Divers of Land Use Change in Brazil

Bruce Babcock
Center for Agricultural and Rural Development
Iowa State University
Energy Independence and Security Act of 2007 specifies

“(H) LIFECYCLE GREENHOUSE GAS EMISSIONS.—The term ‘lifecycle greenhouse gas emissions’ means the aggregate quantity of greenhouse gas emissions (including direct emissions and significant indirect emissions such as significant emissions from land use changes), as determined by the Administrator, related to the full fuel lifecycle, including all stages of fuel and feedstock production and distribution, ...”
Why Consider Land Use Changes?

• Demand for biofuels feedstock (corn) increases
• Price of feedstock increases
• Farmers in U.S. and around the world respond to higher prices by increasing production
• Land is needed for increased production
• Where does the land come from?
  – Other crops
  – Conversion of pasture/grassland
  – Conversion of shrubland/forests
Loss of carbon from land conversion to agriculture

Estimating GHG Emissions from Land Use Changes

• Step 1:
  – Determine the amount of land in a country that will come into production due to expansion of biofuels

• Step 2:
  – Determine where that land will come from (other crops, pasture, forests)

• Step 3:
  – Determine the CO₂ emissions that will result from land conversion
How Much Land is Needed to Meet Biofuels Demand?

• Answer 1:
  – The number of corn acres it takes to grow the feedstock to produce the fuel

• Answer 2:
  – Adjust answer 1 for byproduct quantity (Searchinger)

• Answer 3:
  – Assume that yields will increase (EPA)

• Answer 4:
  – Assume that yields will increase a lot and that food demand will drop significantly (GTAP)
How Many Acres are Needed To Meet Ethanol Demand?

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<tr>
<th>Thousand Acres per Billion Gallons</th>
<th>Direct Corn Acres at US Yield</th>
<th>Searchinger</th>
<th>EPA-RFS2</th>
<th>GTAP-1</th>
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How Many Acres are Needed To Meet Ethanol Demand?

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<td>GTAP-2</td>
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Models Diagree whether U.S. or Brazil will Expand More

- Biofuels increase emissions a lot
- Biofuels reduce emissions a small amount
- Biofuels potentially reduce emissions a lot

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<th>Thousand Acres per Billion Gallons</th>
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<td>United States</td>
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<tr>
<td>Brazil</td>
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- Searchinger
- EPA-RFS2
- GTAP-1
- GTAP-2
Where will Brazilian Land Come From?

- EPA and Searchinger estimate land use conversion from past land use changes
  - Searchinger in the 1990s
  - EPA from 2001 to 2007 (fall planted crop in 2006)
  - GTAP uses a CET production function to capture assumed level of substitution between types of land. Incorporation of land suitability for crops a big addition of reality in GTAP.
Deforestation Causes

• First step
  – Interview knowledgeable people
Jason Clay (WWF)
Senior Vice President Market Transformation

• **Education**
  – PhD - Anthropology and international agriculture, Cornell University
  – Read Economics - London School of Economics
  – BA - Anthropology, Harvard College

• **Areas of Expertise**
  – Indigenous people - nation/state conflicts, natural resource management, global trends
  – Corporate Social Responsibility - reducing social and environmental risks, water and carbon neutrality, value chain management
  – Agriculture and aquaculture
  – Impact assessments of large-scale development projects
  – Trend Analysis - the implications of biofuels, metric-based standards for agriculture and aquaculture, animal protein consumption

• "Our goal is to figure out how to produce more with less land, less water and less pollution, so we won't be the only species left living on this planet."
His Facts

• Use of land was not timber until the 2000s. In the 1990s $2 billion worth of timber was going up in smoke each year because of a lack of markets.

• In the 1970s and 1980s, it was settlement policy combined with subsidies that induced land clearing. Owners brought teams of workers into an area, let them use the land for two years as long as they left it cleared and planted to pasture.

• It was also a way to get loans. Borrowers needed to show that they occupied the land in order to get a loan. The way to show it was to clear the land.
More Clay Facts

• It was all cattle. Cattle walk to market. No soybeans because soybeans did not walk to market.

• Loans were not indexed to inflation. So get a loan for 50 cattle and then 5 years later pay back the loan with a calf.

• Forest land was worth $1 per ha. Cleared it was worth $10/ha.

• The decrease in deforestation rates a result of elimination of subsidies for land clearing and settlement and more enforcement of legal set aside requirements.
Cumulative Amazon Legal Deforestation

- X-axis: Years (1988-2010)
- Y-axis: Million acres
- The graph shows an increasing trend in cumulative Amazon legal deforestation from 1988 to 2010.
Initial Econometric Questions

• Can I create a model that explains land use conversion over time?
• State-level annual observations on deforestation, crop acreage, and macroeconomic variables, two census observations for cattle numbers (1996 and 2006), crop return data
• Are there systemic drivers of deforestation?
Standardized Annual Deforestation Rates in Legal Amazon

Amapá and Roraima are outliers.
Lack of Econometric Progress

• Do not have a state-level model
• At stage of initial exploration to determine if available data gives insight into pertinent questions for EPA analysis
• FAPRI and GTAP and other models of land use changes measure change in land due to a change in demand for crops through prices
• Any evidence of price-induced land use change?
Popular and Scientific Notions: Crop Prices and Deforestation

• Scientific
  – “The mean annual soybean price during 2001–2004 was related to the amount of deforestation for cropland in Mato Grosso ($R^2 = 0.72$).”


• Popular
  – “Deforestation in the states of Mato Grosso and Para has shown a particularly strong correlation to soy prices in recent years” (http://www.mongabay.com/general_tables.htm)
Correlation Between Mato Gross Annual Deforestation and U.S. Soybean Prices: 2001 to 2004

![Graph showing the correlation between Mato Gross Annual Deforestation and U.S. Soybean Prices from 2001 to 2004. The x-axis represents the price per bushel ($/bu) ranging from 0.0 to 8.0, and the y-axis represents million acres ranging from 0.0 to 2.5. The data points are marked with diamonds.]
Correlation Between Mato Gross Annual Deforestation and U.S. Soybean Prices: 2001 to 2004

$R^2 = 0.567$

![Graph showing the correlation between soybean prices and deforestation](image)
Competing Hypotheses: How can expansion of crops increase deforestation?

• Directly planted on deforested land
• Cattle are pushed into the Amazon states by expansion of crops in non-Amazon states
  – If true, then share of cattle should fall in states that have the largest increase in crops
• Expected crop returns drive the decision to deforest, but cattle are put on land first
  – If true, then crops should follow cattle after some period of time
Cattle Reallocated by a Change in Share of Brazilian Herd

No doubt that cattle were reallocated to Legal Amazon between 1996 and 2006

And that cattle share contracted in South
Causal Pathway

• Did states that grew the most in crops have the largest decrease in cattle share?
  – Measure crop change by hectares and by hectares divided by land in the state
Did Cattle Get Pushed Out by Crops Between 1996 and 2006?

Reallocation of Brazilian Cattle

Change in Planted Hectares

Mato Grosso
Relationship Between Change in Cattle Share and Change in Crop Area (1996 to 2006)
Mato Gross is a Big Exception

• Cattle share increased by almost 3%,
• Crops increased by almost 5 million hectares
• Mato Grosso was not land constrained

• Did cattle get “pushed” out or did they go where land was available?
Cattle were reallocated to some states where land was available in 1996.
Which Factor was Most Important?

• Did cattle simply go where land was available or did cattle get pushed out of states where crops were most profitable to grow?
  – States with least land available are not the same states that increased crop production so should be able to differentiate
Regression results for all states

- Dependent variable: Number of Cattle Reallocated

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<td>Cropland expansion ('000 ha)</td>
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<td>% crop expansion</td>
<td>-654</td>
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Regression results for subset of states (N = 16)

• Only include states in south and on frontier

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First Conclusion

• Cattle went to where there was land available
• Consistent with expansion of cattle herd in frontier states because of government policies
  – Need to show beneficial use to obtain title
• Weak evidence that cattle moved out of states where crops expanded and towards states that did not expand crops
  – Not all states that expanded crops lost cattle
Are Cattle a Placeholder for Crops?

• Hypothesis
  – Deforestation is caused by returns to land in crops
  – But cattle ranching is simply the first use of the land
  – Crops will follow

• If true in the time period observed, then we should see crops increase after some lag after deforestation
Deforestation and Crop Acres in Acré

- Cumulative deforestation
- Crop Acres

Graph showing the comparison of cumulative deforestation and crop acres over the years from 1988 to 2009.
Deforestation and Crop Acres in Maranhão

Cumulative deforestation and crop acres from 1988 to 2009. The blue line represents cumulative deforestation, and the red line represents crop acres.
Deforestation and Crop Acres in Roraima

Cumulative deforestation and crop acres from 1988 to 2009. The graph shows a steady increase in cumulative deforestation, while crop acres remain relatively flat.
Deforestation and Crop Acres in Tocantins

Cumulative deforestation and crop acres over the years from 1988 to 2009. The blue line represents cumulative deforestation, which shows a steady increase. The red line represents crop acres, which has seen fluctuations with a peak around 2003 and a steady increase since then.
Deforestation and Crop Acres in Mato Grosso

Cumulative deforestation and crop acres from 1988 to 2009.

- Cumulative deforestation: The blue line shows the increase in deforestation over the years.
- Crop Acres: The red line indicates the growth in crop acres over the same period.

The chart illustrates the significant increase in both deforestation and crop acres, with a particular focus on the years 1990 to 2000.
Observations

1. With the exception of Mato Grosso, the scale of deforestation many times greater than expansion in cropland
2. No evidence outside Mato Grosso that crops followed cattle
3. Either logging or cattle or land acquisition drove most deforestation.
Influence of Soy Prices on Deforestation in the Brazilian Amazon

Deforestation in the Brazilian Amazon states of Mato Grosso and Pará has shown a correlation to soy prices in recent years.
Is there a relationship between prices and deforestation?

• Look at how expected returns to crop production are correlated with crop acreage and deforestation
Deforestation Response to Expected Returns?

Crop returns

Lost forest

'000 ha
reais/ha
A Structural Change in Deforestation?

Crop returns

Forests lost
Reasons for Drop in Deforestation

• Need for Brazil to sell “green” products
  – Low carbon biofuels in EU and USA
  – Soybean moratorium
    • McDonalds and Carrefour
  – Cattle moratorium
    • Blairo Maggi extended soy moratorium to cattle
    • Walmart, Carrefour and Pão de Açúcar

• Better remote sensing and enforcement of legal preserves
TransAmazon Highway

BR-163 (to Amazon port)
Cargill Facility at the Port of Santerém
Lucas do Rio Verde Project
Projeto Lucas do Rio Verde Legal

Nossa experiência
Estamos mapeando e georreferenciando todas as propriedades rurais do município para identificar os passivos e ativos ambientais de áreas de reserva legal e áreas de preservação permanente. No total, mapeamos mais de 700 propriedades rurais, o que corresponde a aproximadamente 360 mil hectares. O compromisso do projeto é transformar Lucas do Rio Verde num dos únicos municípios do país sem passivos socioambientais no setor agropecuário, sem problemas trabalhistas e que utilize corretamente os agroquímicos. A iniciativa servirá de base para o estabelecimento de corredores ecológicos, a recuperação de áreas degradadas, o manejo e aproveitamento econômico das áreas de reserva legal e o incentivo à gestão de bacias hidrográficas.

Por que trabalhamos na região
Lucas do Rio Verde é um dos principais pólos de desenvolvimento agrícola do Estado de Mato Grosso. Embora a área do município represente apenas 0,04% do território brasileiro, ele participa com mais de 1% da produção nacional de grãos, o equivalente a 1,5 milhão de toneladas anuais. É o décimo produtor estadual de milho em quantidade e produtividade. O trabalho na região é voltado para conciliar o desenvolvimento econômico do município com ações de conservação efetiva do meio ambiente. Além disso, há um ambiente econômico, político e social que permite a implantação de ações de conservação.

Quem vive aqui
A cidade nasceu para a produção rural. Os habitantes do município e a economia são voltados para o agropecuário. Lucas é um município criado há menos de vinte anos e que hoje conta com uma infra-estrutura socioeconômica invejável, o que demonstra o dinamismo que a produção rural imprimiu à localidade.

Resultados
Alcançados:
- 700 propriedades rurais mapeadas e georreferenciadas.
- 100% do passivo ambiental identificado.
- Dois fóruns municipais de meio ambiente realizados. O último deles teve como tema o manejo adequado no uso de defensivos agrícolas.

Esperados:
- Redução dos custos de obtenção das informações que subsidiariam o licenciamento ambiental da propriedade rural.
- A transformação do município em modelo socioambiental rural para o Estado de Mato Grosso.
- Compensação dos passivos ambientais, especialmente reserva legal, de forma coletiva, facilitando a implantação de áreas de ecossistemas nativos contínuos sob proteção.
- 100% das propriedades rurais atendendo aos dispositivos do código florestal.
CÓDIGO FLORESTAL BRASILEIRO

RESERVA LEGAL

O Código Florestal Brasileiro, de 1965, e legislações posteriores, determinam que toda propriedade rural precisa ter uma área com vegetação nativa protegida correspondente a um percentual da área da propriedade. Esse percentual varia de 20% a 80% dependendo do bioma. No Cerrado, a reserva legal é de 20%, com exceção dos Estados de Mato Grosso, Tocantins e Maranhão, nos quais a reserva legal no Cerrado é de 35%.

ÁREAS DE PRESERVAÇÃO PERMANENTE (APP)

São áreas, segundo a legislação brasileira, que nunca podem ser desmatadas. Essas áreas são cabeceiras de rios, matas ciliares, áreas alagadas, vegetação de encosta e topo de morro. As matas ciliares variam de largura de acordo com o tamanho do rio: quanto mais largo o rio, mais larga será a mata ciliar.
Conclusions

• Increased cattle numbers associated with large deforestation
• Some evidence that increased crop production caused a reallocation of share historically
  – Statistical tests are weak
• Outside Mato Grosso, no evidence that crops followed cattle onto deforested land
• Strong evidence that a change in technology and enforcement has broken historical correlations between crops and deforestation
Implications for Models

- New driver of deforestation is enforcement of environmental rules and voluntary adoption of soy and cattle moratoriums.
- If rules are enforced, plenty of land to accommodate expansion of agriculture with minimal added deforestation.