Land use-climate feedbacks – Reconciling mitigation and adaptation

note: Day 3 will cover representation of land use in scenario and model development

Julia Pongratz

with input from HERMITIAN Working group (modelling Human-EnviRonMental InTeractions In the ANthropocene)

Victor Brovkin, Galina Churkina, Jonathan Donges, Matthias Garschagen, Thomas Kastner, Tobias Kuemmerle, Mark Rounsevell, Jürgen Scheffran
Land use-climate feedbacks

Biogeochemical effects

Biogeophysical effects

Photosynthesis, carbon storage, Non-CO₂ GHG

reflectivity ("albedo")

roughness
Land use-climate feedbacks

... as does climate change impact on ecosystems

US/Canada heat wave, July 2021

Reliance of humans on land for climate mitigation grows stronger...

Required negative emissions 2050 | 2100
A short history of land use in global climate assessments

CMIP5 preparations: For the first time, land use is a forcing (LUH1)

Research priorities in land use and land-cover change for the Earth system and integrated assessment modelling

Kathy Hibbard, Anthony Janetos, Detlef P. van Vuuren, Julia Pongratz, Steven K. Rose, Richard Betts, Martin Herold and Johannes J. Feddema

Land use likely one of the most important reasons to couple IAMs and ESMs

A comprehensive view on climate change: coupling of earth system and integrated assessment models

Detlef P van Vuuren, Laura Batlle Bayer, Clifford Chuwah, Laurens Ganzeveld, Wilco Hazeneger, Bart van den Hurk, Twan van Noije, Brian O'Neill and Bart J Strengers
A short history of land use in global climate assessments

**CMIP6**: >50 times the information of CMIP6 (LUH2) (higher res; + irrigation, rice, wood harvest types, biofuels)

But this does not mean ESMs can use it...

New high-resolution datasets emerge, e.g. HILDA+

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*Hurtt et al., GMD, 2020*

*Pongratz et al., Glob. Change Biol., 2017*
Coupling approaches around (global) land use

Other coupling around land use: see reviews by Calvin and Bond-Lamberty, ERL, 2018 & Robinson et al., ESD, 2018
Land use role for mitigation “clear”, but for adaptation largely unassessed

Global climate mitigation potential in 2030 (PgCO$_2$e/year)

Forests
- Reforestation
- Avoided Forest Conv.
- Natural Forest Mgmt.
- Improved Plantations
- Avoided Woodfuel
- Fire Mgmt.

Ag. & Grasslands
- Biochar
- Trees in Croplands
- Nutrient Mgmt.
- Grazing - Feed
- Conservation Ag.
- Improved Rice
- Grazing - Animal Mgmt.
- Grazing - Optimal Int.
- Grazing - Legumes
- Avoided Grassland Conv.

Wetlands
- Coastal Restoration
- Peat Restoration
- Avoided Peat Impacts
- Avoided Coastal Impacts

1 PgCO$_2$ = 0.27 PgC

Highest potentials when CO$_2$-fertilization is accounted for (Sonntag et al., GRL, 2016)
Land use role for mitigation “clear”, but for adaptation largely unassessed

Massive local climate effects of terrestrial CDR methods → win-win of mitigation & adaptation (or trade-offs)!

Surface temperature change for global deforestation

Winckler et al., GRL, 2018 / ESD, 2019
Land use role for mitigation “clear”, but for adaptation largely unassessed

Integration of local temperature signal in IAM (MAgPIE) (via CO₂ equivalent) alters afforestation trajectory

→ Strong feedback between global climate change and land use via local climate impact

A/R
+203%
+236 Mha

Scenario
Mean BGP Effect
No BGP Effect
BGP Uncertainty
Signal emergence may influence human decisions

Cascade of delays in the system, from social acceptance of policy measure to implementation to climate signal...
Land use role for mitigation “clear”, but for adaptation largely unassessed

non-local effects of CDR → side-effects elsewhere need to be considered

Guo et al., in prep.
Conclusions

• Push towards CDR in climate policy puts additional pressure on land
  • We need to consider synergies and trade-offs for the multiple usages of land on our way to climate neutrality

• Climate policy currently has narrow GHG focus; large potential to adapt living conditions for humans and ecosystems by local climate effects of land use change

• How should mitigation and adaptation best be linked?