Land clearing and the biofuel carbon debt

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Land Clearing and the Biofuel Carbon Debt

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Increasing energy use, climate change, and carbon dioxide (CO₂) emissions from fossil fuels make switching to low-carbon fuels a high priority. Biofuels are a potential low-carbon energy source, but whether biofuels offer carbon savings depends on how they are produced. Converting rainforests, peatlands, savannas, or grasslands to produce food crop–based biofuels in Brazil, Southeast Asia, and the United States creates a “biofuel carbon debt” by releasing 17 to 420 times more CO₂ than the annual greenhouse gas (GHG) reductions that these biofuels would provide by displacing fossil fuels. In contrast, biofuels made from waste biomass or from biomass grown on degraded and abandoned agricultural lands planted with perennials incur little or no carbon debt and can offer immediate and sustained GHG advantages.
Motivation

• If native ecosystems or land in agricultural reserves is converted to biofuel production, how long does it take until the biofuels produced from this land are lower emitters of GHG than fossil fuels?

• What is the carbon debt of biofuels, and how long does it take to repay it by offsetting fossil fuel use?

• Prepare a transparent assessment
  – All calculations, assumptions, and sources are publicly available
## Scenarios

<table>
<thead>
<tr>
<th>Biofuel</th>
<th>Conversion of native ecosystems to biofuel production</th>
<th>Conversion of degraded cropland to biofuel production</th>
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</thead>
<tbody>
<tr>
<td>Palm biodiesel</td>
<td>Corn ethanol</td>
<td>Prairie biomass ethanol</td>
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<tr>
<td>Palm biodiesel</td>
<td>Palm biodiesel</td>
<td>Prairie biomass ethanol</td>
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<td>Soybean biodiesel</td>
<td>Sugarcane ethanol</td>
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<td>Soybean biodiesel</td>
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<td>Corn ethanol</td>
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<td>Corn ethanol</td>
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<td>Former ecosystem</td>
<td>Prairie biomass ethanol</td>
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<td>Tropical rainforest</td>
<td>Abandoned cropland</td>
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<td>Peatland rainforest</td>
<td>Abandoned cropland</td>
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<td>Tropical rainforest</td>
<td>Central grassland</td>
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<td>Cerrado wooded</td>
<td>Abandoned cropland</td>
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<td>Cerrado grassland</td>
<td>Marginal cropland</td>
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<td>Central grassland</td>
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<td>Location</td>
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<td>Indonesia/Malaysia</td>
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<td>US</td>
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</table>
Example: Variation in Brazilian savanna

From Kauffman et al. (1994)
Example: Agricultural reserve land

- Degradation of carbon accrued after land has been retired from production
- Land out of production for 15 years
- Modeled after CRP program
Projected change in CRP acreage

From Secchi and Babcock (2007)
Treatment of co-products

• What is the motivation behind land conversion?

• Treatment of food and feed coproducts
  – Used to partition “total carbon debt” into “biofuel carbon debt” and “co-product biofuel debt”
  – Market value allocation (mass fraction x market value)

• Treatment of energy coproducts
  – Displacement of appropriate fossil fuel source
  – Complete displacement of fossil fuel emissions
Comments and assumptions

- Factors tending to reduce carbon debt repayment time
  - No improvement in conversion technology
  - No improvement in crop yields

- Factors tending to increase carbon debt repayment time
  - No carbon discounting
  - No market elasticity
  - Land in GHG equilibrium
Discussion

• We did not quantify total land areas devoted to biofuel production.
  – Today
  – Future

• We did not attempt to estimate industry average biofuel emissions (gCO$_2$e/MJ).

• We considered but a subset of all scenarios of land conversion resulting from increased biofuel production.
Final comments

• Ours is a precautionary tale of what *could* happen when biofuel production expands.

• The difficulty of calculating indirect GHG emissions is not a reason to exclude them from GHG analyses.

• Biofuels should be treated like prescription drugs, not like criminals.