The role of greenhouse gas removal in meeting the 1.5°C target

Gideon Henderson
University of Oxford

UNIVERSITY OF OXFORD

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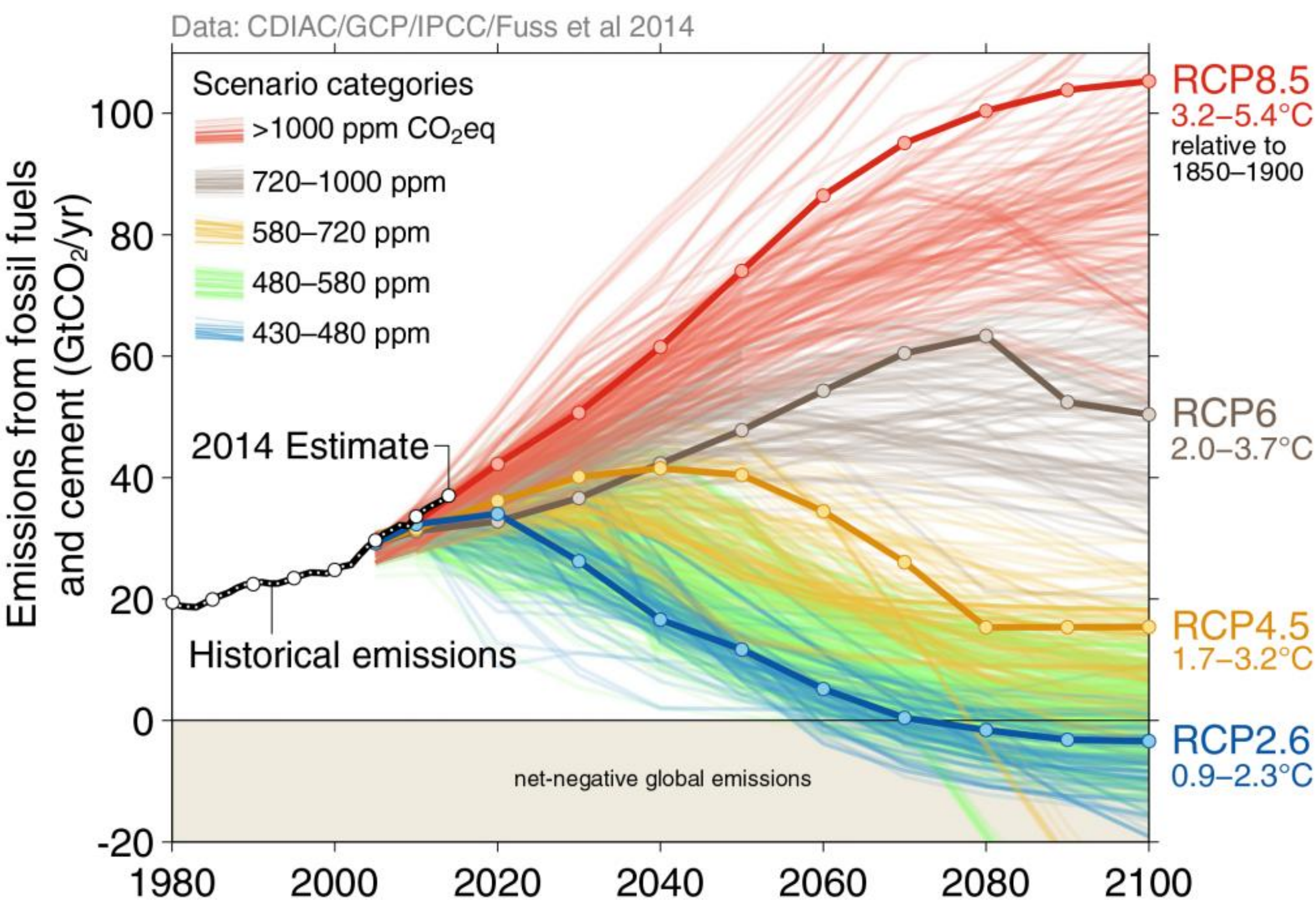
Integrated Assessment Models: Future emission scenarios



IPCC AR5 and at the time of Paris Agreement

87% of 2°C scenarios and 100% of 1.5°C scenarios use some greenhouse gas removal (GGR)

GGR also explicitly required for goal of meeting net-zero emissions

GtCO$_2$ per year levels of GGR required by 2030s

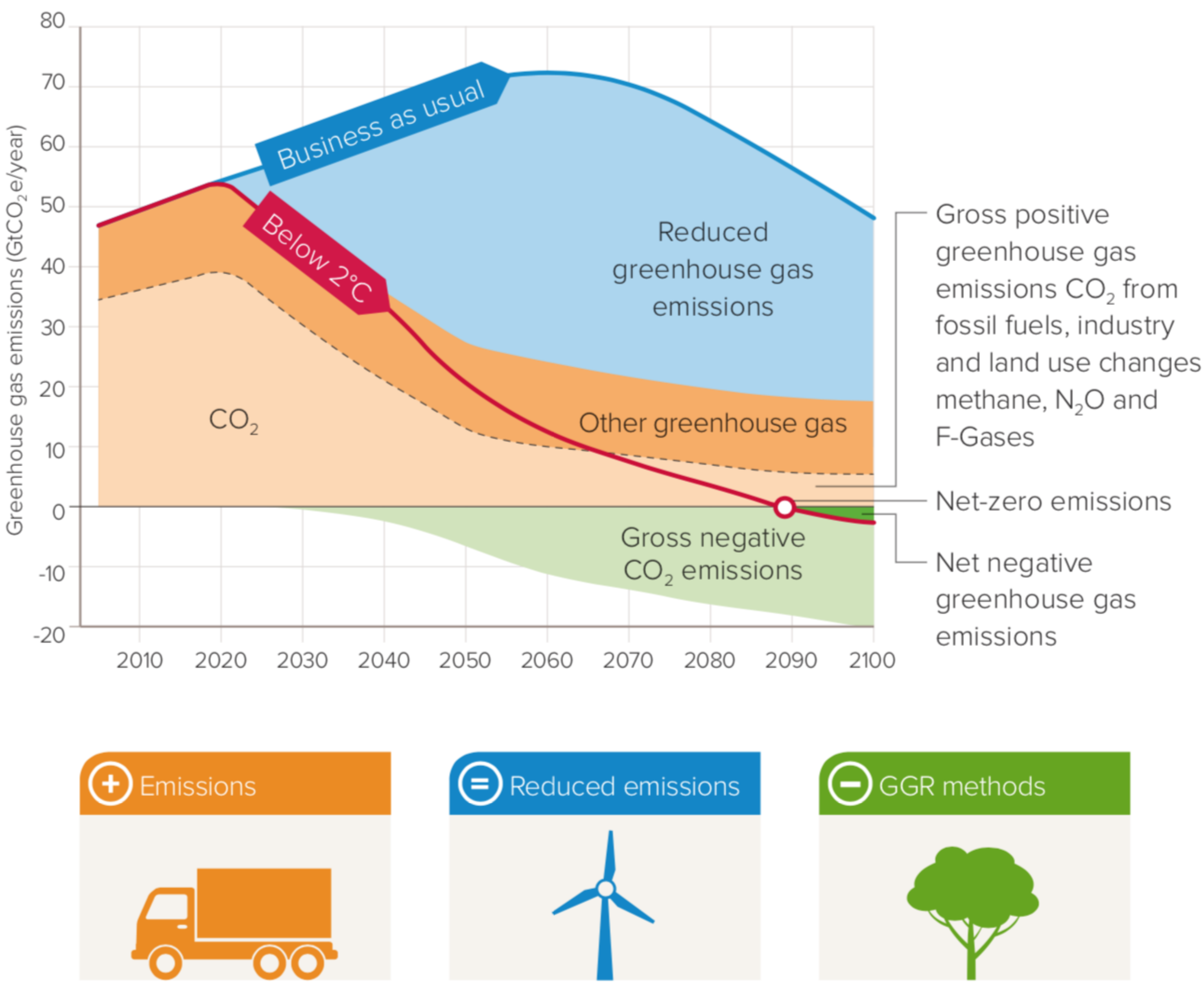
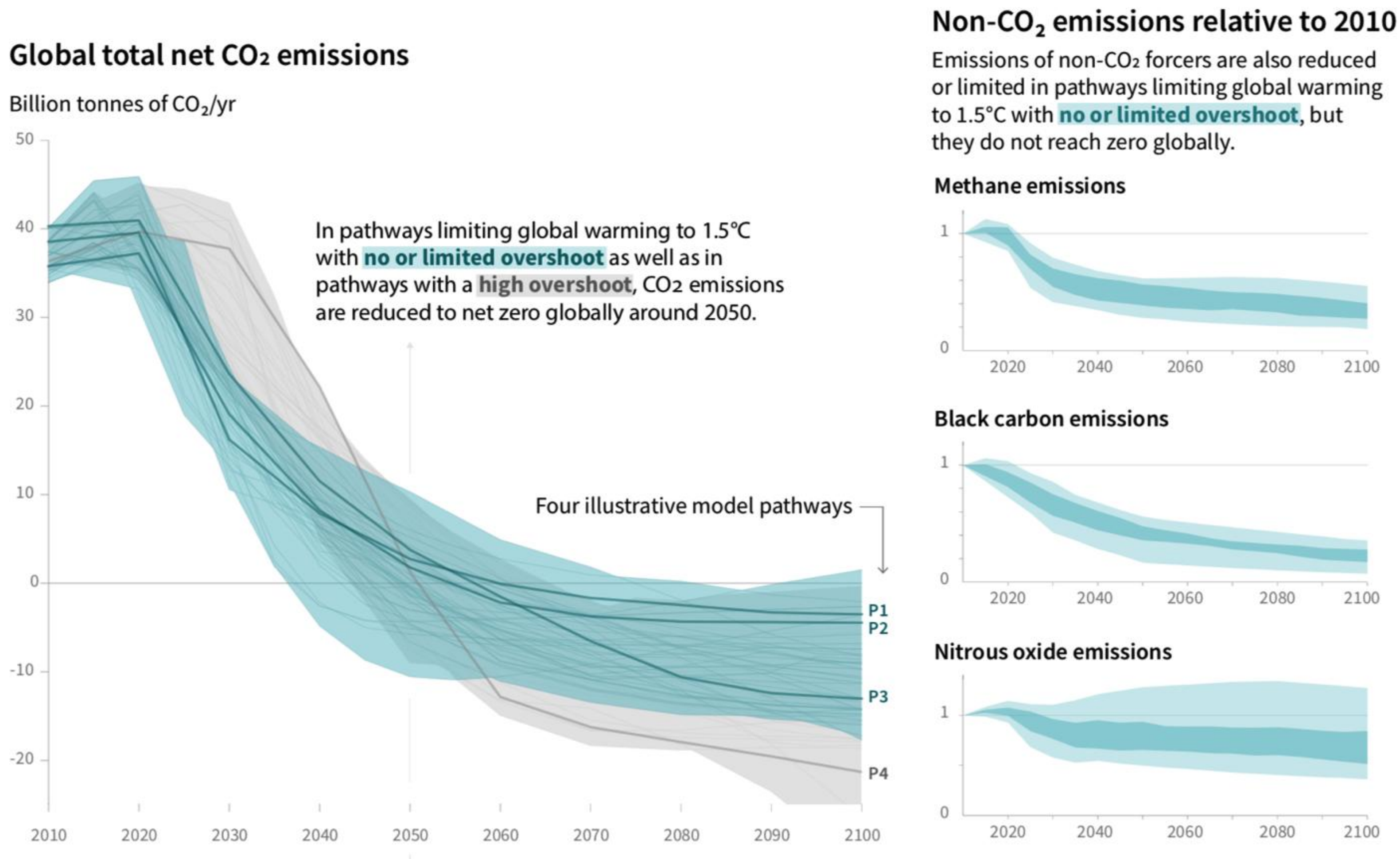


Figure from RS/RAEng GGR report, 2018

Emissions Scenarios in IPCC 1.5°C Report



From Summary for Policy Makers:

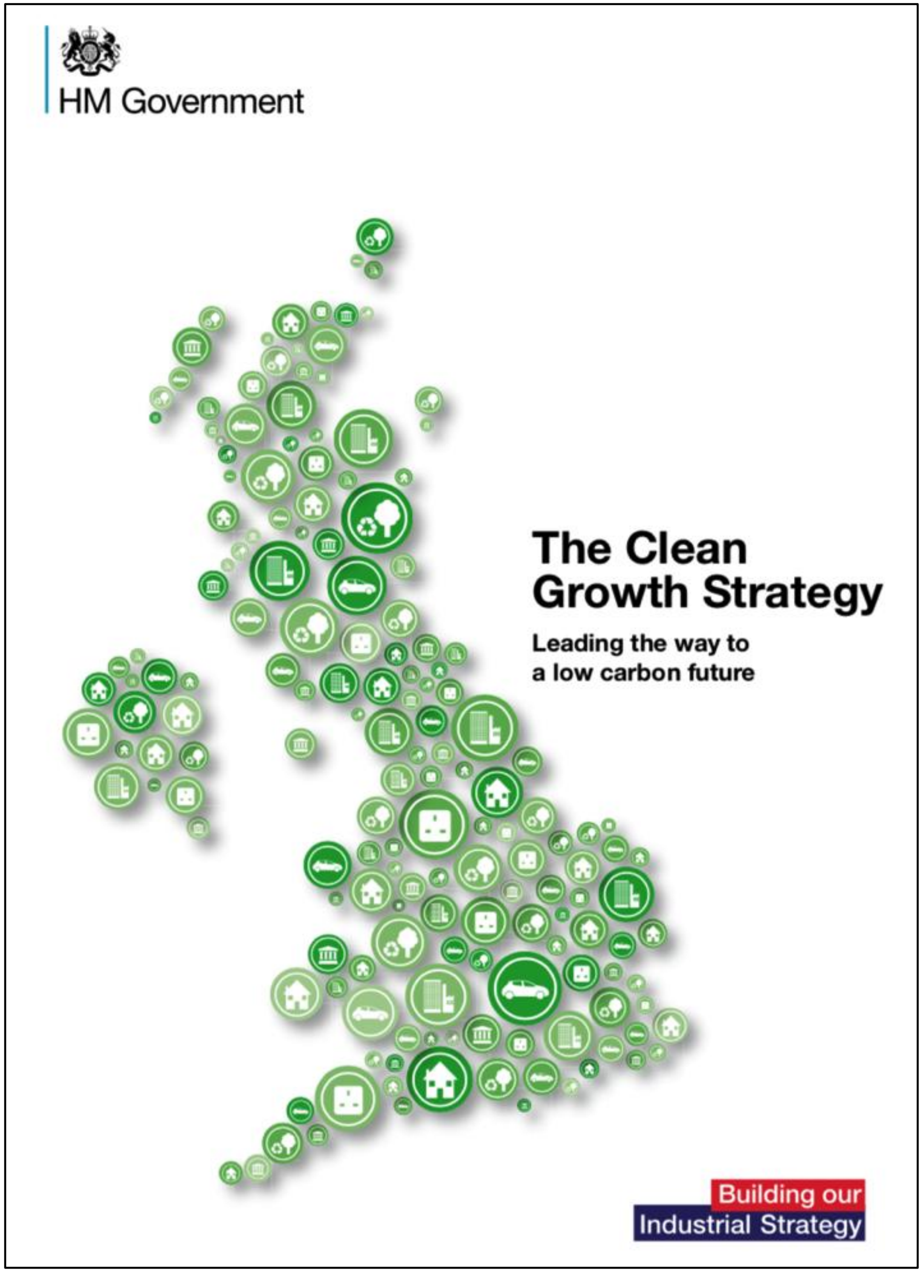
All pathways that limit global warming to 1.5°C with limited or no overshoot project the use of carbon dioxide removal (CDR) on the order of 100–1000 $GtCO_2$ over the 21st century

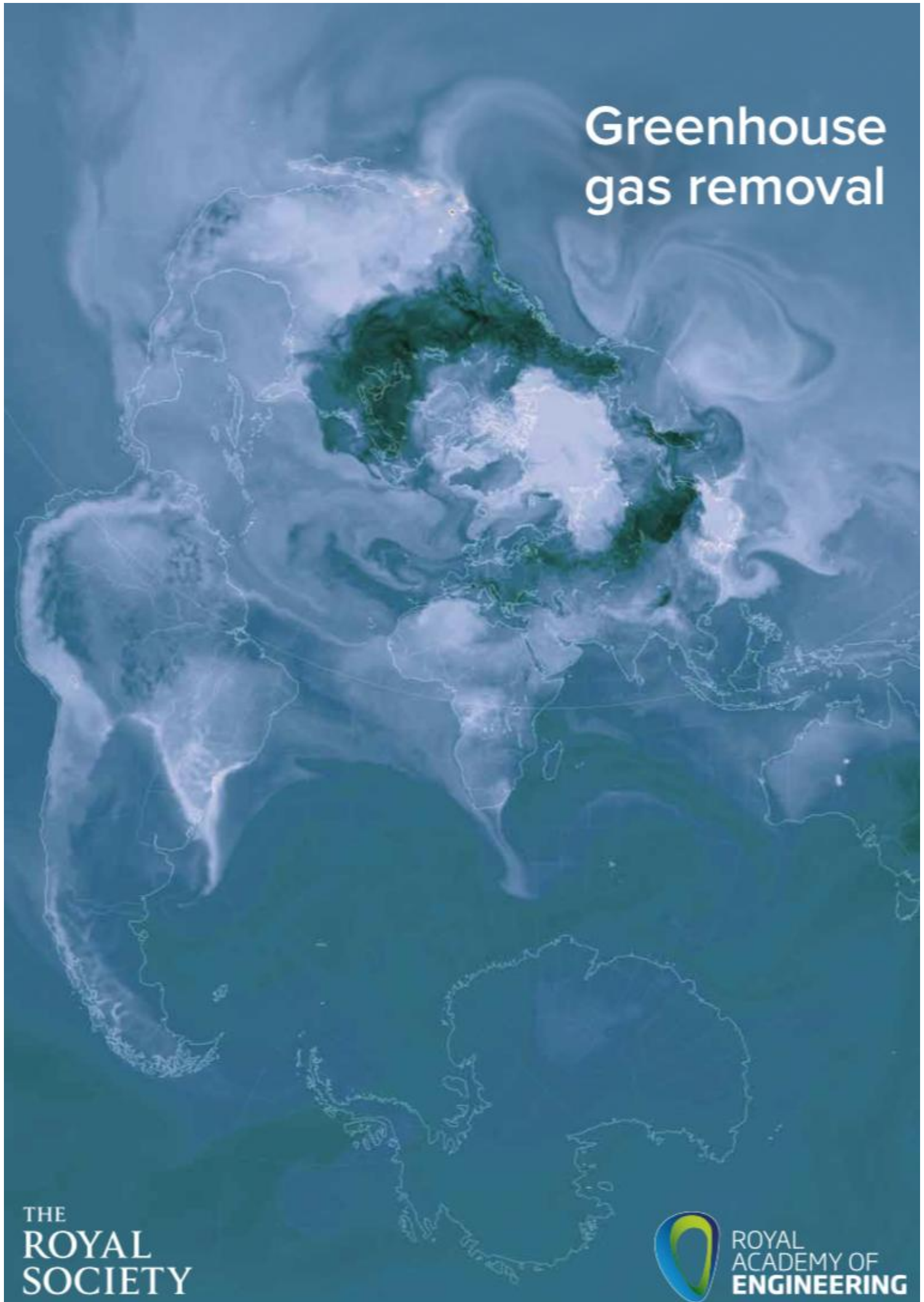
GGR/CDR is with reforestation and BECCS, but report recognizes other methods exist

UK Clean Growth Strategy
Autumn 2017

From key policies and proposals

2.7: Develop our strategic approach to greenhouse gas removal technologies, building on the Government's programme of research and development and addressing the barriers to their long term deployment.





Working group	
Adisa Azapagic FREng	University of Manchester
David Beerling FRS	University of Sheffield
Chris Cheeseman	Imperial College London
Gideon Henderson FRS (Chair)	University of Oxford
Cameron Hepburn	University of Oxford
Jo House	University of Bristol
Corinne Le Quéré FRS	University of East Anglia
Nils Markusson	University of Lancaster
Nilay Shah FREng	Imperial College London
John Shepherd FRS	University of Southampton
Pete Smith FRS	University of Aberdeen

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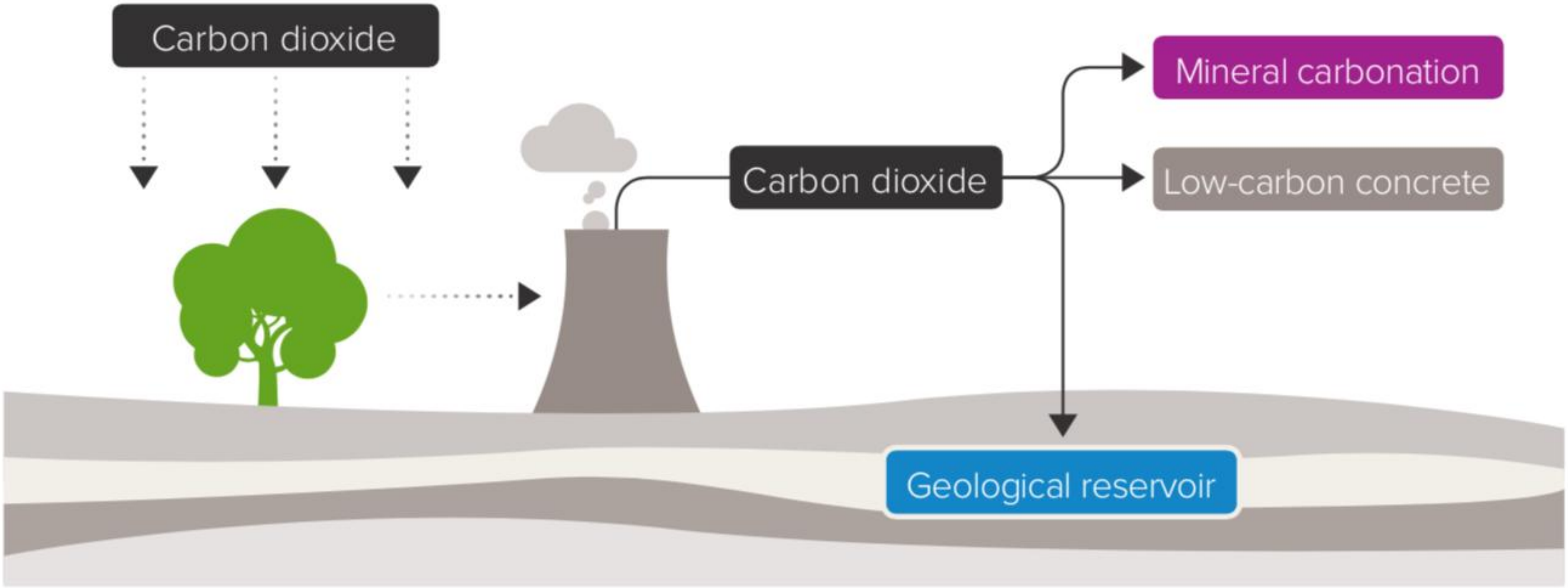
Focus on technical aspects of GGR
Published Sept 2018

GGR methods: Must both remove and store CO_2

Storage location		Greenhouse gas removal method		
		Increased biological uptake	Natural inorganic reactions	Engineered removal
Storage location	Land vegetation (living)	Afforestation, reforestation and forest management; Habitat restoration;		
	Soils and land vegetation (dead)	Soil carbon sequestration; Biochar	Enhanced terrestrial weathering	
	Geological	BECCS	Mineral carbonation at surface	DAC + geological storage DAC + sub-surface mineral carbonation
	Oceans	Ocean fertilisation	Ocean alkalinity	DAC + deep ocean storage
	Built environment	Building with biomass		Low-carbon concrete

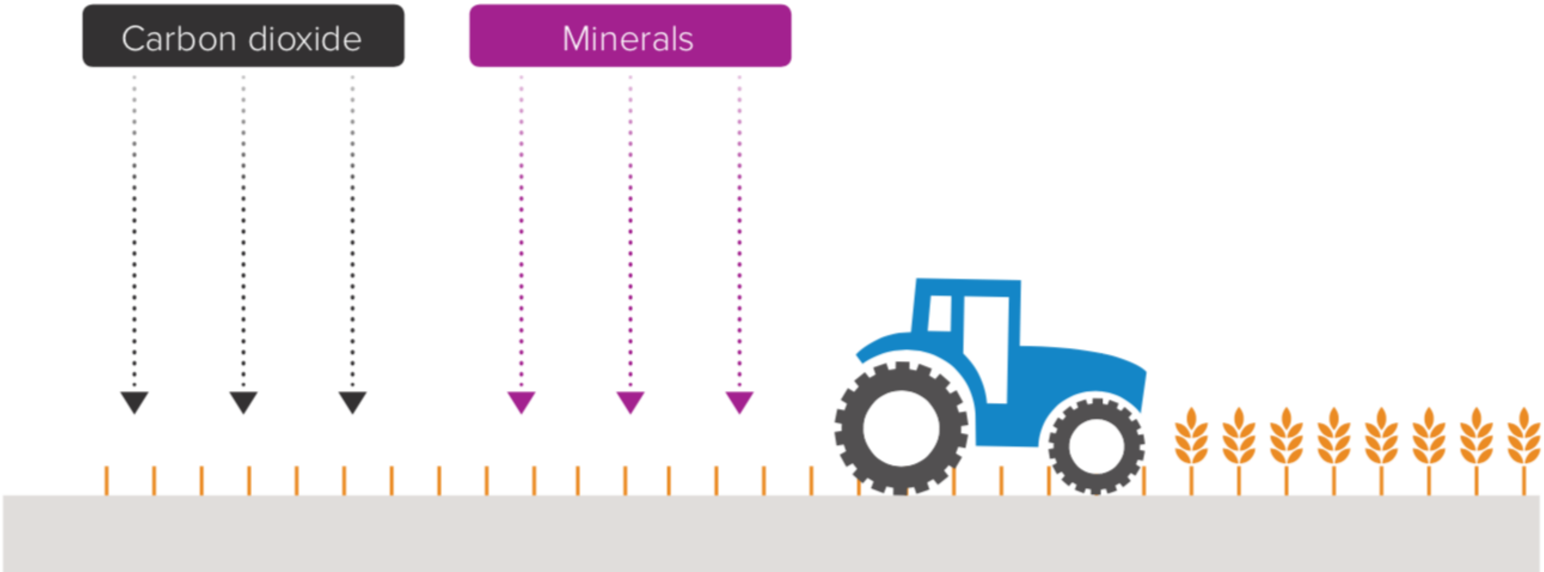
Bioenergy with Carbon Capture and Storage (BECCS)



Utilising biomass for energy, capturing the CO_2 emissions and storing them to provide lifecycle GGR

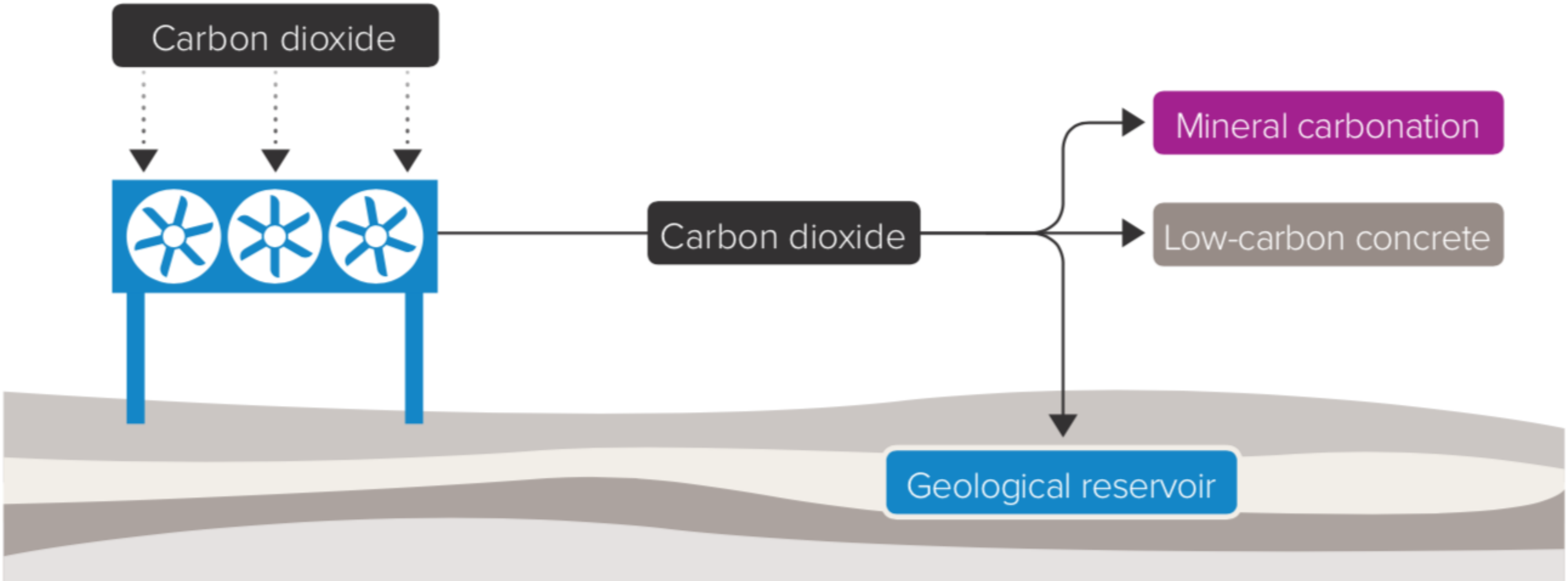
Enhanced Terrestrial Weathering

$$CaSiO_3 + 2CO_2 + H_2O \rightarrow Ca^{2+} + 2HCO_3^- + SiO_2$$



Ground silicate rocks spread on agricultural land react with CO_2 to remove it from the atmosphere

Direct Air Capture and Carbon Storage (DACCS)

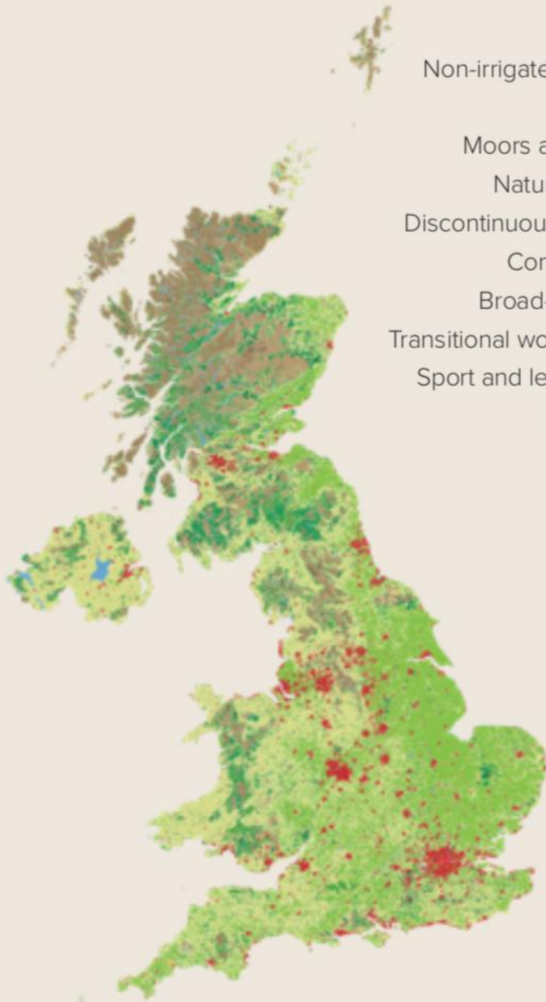


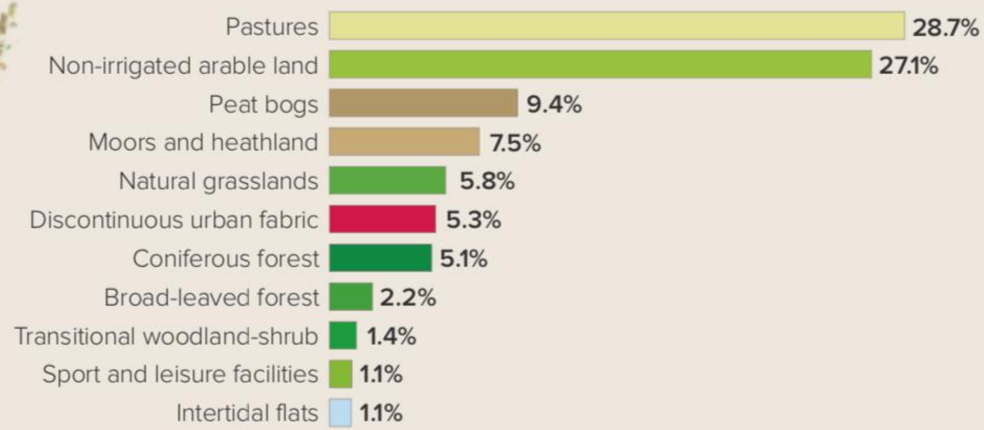
Using engineered processes to capture atmospheric CO_2 for subsequent geological storage

<u>Resource Competition</u>

Between GGR methods (and with other societal needs)

UK land cover as determined by satellite imaging.



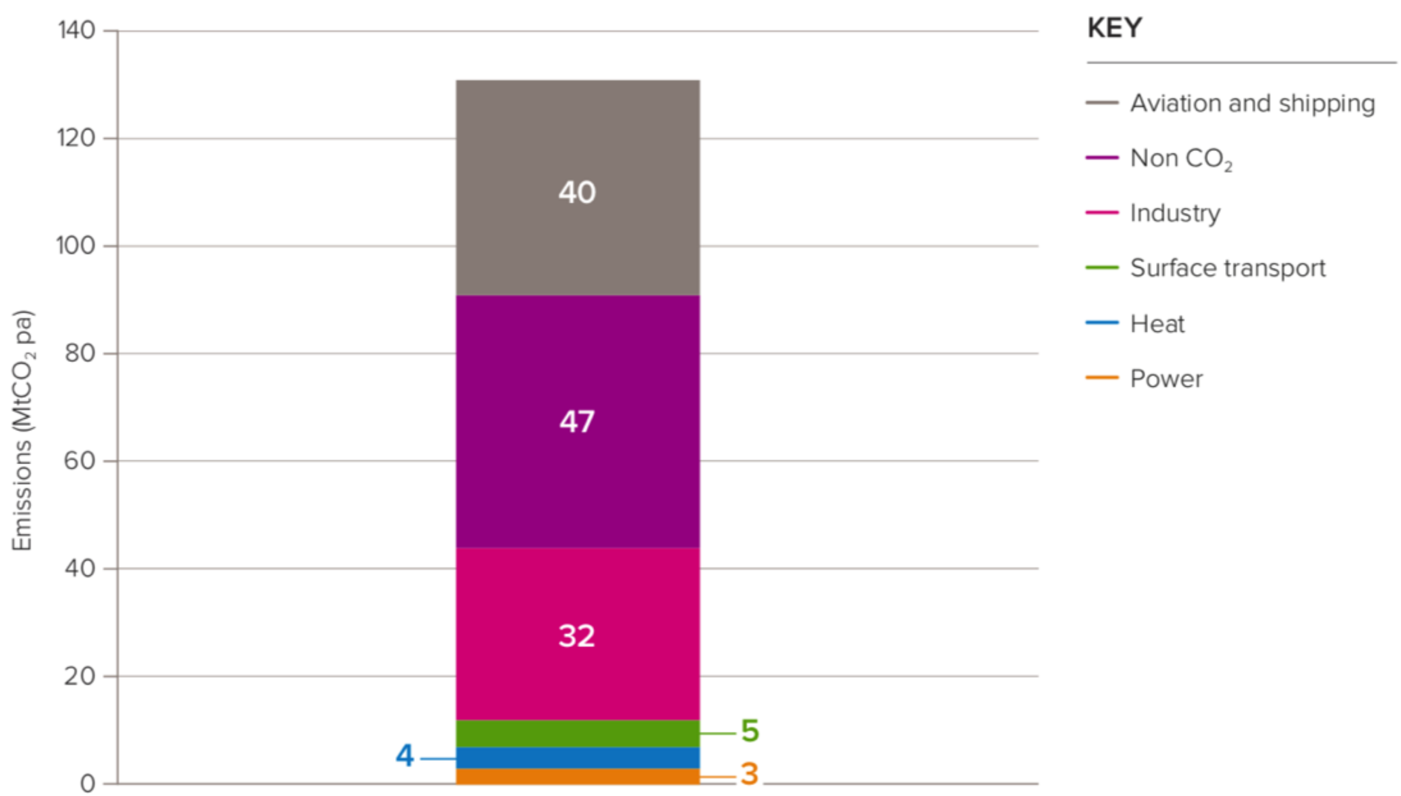


Categories of use	Current area (Mha)
UK	24.3
All agricultural land	17.5
Pastures and meadows	5.9
Arable land	6
‘Available’ land	1.5
Forests	3.2
Peatlands	2.7
Freshwater wetlands	0.8
Salt marshes	0.45

Scenarios: Can the UK achieve net zero by 2050?

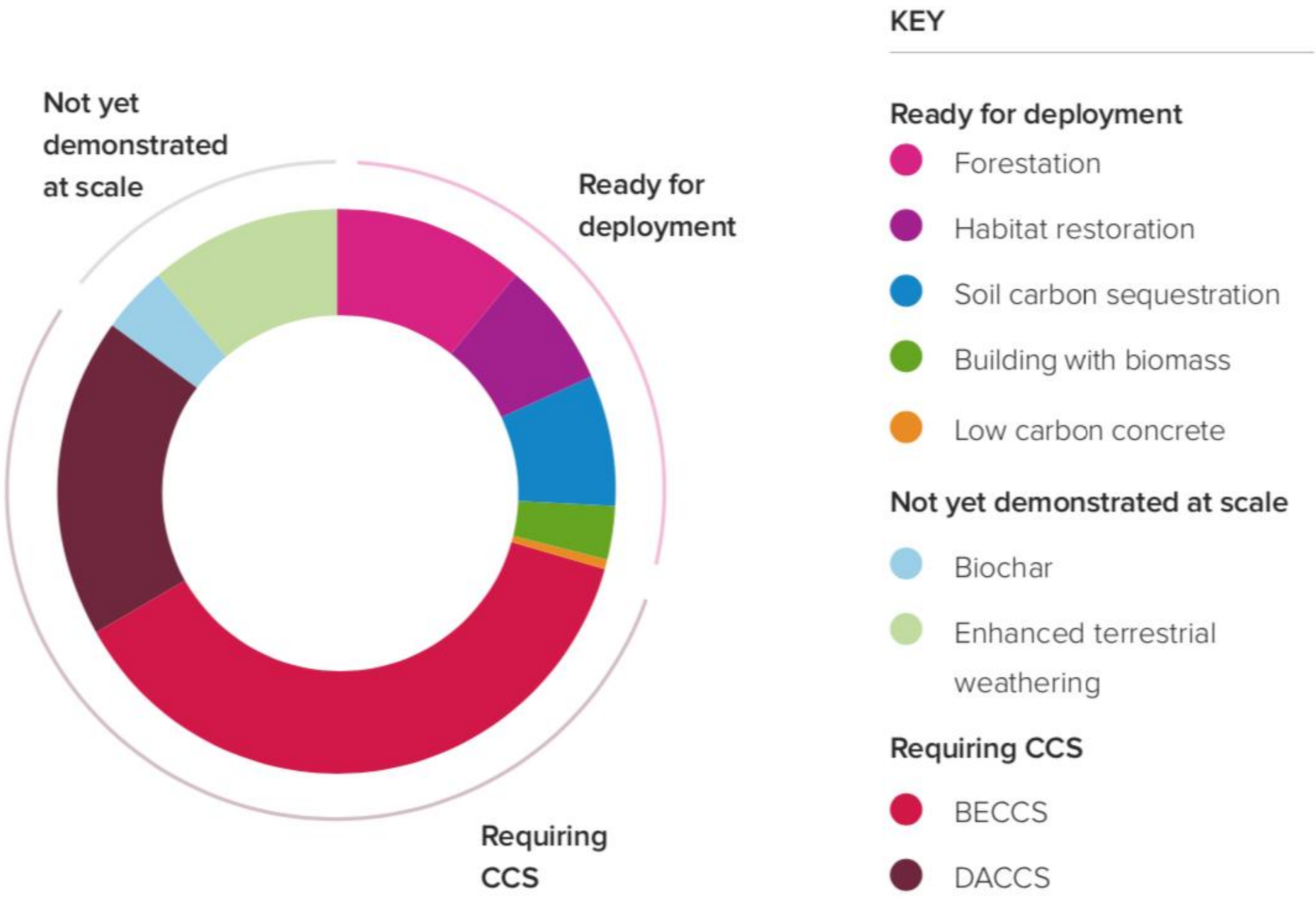
Present emissions 468 $MtCO_2e$ (CCC 2018)
Climate Change Act commits us to reduce to 160 $MtCO_2e$ pa
CCC (2016) considers 130 $MtCO_2e$ pa absolute minimum we could reach

Residual GGR emissions in 2050 with maximum reductions to emissions in all sectors.



Source: Committee on Climate Change 2016 UK climate action following the Paris Agreement report.

A suite of GGR methods are required to remove 130 $MtCO_2$ pa



Global Scenario: Seeking 810 $GtCO_2$ GGR cumulatively by 2100

Saturating storage: 250-670 $GtCO_2$

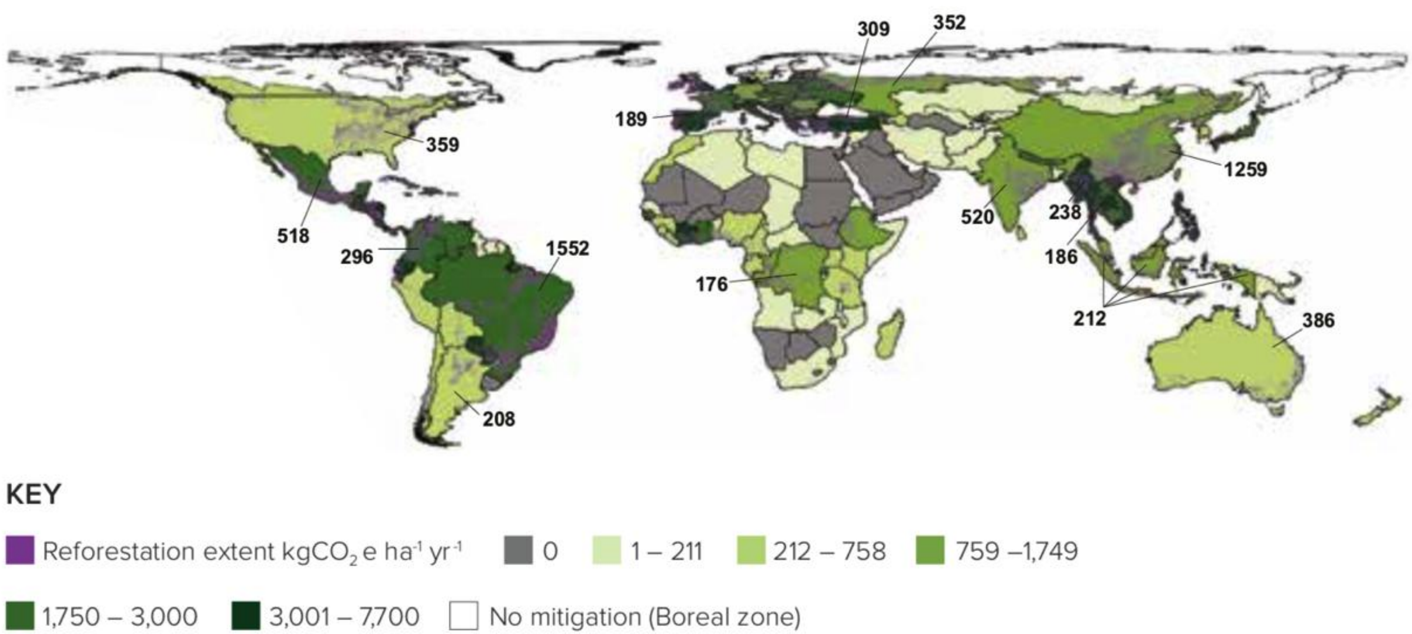
Forestation, habitat change, soils, biochar, building with biomass

Permanent storage: up to 800 $GtCO_2$

BECCS, DACCS, enhanced weathering, ocean alkalinity

FIGURE 4

Distribution of potential GGR by reforestation by country.



Key actions for UK net-zero

- Ramp-up of re forestation, habitat restoration, and soil carbon sequestration
- Establish an incentive or subsidy system to encourage changes of land practice (e.g. post EU Common Agricultural Policy)
- Encourage changes in building practice to use wood and concrete manufactured with carbonated waste
- Develop monitoring and verification procedures
- Grow and import sustainable biomass to meet the need for both energy and GGR demands
- Pursue research into the GGR…. include field-based pilot demonstrations
- Capitalise on UK access to CCS reservoirs, and relevant engineering and industry expertise