Potential Consequences of Climate Mitigation for Land Use Change in the 21st Century

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Potential Consequences of Climate Mitigation for Land Use Change in the 21st Century

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Overview

Typical disciplinary split allows for studies of
- Mitigation (e.g. biofuels, soil C sequestration), assuming plants not impacted by climate change and resources not diverted for adaptation
- Adaptation (e.g. changing crop management), assuming land resources are not affected by mitigation

Both assumptions are false, but sometimes necessary to simplify individual studies.

Can global models provide insights into the significance of these assumptions?

Here we test a land use factor of interest for both mitigation and adaptation - agricultural productivity growth - in a simulated global mitigation policy.
Crop productivity and land use

Crop yields are expected to continue to increase over time (FAO), however this is:
- Uncertain, and also
- Sensitive to the impacts of climate change

Improving agricultural crop productivity reduces deforestation pressure.
- Cumulative land-use change emissions 2005 to 2095: **72 PgC.**

[Graph showing cumulative land-use change emissions from 2005 to 2095, with two lines: Reference 0.25%/yr Crop Productivity Growth and Sensitivity Test: No Crop Productivity Improvement.]

GCAM simulations with no mitigation
Scenario design

- Apply the GCAM model used in emissions scenario simulation and analysis of mitigation policies.
  - Considers future growth in population and income, and future transformations in energy technology
  - No climate impacts are simulated
  - Land use simulated at the global scale for 14 regions and downscaled to a grid

- Mitigation policy discussed here is the RCP4.5 stabilization case:
  - ~650 ppm CO$_2$-e in 2100
  - Emissions price applies equally to emissions from land use as well as emissions from energy and industrial processes.

- Simulations conducted with two set of exogenous parameters on agricultural productivity growth (APG)
  - Standard: Follows FAO to 2030 and converges to 0.25%/year
  - zAPG: Held constant at 2005 yields
Change in crop and forest land from 2005 to 2100 when agricultural productivity DOES NOT increase
Reference Case (zAPG)

Difference in cropland gridcell fraction between 2005 and 2100 -- Reference with Zero APG

Difference in forest gridcell fraction between 2005 and 2100 -- Reference with Zero APG
Climate Mitigation Scenario (zAPG)

Difference in cropland gridcell fraction between 2006 and 2100 -- RCP4.5 with Zero APG

Difference in forest gridcell fraction between 2005 and 2100 -- RCP4.5 with Zero APG
Change in crop and forest land from 2005 to 2100 when agricultural productivity DOES increase
Reference Case

Difference in cropland gridcell fraction between 2005 and 2100 -- Reference

Difference in forest gridcell fraction between 2005 and 2100 -- Reference
Climate Mitigation Scenario (RCP4.5)

Difference in cropland gridcell fraction between 2005 and 2100 -- RCP4.5

Difference in forest gridcell fraction between 2005 and 2100 -- RCP4.5
Mitigation preference for forested land results in less bioenergy crop production than a corresponding reference case.

- Causes higher prices in the energy sector and makes mitigation policies more difficult.
Cost of food production increases.
Food expenditure (as a fraction of income) declines.

Terrestrial C policies encourage a shift away from beef consumption; lower APG has a similar, although smaller, influence.
Findings

► Potential land use change associated with mitigation is large and an important consideration in adaptation planning.

► Pressure to expand crop land is greater when
  ■ Agricultural crop productivity does not increase
  ■ No terrestrial C valuation policy is in place.

► Agricultural productivity improvements can be seen as both an adaptation and mitigation priority.
  ■ Keep the cost of food production low
  ■ Make land available for bioenergy and reforestation
Questions?