Land Use Change in the California LCFS, Uncertainty, and Time

The research reported here was partially supported by the California Air Resources Board and the Energy Biosciences Institute and does not necessarily represent the view of either organization

Michael O’Hare
Goldman School of Public Policy
Univ. of California, Berkeley
ohare@berkeley.edu
Thanks!

Alex Farrell
Mark Delucchi
CARB
EBI
Kevin Fingerman
Andy Jones
Dan Kammen
Tom Hertel
Alissa Kendall
Jeremy Martin
Erin Palermo
Rich Plevin
Sabrina Spatari
Dan Sperling
Brian Turner
Sonia Yeh
LUC in the LCFS

• For producer $j$ in year $t$ who blends $Q_i$ units of fuel with GHI index $G_i$, the fine (or sale of credits) when the standard is $S_t$ will be:

$$AFCI_{jt} = G_p Q_p + \{G_b + iLUC\} Q_b$$

$$C_{jt} = (S_t - AFCI_{jt}) PQ_t$$

Policy implementation comprises (mostly) establishing operational definitions for these variables.
Example

Reduction required 10%
(Gasoline 96 -> 86)

Blend limit 20%

GWI required 45
Fuel

Less food, less meat

Higher Yields (intensity)

Overseas LUC

Domestic LUC

Shares determined by prices and elasticities

iLUC modeling estimates four quantities
<table>
<thead>
<tr>
<th>Fuel</th>
<th>Direct</th>
<th>Indirect*</th>
<th>Total [constant food]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoline</td>
<td>96</td>
<td>0</td>
<td>96 [96]</td>
</tr>
<tr>
<td>Avg. corn ethanol</td>
<td>69</td>
<td>30* **</td>
<td>99 [114]</td>
</tr>
<tr>
<td>Sugarcane ethanol</td>
<td>27</td>
<td>46**</td>
<td>73</td>
</tr>
<tr>
<td>Soybean diesel</td>
<td>27</td>
<td>42**</td>
<td>69</td>
</tr>
<tr>
<td>Electricity</td>
<td>105</td>
<td>(efficiency)</td>
<td>39 [39]</td>
</tr>
</tbody>
</table>

*too low, because of production time
** too low, because of atmospheric residence time (and food?)
Choose increment in biofuels production

Start/end dates
Elasticities
Trade patterns
Policy model

Estimate market impacts

Ecosystem and Geographic data

Map new acreage to ecosystem types

Carbon stock data
Carbon discharge model

Estimate carbon flux

Air physics and chemistry
Residence times
Forcing
Calamity risk
Discounting

Amortize or discount over time

CGE LUC Model Process

e.g., 15 to 30 B gal/yr

economic equilibrium model estimates new acres

may be endogenous or based on historical data

some portion of above-ground and soil carbon

several competing methods have been proposed
(from Hertel et al 2009)
How might these LUC AFCI results be too high/low?

- Higher yields of all crops
- Different allocations of “makeup” to different natural lands
- Better C stock & land use data
- Coproduct accounting
- Counting C recapture after production
- Albedo changes (e.g., snow on former boreal/temperate forest land)
- Nitrogen cycle (yield increase from fertilizer)
- Time and warming effect
- Other greenhouse gases (e.g., cattle, rice methane)
- Extremely low-AFCI biofuel crops (e.g., mixed perennials for biomass conversion)
- Production period
- More conversion from lower-C land types (pasture)
- Increased cattle intensity/better practice
Key concepts and cautions

*Ceteris paribus* principle: Models estimate GHG in atmosphere because of biofuel use that is additional to GHG from everything else happening.

*Implication*: exogenous yield increase does not “make up for” iLUC (but does reduce it)

iLUC cannot be observed in any particular place: it is diffuse and averaged over varying effects.
Four big issues for iLUC (indirect land use change emissions)

• How big is it
  – especially, is it bigger than [GWI(petroleum) - GWI(direct biofuel)]?
  – Can it be reduced at the point of production or consumption?
  – Yields are critical (cellulosic), non-food-competitive feedstocks

• Policymaking and uncertainty in LUC estimates

• Time and fuel GHG comparisons

• Application to non-biofuel contexts
  – Oil and nuclear (capital intensive)
  – Housing and sprawl
  – Highways
  – Coal
  – Oil sands
  – FFF
  – Parks
What policies and practices *in producing and consuming jurisdictions* can reduce iLUC?

Almost nothing except yield.
Corn ethanol: 25 yrs production, 60g direct emissions, 776 g LUC, 30 yrs recovery of 50% of LUC

http://rael.berkeley.edu/BTIME
Corn ethanol: 25 yrs production, 60g direct emissions, 776 g LUC, 30 yrs recovery of 50% of LUC
How should we think about uncertainty?

• Is the GHG intensity of a biofuel an RV with a PDF?
• If so, what statistic should be used for its GHG index in a regulatory context?
• What does the cost-of-being-wrong function look like?

Bayesian posterior

Prior
Model Uncertainty and Parameter Uncertainty

UC/Purdue Maize ethanol

Searchinger Maize ethanol

Gasoline – direct ethanol

g/MJ (linear amortization, 30 yr)
World GHG Emissions Flow Chart

<table>
<thead>
<tr>
<th>Sector</th>
<th>End Use/Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation 13.5%</td>
<td>Road 9.9%</td>
</tr>
<tr>
<td></td>
<td>Air 1.6%</td>
</tr>
<tr>
<td></td>
<td>Rail, Ship, &amp; Other Transport 2.3%</td>
</tr>
<tr>
<td>Electricity &amp; Heat 24.6%</td>
<td>Residential Buildings 9.9%</td>
</tr>
<tr>
<td>Other Fuel Combustion 9.0%</td>
<td>Commercial Buildings 5.4%</td>
</tr>
<tr>
<td>Industry 10.4%</td>
<td>Unallocated Fuel Combustion 3.5%</td>
</tr>
<tr>
<td>Fugitive Emissions 2.9%</td>
<td>Iron &amp; Steel 3.2%</td>
</tr>
<tr>
<td>Industrial Processes 9.4%</td>
<td>Agriculture 15.6%</td>
</tr>
<tr>
<td>Land Use Change 18.2%</td>
<td>Agriculture Soils 6.0%</td>
</tr>
<tr>
<td>Agriculture 19.5%</td>
<td>Livestock &amp; Manure 5.1%</td>
</tr>
<tr>
<td>Waste 9.6%</td>
<td>Methane (CH4) 14%</td>
</tr>
<tr>
<td></td>
<td>Nitrous Oxide (N2O) 8%</td>
</tr>
</tbody>
</table>

Sources & Notes: All data is for 2000. All calculations are based on CO2 equivalents, using 100-year global warming potentials from the IPCC (1996), based on a total global estimate of 41,766 MTCO2 equivalent. Land use change includes both emissions and absorptions; see Chapter 16. See Appendix 2 for detailed description of sector and end use/activity definitions, as well as data sources. Dotted lines represent flows of less than 0.1% percent of total GHG emissions.
How big is LUC?

• Big
  (details to follow)
Time and early discharges change GW estimation
LCFS in practice

- For producer $j$ in year $t$ who blends $Q_i$ units of fuel with GHI index $G_i$, the fine (or sale of credits) when the standard is $S_t$ will be:

$$\text{AFCI}_{jt} = G_p Q_p + \{G_b + \text{ILUC}\} Q_b$$

$$C_{jt} = (S_t - \text{AFCI}_{jt}) PQ_t$$

*ILUC is the elephant in the room of biofuels policy*
LCFS in practice

• For producer $j$ in year $t$ who blends $Q_i$ units of fuel with GHI index $G_i$, the fine (or sale of credits) when the standard is $S_t$ will be:

$$AFCI_{jt} = G_p Q_p + \{G_b + \} Q_b$$

$$C_{jt} = (S_t - AFCI_{jt}) PQ_t$$

Direct LCA
Key parameters

- Fuel yield
- Price elasticity of yield: higher causes less LUC
- Productivity of new land: higher causes less LUC
- Cultivation period: longer causes lower GWI
- Carbon stock data
- Recapture (time and amount)
- Discount rate
(from Hertel et al 2009)
Idle lands and yield increases

• If there is a dynamic *fff/wild boundary* anywhere, the only biofuel crops without iLUC GHG releases are grown on land that cannot grow food

Thought experiment:

(1) *Increase yields, or find ‘idle’ land with low C stock:* a notional empty field.

(2) *Should it be planted with*

   (1) *fff, with GHG benefits from moving the boundary back (slow sequestration) or forward more slowly (avoided fast release), or*

   (2) *Biofuel, with GHG benefits from displacing fossil fuel?*

(3) *Is the answer different if the land to be planted is now in agriculture?*
What is the RV estimated by these models?

Precisely, it is the value of the LUC GW term as defined by the particular model used considering the variability in its underlying parameters.

It is not, except incidentally, the value a different model would produce.

The concept of operational definition is central here.

The “uncertainty issue” is the gap between scientific prediction or estimation and the unyielding demand of policy on the ground for a scalar value with infinite precision, and no “safe” direction to err.
Time and “counting” GHG

• A unit of GHG discharge now is much worse than a unit twenty years from now

  – Residence time

  – Irreversibilities: probability of a calamity such as collapse of a large grounded ice cap or stopping of the Gulf Stream that would vitiate further GHG reduction.

  – Stern-Nordhaus debate on discounting
Key time issues

• Production period
• Analytic horizon
• Policy horizon
• Policy criterion:
  – Fuel carbon content
  – Atmospheric carbon at target time
  – Integral of carbon release
  – Warming
  – Social cost
FWP(t) is total warming up to time t

Discounted at 2.5%
Implications

• These models still don’t include diminishing warming effect with increasing atmospheric C or other discharges

• …but even with a very low initial discharge (800 gm/MJ-y capacity) and 25 years’ production there’s no time in the next century when there is meaningful GW benefit from using maize ethanol instead of gasoline.
Brasil is important

- “Far end” of iLUC causal chain
- Is cane ethanol a good LCFS compliance path if we don’t have corn ethanol?
- What about biodiesel?
- LUC is critical (CARB: 25 & 45 g)
- Local policy is critical
- Experience instructive for ROW

---

**Kenyan courts halt $370 million sugarcane, ethanol project over environmental concerns**

July 14, 2008

http://biofuelsdigest.com/blog2/2008/07/14/kenyan-courts-halt-370-million-sugarcane-ethanol-project-over-environmental-concerns/
FAZENDA ECOLÓGICA – Nª Sª DO LIVRAMENTO – MT
PASTAGEM DEGRADADA – MORRO DA CAIXA D’ÁGUA - (1.994)

1 animal/ha
PASTOREIO RACIONAL VOISIN

Formalizado por André Voisin (1.957)

SISTEMA DE MANEJO QUE PERMITE O EQUÍBRIO DO TRINÔMIO

SOLO  PASTO  GADO

ONDE CADA ELEMENTO TEM UM EFEITO POSITIVO SOBRE OS OUTROS DOIS
Gado em Pastoreio Voisin na Pastagem Ecológica
Fazenda Ecológica - Nossa Senhora do Livramento - MT

4 animals/ha
GW effects from cane

- Possible (cattle intensification absorbs cane land use) vs. likely (cattle expand into natural land).
- Direct cane GHG is very low (Goldemberg et al 2008, Macedo et al 2004, 2008)
- LUC is critical
- At 20% blend, LCFS target requires 45g ethanol
- WTO rules will matter for policy use
Do we want to make liquid fuel out of biomass anyway?

...or just burn it to make electricity and displace coal!
Non-climate issues

• Biofuel crops are mostly
  – Low labor input
  – Industrial monocrop agriculture
  – Land-hungry
  – Water-thirsty

• Next issues will be “sustainability” considerations
  – Species diversity
  – Rural sociology and economics
  – Etc.
“Sustainability” is another whole can of worms!

Assessment of effects and association with ‘batches’ of fuel
Local enforcement capacity
Commensuration (dimensions & prices)
Application in a regulatory environment with real $ consequences and court oversight
WTO rules
“Goal creep”: LCFS and EISA are GW (energy security) policies, not ‘every good thing’ policies
Your thoughts?