Forest management could help limit warming to 1.5°C

Protecting forests, planting new forests, and bioenergy with carbon capture and storage (BECCS) provide a means of removing carbon dioxide from the atmosphere. Scenarios suggest that implementing these over large areas of land can contribute to meeting the Paris Agreement goals of limiting warming to well below 2°C and aiming for 1.5°C

Some carbon is released into the atmosphere when forests are converted to cropland for bioenergy. In areas where carbon storage on the land is high, such as tropical and boreal forests and peatlands, it is often better from a carbon perspective to protect natural ecosystems than implement BECCS over a century time-scale

What this research is about

Almost 200 countries have signed the Paris Agreement to limit global average warming since pre-industrial times to well below 2°C, with an aspiration to limit to 1.5°C. Achieving this goal will likely require deep and rapid reductions in greenhouse gas emissions, but also removal of carbon dioxide from the atmosphere.

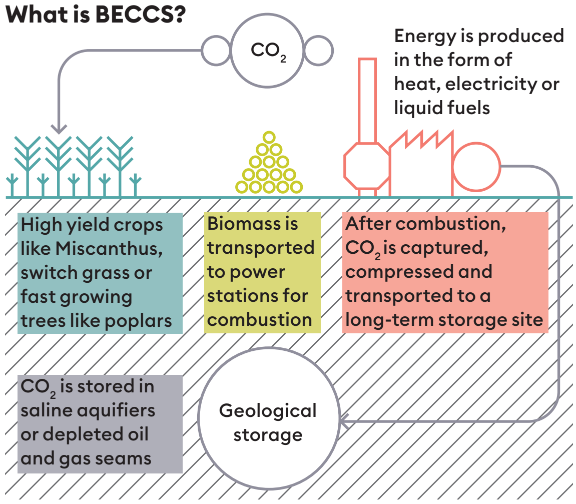
Plants take up carbon dioxide from the atmosphere and store it in biomass and soils. Increasing forest area, or growing plants to use for bioenergy and capturing and storing the carbon released (BECCS), can result in extra carbon dioxide removal.

The vast majority of model simulations of the future that remain consistent with the Paris Agreement require carbon dioxide removal through BECCS, removing a median of 3 billion tonnes of carbon from the atmosphere every year by 2100 (or 30% of present-day emissions).

However, when high carbon systems such as peatlands and forests are converted to croplands for bioenergy use, large amounts of carbon can be lost. The carbon in these ecosystems has accumulated over centuries. While bioenergy crops are fast growing, they take up less carbon than was lost, thus it can take several growth cycles to "pay back" the lost carbon and have a net carbon benefit.

This study looked at two possible futures where BECCS and forests are used to remove carbon dioxide from the atmosphere.

What is BECCS?

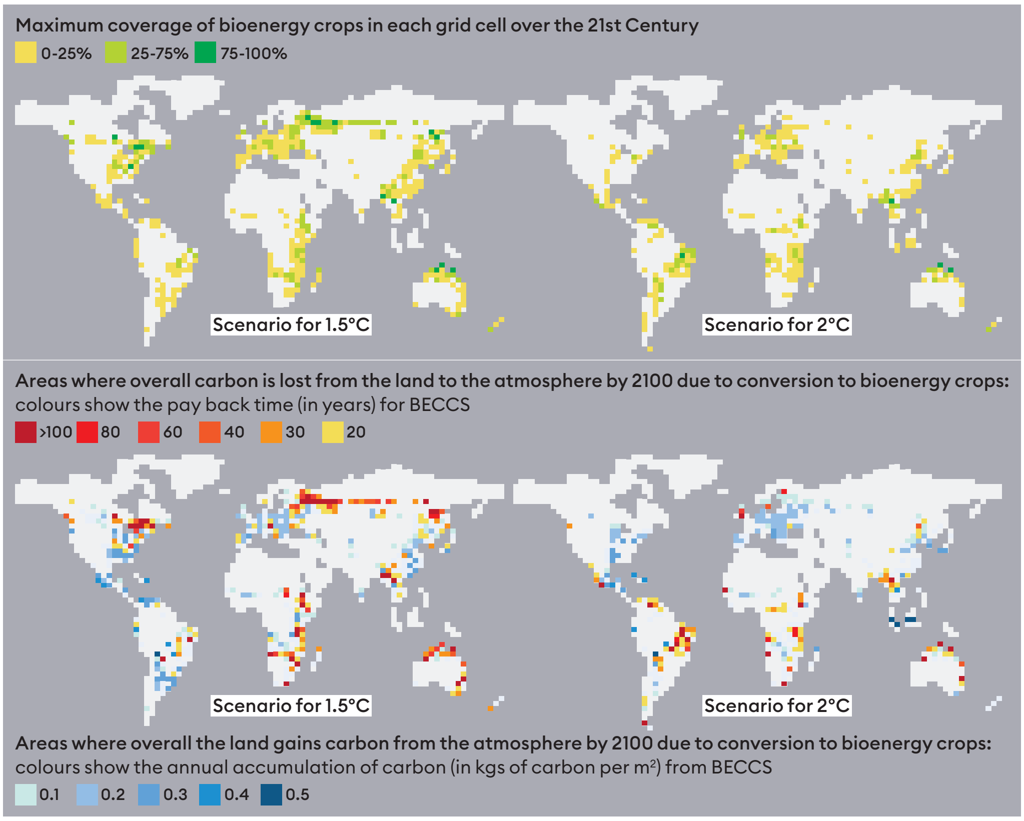


Study findings

The scenario for 1.5°C has a maximum of 550 million hectares of land covered by bioenergy crops, about twice the size of Argentina. The extent of bioenergy crops for the two scenarios are shown in the upper maps below.

This study finds that the carbon "pay back" time varies depending on prior land use. The pay back time is the number of years it takes for the carbon removal through BECCS to compensate the lost carbon through land conversion to bioenergy crops. Pay back times are insignificant when replacing agricultural crops in temperate areas with bioenergy crops. These are the places in blue in the lower maps. The red places in the map are where the pay back time is the longest, usually because bioenergy crops replace ecosystems with high carbon content. Replacing forests leads to pay back times of 10 to 100+ years, and growing crops on peatland soils results in pay back times of more than 100 years

Looking over a 100 year period, the additional land carbon lost to the atmosphere in the 1.5°C scenario largely offsets the additional storage of carbon that BECCS provides. Our modelled bioenergy crop produced around 10 tonnes per hectare (a similar yield to maize). BECCS would be more effective in more areas if crops were more productive.



FURTHER DETAILS

- Projections are made with the JULES-IMOGEN climate impact model which emulates the climate projections made by multiple climate models. This generates uncertainty bounds on estimates, which reflect differences between climate models in regional patterns of warming and precipitation changes between climate models.
- Results are sensitive to the carbon content of plants and soils simulated by JULES, which has been validated in previous studies but could be too high in some forest ecosystems. We repeated this analysis in five other vegetation models and found the same results: emissions from land use change are large and difficult to overcome when forests are replaced with bioenergy crops.
- Some factors would make BECCS more effective, such as using high yield crops (average annual yield > 15 tonnes dry mass per hectare) and limiting losses of biomass from harvest to processing. However, even when we take into account higher yielding crops and more efficient processing, there are some places where removing natural ecosystems for bioenergy crops does not make sense.

Policy relevance

The results of this study highlight the potential for the land in different areas to contribute to climate mitigation through forest conservation, planting new forests, and bioenergy with carbon capture and storage (BECCS). Model simulations of the future that remain consistent with the Paris Agreement suggest crops for BECCS should be grown on 200-760 Mha of land (the upper limit is equivalent to half of current day food cropland).

Some natural ecosystems already store large amounts of carbon in the vegetation and soils, notably tropical and high latitude forests and peatlands. On these areas it is of more mitigation benefit to conserve high carbon ecosystems rather than convert them to new forests or crops for bioenergy. BECCS could be efficient at carbon removal when implemented on current agricultural or degraded areas.

These results are relevant to decision making on how best to manage different land areas for climate mitigation. Policies could be implemented that explicitly protect and restore high carbon landscapes such as forest and peatland, while bioenergy policies could include sustainability criteria and certification schemes.

TO FIND OUT MORE SEE

Land-use emissions play a critical role in land-based mitigation for Paris climate targets: Anna Harper, Tom Powell, Peter Cox, Jo House, Chris Huntingford, Tim Lenton, Stephen Sitch, Eleanor Burke, Sarah Chadburn, William Collins, Edward Comyn-Platt, Garry Hayman, and co-authors. Nature Communications, 2018, doi: http://dx.doi.org/10.1038/s41467-018-05340-z

PARTNERS