Land-based climate mitigation for Paris

Results from CLUES1.5

NERC-BEIS Workshop, 11 September 2018

Anna B. Harper, Peter Cox, Tom Powell, Jo House, Chris Huntingford, Tim Lenton, Stephen Sitch, Edward Comyn-Platt, Eddy Robertson, Andy Wiltshire, Jonathan Doelman, Detlef van Vuuren, MOC1.5 and CLIFFTOP project teams

ARTICLE

DOI: 10.1038/s41467-018-05340-z OPEN

Land-use emissions play a critical role in land-based mitigation for Paris climate targets

Anna B. Harper[1], Tom Powell[2], Peter M. Cox[1], Joanna House[3], Chris Huntingford[4], Timothy M. Lenton[2], Stephen Sitch[2], Eleanor Burke[5], Sarah E. Chadburn[1,6], William J. Collins[7], Edward Comyn-Platt[4], Vassilis Daioglou[8,9], Jonathan C. Doelman[8], Garry Hayman[4], Eddy Robertson[5], Detlef van Vuuren[8,9], Andy Wiltshire[5], Christopher P. Webber[7], Ana Bastos[10,11], Lena Boysen[12], Philippe Ciais[11], Narayanappa Devaraju[11], Atul K. Jain[13], Andreas Krause[14], Ben Poulter[15] & Shijie Shu[13]

Motivation

- 87% of models in previous IPCC report assumed bioenergy with carbon capture and storage (BECCS) will be used to remove CO_2 from the atmosphere (Fuss et al. 2014).
- Scenarios that remained below 2°C warming used up to 25% of agricultural land for bioenergy crops, removing a maximum of 6 GtC per year (Smith et al. 2016).
- Can we just scale up the BECCS for a 1.5°C target?
- And what role could forests play?

Key questions

Are negative emissions in the Integrated Assessment Model (IAM) scenarios feasible?

How do forests and bioenergy crops compare?

What are the impacts on food and water availability?

University of BRISTOL
CEH Centre for Ecology & Hydrology NATURAL ENVIRONMENT RESEARCH COUNCIL
Met Office
UNIVERSITY OF EXETER
EPSRC Engineering and Physical Sciences Research Council
LUC4C
PBL Netherlands Environmental Assessment Agency
NERC SCIENCE OF THE ENVIRONMENT

Key questions & answers

Are negative emissions in the IAM scenarios feasible?

How do forests and bioenergy crops compare?

What are the impacts on food and water availability?

1. We found lower than anticipated negative emissions from BECCS by 2100.

2. Because of emissions following deforestation, it's usually a better option to leave forests intact than to replace them with bioenergy crops.

3. 325-550 Mha of land required in the scenarios we examined.

University of BRISTOL
CEH Centre for Ecology & Hydrology NATURAL ENVIRONMENT RESEARCH COUNCIL
Met Office
UNIVERSITY OF EXETER
EPSRC Engineering and Physical Sciences Research Council
LUC4C
PBL Netherlands Environmental Assessment Agency
NERC SCIENCE OF THE ENVIRONMENT

Methods

- Land-use maps from a Integrated Assessment Model (IMAGE)
- Climate change idealized to 1.5°C and 2°C warming by 2100
- Climate change patterns from previous IPCC report
- JULES dynamic global vegetation model
- Use these to model the potential carbon dioxide removal using forests and BECCS

IMOGEN framework from CLIFFTOP and MOC1.5

Methods: Land-use change scenarios

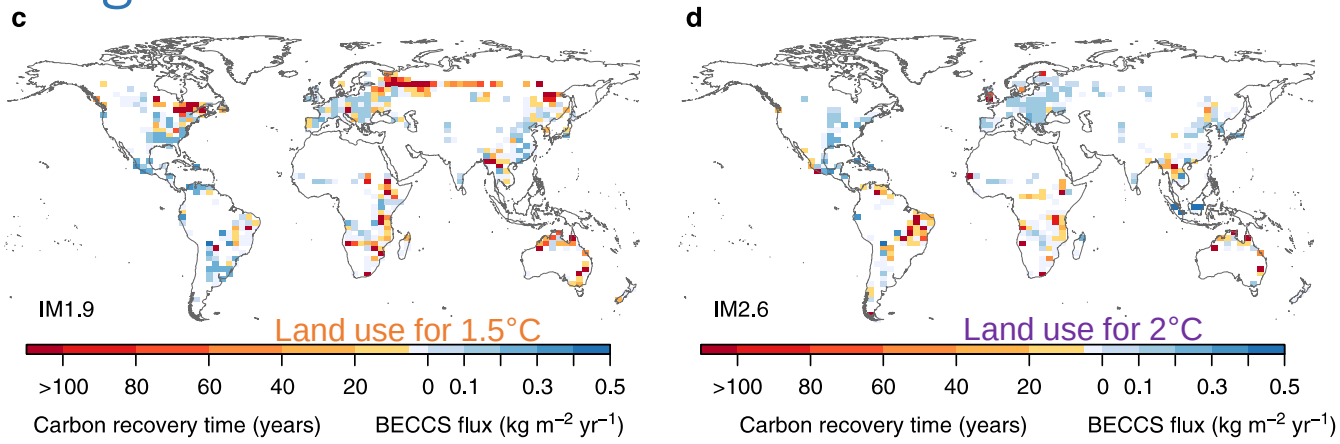
- New IMAGE Integrated Assessment Model scenarios: moderate challenges for adaptation and mitigation = Shared Socioeconomic Pathway 2 (Riahi et al. 2017)
  - IM1.9 (1.5°C scenario)
  - IM2.6 (2°C scenario)
- Land-based mitigation included in mitigation portfolio, but food production is the dominant driver of global land use

Result 1: Lower than expected negative emissions with BECCS

- Only 30 GtC stored with BECCS in our scenarios, compared to 130 GtC in the IMAGE model (IM1.9)

- To get high yields, IMAGE assumes:
  - High-yield bioenergy crops with increasing yields over time
  - Effective storage of the captured carbon
  - Original aboveground biomass used for BECCS (Stehfest et al. 2014)

Result 2: importance of land use change emissions for negative emissions



Blue: Places where BECCS pays off by 2100

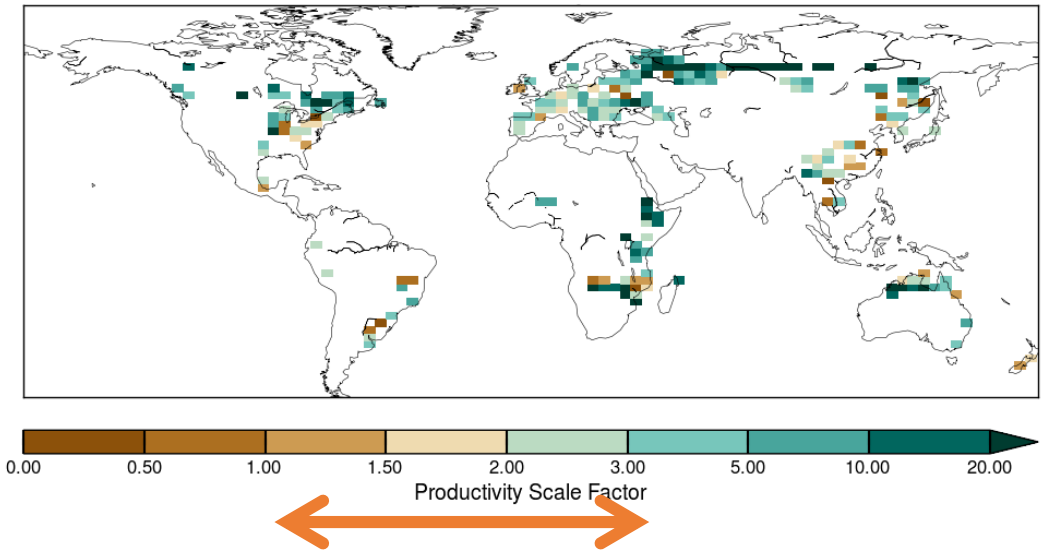
- Deforestation emits carbon to the atmosphere - how long does it take for BECCS to pay off the lost carbon?
- Calculate recovery time (τ) as:

$$\tau\ (yr) = \frac{\Delta \text{C on land with land use change for bioenergy (kg m}^{-2})}{\text{annual average C stored via BECCS (kg m}^{-2}\ \text{yr}^{-1})}$$

Result 3: Better to leave forests intact

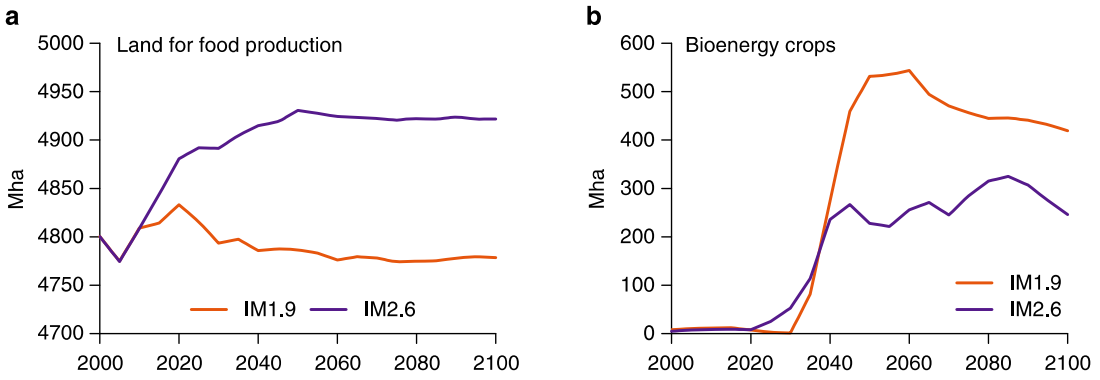
- **1-3 times production: Reasonable range of increased BECCS with different assumptions and yields in JULES**
- Even with 3x the productivity, forests would still be a better option in 40% of grid cells
- In some places, forests are always more productive

How productive does BECCS need to be to make it a better mitigation option than forests?



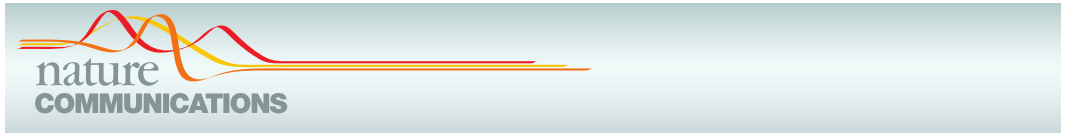
Last point: Successful land-based mitigation will require large land areas

- Maximum land for bioenergy is 550 Mha in 2060 in scenario for 1.5°C
- Land for bioenergy reaches 325 Mha in 2085 in scenario for 2°C
- Bioenergy crops primarily placed on abandoned agricultural land



Conclusions

- Carbon accumulated by BECCS could easily be offset of losses of carbon from soils and vegetation.
- Avoided deforestation, afforestation, and reforestation are often more efficient CO_2 removal strategies.
- BECCS could help with meeting a 2°C target but more is not always better.



ARTICLE

DOI: 10.1038/s41467-018-05340-z OPEN

Land-use emissions play a critical role in land-based mitigation for Paris climate targets

Anna B. Harper[1], Tom Powell[2], Peter M. Cox[1], Joanna House[3], Chris Huntingford[4], Timothy M. Lenton[2], Stephen Sitch[2], Eleanor Burke[5], Sarah E. Chadburn[1,6], William J. Collins[7], Edward Comyn-Platt[4], Vassilis Daioglou[8,9], Jonathan C. Doelman[8], Garry Hayman[4], Eddy Robertson[5], Detlef van Vuuren[8,9], Andy Wiltshire[5], Christopher P. Webber[7], Ana Bastos[10,11], Lena Boysen[12], Philippe Ciais[11], Narayanappa Devaraju[11], Atul K. Jain[13], Andreas Krause[14], Ben Poulter[15] & Shijie Shu[13]

References

- Harper, A.B. *et al.* Land-use emissions play a critical role in land-based mitigation for Paris climate targets. *Nature Communications* 9, 2938 (2018).
- Fuss, S. et al. Betting on negative emissions. *Nature Climate Change* 4, 850-853 (2014)
- Riahi, K. et al., 2017. The Shared Socioeconomic Pathways and their energy, land use, and greenhouse gas emissions implications: An overview. Global Environmental Change-Human and Policy Dimensions, 42: 153-168.
- Smith, P. et al., 2016. Biophysical and economic limits to negative CO2 emissions. Nature Climate Change, 6(1): 42-50.
- Stehfest, E., van Vuuren, D., Kram, T. & Bouwman, L. Integrated assessment of global and policy applications. (Netherlands Environmental Assessment Agency (PBL), 2014).