Programme Area: Bioenergy

Project: Refining Estimates of Land for Biomass

Title: Final Project Report (D10)

Abstract:

This is the shorter PowerPoint version of the final report from the RELB Project. This D10 presentation highlights the findings from the RELB work packages:

Review of existing studies – a review of past estimates in the literature of land availability for new perennial energy crops and new Short Rotation Forestry production in the UK and Europe;

Desk and Field studies – report of and findings from the validation exercises carried out;

Mini case studies – individual reports on the three 50x50 km cells assessed in the field study;

Opportunities and barriers – report of desk study undertaken to understand why bioenergy crop production does not currently utilise the 'available' land and to identify opportunities to increase planting;

Final summary and conclusions

For the detailed version of this report, the reader should see deliverable D9 which is provided in Microsoft Word format.

Context:

Many significant pieces of work have been undertaken to assess UK "2nd generation" bioenergy feedstock production potential. The RELB project was undertaken to help refine and sense-check these existing estimates, including the ETI's own in-house modelling assumptions, in order to understand what further 'correction factors' (if any) may need to be applied to adjust existing estimates. In addition, the project aimed to better understand the process for converting land to 2nd generation bioenergy feedstocks and the impact planting these feedstocks could have on farm businesses. The RELB project had four distinct work packages:

1. A review of latest theoretical estimates of land available for biomass production in the UK and Europe.
2. A desk study to identify additional constraint layers which could be used to refine the ETI's own in-house land availability constraint masks. The suitability of these additional constraint layers was tested through field surveys.
3. A review of the steps and agencies involved in land use change to bioenergy crops and forestry.
4. Case studies of three farmers who have planted bioenergy crops, focusing on the financial and food production impacts of their decision.

Refining Estimates of Land for Biomass

Final Project Report v2.1

February 2016

ADAS

Refining Estimates of Land for Biomass

August – December 2015

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Structure

- Overview
- Review of existing studies
- Refining estimates of land availability
  - Cell selection
  - Field survey
  - Desk study
- Review of processes to convert land
- Review of opportunities and barriers

Refining Estimates of Land for Biomass

Overview

Sarah Wynn

Overview

- Bioenergy is considered to be an important potential component of the UK's future energy mix. The sustainable production of bioenergy crops has the potential to store carbon and reduce carbon dioxide emissions, compared to the use of fossil fuels.
- The Energy Technologies Institute (ETI) has undertaken previous work to provide estimates of the land available to produce bioenergy crops on. This work has involved the development of the Biomass Value Chain Model (BVCM) using the UKERC 9w mask land constraint.
- This project aimed to refine the current estimates of UK land available for bioenergy crop production through desk and field based research, focusing on Miscanthus, Short Rotation Coppice - SRC and Short Rotation Forestry - SRF.

Structure

- Review of existing studies
- Refining the estimates of land availability
  - Field study
  - Desk study
- Review of processes to convert land to biomass
- Review of opportunities and barriers
- Final summary and conclusions

Refining Estimates of Land for Biomass

Review of existing studies

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Introduction:
Aim and scope of WP1

- Aim: To review **estimates of land availability** for new perennial energy crops and new Short Rotation Forestry production in the UK and Europe.
- These estimates were obtained from a detailed review of studies published in the academic and grey literature between **2003 and 2015**. Studies published prior to 2003 are less relevant (set-aside existed).
- Each study with new analysis or novel interpretations of prior work was examined in detail and the land area estimates identified.
- A summary of these estimates is presented in the WP1 report to enable the findings from the wider RELB project to be **set in context**. This also highlights major assumptions and datasets used, identifies the key insights that can be gained from each of the studies reviewed, and draws conclusions on overall strengths and weaknesses.
- Miscanthus, Short Rotation Coppice (SRC) and Short Rotation Forestry (SRF) were in scope – existing forestry and food crops are not

Introduction:
Key caveats of the report

- Most studies assume that **food crop yields increase over time**, and that this automatically releases land for energy crops and other uses - but no certainty will be used for energy crops. Only one model (Biomass Futures 2012a) describes a reduction of land availability in 2030 compared to 2020.
- A **new UK resource inventory** (similar to ADAS, 2008) is needed that reflects the current agricultural reality. The tension with food and land grades remains unresolved in many studies. New work by Alexander et al. (2014) is starting to show land availability as a function of willingness to pay for bioenergy
- Models can quickly become **out-dated by macro-economic volatility**, such as changes in food and energy prices, Common Agricultural Policy (CAP) reform, and bioenergy policy. The world today is different to when many of the studies were conducted - the UK energy crop sector is stagnant, and SRF yet to progress beyond trials.
- The differing contexts, methodologies, data and assumptions of the studies lead to the **area ranges presented being very large**, and hard to compare.
- However, they do allow identification of the **key drivers** and sensitivities (such as population, diet and food yields), so there is a **credible range** of futures within which the sectors may lie – provided the policy, markets and crop technology are all developed and supported.

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Current land area:
Growing perennial energy crops in the UK

- Start by quantifying the current land areas planted with bioenergy resources. Most recent comprehensive report in the UK is provided by Defra (2014)*.
- 2013 area of agricultural land in the UK used for bioenergy estimated to be **51 kha** (~0.8% of all arable land), not including 29.4kha of maize grown for use in AD, nor 2% of cereal straw used for bioenergy purposes.
- Just over 80% (42 kha) of this land was used to produce biofuel crops (oilseed rape, sugar beet and wheat) for the UK road transport market.
- Miscanthus was grown on ~**7.1 kha** of land in England, and SRC (willow & poplar) grown on ~**2.7 kha** of land in England. Industry estimates included in the E4tech (2013) report also identify an additional ~**0.5 kha** of SRC likely to be currently grown in Scotland, Wales and Northern Ireland.
- Defra (2014) data also gives historical crop areas from previous years; it shows that Miscanthus areas are on an **apparent downward trend** (and SRC areas roughly static), with the new areas planted in 2014 and 2015 likely to be much smaller than previous year following the closure of the Energy Crop Scheme 2 (Natural England, 2014). Apparent decrease may still be attributed to the sampling variation in the survey.

*This annual report aggregates and analyses statistics from a range of sources, including The June Survey of Agriculture and Horticulture, Renewable Transport Fuels Obligation data and the Renewable Energy STATistics (RESTATS) Questionnaire. The estimates of crop areas include oilseed rape (OSR), sugar beet, wheat, maize, Miscanthus and SRC. Error bars for this data are typically less than 10%, although data are usually 1-1.5 years behind reality.

Current land area:
Growing perennial energy crops in the EU

- There is no official information on the current EU land area for growing energy crops or SRF (such as through EUROSTAT).
- However a few studies have attempted to quantify ranges by gathering together piecemeal information on individual Member States.
- Biomass Futures (2012a) estimates that bioenergy cropping took place on **5,506 kha** of EU agricultural land on average during 2006 – 2008 (or ~3.2% of the total EU arable area). The majority of this land is being used to produce biofuels, but with ~**19.5 kha** cultivated with Reed Canary Grass (mainly in Finland), and ~38.3 kha of Miscanthus (mainly in the UK, Poland and Italy), although this report cites a UK Miscanthus area estimate of 13.5 kha which is now known to be too high. Adjusting for this, the total Miscanthus area in Europe today might be closer to **31.9 kha.**
- The Biomass Futures data for SRC (28.5 kha of willow and 6.5 kha of poplar) in 2006-2008 has been superseded by a more recent, comprehensive AEBIOM (2011) report, which states that **30 – 36 kha** of willow has been planted, and ~**14 kha** of poplar within the EU27.

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Current land area:
Growing SRF in the UK & EU

- There is no reliable or centralised information available on UK or European SRF areas, as these are not currently distinguished from existing forestry data.
- UK experience is limited to past field trials, with <**0.1 kha** estimated as planted (Forestry Commission, 2010). EU experience seems to be mainly focused on Eucalyptus in Spain, with up to 140 kha planted for industrial pulping (but presumed to be long rotation, not SRF), but only ~**6.7 kha** known to be planted by Energia & Celulosa (ENCE) on an intensive basis (RISI, 2013; Ruiz & López, 2010). Other EU information on SRF areas is similarly old, anecdotal or unclear.
- "Best available" estimated values for current perennial energy crop and SRF areas growing in the UK and EU is summarised below.

kha	Miscanthus and other energy grasses	SRC willow and poplar	SRF
UK	7.1	3.2	< 0.1
EU (including UK)	51.4	47.0	> 6.7

Land availability study methodologies:
Hierarchy of potentials, demand/resource-driven studies

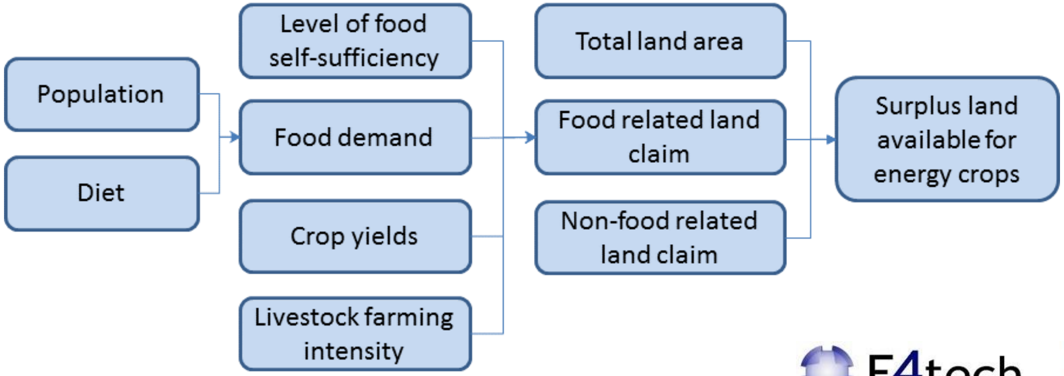
- Numerous assessments of land availability have been undertaken at national, regional and global scales. A common feature of these assessments is that the availability of land is discussed in terms of a hierarchy of potentials:

Theoretical > Technical/Geographic > Economic > Realistic/Implementable

- These terms are not always used consistently or defined for cross comparison. Environmental, biophysical, or economic constraints on land use are used within most studies, but may also be applied at different hierarchy levels.
- Land (and biomass) potential estimates are often classified in the literature as either **demand driven** (how much land to produce X million tonnes) or **resource driven** (compile an inventory of biomass resources, including the different land classes and areas on which energy crops might be grown).
- Resource driven studies range from **simple calculations** based on expert judgement and extrapolation of **land use trends**, to **GIS mapping** and sophisticated **land-balance models**. On this spectrum, the majority of UK focused studies adopt a simple calculation approach. There is considerable overlap, however, with EU focused studies where the use of aggregate land balance models and integrated assessment models is more prevalent.
- Hybrid approaches are frequently found, e.g. a study may start with a land inventory and overlay this with a demand driven scenario analysis.

Study methodologies:
Land-balance modelling

- One of the most important analytical approaches for estimating future land availability is **land-balance modelling**. Fischer et al. (2007) define land available for energy crops as the land remaining after the area needed for food, feed and livestock, urban development, with set-aside for nature conservation excluded.
- The approach can integrate data from sources such as FAO and demand predictions for energy, food, timber. Results are usually presented at an aggregated geographical level.
- The results, however, are only as good as the scenarios used to drive the model. Because many of the variables are uncertain (e.g. dietary trends) or subjective (e.g. the desirable level of food self-sufficiency), a wide range of plausible outputs can be produced - compounding rates of crop yield improvement are particularly problematic. Economic assumptions may also be explicit, or implicit (e.g. it will be economic to invest in crop R&D to improve yields).



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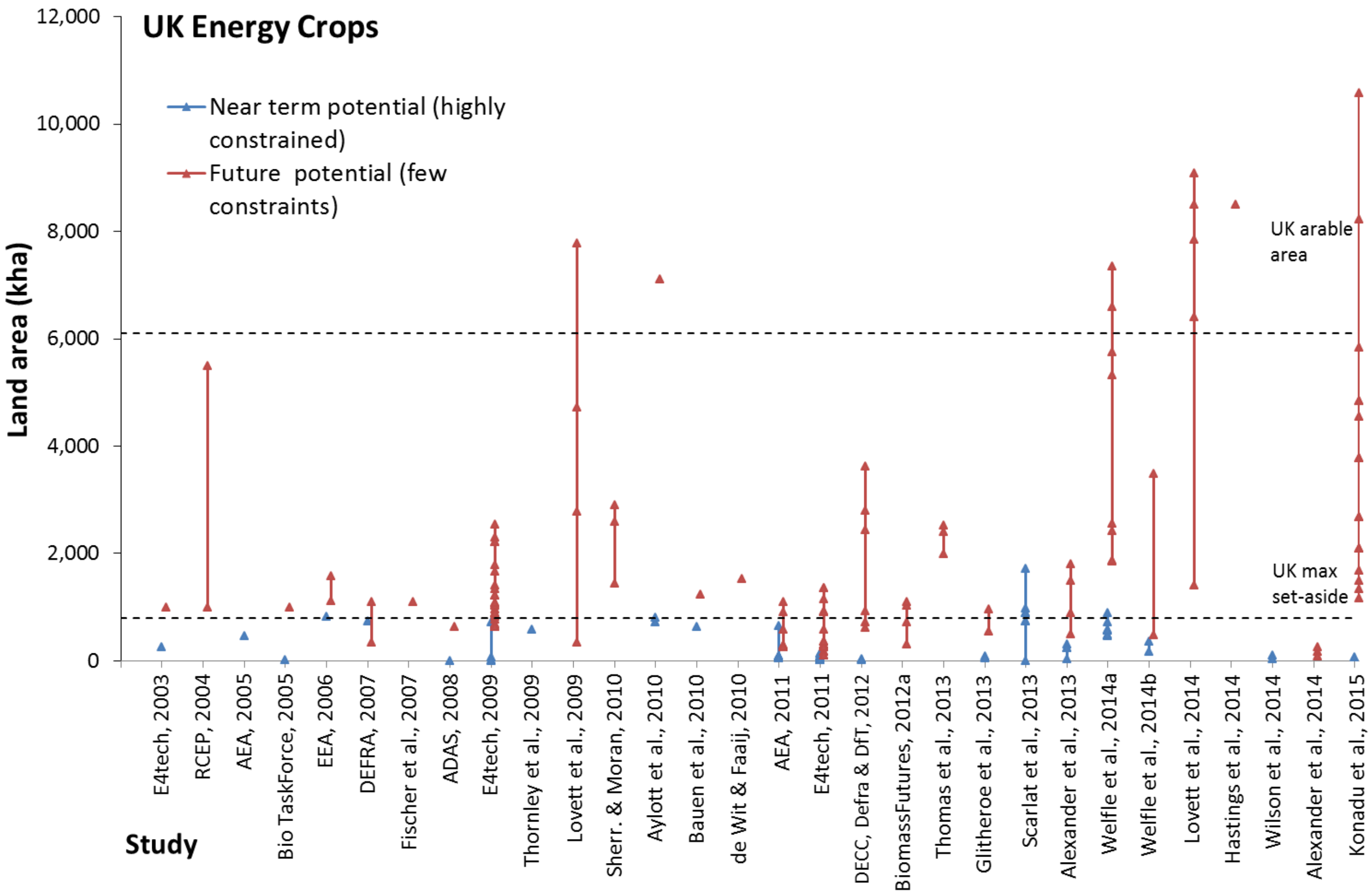
Study methodologies:
Other options

- Greater spatial resolution can be provided using **GIS models**, but these typically only provide a snapshot of how much land is hypothetically available, or suitable, for energy crops after excluded land areas are removed, i.e. without considering food competition. Constraint masks describing excluded land have become increasingly sophisticated, and are an important input into more aggregated land balance models.
- **Meta-analysis studies** are also prevalent. These re-examine prior analysis, often re-evaluating constraints on land use to develop new scenarios. All the UK Government reports (Defra, 2007; DECC, Defra & DfT, 2012), can be considered meta-analyses (as can the WP1 report).
- **Economic modelling** of energy crop production in competition with food crops has been undertaken, but these studies are limited in number and sophistication (see Sherrington & Moran 2010).
- **Agent based simulation** (Alexander et al., 2013), and **farmers surveys** (Wilson et al., 2014; Glitheroe et al., 2013) are new approaches in the UK. Agent based simulations explore the rate of potential up-take of energy crops given assumptions about farmer and power plant investor behaviour in response to demand led economic scenarios. Farmer surveys seek to identify a representative sample of farmers and estimate their willingness to consider energy crops.

Identification and characterisation of studies

- After a literature research and a cross-referencing exercise, 46 studies were identified as being in scope and relevant for examination. This set of studies consists of:
  - 25 studies with UK land availability data
  - 16 studies with EU land availability data (including 5 studies with UK data)
  - 5 studies that were rejected for further analysis, as they either only provided data on current areas grown, did not provide any data points (e.g. only reviewing methods), or were only using hypothetical land scenarios for illustration purposes only

Results:
Land available for energy crops in the UK



Results:
Land available for energy crops in the UK (near-term)

Near-term potential estimates for perennial energy crops in the UK range from **7 - 1,723 kha**

- The bottom is the actual area of energy crops grown in 2007 (ADAS, 2008). The top end of this range corresponds to a demand led scenario in which the entirety of UK's 2020 bioenergy target under the EU Renewable Energy Directive (based on NREAP projections) is met from domestic production.
- Many of the near-term estimates corresponds well with the UK's maximum set-aside area (which peaked at ~800 kha in 2001), as many cite set-aside areas in their derivation. Even after set-aside was removed in 2008, most subsequent *near-term* estimates can still be traced back to earlier studies that reference the set-aside area.
- The recent exceptions are studies that extrapolate the results of farmer surveys; and studies simulating the implications of hypothetical farmer and power plant investor behaviour in response to economic incentives.

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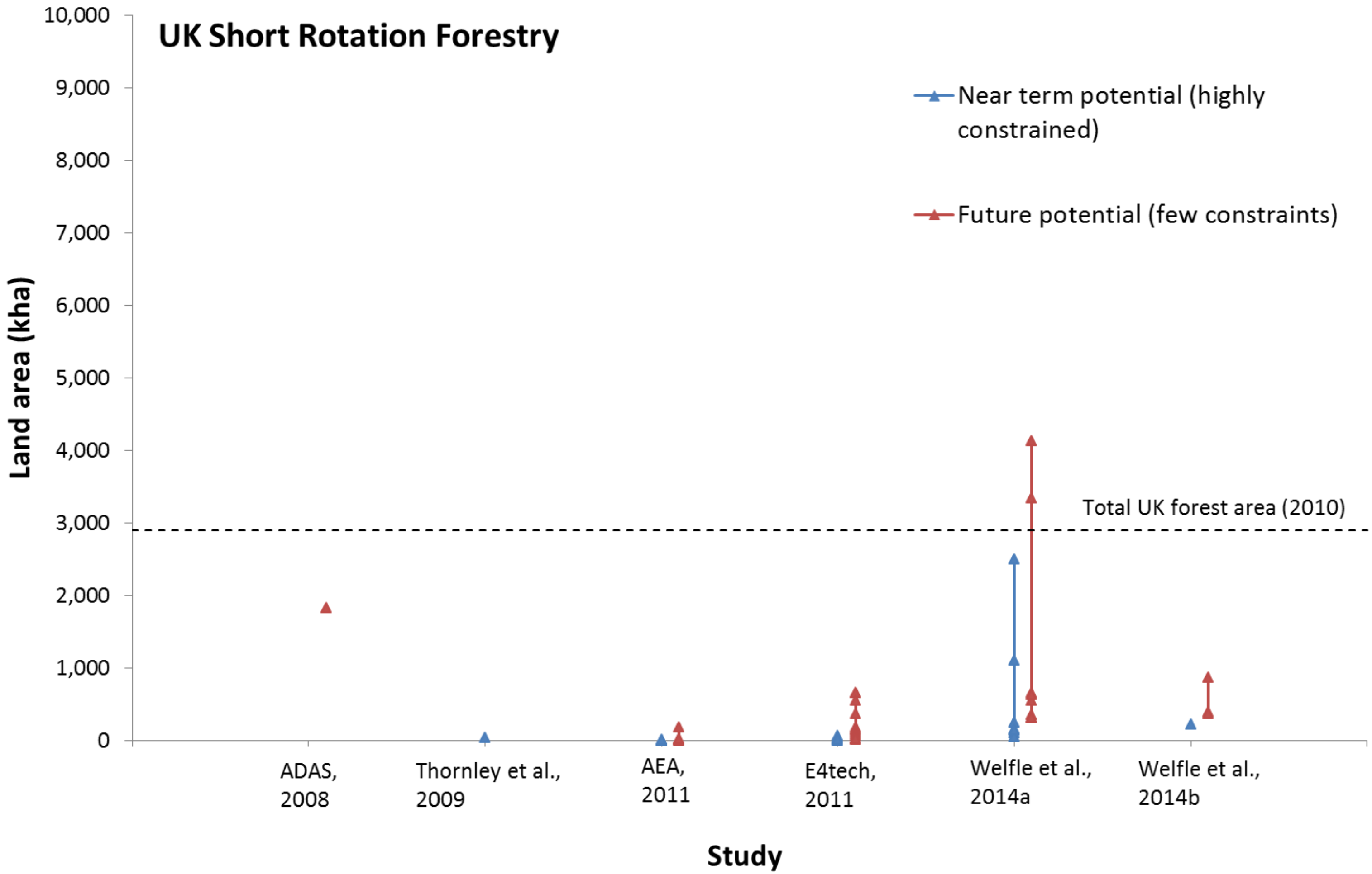
Results:
Land available for energy crops in the UK (future)

Future potential estimates range from **99 - 9,086 kha**

- The bottom assumes that energy crops are severely limited by planting rates between now and 2025 (E4tech, 2011). The top represents the maximum possible area of UK on which energy crops might conceivably be planted, calculated using GIS and assuming a limited land exclusion mask (Lovett et al., 2014) – this is only a first masking step, not a plausible future.
- Other high estimates can be the result of land-balance modelling using optimistic scenarios about food yield improvements to free up lots of land.
- Future land area estimates in all studies reflect different constraint scenarios. Most studies assume that food crop yields will increase and that the provision of food will be prioritised. Studies prior to 2008 assume that energy crops will be located on arable and temporary grassland areas, minimising environmental and biodiversity impact.
- Later studies, however, give greater emphasis to planting on lower grade agricultural land in order to minimise competition with food – despite most UK energy crops currently grown on Grade 2 and 3 arable lands. One of the interesting results of recent analysis has been to highlight the tension between economic viability (which favours planting on good quality land) and minimising competition with food (which favours planting on marginal land).

Results:
Land available for SRF in the UK



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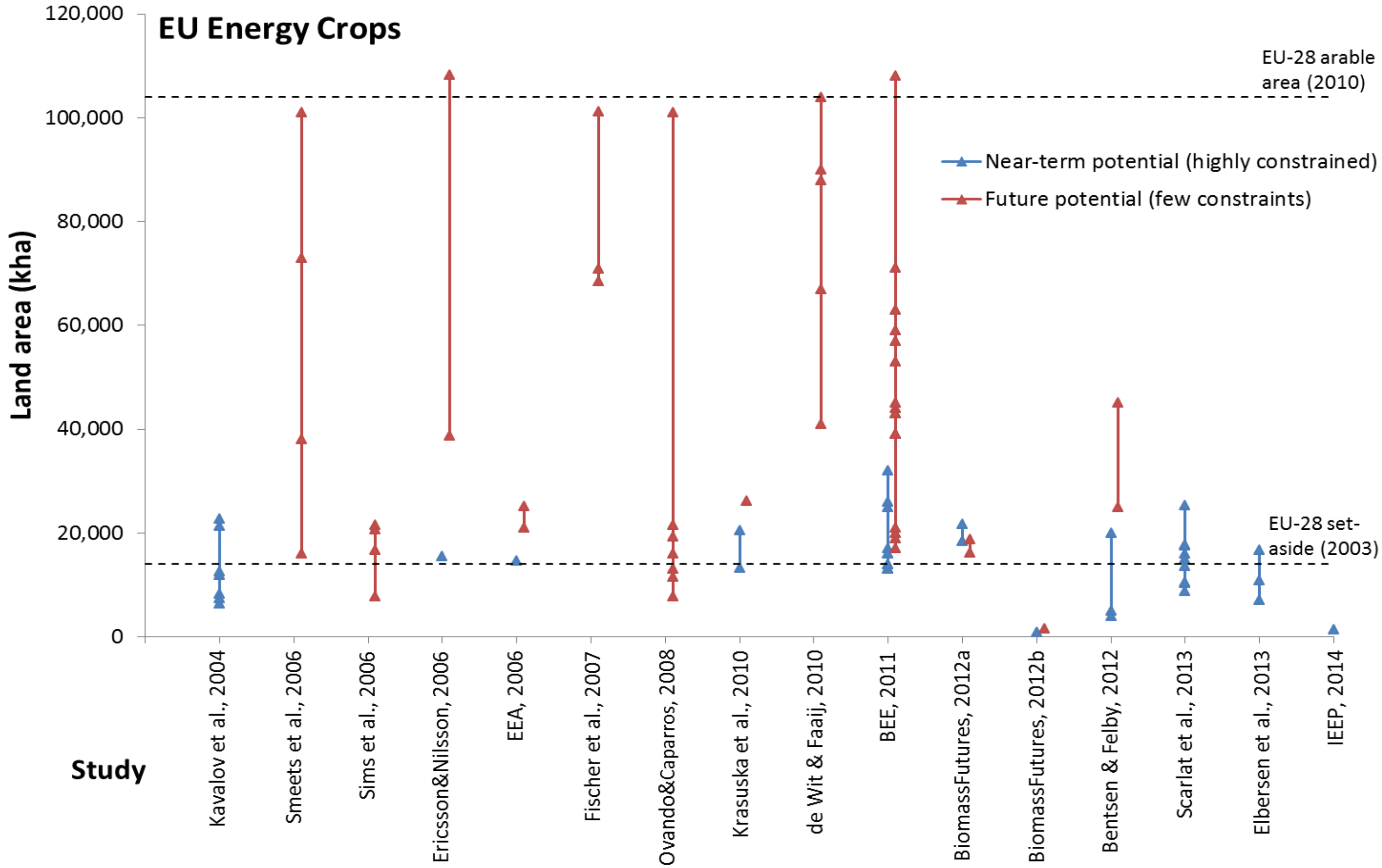
Results:
Land available for SRF in the UK

- Only four studies explicitly identify land available for SRF (ADAS, 2008; Thornley et al, 2009; AEA, 2011; E4tech, 2011).
- The land area estimates in these studies are generally low compared to energy crops, with values ranging from **0 kha** today in 2015 (AEA, 2011) to between **0 - 1,827 kha** in the long term (ADAS, 2008; AEA, 2011).
- All assume that SRF would be allocated to rough grazing and low quality permanent grassland – but this conversion is considered undesirable owing to the release of soil carbon and loss of biodiversity (EEA, 2006).
- Even if a major effort to plant SRF were undertaken in 2015, the first harvest would not be until 2030-2035 at the earliest, and so would be economically unattractive in many cases (ADAS, 2008; E4tech, 2011).
- A further two studies (Welfle et al 2014a; Welfle et al 2014b) which use a simple UK focused land balance model to estimate potential land availability identify large areas of land (**50-2,498 kha** by 2020, and **304-4,131 kha** by 2050) that could be available for "dedicated forest resources" – although it is not clear if this is equivalent to SRF on previously un-forested land or Long Rotation Forestry

Results:
Land available for energy crops in the EU



Results:
Land available for energy crops in the EU (near-term)

Near-term potential estimates in the EU range from **940 - 25,217 kha**

- The bottom comes from the Biomass Futures (2012b) study, which describes an economic potential for SRC only. Interestingly, this value is not dissimilar to a conservative estimate for how much additional land might be available in 2010 (1,350 kha) described by the IEEP (2014) study and estimated via a critical examination of recent trends.
- The top is the result of a demand driven scenario that estimates the area required to meet NREAP targets in 2020 with reduced biofuel imports into the EU (Scarlat et al, 2013). This is also comparable to the estimate of 22,742 kha described in the Kavalov (2004) study and arrived at through a similar demand-led study, which assumed that the EU will reach its transport biofuel targets without importing any bioenergy resources. A value of 15,500 kha shown by Ericsson & Nilsson (2006) comes from a simple assumption that 10% of EU arable land could be made available for energy crops (an area reflecting historic set-aside policy).

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Results:
Land available for energy crops in the EU (future)

Future potential estimates range from **1,640 - 108,200 kha**

- The lowest value again corresponds to an SRC only estimate by Biomass Futures (2012b). The next lowest values (7,780 kha) uses the IMAGE2.2 integrated assessment model using IPCC scenarios for diets, population growth, and technological progress (Sims et al., 2006)
- The upper estimate represents an area greater than the total arable area in the EU28, with a very simplistic calculation that assumes the per capita land area required to feed the EU population can be limited to 0.24 ha (Ericsson & Nilsson, 2006).

Although a range of models are used, all the EU *resource-focused* estimates are derived using variations on a basic land balance approach:

- Typically assumed that food crop yields will increase faster than food demand grows.
- Food production is prioritised, no competition with energy production.
- Environmental limits are imposed using constraint scenarios. The exception to this generalisation is the analysis undertaken as part of the Biomass Futures project using the CAPRI model (BiomassFutures, 2012a).

Summary of the review of existing studies

Area (kha)	Near-term		Long-term	
	Min	Max	Min	Max
UK Energy crops	7	1,723	89	10,569
UK SRF	0	2,498	0	4,131
EU Energy Crops	940	25,217	1,640	108,200

- The studies collected allow identification of the **key drivers and sensitivities**, such as population & GDP growth, diet, energy prices, food crop yield improvements, plus agricultural & land-use policy.
- However, the **differing methodologies and study assumptions** lead to the area ranges being very large. The resulting values often cannot be directly compared, nor authoritative judgements made such as “study X is too low”.
- Overall, currently the data does not exist to provide **precise** land area estimates (nor is it likely that the changing policy or global drivers would ever allow this accuracy, despite the new methodologies already being developed).
- However, there is a **credible range of estimates** within which the future for the energy crop and SRF sectors may lie – provided the policy, markets and crop technology are all developed and supported.

Key studies in the UK context

- In our judgement the best guide to land availability for energy crops in the near-term is obtained from the analysis of recent trends for the principal land categories (arable, pasture, etc). This inventory approach cannot easily evaluate systemic changes, but had the advantage of a high level of transparency and simplicity.
- The study which best exemplifies this approach in the UK is the report by **ADAS (2008)**, although an updated inventory study is now required in the UK to account for the removal of set-a-side, CAP changes and the new global macro-economic environment.
- The availability of land in the more distant future can only be stated in the context of scenarios for the agricultural sector as a whole. Perhaps the best starting point for this discussion in the UK is the constrained GIS mapping approach developed by **Lovett et al. (2014)**
- However, further work is required to enhance this approach with the considerations of food competition and micro-economic aspects such farmer profitability and barriers to update of new crops. This more sophisticated is being developed by **Alexander et al. (2014)**, and shows considerable promise.

Study categorisation

The number of different methodologies can cause confusion - some will be more **appropriate** than others in answering a new study question

Sub-categorisation of studies only gives limited new insights:

- **Large ranges** still exist within the categories, with no distinct clustering.
- Farmer surveys and agent based simulations are typically the most **cautious**, followed by inventories.
- Demand led, GIS and land balance approaches are typically the most **optimistic**.
- Potential demand scenarios **can exceed** the maximum feasible land availability derived by GIS and land balances (imports may be required).

UK estimated area available for energy crops (kha)

kha	Near-term		Future potential	
Study type	min	max	min	max
Demand led	7	1,723	314	10,569
GIS	638	800	337	9,086
Land balance	177	890	478	7,349
Inventory / meta analysis	7	740	99	3,630
Agent based model	39	303	89	1,800
Farmer Survey	29	99	546	968
All studies	**7**	**1,723**	**89**	**10,569**

UK estimated area available for SRF (kha)

kha	Near-term		Future potential	
Study type	min	max	min	max
Land balance	50	2,498	305	4,131
Inventory / meta analysis	0	66	0	1,241
All studies	**0**	**2,498**	**0**	**4,131**

EU estimated area available for energy crops (kha)

kha	Near-term		Future potential	
Study type	min	max	min	max
Demand led	940	25,217	1,640	18,793
Land balance / meta analysis	4,000	20,500	7,780	108,200
Inventory	1,350	1,350	no data	no data
All studies	**940**	**25,217**	**1,640**	**108,200**

Refining Estimates of Land for Biomass

Cell selection

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Background

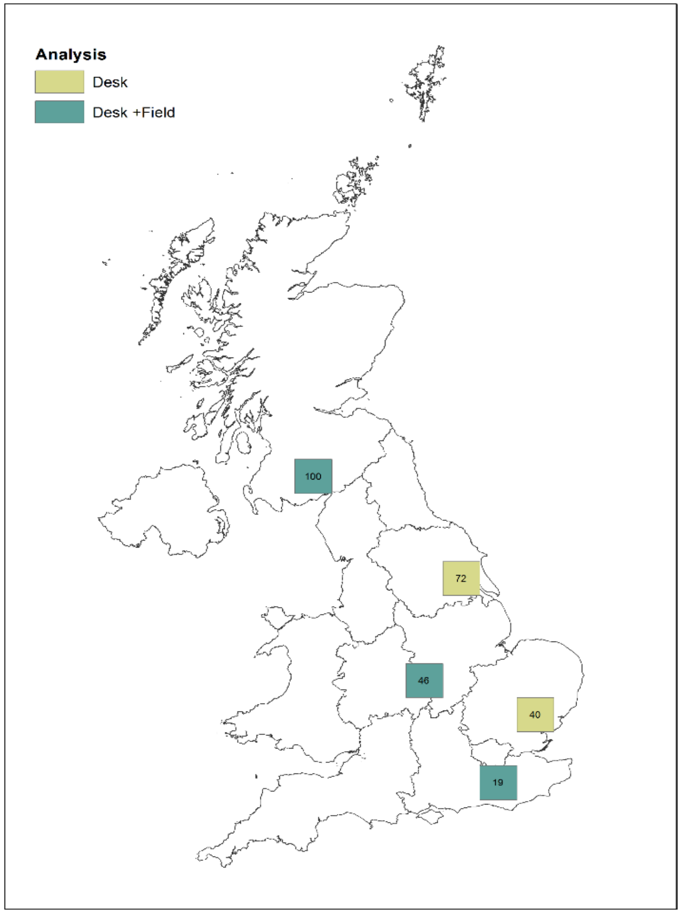
- The ETI's Bioenergy Value Chain Model (BVCM) currently uses national land estimates based on various constraint maps developed through the UKERC Spatial Mapping Project.
- This project builds on one of those constraint maps, **UKERC 9w**, to refine the current estimates of available UK land for the production bioenergy crops –e.g. **short rotation coppice/ forestry and Miscanthus grasses**.
- The objective was to analyse the impact of adding additional datasets to BVCM assumptions on land availability for bioenergy crops using GIS analysis and the results of a field survey.

Cell selection

- A subset of five cell outputs from BVCM were identified for analysis by the ETI.
- Three of these (019, 046 & 100) were selected as preferable for further field survey

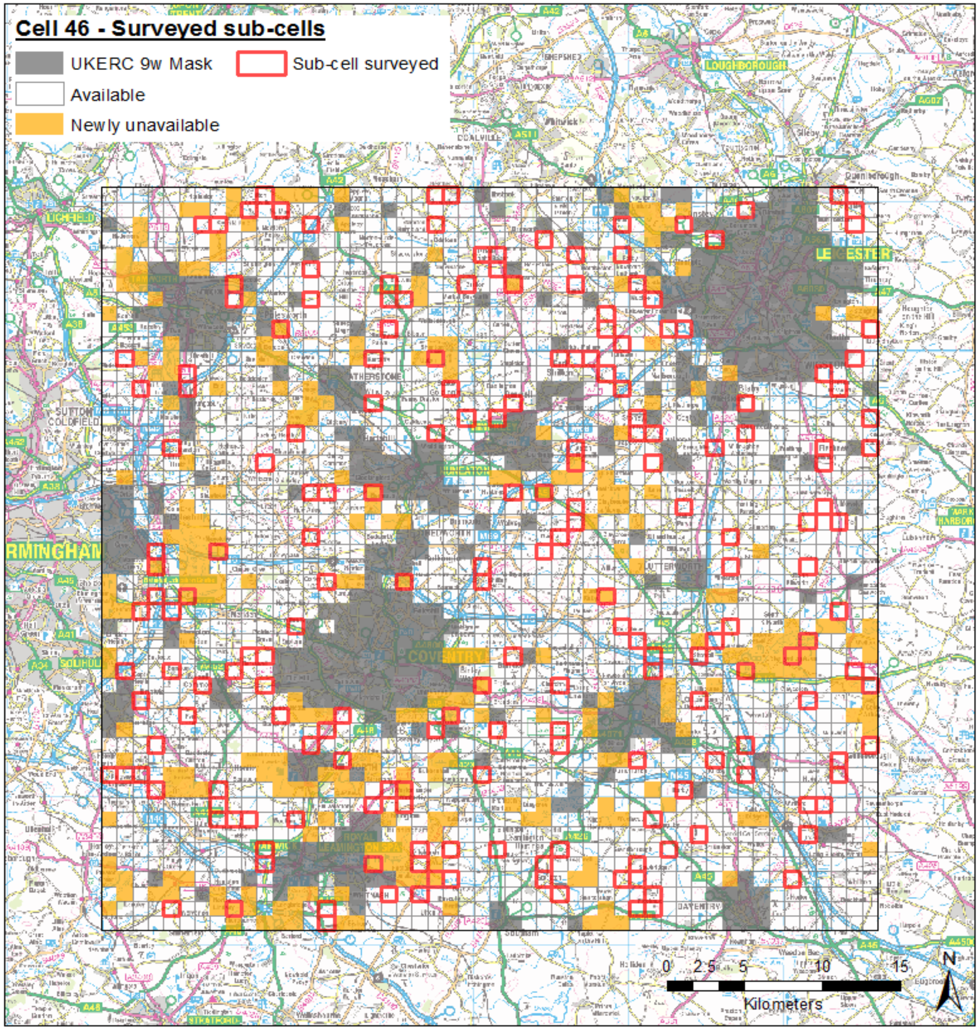
Cell	Arable (None) (ha)	Grass (None) (ha)	Forest (None) (ha)	Arable (9w) (ha)	Grass (9w) (ha)	Forest (9w) (ha)	Suggested Analysis	Reason
19	54,529	120,547	32,341	43,841	72,749	22,137	Desk and field study	BVCM Miscanthus and SRF preference area. Water stressed area.
40	183,740	30,569	3,551	175,021	25,920	3,320	Desk study only	BVCM Miscanthus and SRF preference area. On edge of water stressed zone.
46	128,138	66,795	2,612	120,732	61,608	2,454	Desk and field study	BVCM Miscanthus and SRF preference area. Area with current energy crop production
72	202,484	12,599	2,587	178,354	9,857	2,293	Desk study only	BVCM Miscanthus and SRF preference area. Area with current energy crop production
100	24,900	130,030	45,570	20,258	63,305	34,510	Desk and field study	BVCM SRC Willow preference

Approach to sub-cell selection - field



- Three 50 x 50 km cells selected from the five used in the desk study
  - Cell 100 Dumfries and Galloway
  - Cell 046 Leicestershire and Northamptonshire
  - Cell 019 Kent and Sussex
- Over laid with a 1 km x 1 km grid to produce a series of sub-cells
- UKERC 9w and additional layers applied to identify **'available'** and **'newly unavailable'** sub-cells
- Sub-cells to survey were selected from the original 'available' cells using a number generator producing 250 1 x 1 km sub-cells of which 50 were used as back up sub-cells
- One back up sub-cell was identified for every 4 selected sub-cells
  - If one of those 4 sub-cells was inaccessible the backup cell was used in its place
  - If more than one sub-cell was inaccessible then that backup sub-cell plus the next nearest backup sub-cell was used.

Example of sub-cell selection in 50 x 50 km square



- Selected from originally available sub-cells
- Cross check that 'available' and 'newly unavailable' sufficiently represented – but no adjustments were required
- All sub-cells given unique identifier to enable cross ref between Desk and Field studies
    - Sub-cells numbered 1-50 along northings and eastings
    - Ref is cellno_easting_northing
    - 046_11_02 = M40/A45 junction

Refining Estimates of Land for Biomass

Field study to ground truth theoretical estimates of land available for the growing of energy crops

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Field Study

- Approach
- Results
- Advantages & limitations

Approach

Preparation

- 2-3 surveyors per cell
- Training provided prior to starting work
  - Worked example
  - Using images and Excel template
- Provided with;
  - Field study plan
  - Health and safety docs
  - Equipment list
  - Maps and recording template

Method

- Surveyors accessed sub-cells on public rights of way (PROW)
  - If no PROW or safe stopping location sub-cell deemed 'inaccessible'
  - Used 1-4 locations to maximise visibility
- Visually assessed land type and recorded proportion of each on template
  - Used to calculate 'land available'
- Also gave their view on whether sub-cell was available or not
  - 'surveyor view'

Data recording

How much of the cell is visible from your assessment point(s)?	80%
Proportion of the cell not assessed	20%
Arable	25%
Other cropping e.g horticulture	0%
Type of production	Select
Improved grassland (includes rough grazing areas)	15%
Semi natural grassland	5%
Scrub (unmanaged woody shrubs, tall ruderal vegetation, grasses, brambles)	0%
Moorland (bracken, dwarf shrub heath, fen/marsh/swamp, bog and montane habitats)	0%
Parkland	0%
Semi-natural broadleaved woodland	5%
Semi natural coniferous woodland	0%
Semi natural mixed woodland	0%
Plantation broadleaved	0%
Plantation coniferous	0%
Biomass crops/SRC/SRF	0%
Golf course/Polo pitch/other amenity land	0%
Development Residential/Industrial	0%
Buildings present	20%
Building type (select dominant type if more than one)	Residential building
Water body	0%
Water body type (select dominant type if more than one)	still water i.e pond/lake
Boundary area	9%
Boundary type (select dominant type if more than one)	Hedges
Solar farm	0%
Highways and associated verges	1%
Wind farm	0%

- Each cell was surveyed in a methodical manor
  - Green available
  - Amber unavailable
- Provided comments to clarify, e.g. if pasture is being used for equine uses
- Five photographs were taken at a prominent point P on the map in the order N, E, S, W
- Data captured on the Excel spreadsheet

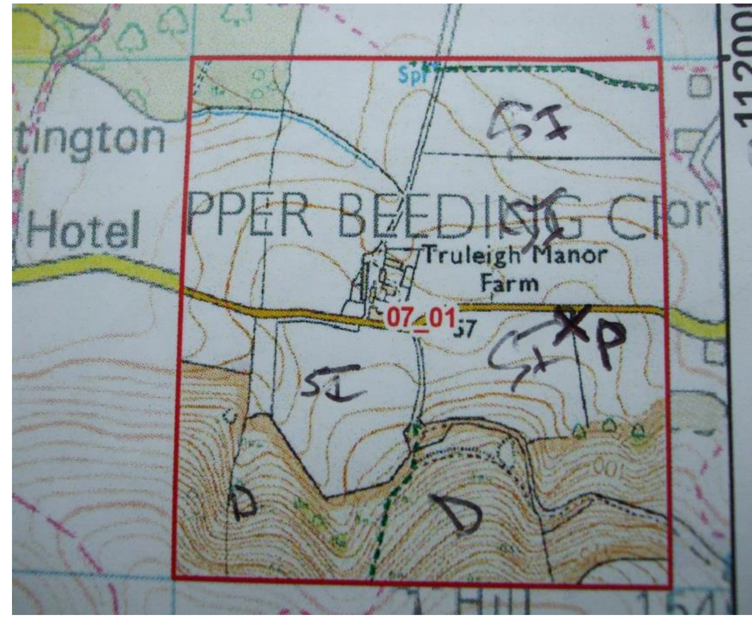
Example of cell 019 – sub-cell 07_01

N

E

S

W



On average across the 610 sub-cells surveyed, 88% of land cover was assessed
(range 50% - 100% across individual sub-cells)

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Consistency

- To ensure consistency;
  - Surveyors **fed back** after first day
    - Identified challenges,
    - Issues
    - Discrepancies
  - Data uploaded to sharepoint and **checked** as soon as available
  - Differences between surveyors questioned
  - Selection of results cross checked against mapping and satellite images and discrepancies discussed
  - **Re briefing** session for all surveyors held at end of first week to feedback and discuss approach
- Majority of information was qualitative – which minimises risk of inconsistency, but it did rely on surveyors having a good eye for the area covered by a particular land use type

Field survey defining available land

- The field survey used two different approaches to calculate the ‘available’ land.
- **Land area forecast –** Unknown (part of sub-cell not visible to surveyor) allocated pro rata based on assessed area.
- **Surveyor forecast –** This was the surveyors view of availability – based on what they could see or interpret from the map taking into account; access, presence of scattered trees, utility poles, public rights of way or waterlogging and whether the use of the grassland was agricultural or equine.
- In 567 sub cells (93%) the surveyor forecast agreed with the land area forecast, however there were 43 sub-cells were there was disagreement.

Surveyor forecast vs land area forecast

- There were 29 sub-cells (5%) where the surveyor considered that the sub-cell was available, even though the land area estimates indicated that it was unavailable. The majority of these sub-cells (18) were in cell 019.
- There were 14 cells (2%) where the surveyor thought that the cell was 'unavailable' even though the land area forecast indicated that it was 'available'. The majority of these (11 sub-cells) were in cell 100.
- There were two main explanations for the differences;
  - The available land area was almost 50%, so the pro rata allocation of unknown land could easily skew the selection of available vs unavailable either way.
  - The surveyor indicated that that they thought the 'unknown land was more likely to be skewed towards a particular land type making the pro rata allocation of 'unknown' inaccurate.
- There were four sub-cells in cell 100 where the surveyor considered them to be **too steep** for cost effective short rotation forestry to be planted, although the land was already being used for plantation forestry.
- There were three cells in cell 019 that were identified as unavailable by the surveyor due to;
  - **containing large areas of gardens and land belonging to a manor house,**
  - **a vineyard present**
  - **used for equestrian purposes.**

Land area forecast (pro rata) / Surveyor forecast	Available	Unavailable	Total
Available	444	29	473
Unavailable	14	123	137
Total	458	152	610

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Summary of field study findings

Summary of sub-cell availability in each of the main cells in comparison original 9w mask

	Originally Available UKERC 9w (whole cell)	Newly unavailable (from desk study)	Number of sub-cells surveyed	Available according to field survey	Unavailable according to field survey	Available according to desk study	Newly unavailable according to desk study
Cell 019	1565	696	206	121	85	126	80
Cell 046	2053	280	202	179	23	181	21
Cell 100	1320	318	202	173	29	156	46

- Sub-cells marked as initially available the surveyors identified in all sub-cells between 23 sub-cells (11%) to 85 sub-cells (41%) as unavailable
- The surveyors' results (based on surveyor opinion) **matched** the initial desk study forecast of available vs newly unavailable in **74%** of sub-cells.
- The highest number of discrepancies between desk study and surveyor opinion occurred in cell 019. Overall cell 046 had the least discrepancies.

Summary of field study findings

- The field survey results indicates that additional information could be used to further refine the UKERC 9w to further reduce the number of ‘available’ sub-cells in a cell. The field survey surveyed 610 sub-cells, all of which are ‘available’ under the UKERC 9w mask.
- Of these, 137 (or 22% of surveyed sub-cells), were found to be unavailable, however this reduction was not even across the cells it ranged from 23 sub-cells (or 11% of surveyed sub-cells) identified as ‘unavailable’ by the surveyors in cell 046 to 85 sub-cells (41% of surveyed sub-cells) identified as unavailable in sub-cell 019
  - The difference in the dominant land use and livestock present was notable according to where the 50 km x 50 km cell was positioned.

Cell No.	Improved pasture %	Coniferous plantation %	Arable %	Semi-natural broadleaved woodland %
Cell 100	34	28	4	4
Cell 46	20	0	39	3
Cell 19	26	1	18	12

  - Livestock - horses featured more frequently in cell 019 where they were almost equal in dominance to that of sheep and cattle, whilst sheep were dominant in cell 046 and cattle in cell 100.

Advantages to the approach

- Provided ground truth of theoretical estimates of land for energy crop production
- Able to access and survey 88% of the planned sub-cells
- Up to date land use was recorded
- Captures recent land use changes, not recorded on older GIS layers.
- Large quantity of information recorded (some of which could not be addressed in the desk study)
  - Some uses not picked up by GIS
    - Golf courses
    - Equestrian
- Minimal number of surveyors (2 or 3 in each cell)
- Flexible approach to surveying. The ability to adjust the surveying techniques according to topography and visibility
  - E.g. using multiple survey points to increase visibility

Limitations to the approach

- Only a small proportion of the total 50x50 km cell was cell assessed, with a focus on ‘available’ and ‘newly unavailable’ sub-cells under the new constraint mask. No sub cells that were ‘unavailable’ under UKERC 9w mask were assessed
- Time consuming – The process of visiting and assessing each cell is time consuming and therefore more expensive to complete than a desk study
- Limited visibility of cell (All cells),
  - Obstructions to view
  - Steep hillsides (cell 100)
  - Weather conditions (cell 100)
  - Residential properties lining the roads (cell 046 & cell 019)
  - Tall thick hedges obscuring viewing (cell 046)
- Lack of public access (All cells)
- Lack of safe access (All cells), even where there was a PROW – e.g. a road, it was not always safe to stop in suitable locations to assess the sub-cell
  - If road was a busy A road, with no safe stopping places
  - If road was a motorway
  - Sometimes meant that less optimal locations were selected for assessment due to being safer to stop in
- Estimating percentage cover when 100% of cell was not visible was challenging. Surveyors had to rely on a combination of information from the map and sometimes satellite imagery to aid estimates.
- Subjective information recorded, although steps were taken to maximise consistency there is always the risk with the more subjective parts of the assessment that you get some variation between surveyors

Aspects identified in field survey but not apparent in the desk study

- Residential garden areas
- Scattered trees
- Access of single lane roads and tracks
- Bridges with weight limits
- Horse pastures & amenity land
- Sudden changes in complex topography
- Visual landscape impact
- Areas of major roads and verges
- Waterlogging
- Pylons and electricity wires

Refining Estimates of Land for Biomass

Review of datasets, creation of provisional mask and validation of mask using results of field study

Lucy Wilson, Ben Hockridge

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Aims of desk study

The desk study aimed to;

- Provide information on the additional datasets that could be applied to the UKERC 9w mask, including their strengths and weaknesses
- Provide information on how the application of constraint masks was refined following a review of field survey data
- Identify the most appropriate combination of datasets for estimating available land for 2G energy crops

Assessment of data layers – constraint layers

- Altitude >300m – OS Terrain 50
- Agricultural land productivity – Grade 1
- Soil texture >80% clay – European Topsoil Physical Properties
- Buildings and water bodies –Ordnance Survey VectorMap District
- BAP priority habitats – Natural England Inventory; no data for Scotland
- Semi-natural woodland – Ancient Woodland Inventory (England) Ancient & Semi-natural Woodland Inventory (Scotland)
- Historic parks & gardens – official registers
- Environmental stewardship options – Environmental Stewardship and classic Countryside Stewardship for England; no data for Scotland
- Water stressed areas – Environment Agency dataset; no data for Scotland
- Visibility – decision taken not to carry out view shed analysis
- Historic environment records – decision taken not to source these records

Assessment of data layers – likelihood layers

- Flood risk – proportion of available land area within flood risk zone; no data for Scotland
- Nitrate vulnerability – proportion of available land area within nitrogen vulnerable zones (NVZ)
- Land tenancy – proportion of farmed land area in county that was rented
- Pollinator density – outputs of species distribution for crop pollination; not suitable for use
- Field size – no clear evidence base; not used
- Areas of rapid land-use change – no clear evidence base; not used
- Local planning studies – decision taken not to source

Use of likelihood layers

Likelihood layer	Summary
Proportion of area in flood risk area	Planting in flood plains may provide additional benefits but more use for targeting planting
Proportion of area in NVZ	Planting in NVZs may provide additional benefits but more use for targeting planting
Proportion of land area rented	County scale data. Indicates likelihood of planting rather than land availability.

Provisional mask creation using constraint layers

Constraint layer	Extra sub-cells excluded in all 5 study cells	Summary
Altitude >300m	174	Absolute constraint but only for cell 100
Grade 1 land	156	Not absolute constraint – financial influence
Soil >80% clay	0	No exclusions in study cells
Buildings/water	22	Absolute constraint but doesn't exclude gardens & amenities
Priority habitats	777	Not absolute constraint & doesn't cover Scotland
SN woodland	510	Doesn't include all Semi natural (SN) woodland
Parks & gardens	126	No clear evidence base
Stewardship	998	Not mapped for Scotland; subject to change
Water stressed areas	2,759	Available dataset excludes large areas. Not as important for small scale planting.

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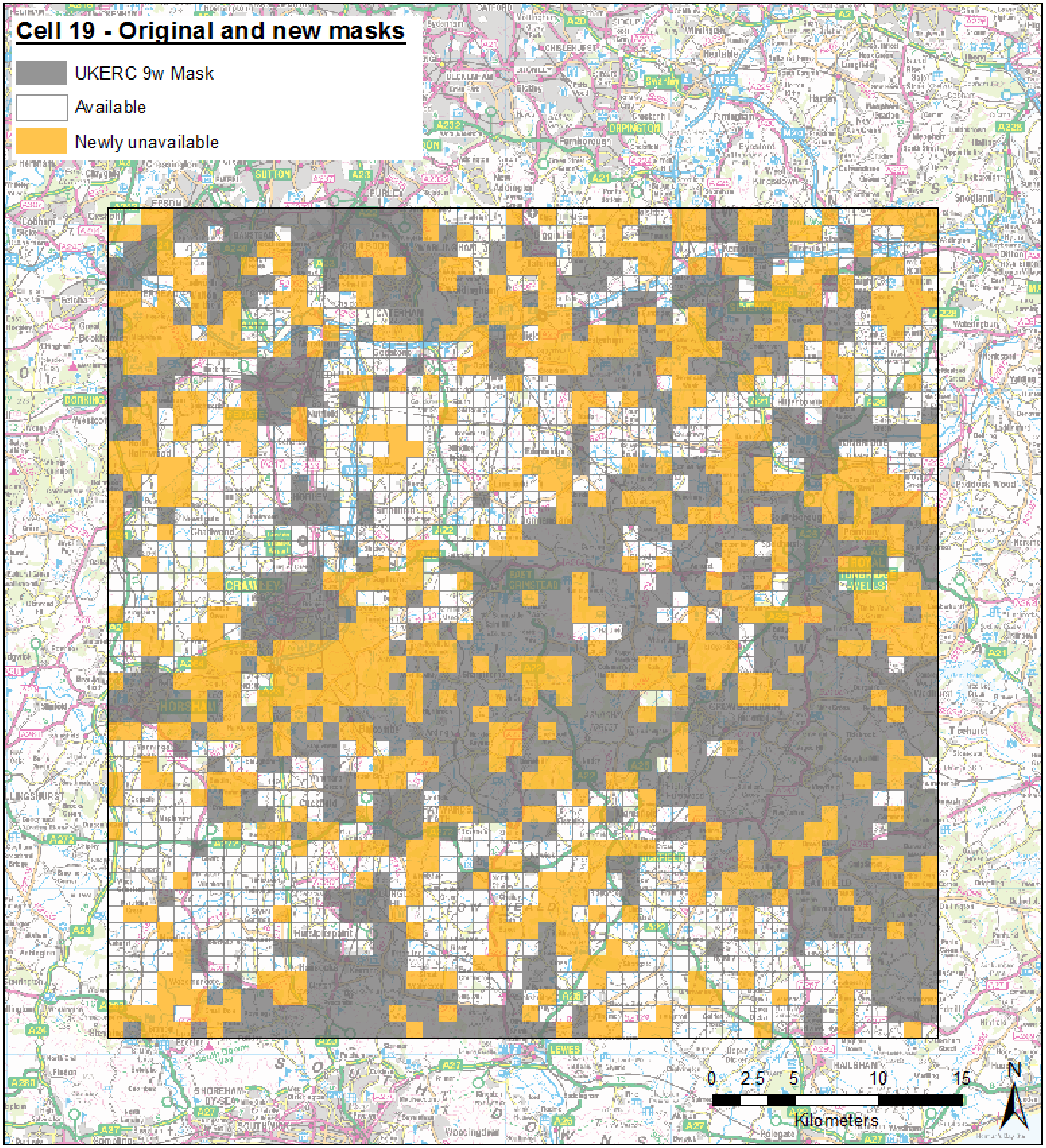
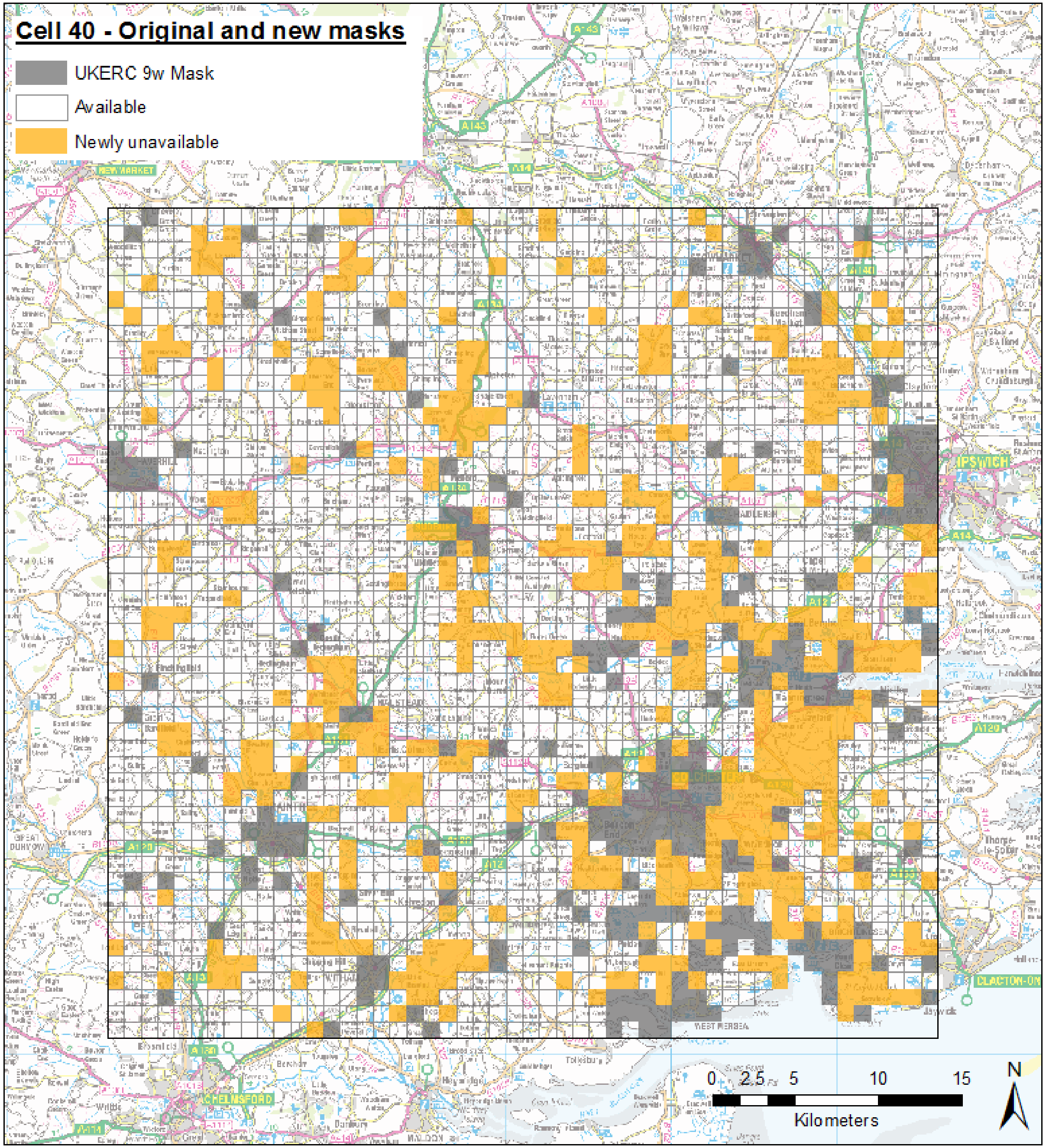


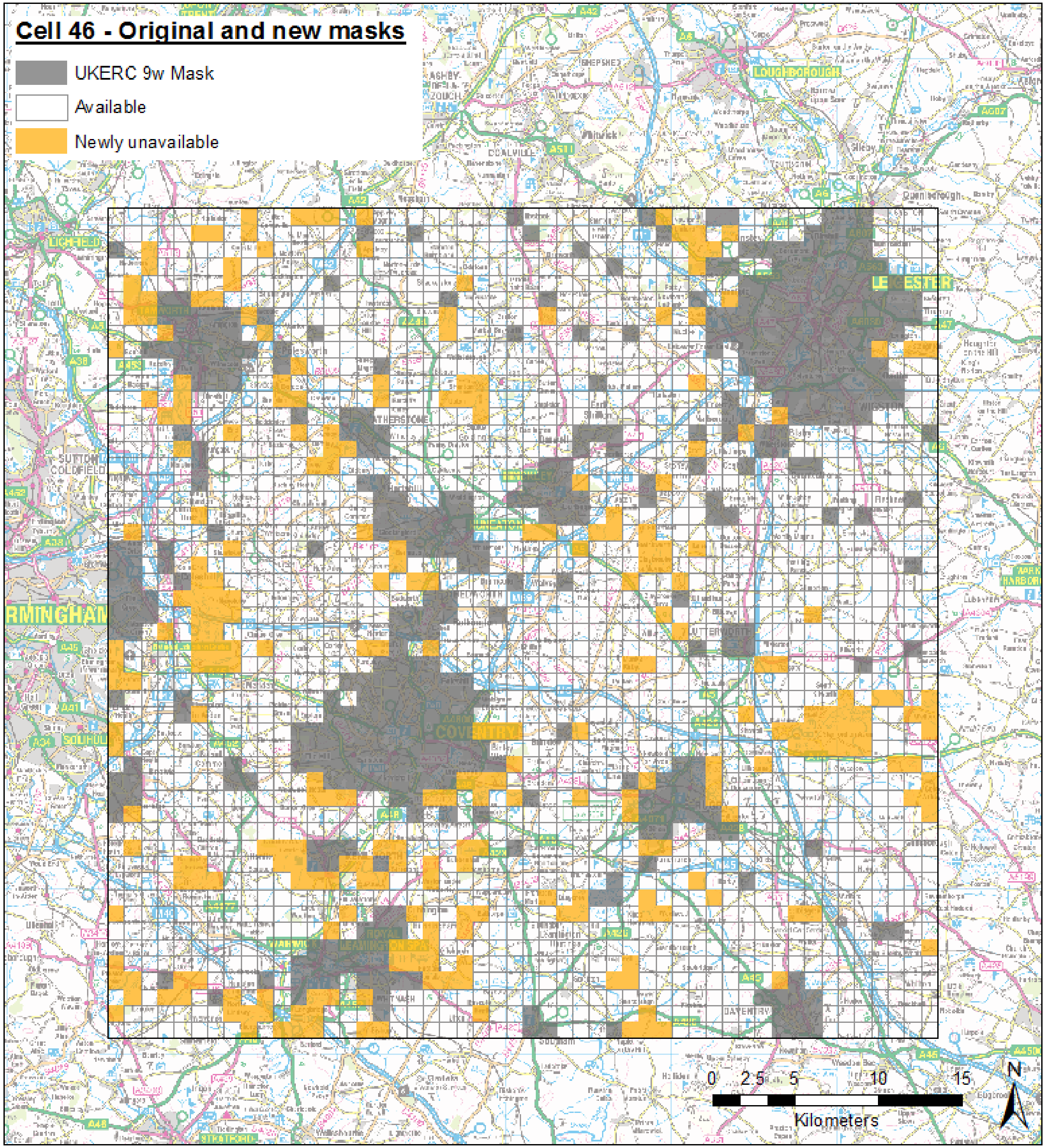
Based on provisional constraint mask

Number of 'available' sub-cells after applying new mask	869
Number of 'newly unavailable' sub-cells	696
Percentage decrease in available sub-cells from UKERC 9w	44%



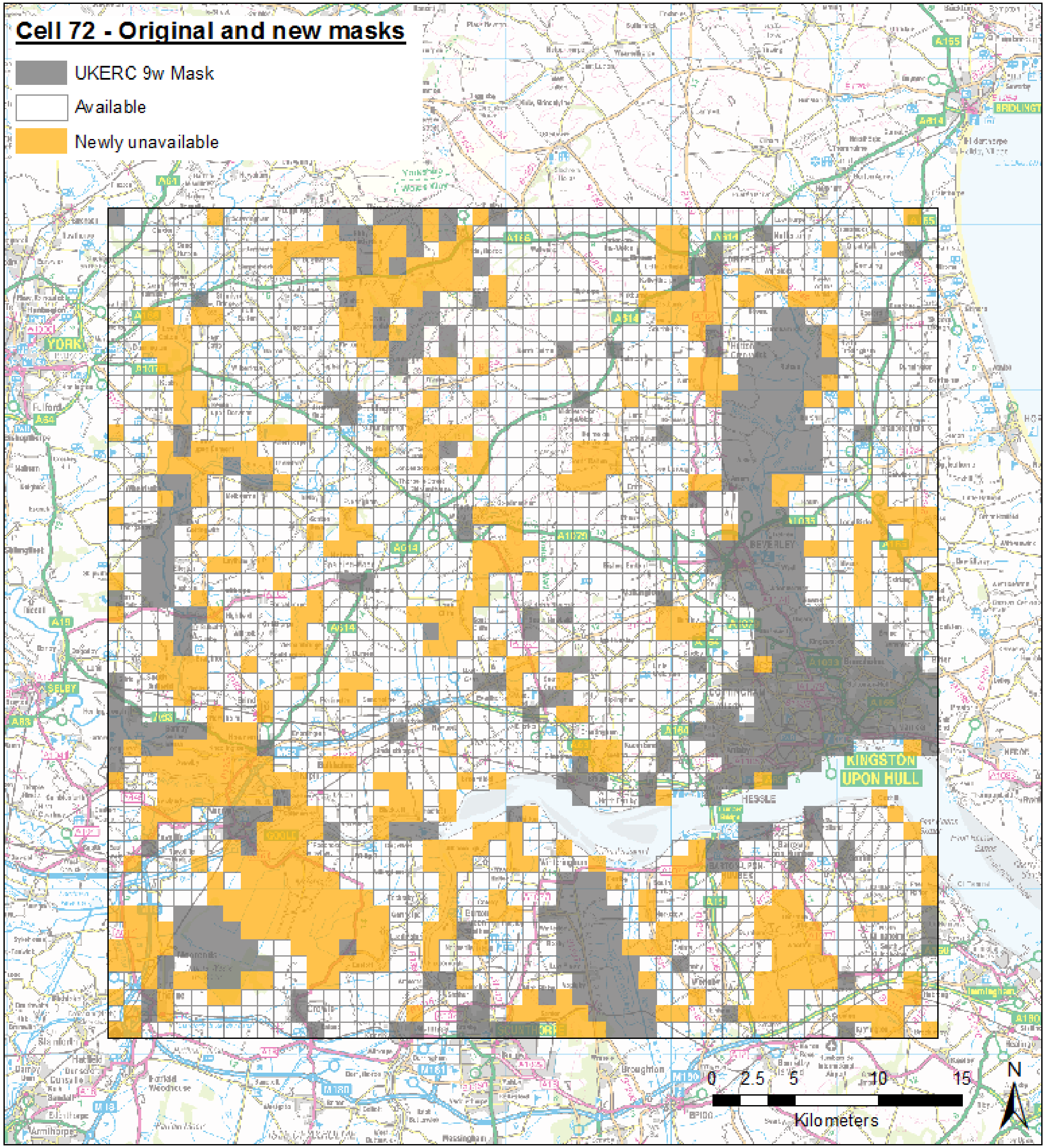
Based on provisional constraint mask

Number of 'available' sub-cells after applying new mask	1711
Number of 'newly unavailable' sub-cells	488
Percentage decrease in available sub-cells from UKERC 9w	22%



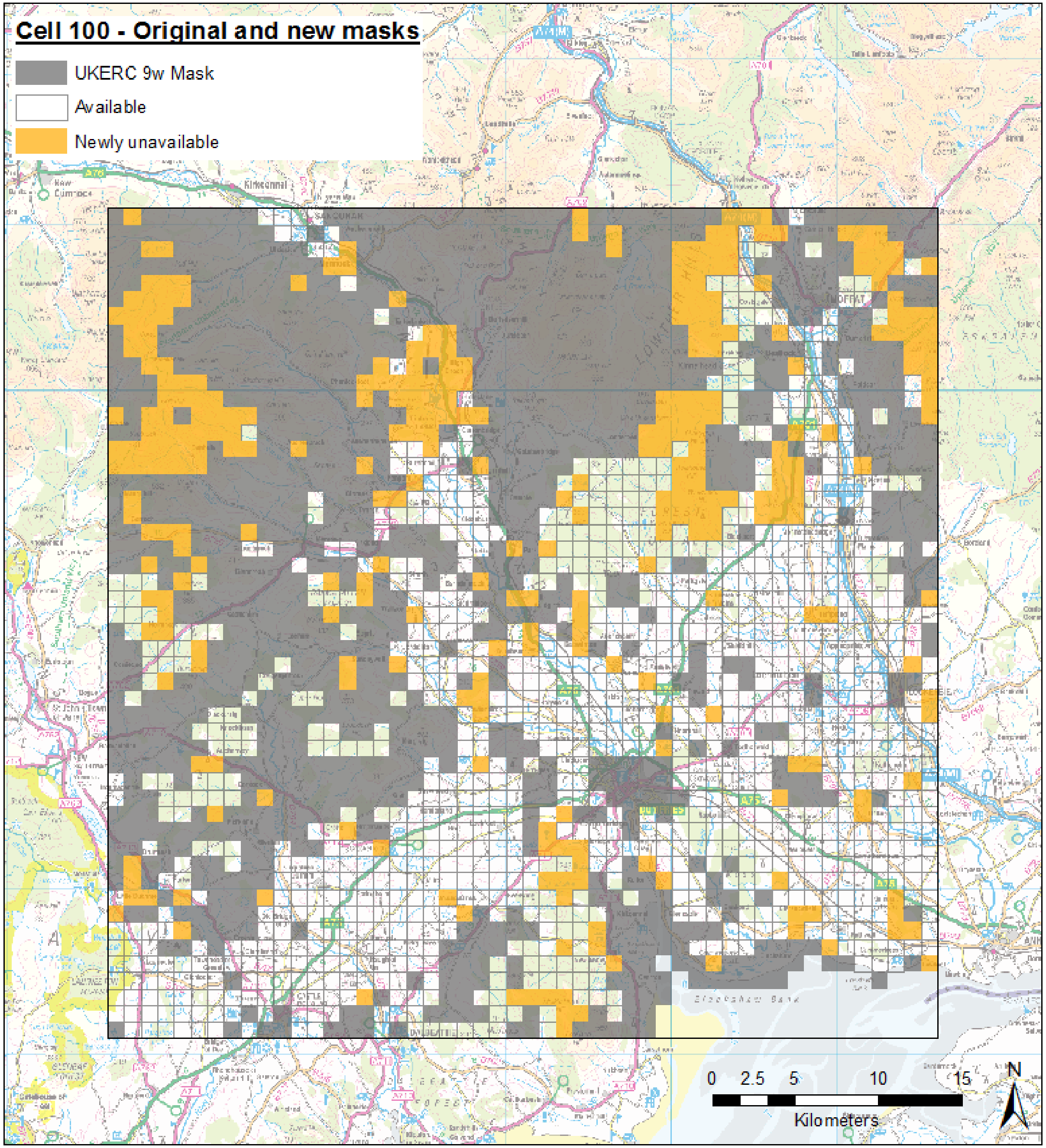
Based on provisional constraint mask

Number of 'available' sub-cells after applying new mask	1773
Number of 'newly unavailable' sub-cells	280
Percentage decrease in available sub-cells from UKERC 9w	14%



Based on provisional constraint mask

Number of 'available' sub-cells after applying new mask	1497
Number of 'newly unavailable' sub-cells	502
Percentage decrease in available sub-cells from UKERC 9w	25%



Based on provisional constraint mask

Number of 'available' sub-cells after applying new mask	1002
Number of 'newly unavailable' sub-cells	318
Percentage decrease in available sub-cells from UKERC 9w	24%

Comparison of provisional mask with field study results

Cell 19		Desk study		
		Unavailable	Available	Total
Field survey	Unavailable	48	37	85
	Available	32	89	121
	Total	80	126	206

Cell 46		Desk study		
		Unavailable	Available	Total
Field survey	Unavailable	8	15	23
	Available	13	166	179
	Total	21	181	202

Cell 100		Desk study		
		Unavailable	Available	Total
Field survey	Unavailable	7	22	29
	Available	39	134	173
	Total	46	156	202

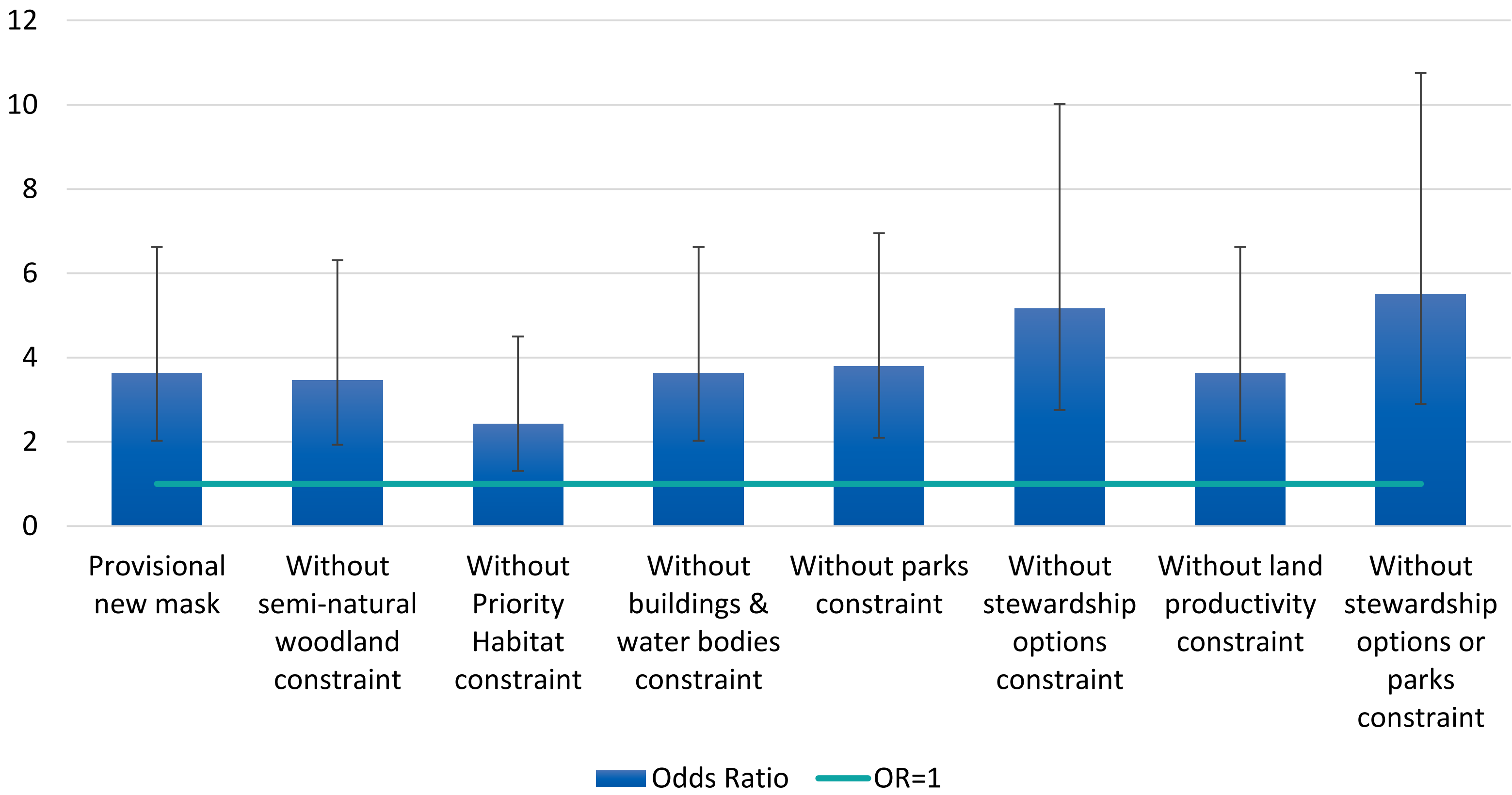
Reasons for discrepancies between desk and field study

Study Cell	Desk misclassifies as available	Survey misclassifies as available	Desk misclassifies as unavailable	Survey misclassifies as unavailable
19	Houses, gardens, golf courses, quarries, carparks not picked up Woodland not in ancient woodland or priority habitat inventories	Over-estimation of unavailable area by surveyors	UKERC-9w mask excluding land for unknown reason	Environmental stewardship option areas not identified Priority habitat / ancient woodland not identified
46	Houses, gardens, golf courses, quarries, motorways/main roads, carparks not picked up	Over-estimation of unavailable area by surveyors		Environmental stewardship option areas not identified ALC Grade 1 and Parks & Gardens areas not identified
100	Woodland not in ancient woodland inventory	Over-estimation of unavailable area by surveyors Slope assessed as too steep	UKERC-9w mask excluding land for unknown reason	Land not identified as over 300m elevation Ancient woodland not identified

Predictions using statistical models

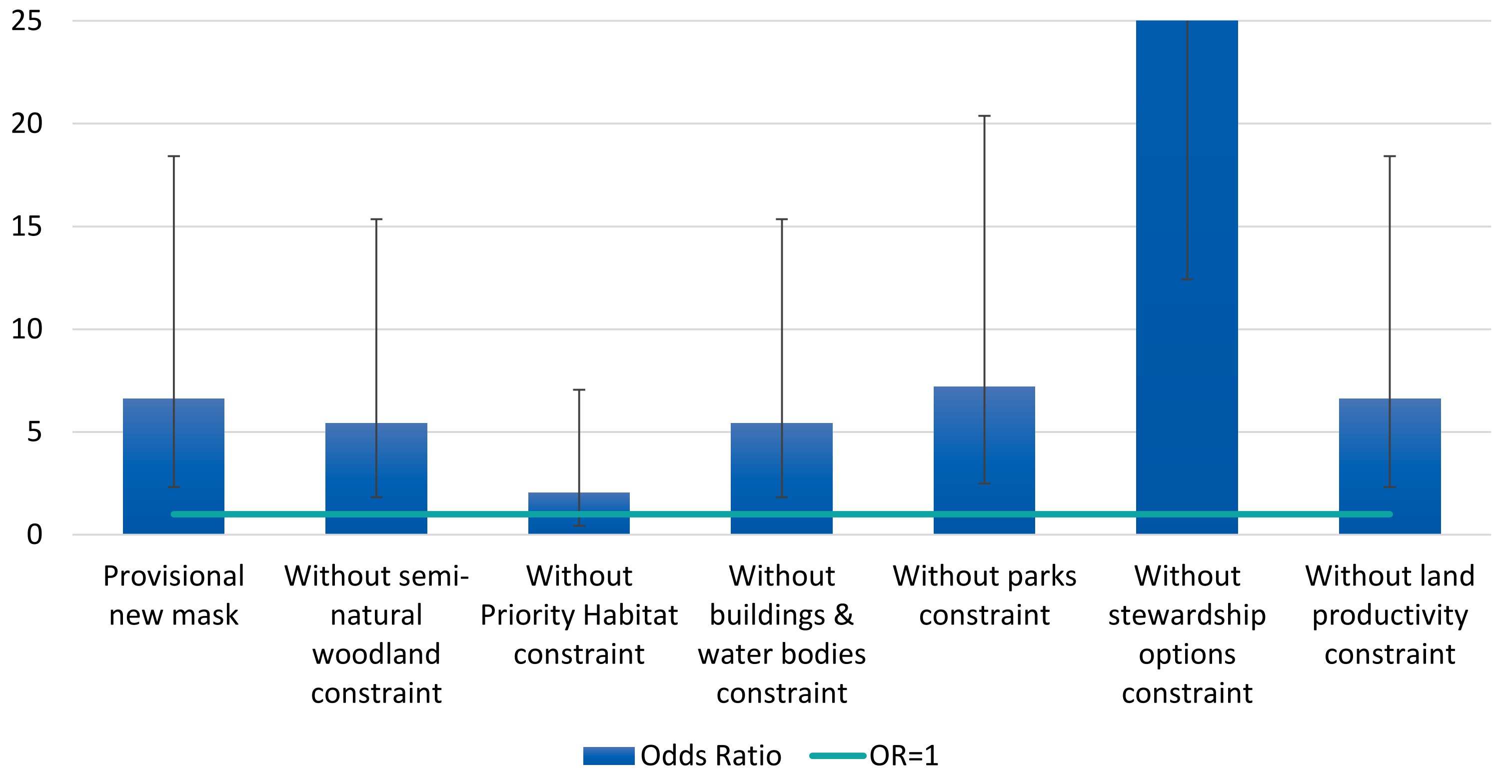
- To help identify relative importance of different constraint layers
- Logistic regression to predict sub-cell availability from field survey using constraint masks
- Removed each constraint in turn from full mask to quantify effect of each using odds ratio and significance value
- Odds ratio (OR) is product of matching classifications divided by product of mis-matching classifications
- A statistically significant OR >1 indicates more matches than would be expected by chance
- A statistically significant OR <1 indicates more mis-matches than would be expected by chance

Results of statistical analysis – cell 19



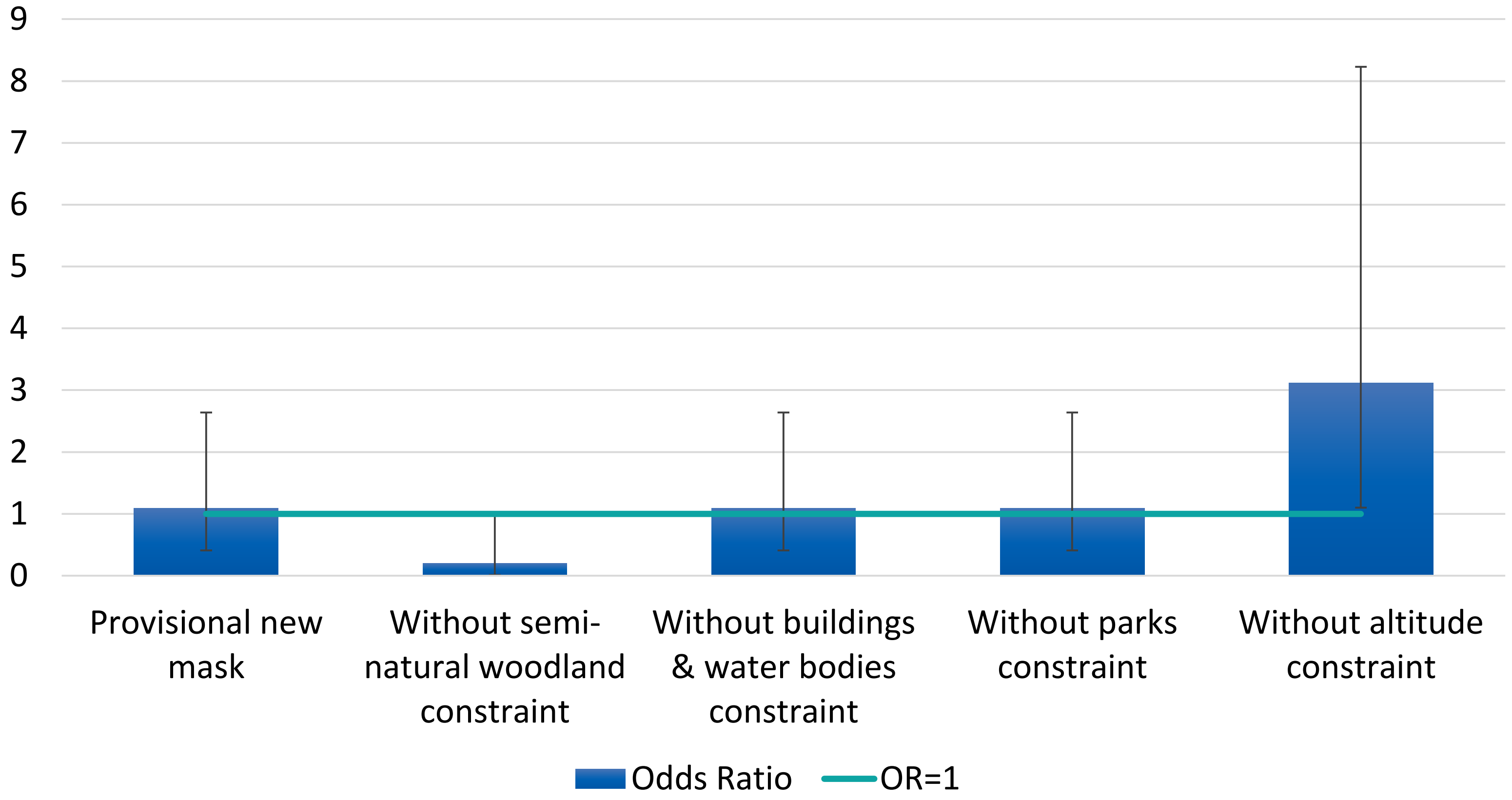
Error bars represent 2.5% - 97.5% confidence intervals around the odds ratio

Results of statistical analysis – cell 46



Error bars represent 2.5% - 97.5% confidence intervals around the odds ratio

Results of statistical analysis – cell 100



Error bars represent 2.5% - 97.5% confidence intervals around the odds ratio

Data layers for final mask

Layer	ECS	Strengths	Weaknesses	Inclusion in final mask?
Altitude	1	Good evidence base; sufficient accuracy	Could not be assessed in survey	Yes
Grade 1	28	Proxy for competition with food crops	Poor evidence base; could not be assessed in survey	Yes
Ordnance survey vector map	1	Excludes additional areas UKERC misses	Couldn't be assessed in cells 19 & 100	Yes
Priority habitats	75	Good evidence base; most important constraint	Some not identified by survey; not Scotland	Yes
Semi-natural wood	1	Good evidence base	Some not identified by survey	Yes
Parks	3	Designated landscape with special historic interest	Couldn't be assessed in cells 19 & 100; limited evidence base	Yes
Environmental stewardship	511	Reasonable evidence base	Could not be assessed in survey	No

ECS = Energy Crop Scheme plantings that fall within constraint layer

Data gaps

Feature not identified	Current limitations	Potential data sources	How would it be used
Gardens	OpenSource datasets only identify the extent of buildings, not gardens. Datasets identifying "Urban areas" miss smaller towns and villages.	MasterMap (Ordnance Survey) UKLand (The GeoInformation Group)	Attributes of the MasterMap dataset include descriptions on the land surface type. Dataset includes "Residential with amenities" as individual features.
Golf Courses	No datasets currently exist	UKLand	Dataset includes "Residential with amenities" as individual features.
Quarries		MasterMap BRITPITS (British Geological Survey) UKLand	Identify features of "Manmade Landforms". Use point data to identify quarry locations then digitize extents. Dataset includes "Mining and spoil areas" as individual features.
Roads (as polygons)	All current OpenSource datasets contain roads as polyline features	MasterMap Current OpenSource data UKLand	Identify features of "Road Or Track" or "Roadside" Use a generic buffer distance for a given road type to estimate the coverage of roads Dataset includes "Principle Transport Roads" as individual features.
Carparks (and other manmade surfaces)	OpenSource datasets do not currently identify carparks	MasterMap UKLand	Identify "Man made" land surfaces Dataset includes "Business parks" and "Retail parks" as individual features which seem to include the carparks.
Playing fields		Future greenspace map Scotland: Greenspace map UKLand	N/A Unknown Dataset includes areas of "Recreational land" as individual features.

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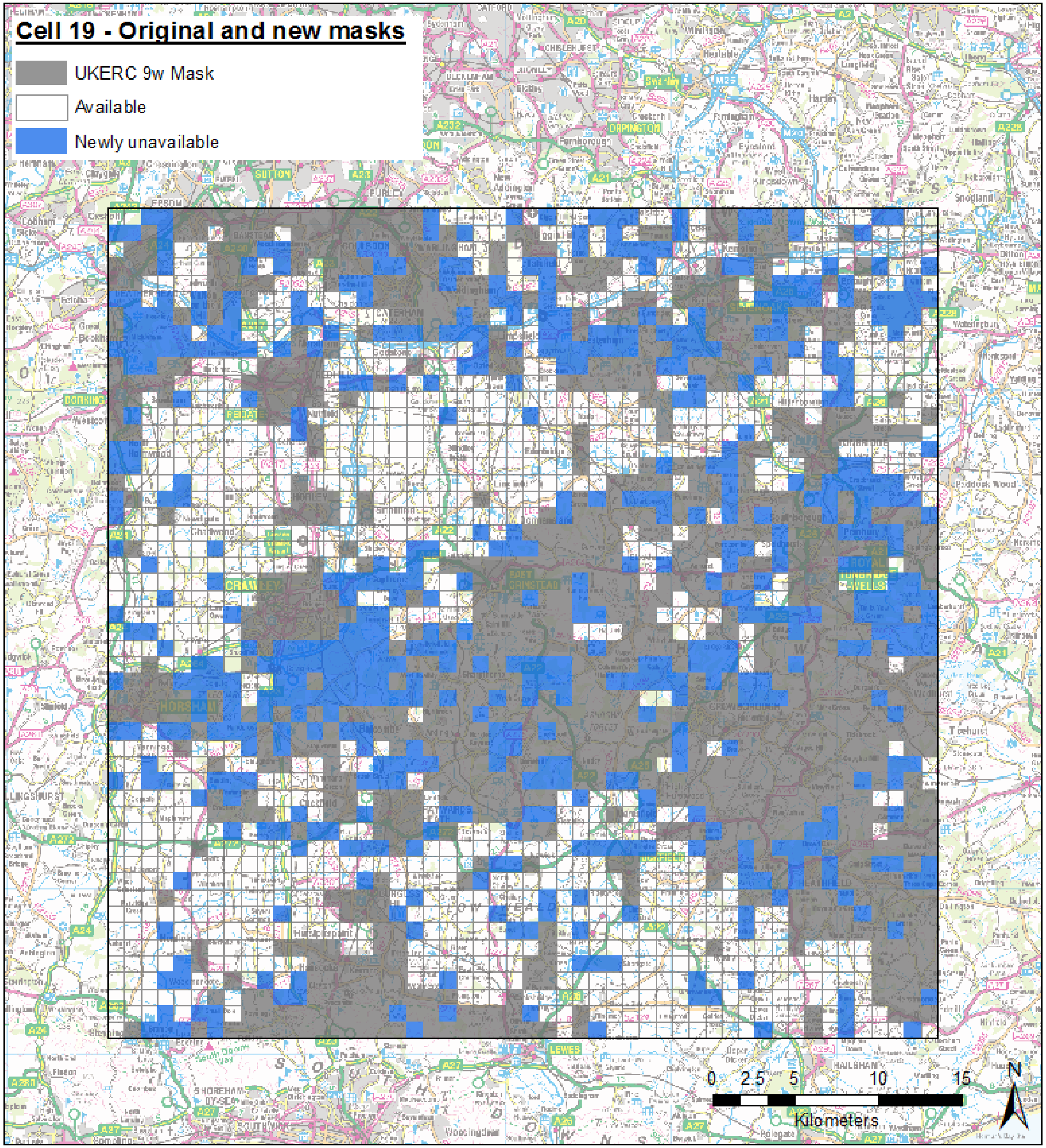
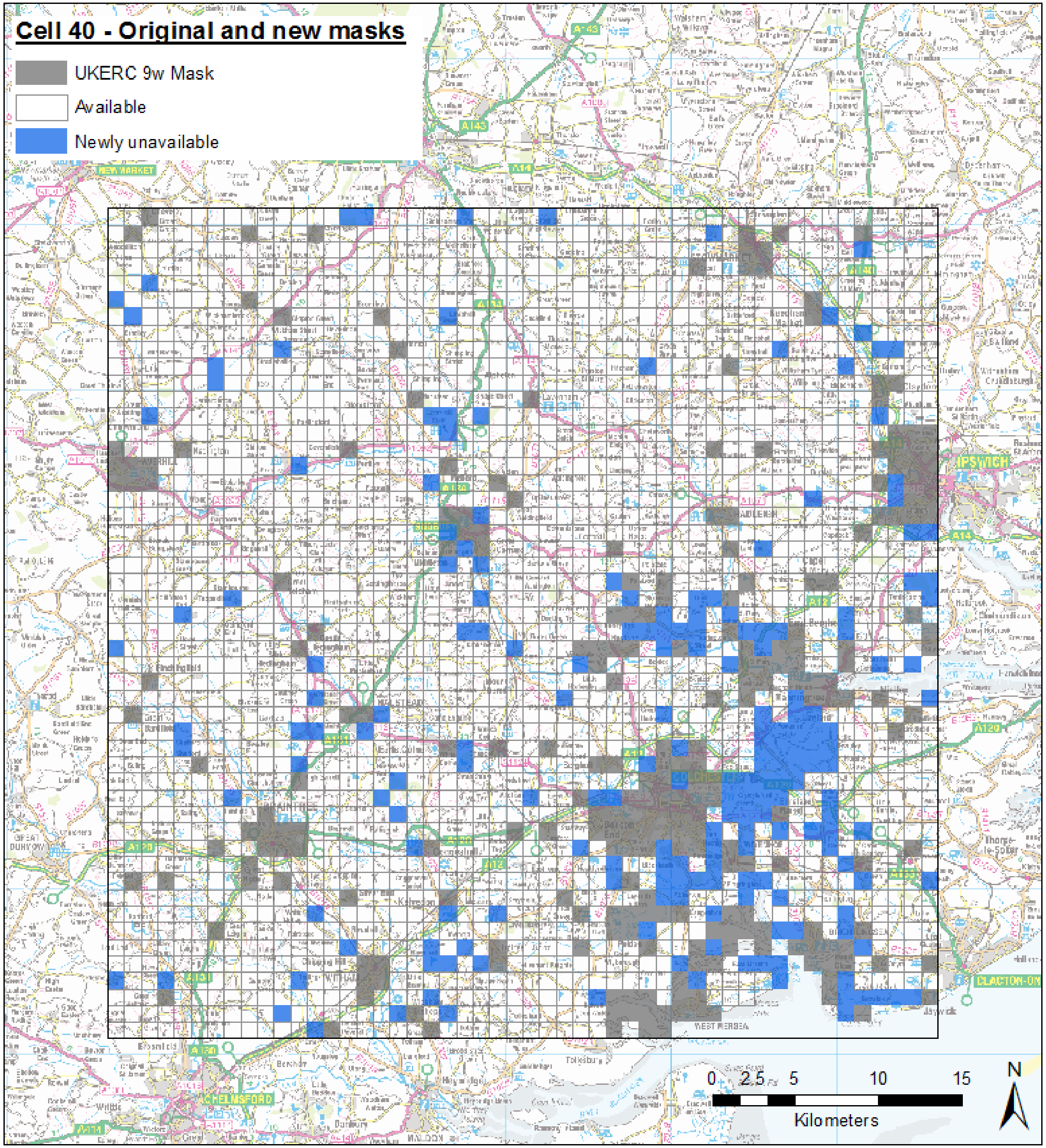


Based on final constraint mask

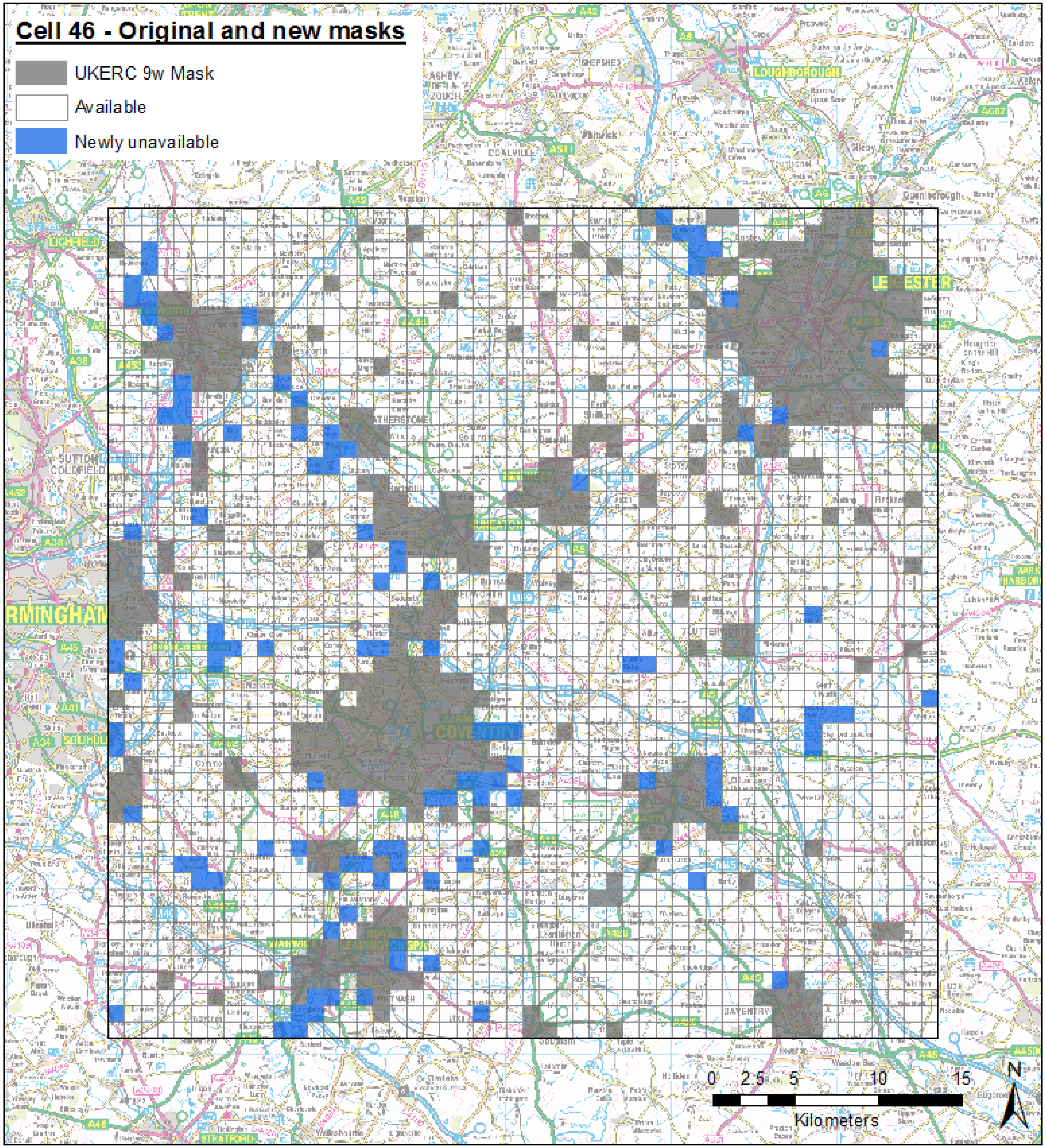
Number of 'available' sub-cells after applying new mask	725
Number of 'newly unavailable' sub-cells	552
Percentage decrease in available sub-cells from UKERC 9w	35%

Based on final constraint mask



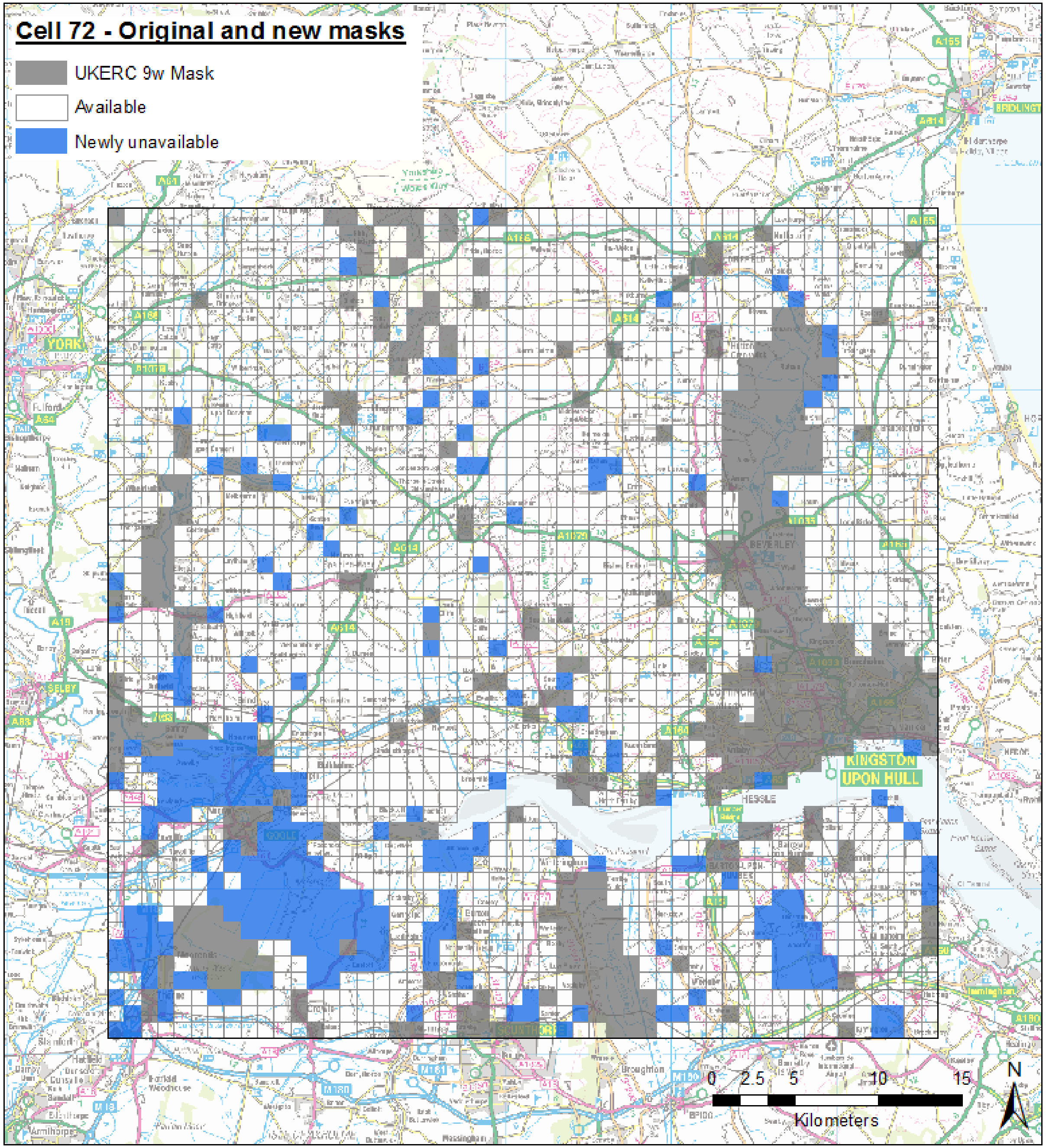
Number of ‘available’ sub-cells after applying new mask	1422
Number of ‘newly unavailable’ sub-cells	199
Percentage decrease in available sub-cells from UKERC 9w	9%

Based on final constraint mask



Number of ‘available’ sub-cells after applying new mask	1608
Number of ‘newly unavailable’ sub-cells	115
Percentage decrease in available sub-cells from UKERC 9w	6%

Based on final constraint mask



Number of 'available' sub-cells after applying new mask	1246
Number of 'newly unavailable' sub-cells	251
Percentage decrease in available sub-cells from UKERC-9w	13%

Comparison of final mask with field study results

Cell 19		Desk study		
		Unavailable	Available	Total
Field survey	Unavailable	43	42	85
	Available	20	101	121
	Total	63	143	206

Cell 46		Desk study		
		Unavailable	Available	Total
Field survey	Unavailable	7	16	23
	Available	1	178	179
	Total	8	194	202

Cell 100		Desk study		
		Unavailable	Available	Total
Field survey	Unavailable	7	22	29
	Available	39	134	173
	Total	46	156	202

Discussion

- Preliminary mask using constraint layers resulted in revised estimate of land availability in study cells of 6,862 km^2 c.f. 9,136 km^2 using UKERC-9w (25% reduction)
- Comparisons with field survey results showed that neither gave perfect representation of land availability, but gaps in desk study constraints highlighted
- Statistical analysis provided a method of ranking constraints by their importance – priority habitats and semi-natural woodland ranked highly
- All assessed constraints except stewardship options included in final mask, based on evidence from both comparisons and statistics
- Final mask resulted in estimate of land availability in study cells of 7,701 km^2 (16% reduction from UKERC-9w)
- Application of a correction factor to other UK cells not considered robust, however recipe for creation of UK constraint mask is provided

Advantages and limitations of approach

Advantages	Limitations
Built upon UKERC study to further refine estimates rather than replicating previous work	UKERC-9w mask not disaggregated and its components could therefore not be ground-truthed
Additional constraints identified based on scientific understanding rather than dataset availability	Gaps in datasets to represent constraints, particularly for Scotland
Field survey provided credibility to the method and enabled refinement of the final mask	There were some constraints that could not be identified by field survey as they were not visible on the ground
Statistical analysis provided a means of ranking constraints by their importance in determining availability	Field survey could not provide 'gold standard' against which to test validity of desk study datasets
Study covered areas of varying landscapes and thus enhanced our knowledge of spatial variability in constraints	Study would have benefited from a larger selection of cells on which to test constraint layers covering all typologies

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Recommendations

- Create a mask for England and Scotland using the constraint layers and methods described in the study and apply to all England and Scotland BVCM cells
- Identify equivalent datasets for Wales and N. Ireland to create mask for these countries
- Periodically review and update constraint layers that are subject to change or when new datasets become available that may better represent them
- Obtain sample of UK Land dataset and assess impact of excluding missed areas
- Consider applying percentage of agricultural land under agri-environment scheme agreement at any one time as a percentage reduction in land availability in BVCM
- Consider use of likelihood layers to target energy crop planting

Refining Estimates of Land for Biomass

Review of processes to convert land to energy crops

Kevin Lindegaard

Crops for Energy

RDI associates

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Review of processes to convert land to energy crops

- Review of steps and agencies involved in land conversion:
  - Land use change regulations
  - Current roles and responsibilities of different agencies
- Review of opportunities and barriers:
  - Information
  - Finance
  - Regulation/Policy
  - Markets
  - Practical considerations

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Land use change regulations

- Before a farmer plants energy crops they should:
  - Determine if an Environmental Impact Assessment (EIA) is required.
  - Consult the Local Authority (LA) and other affected stakeholders (such as utility companies).
  - Comply with other environmental legislation.
  - Comply with planning regulations (where necessary).

Impact of land-use change on farm revenue / Requirements of the energy crop end-user

- Growers also need to:
  - Understand the impact of changing land use in the context of Common Agricultural Policy.
  - Ensure the crop can meet the sustainability requirements of financial incentives for renewable energy:
    - Renewables Obligation
    - Renewable Heat Incentive
    - Contracts for Difference

Environmental Impact Assessment (EIA)

- Agriculture (Natural England)
  - Miscanthus
  - Other arable crops
- Forestry (Forestry Commission)
  - Short rotation coppice
  - Short rotation forestry
  - Afforestation

NATURAL ENGLAND

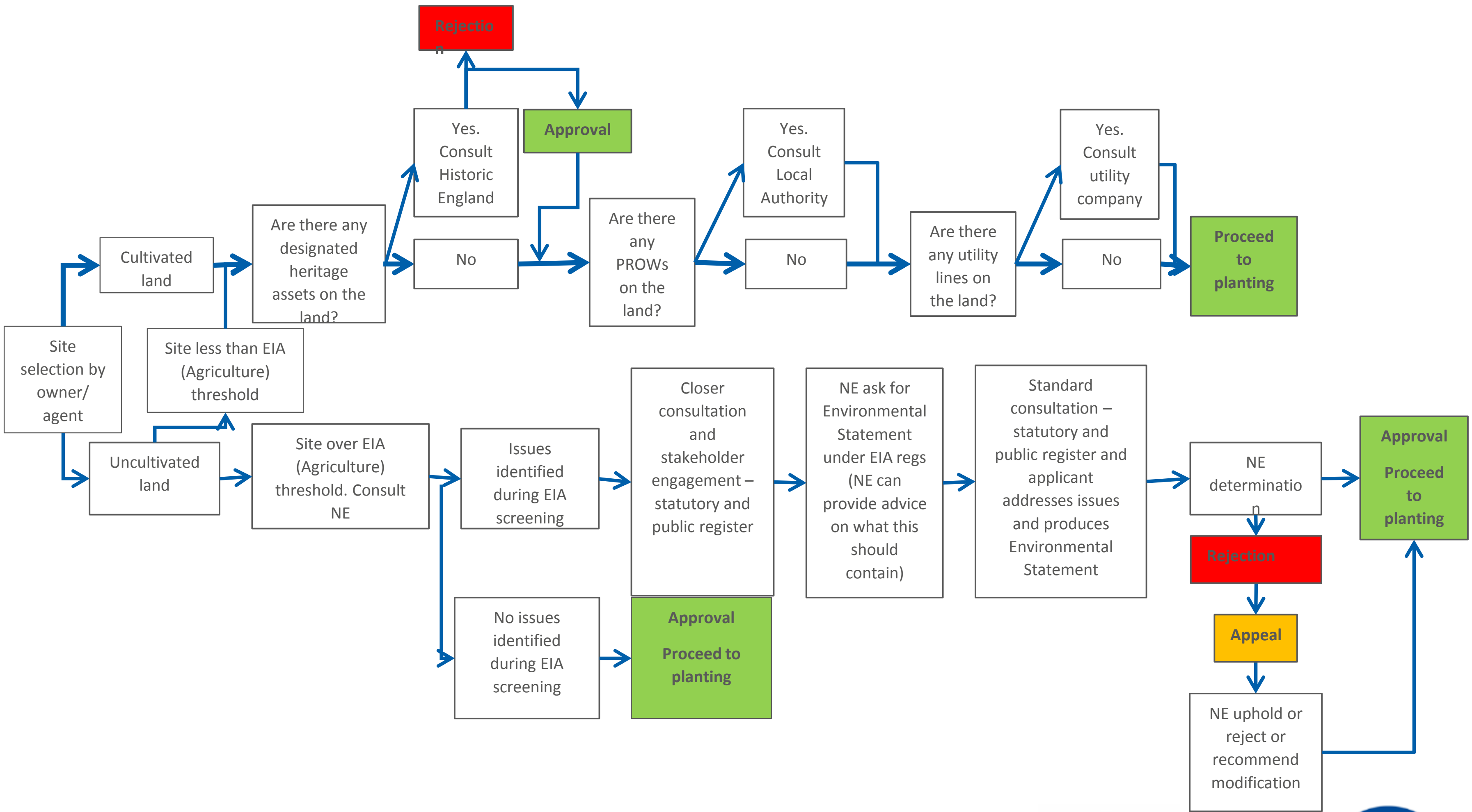
Forestry Commission

Environmental Impact Assessment (EIA)

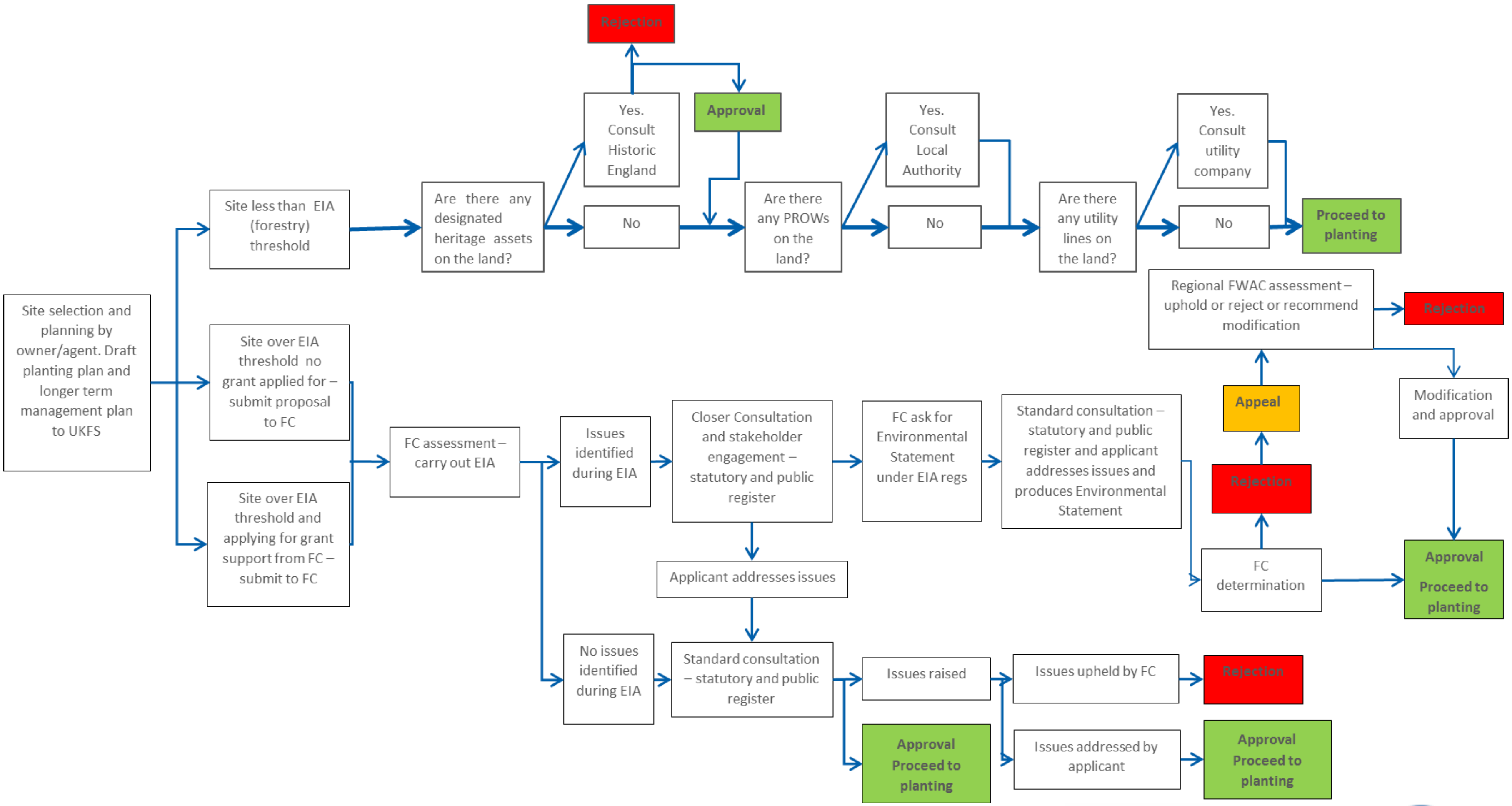
- There are EIA thresholds for different energy crops on various land types.
- If the project exceeds a threshold the grower needs to contact the relevant organisation to conduct an EIA screening.
- In most cases there will be no environmental issues identified and they will be able to proceed to planting.
- In some situations the EIA screening will flag environmental issues and this will require an Environmental Statement to be produced and the proposal to be shared with statutory consultees.
- After a set period the organisation leading the EIA will make a decision on the proposal.
- A rejected application can go through an appeals process.

	Project type	Threshold (where no part of the land is in a sensitive area)	Threshold (where project is wholly or partially within a sensitive area)	Consenting organisation (England)
EIA Agriculture	Planting Miscanthus or arable crops on uncultivated land* (semi natural land in Scotland)	2 ha	2 ha	Natural England
EIA Forestry	Afforestation: any tree planting including SRC and SRF on all land types	5 ha	2 ha (National Park, AONB) No threshold for all other sensitive areas such as SSSIs	Forestry Commission

Steps to consider prior to planting Miscanthus



Steps to consider prior to planting SRF



Planning permission

- Farmers do not need planning permission to change the type of crops they grow on existing agricultural land.
- Planning permission is required if they want to plant crops where there is a historic monument on the intended planting site.
- If the switch to bioenergy production requires the construction of extra farm buildings for storage, planning permission may be required for these developments, depending on size.

Organisations/individuals that should be consulted

- Growers should consult with:
  - Local authorities (if the energy crop may impact on a Public Right of Way or non-designated heritage asset).
  - Historic England (if the energy crop may impact on a designated heritage asset).
  - Utility company (if the energy crop may impact on utility lines).
  - Neighbours (if the energy crop may impact on views).

Sustainability requirements for biomass energy projects

- UK Government backed renewable energy schemes such RHI and RO require biomass fuels to be obtained from sustainable sources.
- End users need to be able to demonstrate that their biomass fuel source:
  - Meets lifecycle greenhouse gas (GHG) emissions target of 60% savings against the EU fossil fuel average.
  - Satisfies land criteria (adheres to rules on the type of land on which the biomass was produced).
- Compliance can be achieved by:
  - Sourcing fuel from an Approved Supplier List (relevant to the RHI).
    - Biomass Suppliers List BSL (woody crops).
    - Waste, Residues, Energy Crops Sustainability List WRECSL (non-woody crops from Feb 2016).
  - Self reporting (more typical of power projects under RO).
    - Monthly or annual reporting (projects >50kWe).
  - Independent sustainability audit (projects ≥1MWe).

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Sustainability requirements for biomass energy projects

- Land criteria is met by:
  - Energy crops which have been assessed as meeting the requirements of the Energy Crops Scheme
  - Evidence showing that the land planted was farmland in 2008
  - Timber Standard for Heat and Electricity

Common Agricultural Policy (CAP)

- Energy crops are permanent crops
- Growers of energy crops needs to adhere to cross compliance rules in order to ensure they are paid the Basic Payment
    - Good Agricultural Environment Conditions (GAEC)
    - Statutory Management Requirements (SMRs)
- Greening measures
    - Miscanthus, SRC or SRF are not on the list of eligible diversification crops for arable land
    - SRC has been included as an Ecological Focus Area (EFA) measure in Wales and Northern Ireland

Current roles and responsibilities of different agencies

- There is no one UK organisation that oversees all aspects of energy crops.
- There are a number of organisations and agencies which have responsibilities for certain parts of the land conversion process.
- The picture is further complicated by the fact that agriculture and forestry are devolved matters so different organisations deal with these activities in different countries within the UK.

Current roles and responsibilities of different agencies

Agency (England)	Involvement in energy crops/tree planting	Responsibilities
Natural England	Energy Crops Scheme; Countryside Stewardship scheme; Catchment Sensitive Farming	Managing claim forms and ongoing agreements under ECS2 until 2021 Statutory body dealing with EIA (Agriculture)
Forestry Commission	Woodland Grant Schemes	Statutory body dealing with EIA (Forestry); Felling licenses
Environment Agency	Energy crops and flooding; Discharge of wastewater; nitrate vulnerable zones	Statutory consultee for discharge of wastewater and treated effluent through bio-filtration systems
Historic England	Protecting designated heritage assets	Statutory consultee for growers wishing to plant on sites with scheduled monuments etc.
Local authorities	Protecting non-designated heritage assets; Maintaining public rights of way (PROWs)	Statutory consultee for growers wishing to plant on sites with non-designated heritage assets and PROWs
DEFRA	Energy Crops Scheme, CAP reform, Rural Development, Funds; Air quality	Agriculture policy; Rural development policy; define the agricultural and environmental research agenda; apply air quality standards and emissions levels from biomass boilers
DECC	Renewable energy incentives (ROCs, CFD, RHI)	Energy policy; define the energy research agenda; in charge of sustainability lists
Ofgem	RO, Domestic and non-domestic RHI	Delivery of Government renewable schemes; Develop guidance notes on sustainability compliance, host carbon calculators

Review of opportunities and barriers

- Information
- Finance
- Regulation/Policy
- Markets
- Practical considerations

Information

Woodland and forestry sector is better served than energy crops sector.

- Official growers guidelines and Internet
  - Much of the official information that is available (e.g. Government sponsored websites and guidance notes) are out of date and refer to schemes such as the ECS that have ceased.
- Open days, farm walks and shows
  - Tend to be industry led and crop specific.
- Training courses
  - Very little training provision for energy crops.
- Trade press
  - A few very active companies means the sector gets more coverage than the small size of the industry would normally justify.
- Membership organisations
  - Energy crops are typically not the key focus of membership groups that growers could belong to (e.g. National Farmers' Union, Country Land & Business Association, Wood Heat Association).
- Consultancy services
  - There is a lack of depth of independent consultancy for making an informed choice on the right crop for a growers land, facilities and local market.

Finance

- Establishment costs
  - High initial outlay/no establishment grants for energy crops. Certain types of SRF planting can, theoretically, be funded under Countryside Stewardship scheme.
- Contracting arrangements
  - Growers can choose from a range of options from “hand’s off” to “hands on”.
  - Energy crops are often perceived as being very risky investments.
- Tax Law
  - Energy crops are dealt with differently to woodland and forestry.
  - Profits from woodland are exempt from tax whilst profits from energy crop sales are subject to income tax and corporation tax.
- Funding opportunities
  - There are a range of potential funding opportunities that farmers can access in order to make the planting of woodland more attractive. These include grants for the establishment of the plantation and annual payments for the benefits the trees provide to the local environment. There is less provision for energy crops.

Crops for Energy RDI associates ADAS

Regulation/Policy

- Common Agricultural Policy (CAP)
  - There are no measures in the CAP that are likely to significantly expand the energy crop area.
  - SRC as an EFA measure only adopted in Wales and N. Ireland which have limited arable area. Low weighting (0.3) requires as much as five times the amount of land to be taken up compared to other measures.
- Renewable Heat Incentive (RHI)
  - Many existing energy crop growers and farm woodland owners have become woodfuel self suppliers – big opportunity to reduce fuel price.
  - The introduction of an emissions threshold on 24 September 2013 has proven to be a barrier to Miscanthus consumption (there is no accepted standard for miscanthus, therefore very few boilers have been tested).
  - The BSL does not cover non-woody fuels like miscanthus and straw. Users of these fuels have been forced to self-report. Many have used consultants to do this for them but this has a significant cost compared to the free BSL service. The WRECSL service will help but users and traders will have to pay an annual subscription.
- Environmental Impact Assessment (EIA)
  - The requirement for an EIA prior to the planting of an energy crop is not widely known about, nor publicised. EIAs are only required in a minority of circumstances.
  - The impact on the farmer is that in the worst case they might be fined up to £5000, asked for their crop to be removed and also see their Basic Payment (BP) affected.

Regulation/Policy

- Multiple uses
  - The multifunctional potential of energy crops is currently being under exploited.
  - There is greater opportunity to access funding for woodland crops that have dual purpose uses (e.g. flood mitigation, water quality improvement, carbon abatement).
  - SRC willows produce profuse amounts of nectar and pollen in the early months of the year. This could play a major role in helping rebuild the populations of bees and other pollinators.
- Plant protection product legislation
  - There have been recent changes to the plant protection product approvals legislation with the introduction of the Sustainable Use Directive and European Union Plant Protection Products (PPP) Regulation - 1107/2009. This has resulted in a number of older plant protection products losing their registration, including a number that were previously approved for use on energy crops.
  - There has also been a lack of funding for research and development into identifying suitable herbicides for use in energy crops.

Markets

- Large scale markets
  - There are only a limited number of large scale outlets for Miscanthus, SRC and SRF in the UK, and due to cost of transport and the bulky nature of the raw materials these tend to have a regional focus, with suppliers tending to have to be from within a certain distance of the plant to make production cost effective.
  - Supply to these large scale outlets is dependent upon a crop meeting certain specifications.
- Small and medium scale heating boilers
  - Supplying fuel for small and medium scale heating boilers presents a real opportunity for energy crop growers. If supplied to local end users (thereby minimising transport costs) then energy crop fuels would be highly competitive compared to other woodfuels, and fossil fuels such as heating oil.
  - However, there are a number of barriers (e.g. lack of infrastructure to develop supply chains) and challenges (e.g. fuel quality) that need to be overcome to enable more rapid expansion of this sector.

Practical considerations

- Time of planting and harvesting
  - Optimum times for energy crop planting and harvesting are often missed because of weather conditions and wet soils or because of limited contracting availability.
  - Later planting can lead to higher costs and lower survival rates/reduced yields and later harvesting can lead to lower fuel quality.
- Storage constraints
  - Energy crops tend to be very bulky fuels taking up a large space for many months.
- Machinery requirements
  - Both Miscanthus and SRC require bespoke planting and harvesting machinery. The machinery required for Miscanthus tends to be cheaper to produce and more widely available than that used for SRC. There is insufficient grant provision to reduce this issue.
  - For SRF there is a well-established contracting base throughout the UK with a range of machinery capable of harvesting and extracting timber from plantations on a range of sites with different constraints.
- Black-grass control
  - Planting Miscanthus (or SRC) could be an option for arable growers who have a pervasive issue with black-grass (*Alopecurus myosuroides*) in their arable fields.

Opportunities to overcome barriers

- A number of opportunities for progress have been considered. The most promising idea would be to deliver funding and support through Local Enterprise Partnerships.
- A wider range of benefits from energy crops and woodland would be considered including flood mitigation, water quality, and pollination. The cost would still be reasonable whilst simultaneously saving money on local heating bills and creating job opportunities, but a full review of this proposal and pilot studies are recommended.
- Other potential opportunities include:
    - Greater incentive for SRC in CAP greening
    - Setting up a levy body
    - Developing a Miscanthus standard
    - More research on herbicides
    - Land reversion grants for new growers
    - Updating official guidance
    - Targeting woodland creation more effectively.

Refining Estimates of Land for Biomass

Overall conclusions

Sarah Wynn & All

Existing estimates

- Estimates of UK land area available for energy crops from these studies ranged between 7 kha and 1,723 kha in the near-term (up to ~2020).
  - The bottom of this range represents a historical figure for the area of energy crops planted, which contrasts with the 10.3 kha known to be planted today from Defra (2014) statistics. The top end of this range corresponds to a demand led scenario in which the entirety of UK's 2020 bioenergy target under the EU Renewable Energy Directive is met from domestic production.
- UK studies also give a range of 99 – 9,086 kha available for energy crops as a long-term potential, and areas of 0 – 4,131 kha available for SRF planting in the long-term.

Refined estimates

- Across the five cells included in the study, the estimated available land was 9,136 km^2 (74% of total cell area) with the UKERC 9w mask, which was reduced to 7,701 km^2 (62%) with the final desk study mask.
- Additional datasets used to create the final mask included:
  - Elevation – provided by an accurate dataset with a threshold supported by scientific studies
  - Agricultural Land Productivity – a strong driver for limiting the planting of bioenergy crops, however it does not represent a hard constraint, and requires an update
  - Buildings and Water bodies – provided by an accurate and up-to-date dataset, however was not able to provide all of the desired information (e.g. coverage of gardens or carparks)
  - BAP Priority habitats – designed for the purpose of representing prioritised land at a sufficient scale
  - Semi-natural woodland – extent determined by Ancient Woodland Inventory plus a Semi-Natural Woodland Inventory in Scotland. The Ancient Woodland dataset does not identify all semi-natural woodland for England.
  - Parks and gardens – provided by an accurate dataset representing land unlikely to be used for planting

Alignment with field survey

- The final mask had a 77% match with the field survey, where only sub-cells that were classed as available using the UKERC 9w mask were surveyed.
- The field survey was able to help highlight constrained areas not identified in the desk study. These included;
  - private gardens,
  - golf courses,
  - quarries and
  - carparks.
- Conversely, there were masked areas identified by the desk study which could not be identified by the field study. These included;
  - high grade land,
  - high altitude land and
  - certain land designations.
- Given that the field study could not provide a perfect estimation of land availability due to some constraints not being visible on the ground, and because UKERC 9w was not disaggregated, it was not possible to provide an accurate value for the level of uncertainty in the final estimates.

Scaling up to the UK

- Due to resource and time limitations, the field survey was only carried out in 10% of available sub-cells within three 50 km x 50 km cells.
- Furthermore, one of these cells was in Scotland and the other two in England. Due to the small sample size and the variability in landscape and dataset availability across the UK, the predictive capability of the final mask cannot be assessed for the whole range of landscapes and constraints that occur in the UK.
- We therefore conclude that a UK-wide correction factor cannot be applied.
- Creation of a mask using the recommended datasets at UK scale would enable a national estimate to be produced, although the associated level of uncertainty would not be known.
- The inclusion of a field survey in this study has been fundamental in providing both a means for testing the strength of the inclusion of each dataset, and also in the identification of ‘gaps’ in methodologies. It is therefore recommended that any further study include a field survey or ground-truthing method to test the legitimacy of using the recommended mask in other cells.

Implications for land availability modelling

- Ultimately, the area available for energy crops depends on how competing demands for land are prioritised now and in the future. Social, technological, economic, environmental and political factors affect this prioritisation. Set against the complexity of attempting to determine a normative “best use” of land, the questions that bioenergy crop assessments can effectively tackle are comparatively simplistic.
  - Demand led assessments only describe what might be needed, not how or where it can be achieved.
  - Land balance models are sensitive to simple parameters describing complex phenomenon such as future yield growth and dietary trends, and consequently they are best used for scenario analysis.
  - Agent based simulation and farmer survey methods are currently insufficiently mature to provide anything other than a crude indication of what might be achievable or plausible, given current expectations of decision makers’ behaviour.
- GIS models can provide detailed scenarios for land use, but the fact that there are some discrepancies between the results of the desk based study and the field survey should not be too surprising given the spatial heterogeneity of the UK agricultural landscape.
- Lovett used planting grant data from Natural England to show that only 83% of planted UK energy crops lie within areas modelled by the GIS masks as potentially suitable, underlining the importance of market factors and real world decision making, compared to just relying on GIS approaches.

Refining Estimates of Land for Biomass

Final Project Report v2.0

February 2016

Data sources and attributions used in GIS mapping

Data layer	Source of data	Download location	Licence	Attribution statement
Altitude	Terrain 50 (Ordnance Survey)	https://www.ordnancesurvey.co.uk/opendatadownload/products.html	http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/	Contains OS data © Crown copyright [and database right] (2015)
Agricultural land productivity	ALC (Natural England)	http://www.magic.gov.uk/	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/391764/OGL-NE-OS.pdf	© Natural England copyright. Contains Ordnance Survey data © Crown copyright and database right [2002]
Agricultural land productivity	LCA (James Hutton Institute)	http://www.macaulayscientific.com/gis2_dataset_5a.php	The James Hutton Institute Open Data Li	Land Capability for Agriculture copyright and database right The James Hutton Institute 2015. Used with the permission of the James Hutton Institute. All rights reserved. Any public sector information contained in these data is licensed under the Open Government Licence v.2.0.
Soil Parameters	European Topsoil Physical Properties	http://esdac.jrc.ec.europa.eu/content/topsoil-physical-properties-european-scale-using-lucas-topsoil	N/A	Ballabio C., Panagos P., Montanarella L. Mapping topsoil physical properties at European scale using the LUCAS database (2016) Geoderma, 261 , pp. 110-123.
Buildings and water bodies	VectorMap District (Ordnance Survey)	https://www.ordnancesurvey.co.uk/opendatadownload/products.html	http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/	Contains OS data © Crown copyright [and database right] (2015)
BAP Priority Habitats	Priority Habitat Inventory (Natural England)	http://www.gis.naturalengland.org.uk/pubs/gis/GIS_register.asp	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/391764/OGL-NE-OS.pdf	© Natural England copyright. Contains Ordnance Survey data © Crown copyright and database right [2015]

Data layer	Source of data	Download location	Licence	Attribution statement
Semi-natural woodland	Ancient woodland/ semi-natural woodland inventories (Natural England/ Scottish Natural Heritage)	http://www.magic.gov.uk/dataset_download_summary.htm	http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/	© Natural England copyright. Contains Ordnance Survey data © Crown copyright and database right [2015] Contains public sector information licensed under the Open Government Licence v3.0. Copyright Scottish Natural Heritage Contains Ordnance Survey data © Crown copyright and database right (2015)
Parks & gardens	Historic Parks & Gardens (English Heritage)	https://historicengland.org.uk/listing/the-list/data-downloads/	http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/	© English Heritage [2015]. Contains Ordnance Survey data © Crown copyright and database right [year] The English Heritage GIS Data contained in this material was obtained on [2015]. The most publicly available up to date English Heritage GIS Data can be obtained from http://www.english-heritage.org.uk.
Parks & gardens	Gardens & Designated Landscapes (Historic Environment Scotland)	http://portal.historic-scotland.gov.uk/spatialdownloads/gardens	http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/	Contains Historic Environment Scotland and Ordnance Survey data © Historic Environment Scotland - Scottish Charity No. SC045925 © Crown copyright and database right [2015].
Stewardship options	Environmental Stewardship and classic Countryside Stewardship options/areas	http://www.geostore.com/environment-agency/WebStore?xml=environment-agency/xml/ogcDataDownload.xml	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/391764/OGL-NE-OS.pdf	© Natural England copyright. Contains Ordnance Survey data © Crown copyright and database right [2015]

Data layer	Source of data	Download location	Licence	Attribution statement
Water stressed areas	Water Resource Availability and Abstraction Reliability (Environment Agency)	http://www.geostore.com/environment-agency/WebStore?xml=environment-agency/xml/ogcDataDownload.xml	http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/	Contains public sector information licensed under the Open Government Licence v3.0.
Flood Risk	Flood Risk Areas (Environment Agency)	http://www.geostore.com/environment-agency/WebStore?xml=environment-agency/xml/ogcDataDownload.xml	http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/	Contains public sector information licensed under the Open Government Licence v3.0.
Nitrate vulnerability	Nitrate Vulnerable Zones (Defra/ Scottish Government)	http://www.magic.gov.uk/Dataset_Download_Summary.htm https://data.gov.uk/dataset/nitrate-vulnerable-zones1	http://www.magic.gov.uk/Copyright_Information_Data_Download.htm http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/	Copyright Defra, contains Ordnance Survey data Copyright Scottish Government, contains Ordnance Survey data
Land tenancy	June Survey of Agriculture county level results (Defra/ Scottish Government)	https://www.gov.uk/government/statistical-data-sets/structure-of-the-agricultural-industry-in-england-and-the-uk-at-june	http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/	Contains public sector information licensed under the Open Government Licence v3.0.