and their advisors, to identify barriers to land-use change [119] and policies suggested by the interviewees were also assessed in the policy Delphi.

The policy Delphi

Recruitment. The policy Delphi panel comprised a balance of advocates for specific sectors and more impartial analysts with a policy formulation role in government or research (including two ecologists, a forester and a chartered environmentalist). All panellists were familiar with land-use policies. Nine members were recruited for round one in June/July 2020 and eight completed round two in August/September 2020. Details of the panellists are included in Table 2.

Data preparation. The data-pack issued to panellists (S1 Data) contained: an introduction to the research and the policy Delphi process, lists of key barriers to PEC cultivation and woodland creation, details of the three net zero scenarios (Table 1), Likert scales used to assess the policies (Table 2), and the list of policies to be reviewed (without details of their source and type). The data-pack was detailed enough to show that the key issues had been identified, but short enough to be read in ten minutes. Panellists were asked to have the document to hand during the round-one consultation.

Likert scales. When many judgements are being made in a Delphi (such as in this case where 43 policies are to be assessed), rating using a Likert scale [120] is recommended rather than ranking [112]. A four-point scale is recommended for a policy Delphi [117], to force participants to make a choice: being neutral is not an option, although *no response* is a valid fifth option when panellists are genuinely unable to form an opinion. The attributes to be assessed were *desirability* in an ideal world, *feasibility* in the real world [121] and potential *effectiveness* [122] of the policy in the real world. The rating scales developed from Turoff's definitions [121], are shown in Table 3.

There has been much discussion on the best way to treat Likert scale data, [123–125]. The data was treated as ordinal and the responses presented in divergent stacked bar charts [115,126,127] to allow easy comparison of responses [128].

Table 2. Panel members.

Panel Member	Organisation	Job Description	Area of Expertise	Role
1	Aberystwyth University	Research Group Leader	PECs	Advocate
2	CCC	Senior Analyst	All	Analyst
3	Forestry Commission	Principal Advisor for Climate Change	Woodland	Analyst and advocate
4	Natural England	Climate Change Mitigation Specialist	All	Analyst and advocate
5	Royal Forestry Society	Chief Executive	Woodland	Advocate
6	Terravesta	Chairman	PECs	Advocate
7	Strutt and Parker	Director of Research	All	Analyst
8	UKCEH	Research Scientist	All	Analyst
9	Woodland Trust	Director of Woodland Outreach	Woodland	Advocate

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Table 3. Likert scale definitions used in the policy Delphi. Adapted from Turoff [121, pp. 86–87].

Attribute	Rating	Description
Desirability	Very desirable	Clearly beneficial.
	Desirable	Beneficial but may have minor negative effects.
	Undesirable	Will have some negative effects but may be justified overall in conjunction with other policies.
	Very undesirable	Extremely harmful or not justifiable.
Feasibility	Definitely feasible	Proven approach with no political or public objections likely.
	Possibly feasible	Possibly implementable, but not fully proven or some objections anticipated.
	Possibly infeasible	Some indications that it may be unworkable or unacceptable.
	Definitely infeasible	Unworkable or unacceptable politically or to public.
Effectiveness	Very effective	Very likely to deliver the desired effects.
	Effective	Likely to deliver some of the desired effects.
	Ineffective	Will have no effect either positive or negative.
	Counter productive	Likely to produce negative effects.

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Consultations. Individual consultations, based around the data-pack, were held with the panel members in spring and summer 2020 and, as a result of Covid-19 restrictions in force at the time, could not be held face-to-face. Telephone interviews were conducted and were recorded.

In round one, participants rated seven types of land-use for desirability (so their personal, or their organisation's values could be understood), reviewed a list of barriers to woodland and PEC planting and added any they thought were missing, as well as rating three land-use scenarios (Table 1) for desirability and feasibility. Finally, 43 candidate policies for delivering land-use changes by 2050 were rated using the four-point Likert scales in Table 3, with *no answer* as a fifth option. Participants were also asked to identify likely problems, unintended effects or interactions for each policy, and to propose new policies. Opportunities were provided for adding comments, explanations, and ideas throughout the consultation which was designed to be completed within an hour. The process and documents were pilot tested [118].

The data gathered in round one was recorded in an Excel spreadsheet from which divergent stacked bar charts, and tables of comments, were generated for inclusion in the round one report issued to the panellists (S2 Data). To be consistent with the Delphi philosophy, no interpretation or judgement was made by the researcher in producing the report, opinions were simply collated and presented for discussion. In round two, the report from the first round was reviewed by panellists during individual telephone calls lasting up to 50 minutes.

Analysing the Delphi data

The ratings from round one and the comments from both rounds were analysed together. The groups of policies (general, woodland, agroforestry, and PEC) were further segmented by policy type: information, economic, regulation and organisation. These types are based on commonly used policy instrument taxonomies including those of Hood [129], Howlett [130], Balch [131], Vedung [132], Lowi [133] and Doern [130].

Results

Policies Identified

The policies identified from literature and from interviews with farmers, landowners and advisors are listed in Table 4 and categorised into one of four types, based on their impact on the landowner's decision-making.

Table 4. Policies for review.

Policy Number	Policy	Source	Policy Type
	General Policies		
1	Develop a single, integrated land-use strategy and a single countryside and land-use policy covering farming, agriculture, and ecosystems services delivery (balancing carbon sequestration with other priorities including food and timber production).	Energy Systems Catapult [8]; Whitaker [104]; Confor [105]; Soil Association and Woodland Trust [107]; Interviews	Regulation
2	Use public money to deliver public goods including evidenced based rewards for climate related activity.	CLA [102], Whitaker [104]	Economic
3	Payments for public goods should be more generous than current schemes and should include an element of profit for the land manager rather than being based on average costs and income forgone.	CLA [102]	Economic
4	Remove any remaining tenancy constraints on change of land-use.	CCC [2]; Soil Association and Woodland Trust [107]	Regulation
5	Ensure that all carbon sequestration activity and public goods delivery (including woodland creation) is treated favourably in tax policy.	CLA [102]; CCC [2]; Forestry Commission [34]	Economic
	Woodland policies		
6	Use a carbon market or trading scheme for land to attract private sector investment and increase the value of woodland creation.	Woodland Trust [37]; NFU [103]: CCC [2]; Forestry Commission [34]	Economic
7	Allocation of land to trees should be a priority of a single land use strategy.	Woodland Trust [37]	Regulation
8	Set national annual woodland planting targets.	Woodland Trust [37]	Information
9	Local authorities must set annual planting targets and identify land for trees.	Woodland Trust [37]	Information/ organisation
10	Deliver government funded advice on woodland creation to landowners and farmers to help remove the divide between forestry and farming.	CLA [102]; NFU [103]; Forestry Commission [34]; Soil Association and Woodland Trust [107]; Interviews	Information
11	Remove the division between forestry and farming in education.	Interviews	Information
12	Provide long term policy certainty to enable scaling-up of domestic forestry supply chain from nurseries to sawmills rather than a series of 5-year policies.	CCC [2]; Interviews	Regulation
13	Woodland creation grants should provide adequate payments for establishment, pest protection and annual payments (to be competitive with other land uses).	CLA [102]; Forestry Commission [34]; Interviews	Economic
14	Provide public funding for woodland creation for non-carbon benefits e.g. for flood control, public access, or biodiversity.	CCC [2]; Interviews	Economic
15	Grant funding should increase with time as progressively better land is required for tree planting.	Interviews	Economic
16	Reduce the bureaucracy of woodland creation: streamline applications and approvals, increase the capacity of administrators, and make regulations simpler (Forestry Act, felling licence regime, EIA requirements).	CLA [102]; CCC [2]; Forestry Commission [34]; Confor [108]; Interviews	Regulation
17	Reduce the penalties incurred when planting schemes fail.	Interviews	Regulation
18	New construction developments must include a minimum of 30% tree cover.	Woodland Trust [37]	Regulation
19	More forest partnerships like the Northumberland Forest should be formed.	Confor [108]	Organisation
20	The importance of the commercial market must be recognised in all strategies and policies relating to the forestry and woodland sector.	CLA [106]; Interviews	Regulation
21	Improve the public perception of commercial forestry	Interviews	Information
22	Allow planting of a wider range of species (including conifers and non-natives) to deliver resilience.	Interviews	Regulation
23	Set targets for the use of UK timber.	Confor [108]	Information
24	Remove subsidies for farming land that is more suited to forestry.	Forestry Commission [34]; Interviews	Economic
25	Expand the UK nationally owned forests including working with public bodies with large land holdings.	Forestry Commission [34]	Organisation
26	Remove the requirement to replant from terms of felling licences thus removing permanence of land-use change.	Interviews	Regulation
	Agroforestry policies		
27	The Government should provide a clear definition of agroforestry, and regulate it as agriculture.	Soil Association and Woodland Trust [107]; Interviews	Regulatory

(*Continued*)

Table 4. (Continued)

Policy Number	Policy	Source	Policy Type
28	The Government should recognise the environmental benefits of agroforestry by including it in public goods environmental schemes.	Soil Association and Woodland Trust [107]; Interviews; CCC [2]	Economic
29	The Government should support the trialling of agroforestry, e.g. supporting independent networks and innovation networks.	Soil Association and Woodland Trust [107]	Information
30	Develop a market mechanism to fund agroforestry (e.g. include it in woodland carbon trading).	CCC [2]	Economic
	PEC Policies		
31	The government should signal their long-term commitment to bioenergy.	Whitaker [104]; Interviews	Regulation
32	Use demand side instruments to develop and strengthen the market for energy crops, e.g. carbon pricing support for bioenergy with CCS and continued support of biomass generation through existing measures (e.g. exclusion from emission trading scheme obligations).	CCC [2]	Economic
33	The Government should provide backing for energy crop supply contracts.	Interviews	Economic
34	Oblige biomass combustion facilities to source a proportion of biomass from the UK with the proportion to rise over time.	CCC [2]	Regulation
35	Establish an advisory service for energy crops to disseminate information to farmers.	Whitaker [104]	Information
36	Provide planting subsidies/grants for establishment costs and to replace lost incomes during establishment.	Whitaker [104]; CCC [2]; Lindegaard [22]; Interviews	Economic
37	Include grants for establishing PECs in environmental schemes for delivering the public goods of biodiversity, nitrate and flood control.	Whitaker [104]; Lindegaard [22]; Interviews	Economic
38	Streamline cross-agency approvals of planting PECs.	Whitaker [104]; Lindegaard [22]	Regulation
39	Support energy crop research and development.	Whitaker [104]	Information
40	Support private sector intermediaries who can raise awareness of financial benefits and arrange long-term contracts between farmers and users.	CCC [2]	Organisation
41	Promote the benefits of PECs to the public and local communities.	Whitaker [104]	Information
42	Provide grants to support the development of the full supply chain from planting materials through to harvesting and processing.	Whitaker [104]; CCC [2]; Lindegaard [22]	Economic
43	Provide grants for removal of the crops at the end of their life.	Lindegaard [22]	Economic

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Analysis of policy Delphi data

The policy Delphi results are presented as divergent stacked bar charts in the order in which they were discussed with the panel. The analytical framework of policy types is used to structure a discussion of the ratings and comments from panellists. The bar charts show where there is significant disagreement and where there are problems with feasibility or effectiveness. In all bar charts the *no answer* responses have been removed. Generally, *no answer* was gathered when panellists felt they had insufficient relevant expertise, but in some cases, panellists were unwilling to provide an effectiveness rating if they had rated a policy as undesirable or unfeasible. In keeping with the Delphi method, comments are not attributed to individual panellists in the discussions below.

Land use. Panellist were asked to rate the desirability of seven types of land use, primarily to understand their individual values, and provide context for their policy ratings. The ratings shown in Fig 1 have an unexpectedly high level of consensus for a diverse panel.

Peatland restoration and hedgerow expansion were viewed as the most desirable new land uses with peatland restoration being described as the single most important activity, but it was noted that this receives less media coverage than tree planting. Woodland creation was almost as highly rated, although panellists stressed the importance of selecting the right land to avoid

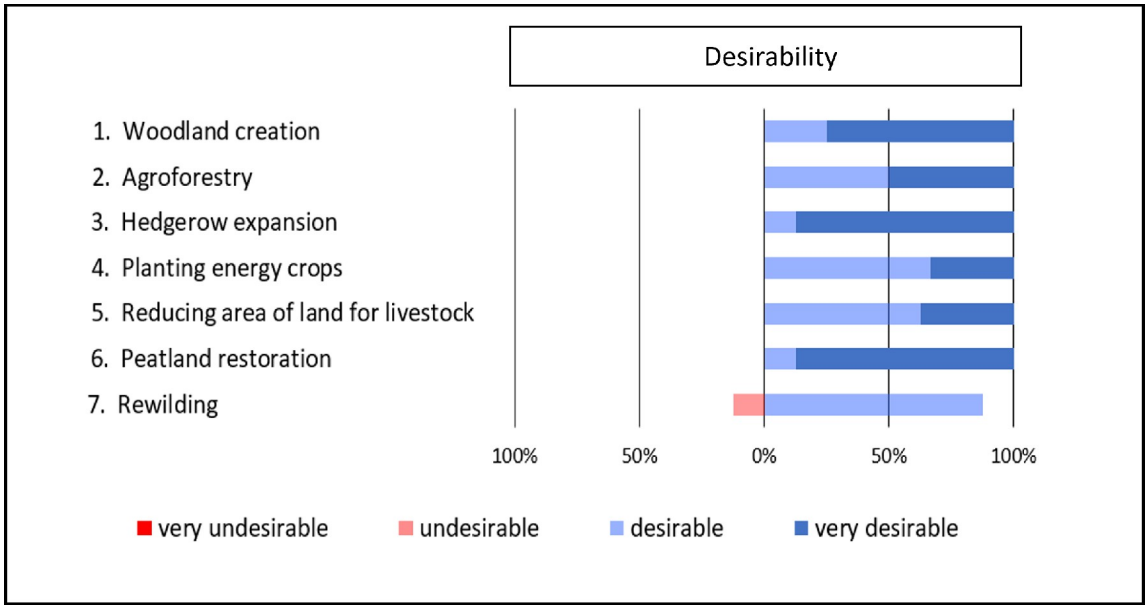

Fig 1. Ratings for desirability of different types of new land use.

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negative impacts on habitats and soil carbon, and particularly to avoid planting on peat. The UK Forest Standard [33] was expected to prevent the undesirable planting of the past decades.

Agroforestry was highly rated, although one panellist had reservations about the feasibility because it was not a part of the UK culture. This view was countered by others pointing out that the perception of agroforestry as '*stripes*', resulting from alley cropping, is a very narrow view. This is discussed in more depth below.

Reducing the area of land used for livestock and increasing the area of energy crops were both viewed as desirable, but different attitudes to the scale of their adoption appeared later in discussions. In round two some panellists were surprised that the cultivation of energy crops was viewed as desirable by all panellist, and had expected more partisan lobbying from the woodland sector. However, there was clearly a consensus that all land uses considered here were part of the solution for net zero emissions.

Rewilding was the least supported option and the panellists thought that the term *rewilding* was not well defined, covering a range of activities from managed rewilding to land abandonment, and that a clear definition is needed before it can be regulated or incentivised. One panellist felt that there were better uses for land than rewilding, and another predicted that it could be unpopular with farmers who see their role as managing the countryside. It was recognised by the panel that more research on the carbon balances for rewilding would be needed before including it in plans for GHG reduction.

Net zero scenarios and suitability of land for planting. Opinion on the desirability and feasibility of the three land-use change scenarios (Table 1) was much more diverse. The ratings are displayed in Fig 2. The CCC *Further Ambition* scenario, the least ambitious of the three, was rated as the most desirable *and* achievable, with reservations expressed by one panellist about the area of energy crops. The planting levels were considered achievable with considerable effort and policy intervention. One panel member viewed 23 kha per annum of PEC planting as unachievable based on the lack of progress in the last 15 years, but there was more confidence in the creation of 30 kha of woodland per annum because of the planting achieved recently in Scotland and, in the past, in England. In round two there was agreement that the

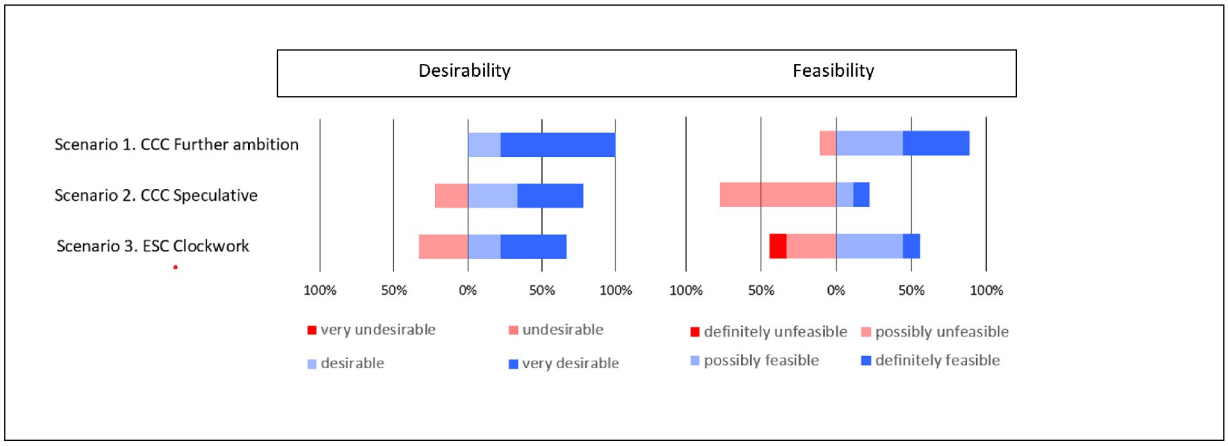

Fig 2. Desirability and feasibility ratings of the three land-use scenarios.

https://doi.org/10.1371/journal.pstr.0000109.g002

level of ambition in the *Further Ambition* Scenario had been discussed long enough for attitudes to shift to the point where it is accepted as realistic: politically, and in the agriculture and forestry industries.

The *CCC Speculative* scenario, with higher levels of PECs and woodland, was rated as less desirable and least feasible, with some objections to the levels of both woodland and PEC planting, with the woodland planting causing significant and noticeable landscape impacts.

The *ESC Clockwork* scenario was least desirable because of the level of PEC planting, but ratings of feasibility were highly divergent, with the woodland planting viewed as feasible, but with concerns about the level of PEC planting. One rating of definitely unfeasible was given because of the impact on the landscape, and the concern that energy crops are less acceptable to the public than woodlands.

The ratings of the scenarios again showed the panellists were open minded about the types of land use considered, even if their level of knowledge varied between types. Although some of the panellists were advocates of woodland creation or energy crops, they all appreciated that many other changes of land use are needed to deliver GHG reduction. The main differences of opinion were over the relative scale of planting that was desirable.

Analysis of general land-use policies. The panel's ratings of the general land-use policies are shown in Fig 3. These ratings and the comments from both Delphi rounds are now discussed with the number of the policy under discussion (see Table 4), shown in round brackets.

Regulatory policies. A single countryside land use policy (Policy 1 in Fig 3) was rated as highly desirable, feasible, and effective. Panel members were optimistic that the time was right for the ELM scheme to deliver this in England, following the success of similar schemes in Scotland [134]. However, there was doubt about how this could be made to work. Panellists felt that land-use decisions should ultimately be made by the landowner and there should be no top-down compulsion. There was a fear that ELM could focus on wildlife, missing the opportunity to deliver carbon sequestration, and resulting in more intensive farming of productive arable land to compensate for the removal of subsidies.

Although the barrier that tenancy poses to land-use change was recognised, *Removing tenancy constraints to land-use change (P4)* provoked highly polarised responses. Some viewed it as a positive way to overcome the barrier while others viewed it as a highly undesirable policy that could be unfair to landowners *and* tenants, and could lead to land being taken back in-

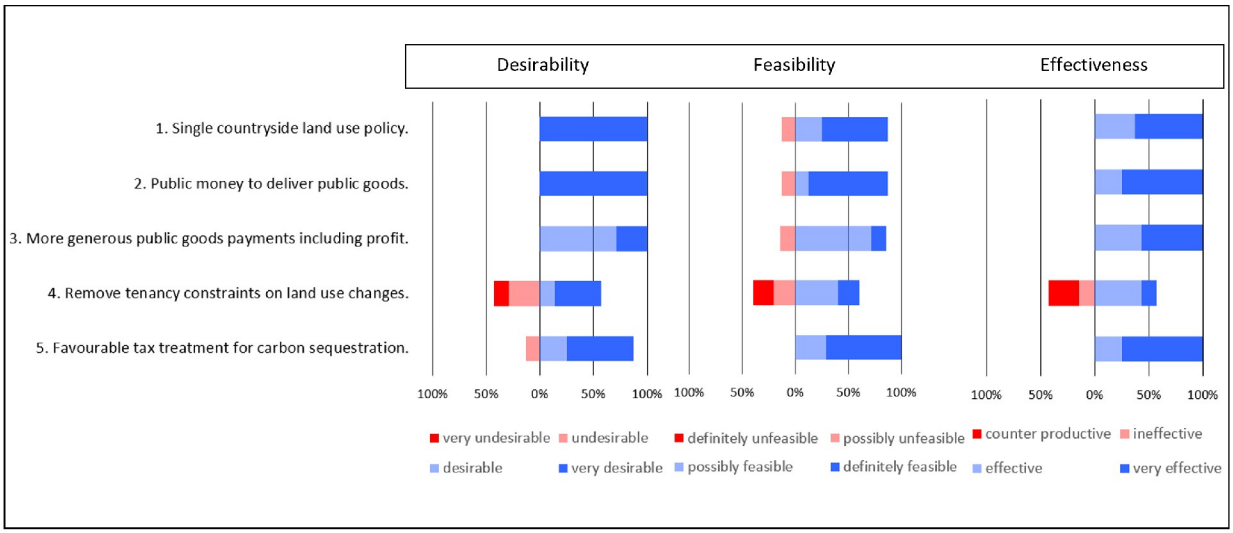

Fig 3. Ratings of desirability, feasibility, and effectiveness for general policies.

https://doi.org/10.1371/journal.pstr.0000109.g003

hand, ultimately causing a shortage of tenancies. It was suggested that *amending* rather than *removing* constraints would be a better description of this policy, which would be legally challenging to deliver.

Economic policies. Using public money to pay for the delivery of public goods (P2) was another highly rated policy and the Government is expected to deliver this with the new ELM scheme. However, to be effective it was argued that the rewards must be based on *evidence* of delivery of fundamental environmental benefits such as carbon sequestration, rather than the many '*soft and cuddly*' habitat and wildlife schemes, such as growing nectar-rich wild flowers [135] which they felt could be more popular than planting trees and so reduce the delivery of carbon sequestration.

Making payments for public goods more generous to include an element of profit (P3), was also rated highly but nevertheless provided a range of conflicting comments. While some of the panel argued that it was important to provide an element of profit to reward farmers and replace EU CAP farm payment income, others were not keen on basing payments on profit, and there was concern about whether this money was available.

Delivering favourable tax treatment for carbon sequestration activities (P5), although rated as potentially highly effective, would be hard to deliver without unintended consequences because of the complexity of the tax system. The panellists had seen this cause undesirable outcomes in the past, e.g. poor-quality woodland and planting on peat in the 1980s [136–138].

Analysis of woodland creation policies. The ratings for woodland creation policies are shown in Figs 4 and 5. These ratings and the comments from panel members are discussed below.

Regulatory policies. The proposal that *the allocation of land to trees should be a priority of a single land use strategy (P7)*, was viewed as undesirable and potentially counter-productive by many panellists. No preference should be given to trees in a land use strategy, and the best use should be determined individually for each piece of land, with a full range of uses being considered (including food production or peat restoration), with the decision made by the landowner. Giving priority to trees in all cases could lead to missing the 2050 targets for GHG reduction.

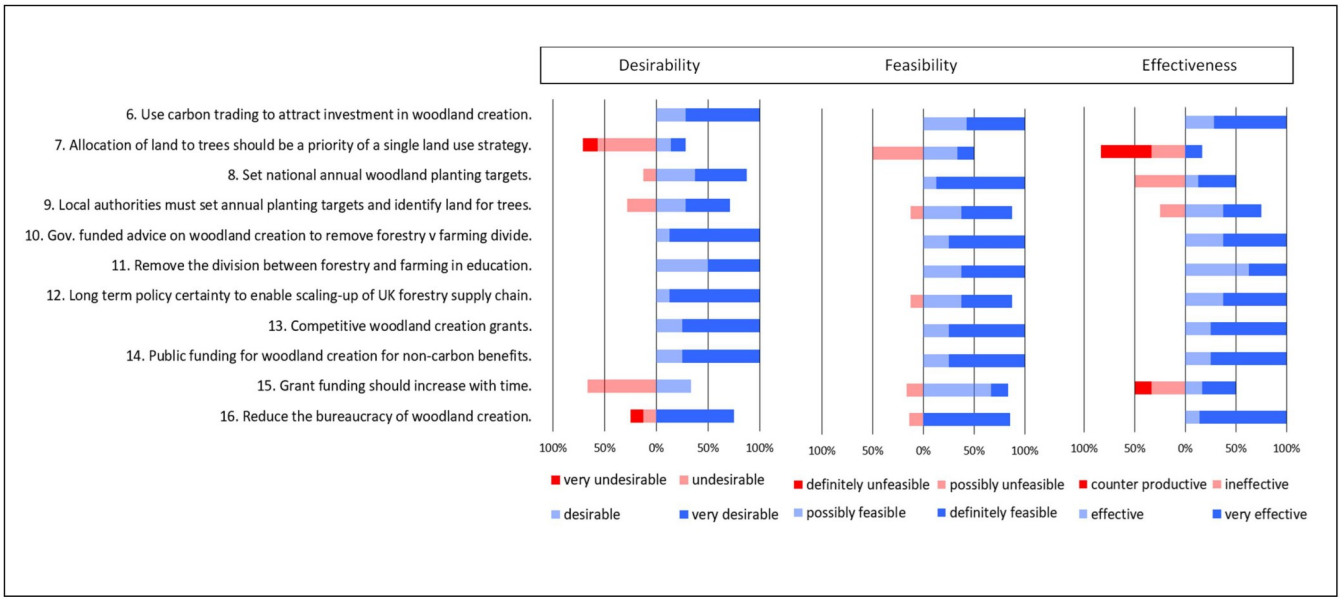

Fig 4. Ratings of woodland policies 6 to 16 for desirability, feasibility, and effectiveness.

https://doi.org/10.1371/journal.pstr.0000109.g004

Long term policy certainty to enable scaling-up of the UK forestry supply chain (P12) was viewed as vital to meeting targets, and confidence has been undermined in the past by policies changing, e.g. nurseries are now unwilling to commit to producing higher levels of stock having previously been left with unsaleable saplings. The panellists thought that continuity is always likely to be a problem, as governments can only supply funding for five-year periods, rather than for the long term. Therefore, initial investment, followed by self-sufficiency was viewed as more likely to be successful than permanent support of the supply chain. Unexpected changes in policies are likely to discourage investment in renewable energy projects [56], while policy

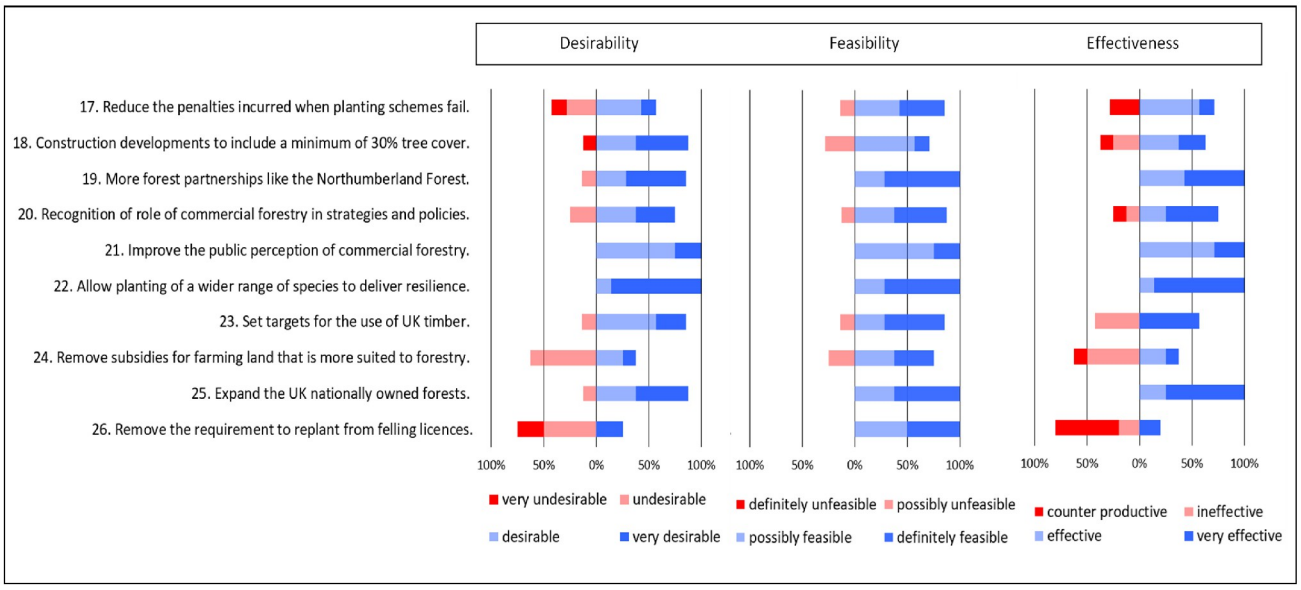

Fig 5. Ratings of woodland policies 17 to 26 for desirability, feasibility, and effectiveness.

https://doi.org/10.1371/journal.pstr.0000109.g005

certainty or predictability has been shown to be a key determinant of success e.g. the effectiveness of FITs increase when contract durations are increased [139] with 20 year terms of contracts being effective [140]. The need for governments to retain flexibility in policy conditions, to adapt to changes in technology and markets, must be balanced with the investors' need for certainty [141]. *Reducing the bureaucracy of woodland creation by streamlining applications and approvals, increasing the capacity of administrators, and making the regulations in the forestry act, felling licences and environmental impact assessments (EIA) simpler (P16)* was viewed as a potentially highly effective policy. The success of these measures has already been demonstrated in Scotland [142]. However, the panel suggested that this policy should have been split into two for assessment. Although the panellists all supported having a more efficient administrative process, there were warnings that the regulations should not be diluted, and a rigorous process should be followed for approving permanent changes of land-use.

Although there was sympathy for farmers whose trees fail to establish, support for *reducing the penalties incurred when planting schemes fail (P17)* was limited. It was felt that with good advice and funding it was fair for farmers to bear the risk of failure, thus encouraging high quality planting and management. A good working relationship between landowners and forestry inspectors could help spot problems early enough for remedial action, with penalties remaining as a last resort. However, if failures did occur despite good practice e.g. because of climate change, then it would be unfair to penalise the landowner.

The suggestion that *construction developments should include a minimum of 30% tree cover (P18)*, was viewed as well-intentioned and good for health and well-being, but capable of delivering only a small area of canopy cover and could drive up development (including housing) costs. This may not be feasible, particularly on urban sites and there was concern over whether the trees would be well managed. The figure of 30% and the requirement for trees rather than an environmental net-gain (which is expected to be delivered as a part of the UK Environment Bill [143]) were also challenged. Planting trees on a more suitable site near the development was supported.

Recognising the role of commercial forestry in strategies and policies (P20) received wide-ranging responses. Although many felt that commercial forestry is vital to hitting planting targets and to building a timber industry, others considered that there was no need for commercial forestry to be considered in all cases e.g. restoration and biodiversity planting. One panellist commented that considering *productive* forestry rather than *commercial* forestry could highlight the benefit of timber production.

The proposal of *allowing planting of a wider range of species to deliver resilience (P22)* was strongly supported, with good information already available from the Forestry Commission. One panellist thought that the wording should be changed to *encourage* the planting of a wider range of species rather than just *allowing* planting of these species. However, another proposed that more research on performance in different growing conditions was needed, and one was worried about the possible impact of planting in protected areas.

The proposal that *the requirement to replant could be removed from felling licences (P26)* was the policy which provoked most comments, with panellists split into two camps. Those who feared that this would be applied to all felling licences were concerned about an overall fall in canopy cover. Whereas those who strongly supported it saw this applying only to ***new*** planting, particularly energy forestry, and one considered it to be the single most important policy to encourage woodland creation, overcoming the reluctance of farmers to permanently change their farm into woodland, by giving the option to revert to farming in the future. Temporary planting on land scheduled for future redevelopment was also proposed as suitable for energy forestry, with permission granted to remove 60% when development was carried out but retaining 40% of established trees.

Economic policies. Using a carbon market or trading scheme for woodland to attract private sector investment and increase the value of woodland creation (P6) was strongly supported. It was viewed as vital in getting the private sector involved, and although some trading is already in place, it was recognised that it is not easy to get this working effectively, and more Government action is needed. Land price inflation could result, and speculative investment in land suitable for woodland creation has already taken place. It was suggested that bringing existing woodland into sustainable management should also be rewarded; but as this is less attractive to the general public, it is less likely to gain political support.

Competitive woodland creation grants providing adequate payments for establishment, pest control and annual payments (P13) were highly rated by panel members. These payments have already been shown to be effective, e.g. applications to the *Woodland Carbon Fund* increased after annual maintenance payments were included. It was suggested that farmers may overestimate the profitability of their farming activities and that after the removal of basic farm payments forestry may become more competitive. Enforcement to ensure high quality planting and management was supported.

Providing Public funding for non-carbon benefits (P14) was also highly rated. There is already funding for trees for flood control and more types will be delivered by ELM, but it was recognised that these non-carbon benefits can be hard to quantify.

The proposal that *grant funding should increase with time as progressively better land is required for tree planting (P15)* polarised opinion. Some panel members felt that this would be needed to continue the supply of land, that regular reviews of incentives would be needed, and that the level of grants should reflect the opportunity cost of planting. However, others thought that it could delay planting as landowners waited for better grants to become available. It was also felt that there was plenty of land suitable for planting already without the need for increasing grant rates, and if rates were too high trees could be planted on better land suitable for other uses such as food production.

Although it is accepted that changes to diet will be needed to reduce GHG emissions, resulting in fewer cattle and sheep grazing in the UK, and that ELM will remove subsidies to hill farmers, a policy to *remove subsidies for farming land which is more suited to forestry (P24)* proved very controversial. Panellist were wary of any compulsion from the Government dictating how a farmer should use their land. Choice should always remain with the farmer, and there was even a fear that compulsion to plant trees could result in a deeper division between farming and forestry. It was stressed that a just transition was needed for landowners and tenants, possibly carried out over a period longer than the one planned by ELM (by 2028), implemented with the consent of those affected, and with fair financial compensation to those forced to leave farming.

Informational policies. Setting national annual woodland planting targets (P8) was considered to be an informational policy, as targets are only an indication of intent unless supported by policies to deliver change. Although targets were viewed as desirable, and easy to implement, they were unlikely to be effective, as recent annual targets had not been met. However, it was agreed that woodland planting targets *were* required, and without them there could be even less planting. Targets at regional or county (sub-regional) level could be effective in monitoring delivery against target. There is also a risk that targets could deliver inappropriate planting as has happened in the past. One panellist stressed that targets had to be set as areas of planting or canopy cover and that targets in terms of tree numbers were not appropriate.

Requiring local authorities to set annual planting targets and identify land for trees (P9) was a policy which was open to interpretation in different ways. Setting annual targets without policies to deliver them was viewed by one panellist as little more than an aspiration, so is also classified as an information policy. Voluntary local targets were supported but there were reservations

about local authorities developing their own strategies; it was felt that they did not have the instruments to deliver local targets, and delivery would only be possible using the grants delivered at national level. If the land identified for trees was council-owned land, then this could be thought of as an organisational policy, with the councils having the agency to deliver tree planting, and this was rated as a potentially desirable and effective policy. There was opposition to local authorities having the regulatory power to force other landowners to plant trees.

As the cultural divide between farming and forestry is a key barrier to woodland creation the policy of *government funded advice on woodland creation being delivered to remove the forestry farming divide (P10)* was rated highly for effectiveness. However, there was disagreement over who should deliver the advice. The Forestry Commission already partly fills this role but this was not felt to be effective, and there was support for advice being delivered by impartial advisors, commercial foresters, or landowners' organisations such as the CLA (Country Land and Business Association). One panellist stressed the importance of information coming from peers: such as neighbours who are already planting woodland.

Removing the division between forestry and farming in education (P11) was viewed as a potentially effective in breaking down the cultural barriers by reaching '*young minds*', and was thought to be more feasible than some policies because it may not need government money.

Improving the public perception of commercial forestry (P21) was viewed as difficult to deliver but also potentially effective as public support for significant planting will be required, and they need to understand the social and environmental benefits delivered by commercial forestry. Ensuring that quality planting was carried out would improve the image of productive forestry, which is still marred by the evidence of past mistakes.

Setting targets for the use of UK timber (P23) was viewed as ineffective by some panel members as there is not enough UK timber to meet the current demand and imports are needed. With time it was felt that if targets for timber use were aligned with planting targets, then this policy could build more confidence in woodland creation.

Organisational policies. *Forming more forest partnerships like the Northumberland Forest (P19)*, although well supported provoked divergent comments about the relative success of projects like the National Forest, the Northern Forest, and the Northumberland Forest. The National Forest [144] has been successful in creating woodland and a pleasant environment for residents. However, the panellists recognised that large-scale projects are difficult to deliver, e.g. the Northern Forest [145] has little control over the land or planting and as a result delivery has been slow. Partnerships such as the Northumberland Forest [146], with more proactive roles played by the Forestry Commission and the Government, have demonstrated how effective the partnership model can be. These larger projects were viewed as potentially more effective than smaller, local authority level projects. Some panellists suggested support for projects delivering ecosystem benefits not just forestry, which could be landscape scale activities included in tier 3 of ELM. One panel member feared that large-scale projects could deliver too many conifers.

Expanding the UK nationally owned forests (P25) was viewed as highly effective and panel members had seen this demonstrated in Scotland, especially in achieving planting in the short term [142,147]. There were some doubts about how much public money should be spent on land for tree planting, the reaction of private landowners and the possibility of distorting the forestry market. It was also suggested that nationally owned diversity forests should be included as well as productive forests.

Analysis of agroforestry policies. The panel's ratings of the agroforestry policies are shown in Fig 6 and their ratings and comments are discussed below.

Regulatory policies. *Introducing clear definition and regulation (P27)* was unanimously supported, although participants warned that the regulation should not be too narrow or

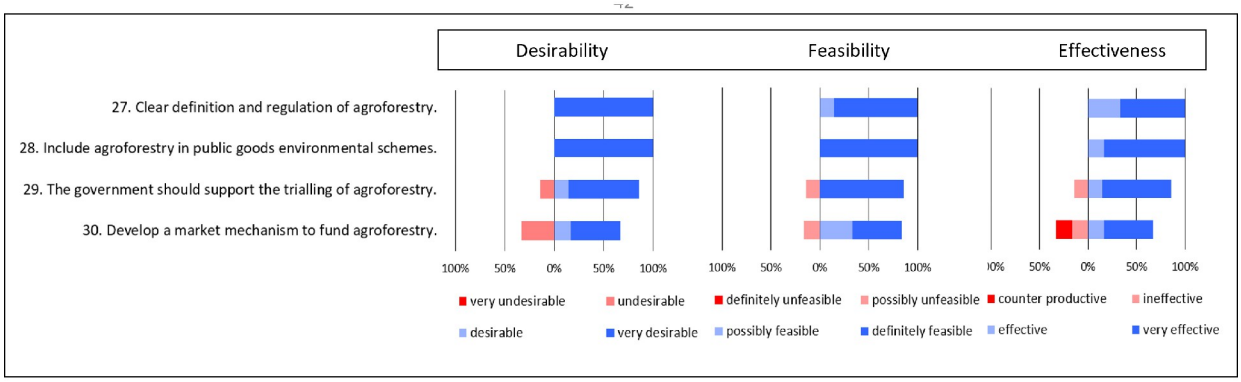

Fig 6. Ratings of agroforestry policies for desirability, feasibility, and effectiveness.

https://doi.org/10.1371/journal.pstr.0000109.g006

restrictive, and should cover all types of agroforestry from alley cropping to shelter belts, and wood pasture. Action is needed soon because the farm subsidies which currently make agroforestry uneconomic will not be fully phased out for another five years. One panellist was concerned that agroforestry regulations could be used to avoid forestry regulations.

Economic policies. Providing financial rewards for agroforestry by including it in agri-environmental schemes (P28) was well supported. The panellists considered that the benefits of agroforestry had been proven by research and that these should be rewarded. There was less support for *developing a market mechanism for funding agroforestry (P30)*. This was viewed as unnecessary when there were other mechanisms such as agri-environmental schemes and woodland grants, and there was a risk of undermining confidence in the carbon market for woodlands if low density planting was included.

Informational policies. Rather than *trialling agroforestry (P29)* it was suggested that *demonstrating* it would be an effective way of encouraging uptake because successful trials had already been carried out.

During discussions it became clear that there are a number of misconceptions about agroforestry, leading to fears of negative impacts on the landscape which are incompatible with UK farming culture. Panellists pointed out that alley cropping, which *would* change the landscape with stripes of trees on arable land, is an extreme type of agroforestry. Hedgerows, shelter belts and wood pasture are also agroforestry and are already part of traditional British farming, but their role may be overlooked. A policy is needed to provide agroforestry information and education to farmers and the general public, allaying fears by increasing knowledge of all the types of agroforestry and their benefits e.g. highlighting trees in traditional parkland landscapes which provide shelter to livestock from heat in summer and cold in winter.

Analysis of PEC policies. The panel ratings for the PEC policies are shown in Fig 7 and these ratings and panellists' comments are discussed below.

Regulatory policies. Providing policy certainty for the energy crop sector (P31) was viewed as vital in restoring confidence. After a history of support being provided then withdrawn, a clear signal to the power stations is needed. *Streamlining planting approvals (P38)* had the potential to encourage higher levels of willow planting but would not be needed for miscanthus. In the long term it could be effective to *oblige biomass combustion facilities to source a proportion of their feedstock from the UK (P34)*, especially for new users, but there was the risk of creating counterproductive carbon outcomes by changing existing supply chains.

Economic policies. Using demand side instruments to develop the energy crop market through carbon pricing and generator incentives (P32) was viewed as the single most effective policy for

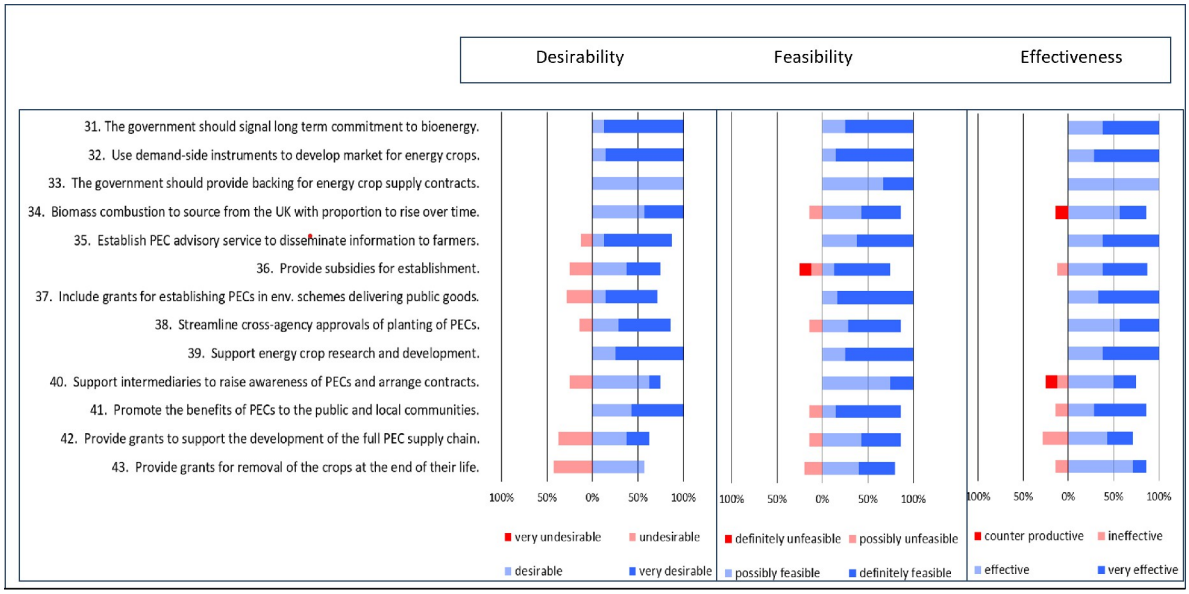

Fig 7. Ratings of perennial energy crop policies for desirability, feasibility, and effectiveness.

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stimulating the energy crop sector. Injecting investment in generation was expected to create a market for energy crops that could support financially attractive contracts for growers, which would in turn stimulate development of the entire supply chain from plant breeders and suppliers, through to contractors who plant and harvest the crops. Although policies to *provide backing for PEC supply contracts (P33)* and to *develop the full supply chain (P42)* were positively rated they would not be needed if generator incentives were effective.

Similarly, *providing subsidies for establishment (P36)* of energy crops was viewed as potentially very effective but would not be needed if a sufficiently attractive contract was on offer. However, some felt that establishment grants may be needed as a short-term measure, or to create parity with woodland creation or other land uses supported by incentive schemes, but they had to be better than the previous UK energy-crops schemes, which were under subscribed and encouraged poor quality planting. Although the prospect of high costs for removing crops after their productive life has come to an end can be a psychological barrier to planting, it was considered that after 15 to 20 years of income from a contract there should be no need to *subsidise removal (P43)*.

Including PECs in environmental schemes rewarding the delivery of public goods (P37) was viewed as undesirable by some panellists who thought that there were better uses of land for delivering public goods, such as woodland creation, and that it was hard to quantify the benefits of PECs. Others considered that the benefits of PECs were clear, and that their inclusion in agri-environmental schemes could be more effective than providing planting grants.

Information policies. The three PEC information policies were all rated positively. The *establishment of a PEC advisory service to disseminate information to farmers (P35)* was considered to be something that was definitely needed, but some panellists thought it should be delivered by independent advisors who advise on a range of agricultural matters (such as ADAS, an independent agricultural and environmental consultancy), while others felt that the private sector could deliver this. *Promoting the benefits of PECs to the general public (P41)* was viewed as being less important but it could help overcome the misconceptions that the general public has about energy crops and increase support. One panellist thought that it was important to make it clear that using energy crops is not deforestation.

As relatively new crops it was felt that there was still a lot of potential for improving cultivars to increase yield and research is needed on climate resilience, so there was strong support for *government money to support energy crop research and development (P39)*. In particular, government support and international cooperation are needed for breeding research, where the long breeding cycles make commercial research unfeasible, and thus continuity of funding is important.

Organisational Policies. The policy of *supporting intermediaries to promote PECs and arrange contracts (P40)* prompted divergent responses. Some panel members thought that this should not require government funding, as the promotional role was already being filled by private sector companies such as Iggesund and Terravesta. They felt that arranging contracts was a role that power stations could fill. However, another panellist proposed that energy crops should be promoted by an independent organisation, not tied to breeders or contract suppliers.

Discussion

A policy Delphi was used to assess 43 individual policy options which could be implemented as components of a policy package to deliver woodland creation and perennial biomass production. Using a policy Delphi to gather data from individual consultations with experts was particularly suitable for collaborative research during a pandemic, by providing better opportunities to gather personal values and opinions than group discussion, it remains a valuable method when personal contacts are not restricted. Although the panel in this research was small, they were all experts in the field and provided in depth assessments of the policies under discussion, identifying potential problems and highlighting the key areas for action. A series of one-to-one interviews was felt to have provided richer data than a group workshop could have done.

The levels of woodland creation and PEC planting needed in the UK to meet net zero targets may look ambitious when compared with recent levels of planting, but the conclusion of this research is that these targets (700 kha of PEC and 900 kha of new woodland by 2050) are achievable with significant government effort including a carefully balanced set of policies.

The key to delivering 30 kha of trees or more annually is to offer landowners financial incentives that will replace farming income foregone. The new EWCO and Stewardship options provide this income [41,148], as do the leasehold partnerships announced by the Government in Spring 2021, [43] and all three could result in significant planting. As well as being financially rewarding, to be effective these grants need to be easier to apply for, but this does not mean that standards for woodland creation should be lowered. While farmers' fear of devaluing their land by planting trees, the removal of EU farm subsidies and the introduction of ELM may radically alter land values, possibly removing this barrier to planting. Information provision from trusted sources and education both have an important role to play in tackling the social and cultural barriers to woodland creation and the cultural divide between farming and forestry. Although small urban woodland projects make valuable contributions to wellbeing and the environment, they contribute little to canopy cover. Large-scale planting is needed and much of this will have to be productive forestry: either commercial operations or part of the nationally owned forest.

Agroforestry must be regulated so farmers can be supported by either forestry or agri-environmental grants, and a policy to promote knowledge of agroforestry and its benefits to landowners and the general public is needed.

The clear recommendation for encouraging PEC cultivation is to deliver policies at the top of the supply chain, to encourage the development of generation capacity which can at some point deploy CCS. A way of rewarding the negative emissions from BECCS is needed as these are currently not covered by emissions trading schemes. By creating the demand for biomass,

the whole supply chain can be stimulated, and although direct support for farmers of PECs may be needed this should only be for a short period. The Drax and NFU partnership promoting the domestic supply of PECs [30,149] is a promising recent development. Policy certainty, the inclusion of PECs in agri-environmental schemes, and more information to improve farmers' and the general public's perceptions of PECs, would all support their adoption. Further support for research into breeding and cultivation is required. The assumption was made here that combustion would be the preferred process for BECCS rather than gasification or pyrolysis; this may not be the case in practice, but it would be advisable to use proven generation technology rather than repeating the mistakes of the ARBRE project.

It is vital that the new ELM system delivers a single land-use policy that is balanced to support *all* the desired changes of land use: woodland, agroforestry, PEC, food production, habitat restoration and other environmental schemes. There is a danger that the strong public sentiment for woodland creation and rewilding, and the lack of public and government support for PECs, could lead to a failure to provide balanced policies. Mistakes could lead to missing GHG reduction targets because of a shortfall in biomass, and emissions could be exported if food production is displaced from UK farms to countries with higher emission practices. Konadu et al. [150] warn that setting targets for energy crop cultivation will create competition for land use and if these are not formulated in conjunction with overall projected land-use changes, physically unfeasible land-use targets can be set for energy crops. This argument could be extended to woodland creation targets too.

As Warren et al. [76] observed, PECs are at the '*interface between agriculture*, *forestry and energy policies*'. The division of responsibilities between government departments makes it more difficult to coordinate policies: DEFRA is responsible for forestry and farming, and the department for energy security and net zero (DESNZ which replaces BEIS) for energy crops.

One recurring theme in the Delphi was the importance of delivering policies which avoid coercion of farmers and landowners into making permanent changes of land use. It is important to have willing participants in the changes required over the next 30 years. The panel members also recognised the importance of non-financial motivations in the design of effective policies. The informational policies tackling issues such as the divide between forestry and farming and the need for greater knowledge of new practices are important components of a well-balanced and effective suite of policies.

The 2021 policy statement [151] recognised that by 2050 10% of the UK energy demand could be met by Biomass, while highlighting the importance of sustainability and air quality as well as GHG emissions reductions. The new UK biomass strategy was announced in 2023 [28], but contained little on land use for perennial energy crops or tree planting, instead deferring these announcements to the new Land Use Framework for England initially due to be published in 2023, but now expected in 2024 [152]. The new land use framework and ELM must support PECs and woodland creation to help the UK meet its net zero targets and recognise the role that domestic biomass can play in increasing energy security.

Countries worldwide face similar challenges of climate change, energy security and volatile energy markets, and although each country has its own unique policy and energy circumstances, the approach taken here of using a policy Delphi could be used in any country to assess potential policies and findings compared with this UK policy study.

Supporting information

S1 Data. Land-use change policy Delphi: data pack.
(PDF)

S2 Data. Land-use change policy Delphi: Round two.
(PDF)

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Supervision: Peter G. Taylor.

Visualization: Judith S. Ford.

Writing – original draft: Judith S. Ford.

Writing – review & editing: Judith S. Ford, Peter G. Taylor.

References

1. IPCC. Global Warming of 1.5˚C. An IPCC Special Report on the impacts of global warming of 1.5˚C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty 2018 [Available from: https://www.ipcc.ch/sr15/chapter/spm/.
2. CCC. Land use: Policies for a Net Zero UK 2020 [Available from: https://www.theccc.org.uk/publication/land-use-policies-for-a-net-zero-uk/.
3. HM Government, The Scottish Government, The Welsh Assembly Government, Department of the Environment NI, The Committee on Climate Change. Committee on Climate Change framework document 2010 [Available from: https://www.theccc.org.uk/wp-content/uploads/2013/03/CCCFramework-Document.pdf.
4. BEIS. Digest of UK Energy Statistics Annual data for UK, 2020. 2021.
5. CCC. Net Zero: The UK's contribution to stopping global warming 2019 [Available from: https://www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-The-UKs-contribution-to-stopping-global-warming.pdf.
6. CCC. Policies for the Sixth Carbon Budget and Net Zero 2020 [Available from: https://www.theccc.org.uk/wp-content/uploads/2020/12/Policies-for-the-Sixth-Carbon-Budget-and-Net-Zero.pdf.
7. EAT. Healthy Diets From Sustainable Food Systems: Food Planet Health 2019 [Available from: https://eatforum.org/content/uploads/2019/07/EAT-Lancet_Commission_Summary_Report.pdf.
8. Energy Systems Catapult. Innovating to net zero 2020 [Available from: https://es.catapult.org.uk/report/innovating-to-net-zero/.
9. CCC. The Sixth Carbon Budget: The UK's path to Net Zero 2020 [Available from: https://www.theccc.org.uk/wp-content/uploads/2020/12/The-Sixth-Carbon-Budget-The-UKs-path-to-Net-Zero.pdf.
10. DEFRA. Area of crops grown for bioenergy in England and the UK: 2008–2020 2021 [Available from: https://www.gov.uk/government/statistics/area-of-crops-grown-for-bioenergy-in-england-and-the-uk-2008-2020/summary.
11. Forest Research. Provisional Woodland Statistics 2023 2023 [Available from: https://cdn.forestresearch.gov.uk/2023/06/PWS-statsnotice-15jun23.pdf.
12. Robson P, Hastings A, Clifton-Brown J, McCalmont J. Sustainable use of Miscanthus for biofuel. In: Saffron C, editor. Achieving carbon negative bioenergy systems from plant materials (Burleigh Dodds series in agricultural science): Burleigh Dodds Science Publishing; 2020.
13. Clifton-Brown J, Harfouche A, Casler MD, Dylan Jones H, Macalpine WJ, Murphy-Bokern D, et al. Breeding progress and preparedness for mass-scale deployment of perennial lignocellulosic biomass

crops switchgrass, miscanthus, willow and poplar. GCB Bioenergy. 2019; 11(1):118–51. https://doi.org/10.1111/gcbb.12566 PMID: 30854028

14. McCalmont JP, Hastings A, McNamara NP, Richter GM, Robson P, Donnison IS, Clifton-Brown J. Environmental costs and benefits of growing Miscanthus for bioenergy in the UK. GCB Bioenergy. 2017; 9:489–507. https://doi.org/10.1111/gcbb.12294 PMID: 28331551
15. Glithero NJ, Wilson P, Ramsden SJ. Prospects for arable farm uptake of Short Rotation Coppice willow and miscanthus in England. Applied Energy. 2013; 107:209–18. https://doi.org/10.1016/j.apenergy.2013.02.032 PMID: 23825896
16. Harris ZM, Alberti G, Viger M, Jenkins JR, Rowe R, McNamara NP, Taylor G. Land-use change to bioenergy: Grassland to short rotation coppice willow has an improved carbon balance. GCB Bioenergy. 2017; 9(2):469–84.
17. Weih M, Hansson P-A, Ohlsson JA, Sandgren M, Schnürer A, Rönnberg-Wästljung A-C. Sustainable production of willow for biofuel use: Burleigh Dodds Science Publishing Limited; 2019.
18. Cunniff J, Purdy SJ, Barraclough TJP, Castle M, Maddison AL, Jones LE, et al. High yielding biomass genotypes of willow (Salix spp.) show differences in below ground biomass allocation. Biomass and Bioenergy. 2015; 80:114–27. https://doi.org/10.1016/j.biombioe.2015.04.020 PMID: 26339128
19. Alderton S. How willow can reduce flood risk. Farmers Weekly. 2018 22 June 2018.
20. Nisbet T, Silgram M, Shah N, Morrow K, Broadmeadow S. Woodland for Water: Woodland measures for meeting Water Framework Directive objectives. Forest Research; 2011.
21. NNFCC. Domestic energy crops: Potential and constraints review 2012 [Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/48342/5138-domestic-energy-crops-potential-and-constraints-r.PDF.
22. Lindegaard K. Why we need an energy crops scheme 3: Crops For Energy; 2013 [Available from: http://www.crops4energy.co.uk/wp-content/uploads/2013/08/Critical-appraisal-of-the-ECS-final-version.pdf.
23. Adams PWR, Lindegaard K. A critical appraisal of the effectiveness of UK perennial energy crops policy since 1990. Renewable and Sustainable Energy Reviews. 2016; 55:188–202.
24. Mawhood B, Slade R, Shah N. Policy options to promote perennial energy crops: the limitations of the English Energy Crops Scheme and the role for agent-based modelling in policy design. Association of Applied Biologists conference 'Biomass and Energy Crops V'; 20th-22nd October 2015; Brussels2015.
25. Terravesta. Miscanthus SFI payments explained 2023 [Available from: https://terravesta.com/uk-farming/miscanthus-sfi-payments-explained/.
26. UK Governement. SFI actions for integrated pest management 2023 [Available from: https://www.gov.uk/guidance/sfi-actions-for-integrated-pest-management.
27. DfT, DECC, DEFRA. UK Bioenergy Strategy 2012 [Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/48337/5142-bioenergy-strategy-.pdf.
28. DESNZ. Biomass Strategy 2023 [Available from: https://www.gov.uk/government/publications/biomass-strategy.
29. BEIS. Biomass Feedstock Innovation Programme: Phase 1. 2021.
30. Drax. Drax and NFU partner to boost UK energy crop market 2021 [Available from: https://www.drax.com/press_release/drax-and-nfu-partner-to-boost-uk-energy-crop-market/.
31. Forest Research. The UK Forest Standard Farnham: Forest Research; 2023 [: [Available from: https://assets.publishing.service.gov.uk/media/651670336a423b0014f4c5c0/Revised_UK_Forestry_Standard_-_effective_October_2024.pdf.
32. Reid WV, Ali MK, Field CB. The future of bioenergy. GCB Bioenergy. 2019; 26:274–86. https://doi.org/10.1111/gcb.14883 PMID: 31642554
33. Forestry Commission. The UK Forest Standard: The governments' approach to sustainable forestry 2017 [Available from: https://assets.publishing.service.gov.uk/media/5aa28e64ed915d4f595c5213/The_UK_Forestry_Standard.pdf.
34. Forestry Commission. Forest services board paper: 24 April 2019 2019 [Available from: https://www.gov.uk/government/publications/forest-services-board-meeting-24-april-2019-bristol.
35. HM Government. A green future: Our 25 year plan to improve the environment. 2018.
36. Confor. Woodland carbon targets for the UK 2019 [Available from: https://www.confor.org.uk/media/247403/woodland-carbon-targets-for-the-uk-april-2019.pdf.
37. Woodland Trust. Emergency tree plan for the UK 2020 [Available from: https://www.woodlandtrust.org.uk/publications/2020/01/emergency-tree-plan/.

38. Prime Minister's Office. PM outlines his Ten Point Plan for a Green Industrial Revolution for 250,000 jobs 2020 [Available from: https://www.gov.uk/government/news/pm-outlines-his-ten-point-plan-for-a-green-industrial-revolution-for-250000-jobs.
39. DEFRA. Tree planting rates to treble by end of this Parliament 2021 [Available from: https://www.gov.uk/government/news/tree-planting-rates-to-treble-by-end-of-this-parliament.
40. NAO. Planting Trees in England 2022 [Available from: https://www.wired-gov.net/wg/news.nsf/articles/Planting+Trees+in+England+07032022111500?open.
41. Forestry Commission. Grant Comparison Table 2022 [Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1053859/FC_Grant_table_Feb_22.pdf.
42. Forestry Commission. Woodland grants and incentives overview table 2022 [Available from: https://www.gov.uk/government/publications/woodland-grants-and-incentives-overview-table/woodland-grants-and-incentives-overview-table.
43. DEFRA. The England Trees Action Plan 2021–2024. 2021.
44. Forestry Commission. Plant your future: The case for trees. 2022.
45. Forestry Commission, HMRC, Natural England. Woodland owners: tax planning 2018 [Available from: https://www.gov.uk/guidance/woodland-owners-tax-planning.
46. Valuation Office Agency. Inheritance Tax manual: Section 10: Woodlands 2017 [Available from: https://www.gov.uk/guidance/inheritance-tax-manual/section-10-woodlands.
47. Helliwell R. Where did the marginal land go? Farmers perspectives on marginal land and its implications for adoption of dedicated energy crops. Energy Policy. 2018; 117:166–72.
48. Adams PWR, Hammond GP, McManus MC, Mezzullo WG. Barriers to and drivers for UK bioenergy development. Renewable and Sustainable Energy Reviews. 2011; 15:1217–27.
49. Clifton-Brown J, Hastings A, Mos M, McCalmont JP, Ashman C, Awty-Carroll D, et al. Progress in upscaling Miscanthus biomass production for the European bio-economy with seed-based hybrids. GCB Bioenergy. 2017; 9:6–17.
50. Sherrington C, Bartley J, Moran D. Farm-level constraints on the domestic supply of perennial energy crops in the UK. Energy Policy. 2008; 36:2504–12.
51. Thornley P, Upham P, Tomei J. Sustainability constraints on UK bioenergy development. Energy Policy. 2009; 37 5623–35.
52. Brown C, Bakam I, Smith P, Matthews R. An agent-based modelling approach to evaluate factors influencing bioenergy crop adoption in north-east Scotland. GCB Bioenergy. 2016; 8:226–44.
53. Convery I, Robson D, Ottitsch A, Long M. The willingness of farmers to engage with bioenergy and woody biomass production: A regional case study from Cumbria. Energy Policy. 2012; 40:293–300.
54. Sherrington C, Moran D. Modelling farmer uptake of perennial energy crops in the UK. Energy Policy. 2010; 38:3567–78.
55. McCormick K, Kåberger T. Key barriers for bioenergy in Europe: Economic conditions, know-how and institutional capacity, and supply chain co-ordination. Biomass and Bioenergy. 2007; 31(7):443–52.
56. White W, Lunnan A, Nybakk E, Kulisic B. The role of governments in renewable energy: The importance of policy consistency. Biomass and Bioenergy. 2013; 57:97–105.
57. Mola-Yudego B, Dimitriou I, Gonzalez-Garcia S, Gritten D, Aronsson P. A conceptual framework for the introduction of energy crops. Renewable Energy. 2014; 72:29–38.
58. DECC. UK Bioenergy Strategy 2012 [Available from: https://www.gov.uk/government/publications/uk-bioenergy-strategy.
59. Stenhouse EH. Farm wood fuel and energy project. Renewable Energy. 1999; 16:1029–30.
60. Wilson P, Glithero NJ, Ramsden SJ. Prospects for dedicated energy crop production and attitudes towards agricultural straw use: The case of livestock farmers. Energy Policy. 2014; 74:101–10. https://doi.org/10.1016/j.enpol.2014.07.009 PMID: 25844008
61. OECD. Farmer behaviour, agricultural management and climate change. 2012 01/01.
62. Piterou A, Shackley S, Upham P. Project ARBRE: Lessons for bio-energy developers and policy-makers. Energy Policy. 2008; 36:2044–50.
63. Mitchell C, Connor P. Renewable energy policy in the UK 1990–2003. Energy Policy. 2004; 32 (17):1935–47.
64. Foxon TJ, Grossa R, Chase A, Howes J, Arnall A, Anderson D. UK innovation systems for new and renewable energy technologies: Drivers, barriers and systems failures. Energy Policy. 2005; 33:2123–37.

65. ADAS. Refining estimates of land for Biomass: Final project report: Energy Technologies Institute; 2016 [Available from: https://adas.co.uk/wp-content/uploads/2021/01/160519_BI2012_D12_Extension-report_v2-1_FINAL.pdf.

66. Clifton-Brown J, Hastings A, von Cossel M, Murphy-Bokern D, McCalmont J, Whitaker J, et al. Perennial biomass cropping and use: Shaping the policy ecosystem in European countries. GCB Bioenergy. 2023. https://doi.org/10.1111/gcbb.13038 PMID: 38505831

67. Thomas HJD, Paterson JS, Metzger MJ, Sing L. Towards a research agenda for woodland expansion in Scotland. Forest Ecology and Management. 2015; 349:149–61.

68. RFS. Woodland creation opportunities and barriers—survey results 2020 2020 [Available from: https://www.rfs.org.uk/media/710684/woodland-creation-opportunities-and-barriers-020620-embargo-3-june.pdf.

69. Lawrence A, Dandy N. Private landowners' approaches to planting and managing forests in the UK: What's the evidence? Land Use Policy. 2014; 26:351–60.

70. Eves C, Johnson M, Smith S, Quick T, Langley E, Jenner M, Richardson W., et al. Analysis of the potential effects of various influences and interventions on woodland management and creation decisions, using a segmentation model to categorise sub-groups: Volume 1: Summary for Policy-makers. London: DEFRA; 2014.

71. House of Commons. Forestry in England: Seeing the wood for the trees. In: DEFRA, editor. 2017.

72. Hardaker A. Is forestry really more profitable than upland farming? A historic and present day farm level economic comparison of upland sheep farming and forestry in the UK. Land Use Policy. 2018; 71:98.

73. Forestry Commission. Forestry statistics 2017: Chapter 2: UK-grown timber. 2017.

74. Forestry Commission. A Woodfuel Strategy for England. c2006.

75. Hopkins J, Sutherland L-A, Ehlers M-H, Matthews K, Barnes A, Tomad L. Scottish farmers' intentions to afforest land in the context of farm diversification. Forest Policy and Economics. 2017; 78:122–32.

76. Warren CR, Burton R, Buchanan O, Birnie RV. Limited adoption of short rotation coppice: The role of farmers' socio-cultural identity in influencing practice. Journal of Rural Studies. 2016; 45:175–83.

77. CEH and Rothamsted Research. Quantifying the impact of future land use scenarios to 2050 and beyond—Final Report 2018 [Available from: https://www.theccc.org.uk/publication/quantifying-the-impact-of-future-land-use-scenarios-to-2050-and-beyond-centre-for-ecology-and-hydrology-and-rothamsted-research/.

78. Forestry Commission. A guide to planning new woodland in England 2021 [Available from: https://assets.publishing.service.gov.uk/media/618e79658fa8f503764ed2cf/A_Guide_to_Planning_New_Woodland_in_England_V1.0_Nov2021.pdf.

79. Liu CLC, Kuchma O, Krutovsky KV. Mixed-species versus monocultures in plantation forestry: Development, benefits, ecosystem services and perspectives for the future. Global Ecology and Conservation 2018;15.

80. Felton A, Nilsson U, Sonesson J, Felton AM, Roberge J-M, Ranius T, et al. Replacing monocultures with mixed-species stands: Ecosystem service implications of two production forest alternatives in Sweden. Ambio. 2016; 45:S124–S39. https://doi.org/10.1007/s13280-015-0749-2 PMID: 26744048

81. Thornley P, Cooper D. The effectiveness of policy instruments in promoting bioenergy. Biomass and Bioenergy. 2008; 32:903–13.

82. OFGEM. About the RO 2020 [Available from: https://www.ofgem.gov.uk/environmental-programmes/ro/about-ro.

83. BEIS. Policy paper: Contract for Difference updated 13 March 2017. 2017.

84. BEIS. Contracts for difference: Methodology used to set administrative strike prices for CfD allocation round 4. 2021.

85. OFGEM. Feed-in Tariff (FIT) Generation & Export Payment Rate Table, 1 April 2016, 31 March 2019 to 1 October 2016 Version 2016 [Available from: https://www.ofgem.gov.uk/system/files/docs/2016/11/tariff_rates_october_2016.pdf.

86. OFGEM. About the FIT scheme 2020 [Available from: https://www.ofgem.gov.uk/environmental-programmes/fit/about-fit-scheme.

87. BEIS. Business model for power bioenergy with carbon capture and storage ('Power BECCS'): A consultation seeking views on potential business models for power bioenergy carbon capture and storage 2022 [Available from: https://www.gov.uk/government/consultations/business-model-for-power-bioenergy-with-carbon-capture-and-storage-power-beccs.

88. DESNZ. Greenhouse Gas Removals: Update on the design of the Greenhouse Gas Removals (GGR) Business Model and Power Bioenergy with Carbon Capture and Storage (Power BECCS) Business

Model 2023 [Available from: https://assets.publishing.service.gov.uk/media/6581851efc07f3000d8d447d/ggr-power-beccs-business-models-december-2023.pdf.

89. Biofuelwatch et al. Open Letter calling on the UK Government to redirect renewable subsidies from biomass burning to genuinely renewable energy2021 24 March 2021. Available from: https://www.biofuelwatch.org.uk/wp-content/uploads/open-letter-BEIS-ROCs-biomass-for-web.pdf.
90. RSPB. Bioenergy: A burning issue 2011 [Available from: http://ww2.rspb.org.uk/Images/Bioenergy_a_burning_issue_1_tcm9-288702.pdf.
91. RSPB, Friends of the Earth, Greenpeace. Dirtier than coal? Why Government plans to subsidise burning trees are bad news for the planet. 2012.
92. BBC News. Drax: UK power station still burning rare forest wood 2024 [Available from: https://www.bbc.co.uk/news/science-environment-68381160.
93. Climate Assembly UK. The path to net zero: Climate Assembly UK full report: Where our electricity comes from 2020 [updated Available from: https://www.climateassembly.uk/report/read/where-our-electricity-comes-from.html.
94. Climate Assembly UK. The path to net zero: Climate Assembly UK full report: Greenhouse gas removals 2020 [Available from: https://www.climateassembly.uk/report/read/greenhouse-gas-removals.html#greenhouse-gas-removals.
95. Hanemann M. Cap-and-trade: a sufficient or necessary condition for emission reduction? Oxford Review of Economic Policy. 2010; 26(2):225–52.
96. Hepburn C. Environmental policy, government, and the market. Oxford Review of Economic Policy. 2010; 26(2):117–36.
97. Stern N. The economics of climate change: The Stern review: Cambridge University Press; 2007.
98. Mazzucato M. The innovative state: Governments should make markets, not just fix them. Foreign Affairs. 2015; 94(1):61–VI.
99. DEFRA. Farming for the future: Policy and progress update. 2020.
100. Kingdon JW. Agendas, alternatives and public policy. 2nd ed: Addison-Wesley Longman; 1995.
101. Spencer B, Yorke H. Boris Johnson turns his back on green agenda with rewilding rethink: Cost of living crisis forces PM into policy change. The Sunday Times. 2022.
102. CLA. Agriculture, achieving net-zero emissions inquiry: Environment, Food and Rural Affairs Committee. 2019.
103. NFU. Achieving net zero: Farming's 2040 goal. 2019.
104. Whitaker J. Steps to scaling up UK sustainable bioenergy supply: A stakeholder workshop convened by the Centre for Ecology & Hydrology and the Committee on Climate Change CEH: Centre for Ecology and Hydrology; 2018 [Available from: https://www.theccc.org.uk/publication/steps-to-scaling-up-uk-sustainable-bioenergy-supply-ceh/.
105. Confor. A common countryside policy: Securing a prosperous green future after Brexit 2017 [Available from: https://www.confor.org.uk/media/246687/common-countryside-policy.pdf.
106. CLA. Forestry and woodland vision and policy: Seeing the wood for the trees. 2009.
107. Soil Association and Woodland Trust. Agroforestry in England: Benefits, barriers & opportunities2018. Available from: https://www.woodlandtrust.org.uk/media/1700/agroforestry-in-england.pdf.
108. Confor. The future is forestry: Tackling climate change with trees 2019 [Available from: http://www.confor.org.uk/media/247586/confor-election-manifesto-2019-for-web.pdf.
109. FFCC. Land Use Framework: A solution for better decisions about land 2022 [Available from: https://ffcc.co.uk/land-use-framework.
110. Rowe R, Arshad MN, Welfle A, Holland R, Yuan R, Sparks J, et al. Workshop Report: Land use decision-making for biomass deployment, bridging the gap between national scale targets and field scale decisions.; 2022.
111. Landeta J. Current validity of the Delphi method in social sciences. Technological Forecasting & Social Change. 2006; 73:467–82.
112. Turoff M. The Design of a policy Delphi. Technological Forecasting and Social Change. 1970; 2:149–71.
113. McKenna HP. The Delphi technique: A worthwhile research approach for nursing? Journal of Advanced Nursing. 1994; 19:1221–5. https://doi.org/10.1111/j.1365-2648.1994.tb01207.x PMID: 7930104
114. Tapio P, Rintamäki H, Rikkonen P, Ruotsalainen J. Pump, boiler, cell or turbine? Six mixed scenarios of energy futures in farms. Futures. 2017; 88:30–42.

115. de Loë RC, Melnychuk N, Murray D, Plummer R. Advancing the state of policy Delphi practice: A systematic review evaluating methodological evolution, innovation, and opportunities. Technological Forecasting & Social Change. 2016; 104:78–88.

116. Rauch W. The decision Delphi. Technological Forecasting And Social Change. 1979; 15:159–69.

117. de Loë RC. Exploring complex policy questions using the policy Delphi: A multi-round, interactive survey method. Applied Geography. 1995; 15(1):53–68.

118. Hasson F, Keeney S, Mckenna HP. Research guidelines for the Delphi Survey Technique. Journal of Advanced Nursing. 2000; 32(4):1008–15. PMID: 11095242

119. Ford JS, Bale CSE, Taylor PG. The factors determining uptake of energy crop cultivation and woodland creation in England: Insights from farmers and landowners. Biomass & bioenergy. 2024; 180 (107021).

120. Likert R. A technique for the measurement of attittudes. Archives of Psychology. 1932; 140:5–55.

121. Turoff M. The policy Delphi. In: Linstone HA, Turoff M, editors. The Delphi method techniques and applications2002.

122. Ludlow J. Delphi inquiries and knowledge utilization. In: Linstone HA, Turoff M, editors. The Delphi method techniques and applications2002.

123. Liddell TM, Kruschke JK. Analyzing ordinal data with metric models: What could possibly go wrong? Journal of Experimental Social Psychology. 2018; 79:328–48.

124. Kuzon WM, Urbanchek MG, McCabe S. The seven deadly sins of statistical analysis. Annals of Plastic Surgery. 1996; 37:265–72. https://doi.org/10.1097/00000637-199609000-00006 PMID: 8883724

125. Jamieson S. Likert scales: how to (ab)use them. Medical Education. 2004; 38:1217–8. https://doi.org/10.1111/j.1365-2929.2004.02012.x PMID: 15566531

126. Heiberger RM, Robbins NB. Design of diverging stacked bar charts for Likert scales and other applications. Journal of Statistical Software. 2014; 57(5).

127. Sullivan GM, Artino AR. Analyzing and Interpreting data from Likert-type scales. Journal of Graduate Medical Education. 2013(December 2013):541–2. https://doi.org/10.4300/JGME-5-4-18 PMID: 24454995

128. Robbins NB, Heiberger RM, editors. Plotting Likert and other rating scales. JSM Proceedings, Section on Survey Research Methods American Statistical Association; 2011; Alexandria, Virginia.

129. Hood CC. The tools of government. London: Palgrave; 1983.

130. Howlett M. Designing public policies: Routledge; 2011.

131. Balch GI. The stick, the carrot, and other strategies: A theoretical analysis of governmental intervention. Law and Policy Quarterly. 1980; 2:35–60.

132. Vedung E. Policy instruments:Typologies and theories. In: Bemelmans-Videc M-L, Rist RC, Vedung E, editors. Carrots, sticks and sermons: Policy instruments and their evaluation. New Jersey: Transaction; 1998.

133. Lowi T. Four systems of policy, politics, and choice. Public Administration Review. 1972; 32(4):298.

134. The Scottish Government. Getting the best from our land–a land use strategy 2016 to 2021: First annual progress report 2020 [Available from: https://www.gov.scot/publications/first-annual-progress-report-getting-best-land-land-use-strategy-scotland-2016-2021/pages/3/.

135. Rural Payments Agency and Natural England. Countryside Stewardship grant finder 2024 [Available from: https://www.gov.uk/countryside-stewardship-grants?page=1.

136. Crane E. Woodlands for climate and nature: A review of woodland planting and management approaches in the UK for climate change mitigation and biodiversity conservation. RSPB; 2020.

137. Barkham P. Fir's fair: UK must embrace conifers in climate fight, says forestry chief. The Guardian. 2020 26th February 2020.

138. Payne RJ, Anderson AR, Sloan T, Gilbert P, Newton A, Ratcliffe J, et al. The future of peatland forestry in Scotland: Balancing economics, carbon and biodiversity. Scottish Forestry. 2018; 72(1):34–40.

139. Dijkgraaf E, Dorp TPv, Maasland E. On the effectiveness of feed-in tariffs in the development of solar photovoltaics. The Energy journal (Cambridge, Mass). 2018; 39(1):81.

140. Rogge KS, Reichardt K. Policy mixes for sustainability transitions: An extended concept and framework for analysis. Research Policy. 2016; 45(8):1620–35.

141. Gawel E, Lehmann P. Should renewable energy policy be 'renewable'? Oxford Review of Economic Policy. 2019; 35(2):218–43.

142. Scottish Forestry. Scottish Forestry Annual Reports and Accounts 2020 [Available from: https://forestry.gov.scot/publications/1315-annual-report-and-accounts-2020-to-2021.

143. DEFRA. Net gain: Summary of responses and government response 2019 [Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/819823/net-gain-consult-sum-resp.pdf.

144. The National Forest. About our National Forest 2020 [Available from: https://www.nationalforest.org/about.

145. Woodland Trust. A new Northern Forest 2018 [Available from: https://www.woodlandtrust.org.uk/publications/2018/02/a-new-northern-forest/.

146. Forestry England. Forestry England makes significant land purchase 2020 [Available from: https://www.forestryengland.uk/news/forestry-england-makes-significant-land-purchase.

147. Forest Enterprise Scotland. Strategy for Woodland Creation on the National Forest Estate 2018 [Available from: https://forestry.gov.scot/images/corporate/pdf/Strategy-for-Woodland-Creation-on-the-National-Forest-Estate.pdf.

148. Forestry Commission. eAlert: 17 January 2022—Increase to EWCO maintenance payments 2022 [Available from: https://www.gov.uk/government/publications/ealert-17-january-2022-increase-to-ewco-maintenance-payments/ealert-17-january-2022-increase-to-ewco-maintenance-payments.

149. Swire J. DRAX and NFU partner to boost UK energy crop market 2021 [updated 27 September 2021. Available from: https://www.aafarmer.co.uk/news/environment/drax-and-nfu-partner-to-boost-uk-energy-crop-market.html.

150. Konadu DD, Mourão ZS, Allwood JM, Richards KS, Kopec G, McMahon R, Fenner R. Land use implications of future energy system trajectories—The case of the UK 2050 Carbon Plan. Energy Policy. 2015; 86:328–37.

151. BEIS. Biomass Policy Statement 2021 [Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1031057/biomass-policy-statement.pdf.

152. UK Parliament. Land Use Question for Department for Environment, Food and Rural Affairs 2024 [Available from: https://questions-statements.parliament.uk/written-questions/detail/2024-02-16/14152.