Biofuels: Land Use Change, Uncertainty, and Time

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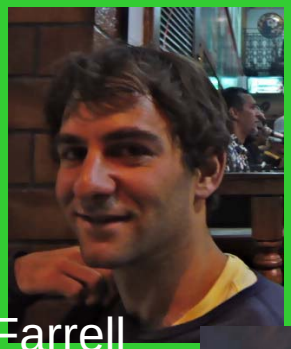
Thanks!



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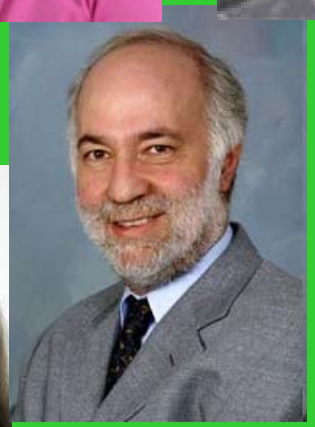

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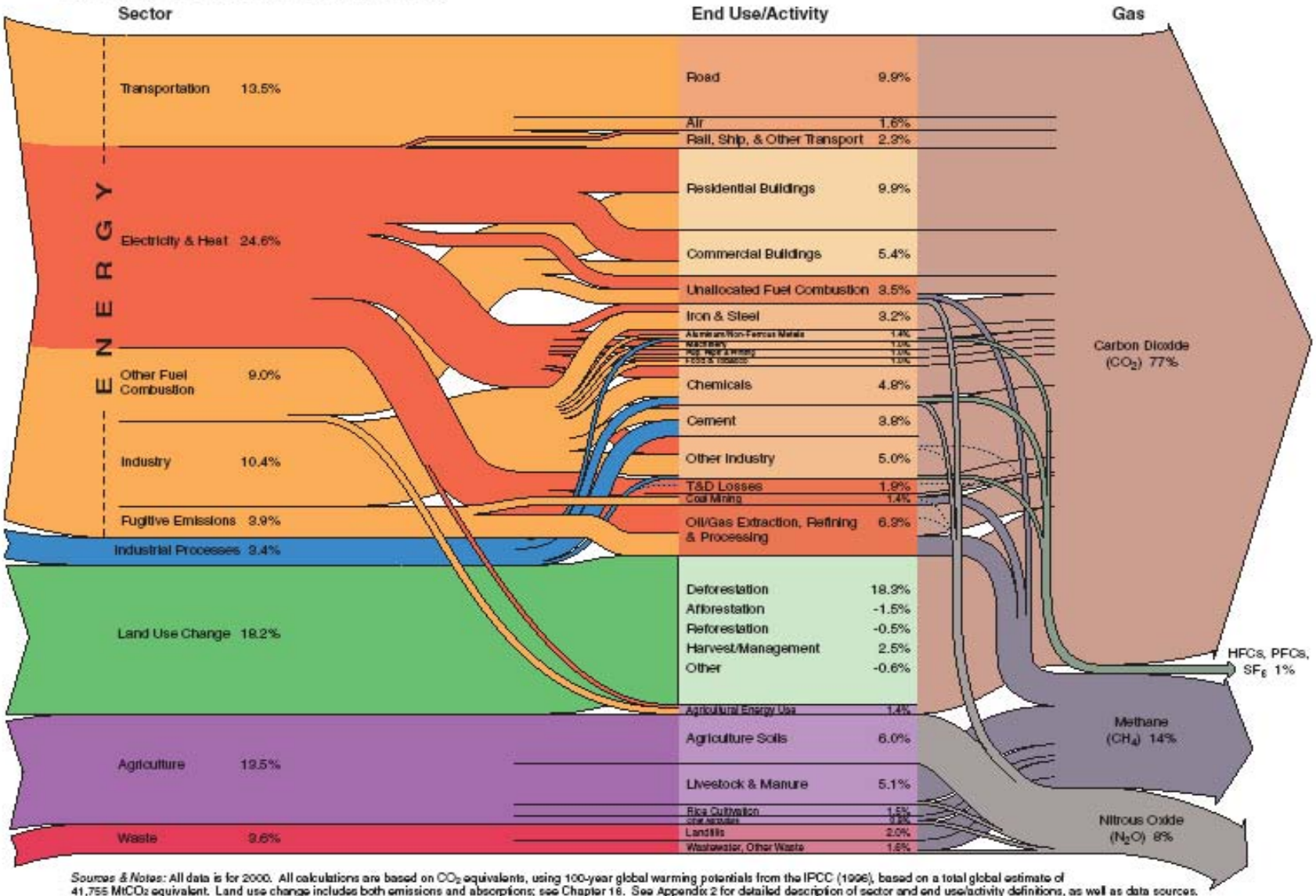
World GHG Emissions Flow Chart



Sources & Notes: All data is for 2000. All calculations are based on CO_2 equivalents, using 100-year global warming potentials from the IPCC (1996), based on a total global estimate of 41,755 $MtCO_2$ 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.

Five big issues for iLUC (indirect land use change emissions)

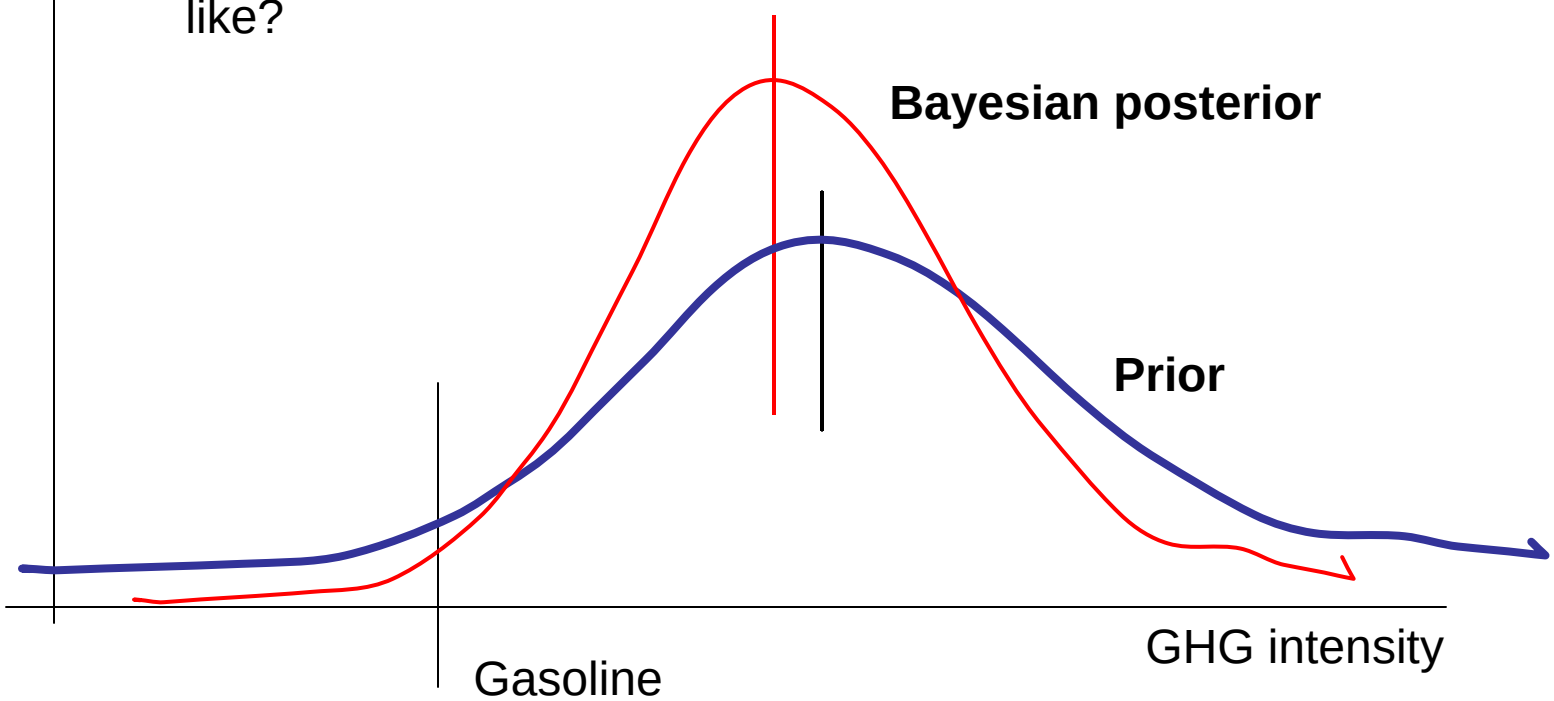
- How big is it
  - especially, is it bigger than [GWI(petroleum) - GWI(direct biofuel)?
  - Can it be reduced at the point of production or consumption?
  - What about yields?
- Policymaking and uncertainty in LUC estimates
- Time and fuel GHG comparisons
- International considerations
- Application to non-biofuel contexts
  - Oil and nuclear (capital intensive)
  - Housing and sprawl
  - Highways
  - Coal
  - Oil sands
  - FFF!

How big is LUC?

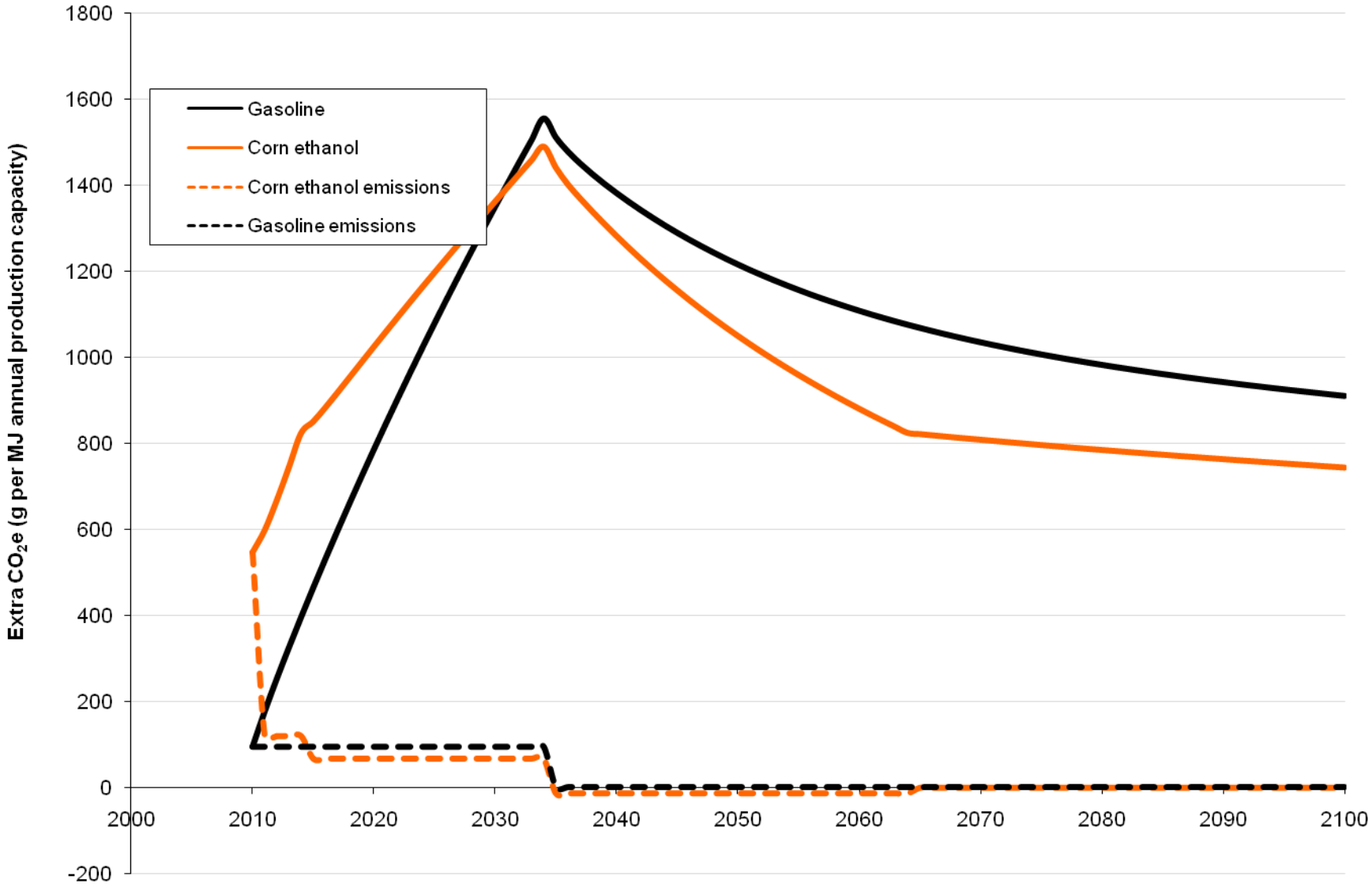
- Big
  (details to follow)

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?



Time and early discharges change GW estimation



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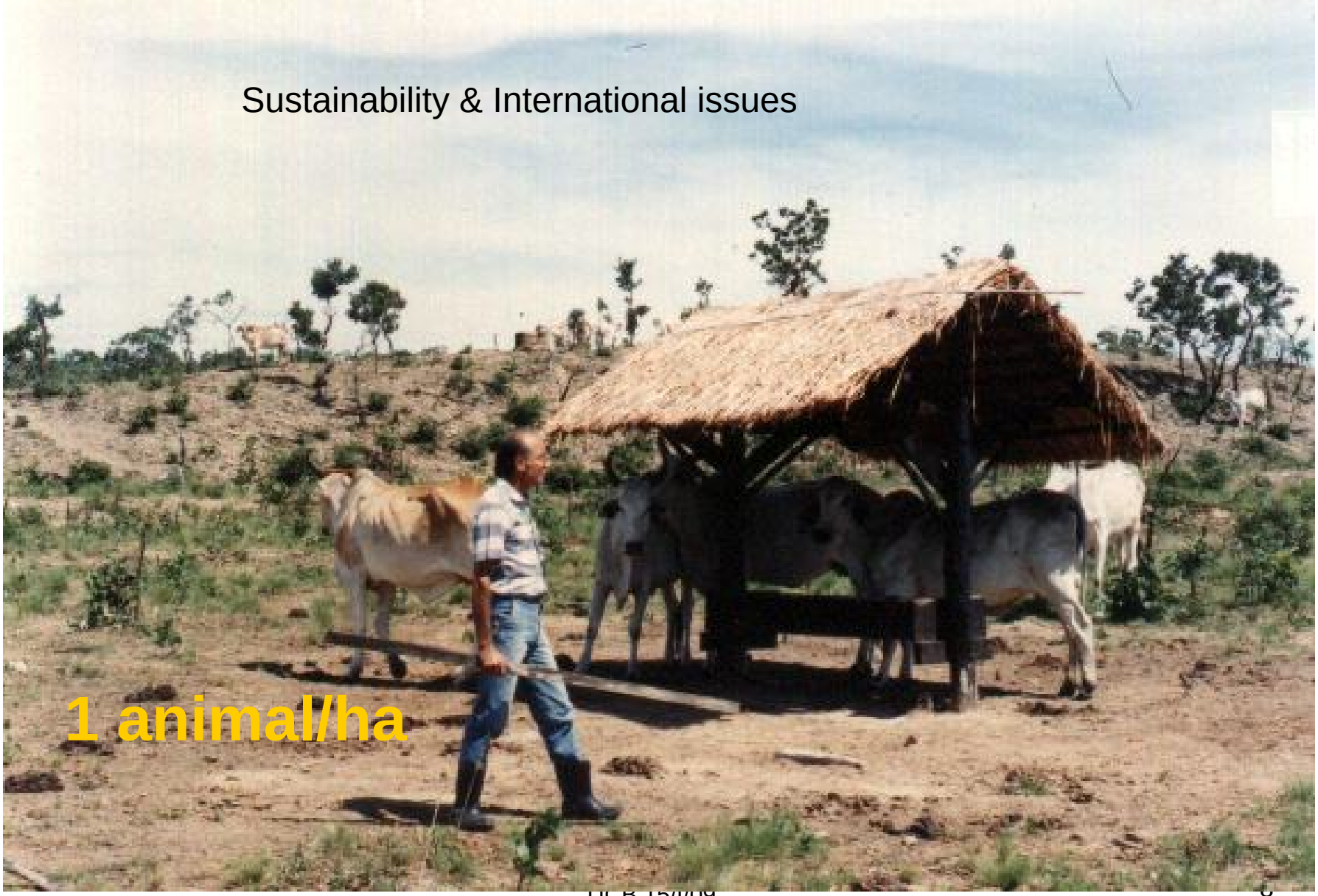


LUC in the LCFS

- 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:

Direct LCA

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

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

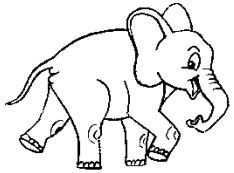
Policy implementation comprises (mostly) establishing operational definitions for these variables.

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:

Direct LCA

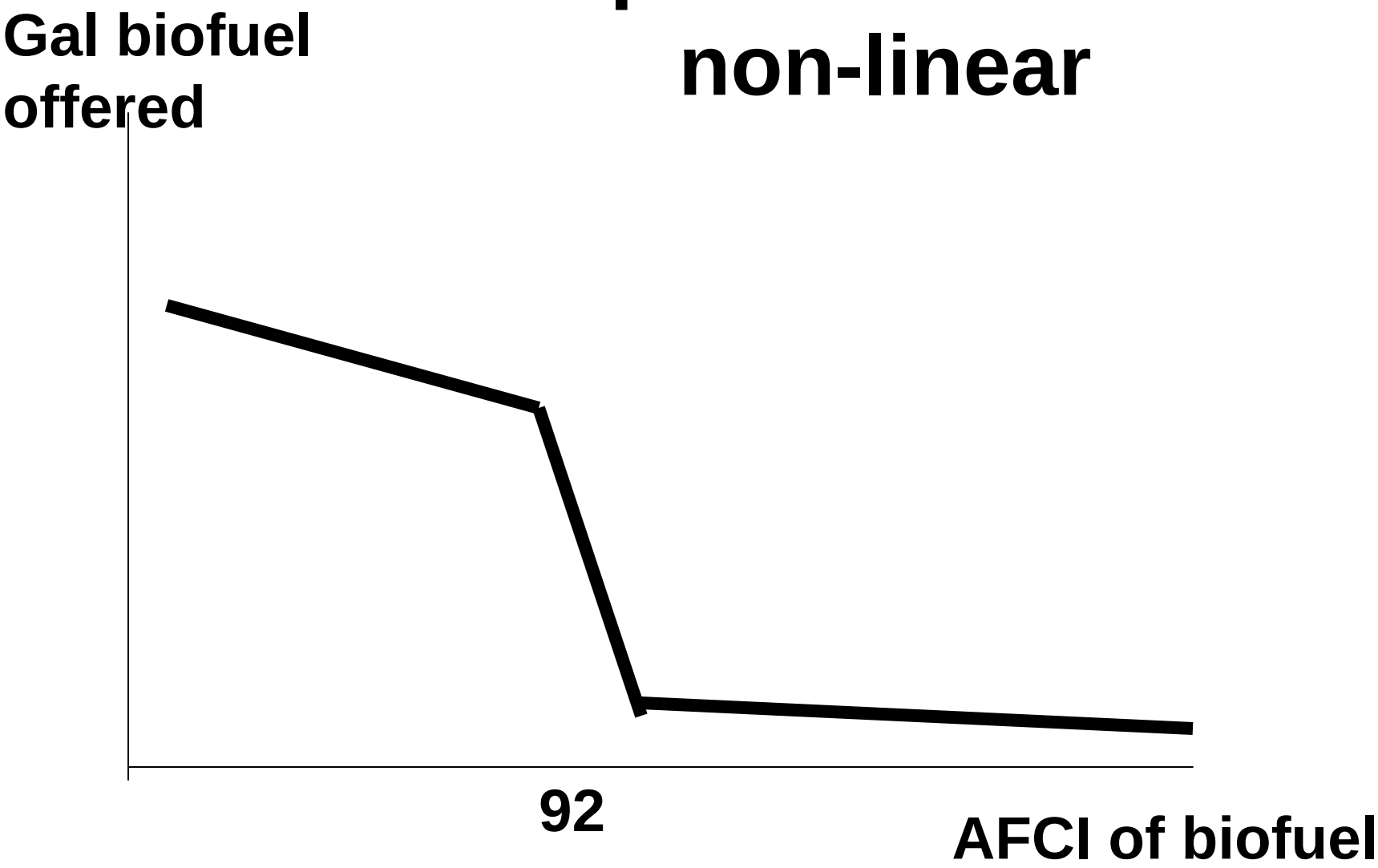
$$AFCI_{jt} = \boxed{G_p} Q_p + \{\boxed{G_b} + \}Q_b$$

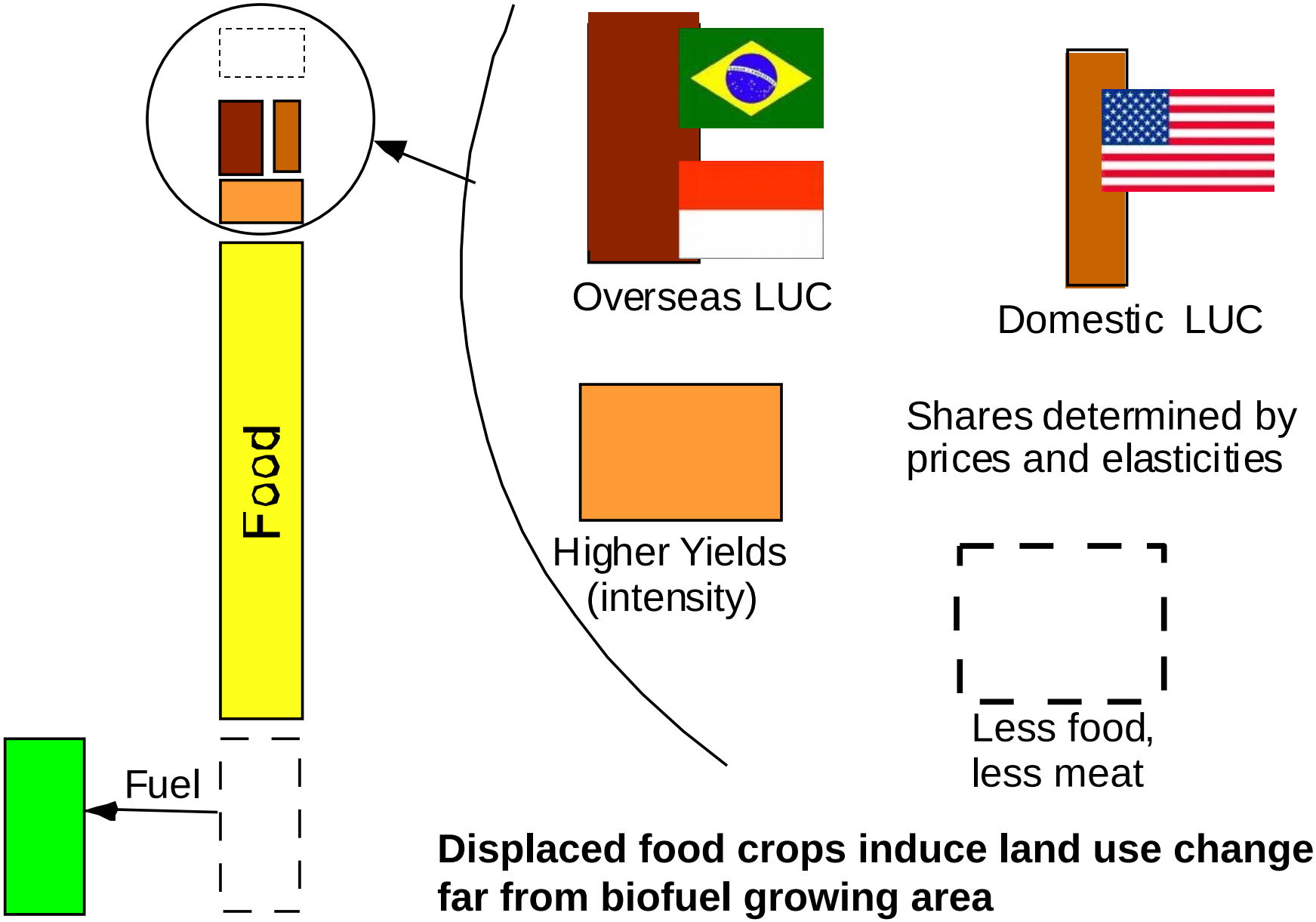


$$C_{jt} = \left(S_t - AFCI_{jt}\right)PQ_t$$

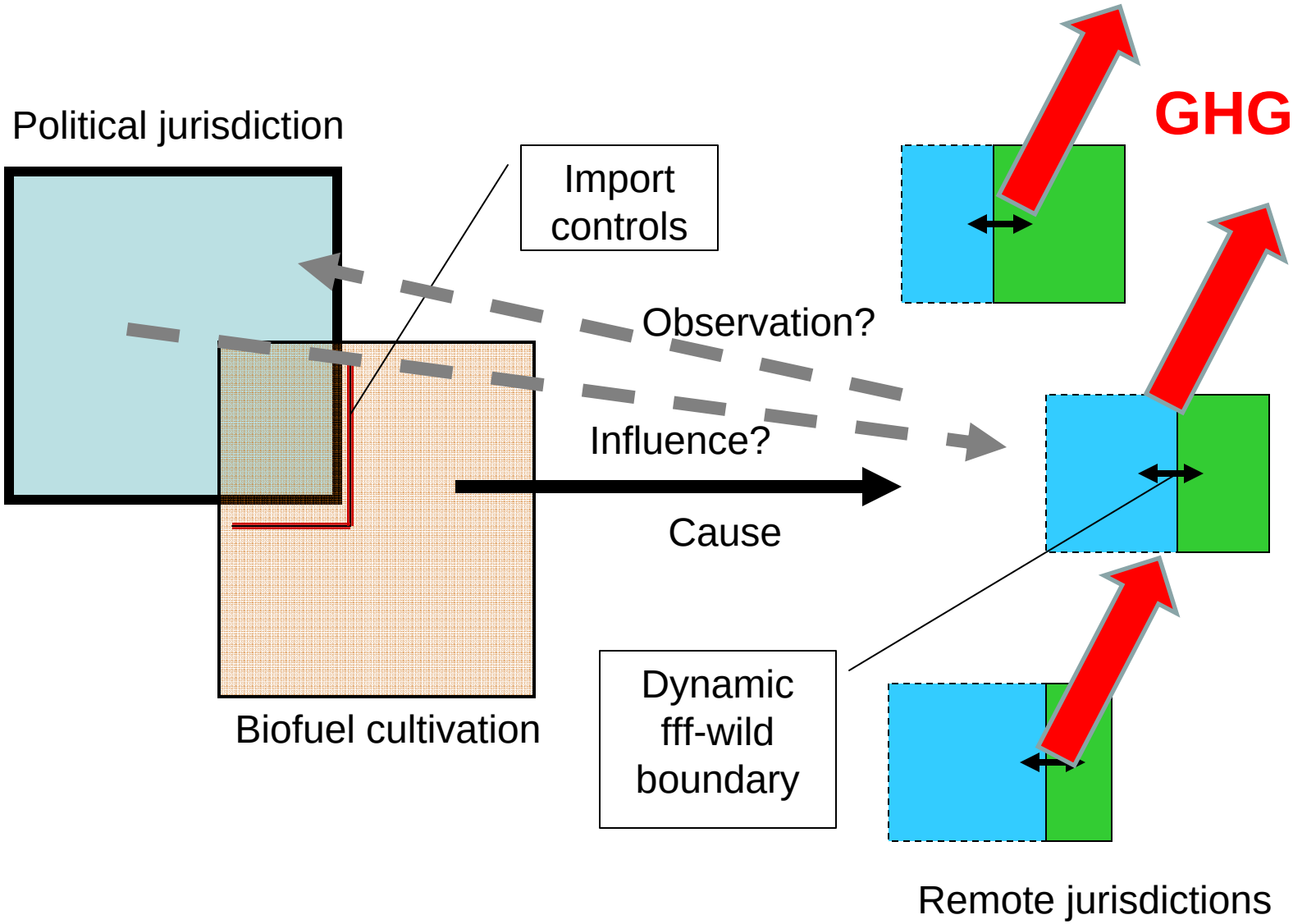
ILUC is the elephant in the room of biofuels policy

Response function is non-linear





Displaced food crops induce land use change far from biofuel growing area


Political jurisdiction
Import controls
Observation?
Influence?
Cause
GHG
Biofuel cultivation
Dynamic fff-wild boundary
Remote jurisdictions

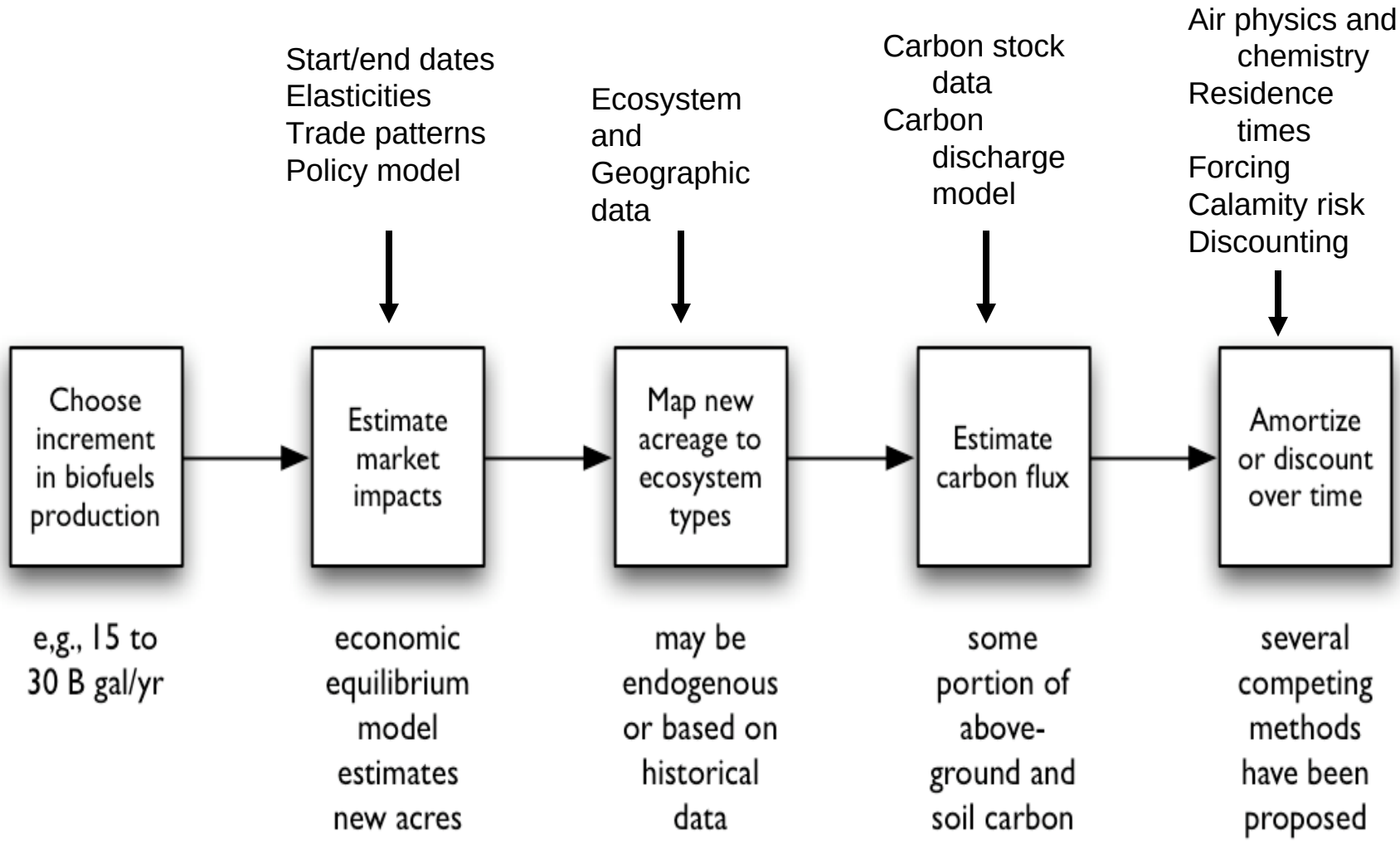
How big is LUC?

- Cal/Purdue GTAP estimates for corn ethanol at 2007 yields are about
  - 800 g/MJy allowing food prices and consumption to rise/fall *(note: not g/MJ)*

    (“straight-face” range about 500-4000)
  - 1200 g/Mjy holding food constant
  - Searchinger 2008: ~3000
- Gasoline is about 95 g/MJ
- CARB is using 70 g/MJ for average direct corn ethanol

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



CGE LUC Model Process

Decomposition of LUC

Gross US land for 56 GL ethanol: 15 m ha

Reduced exports and coproducts: 6 m ha

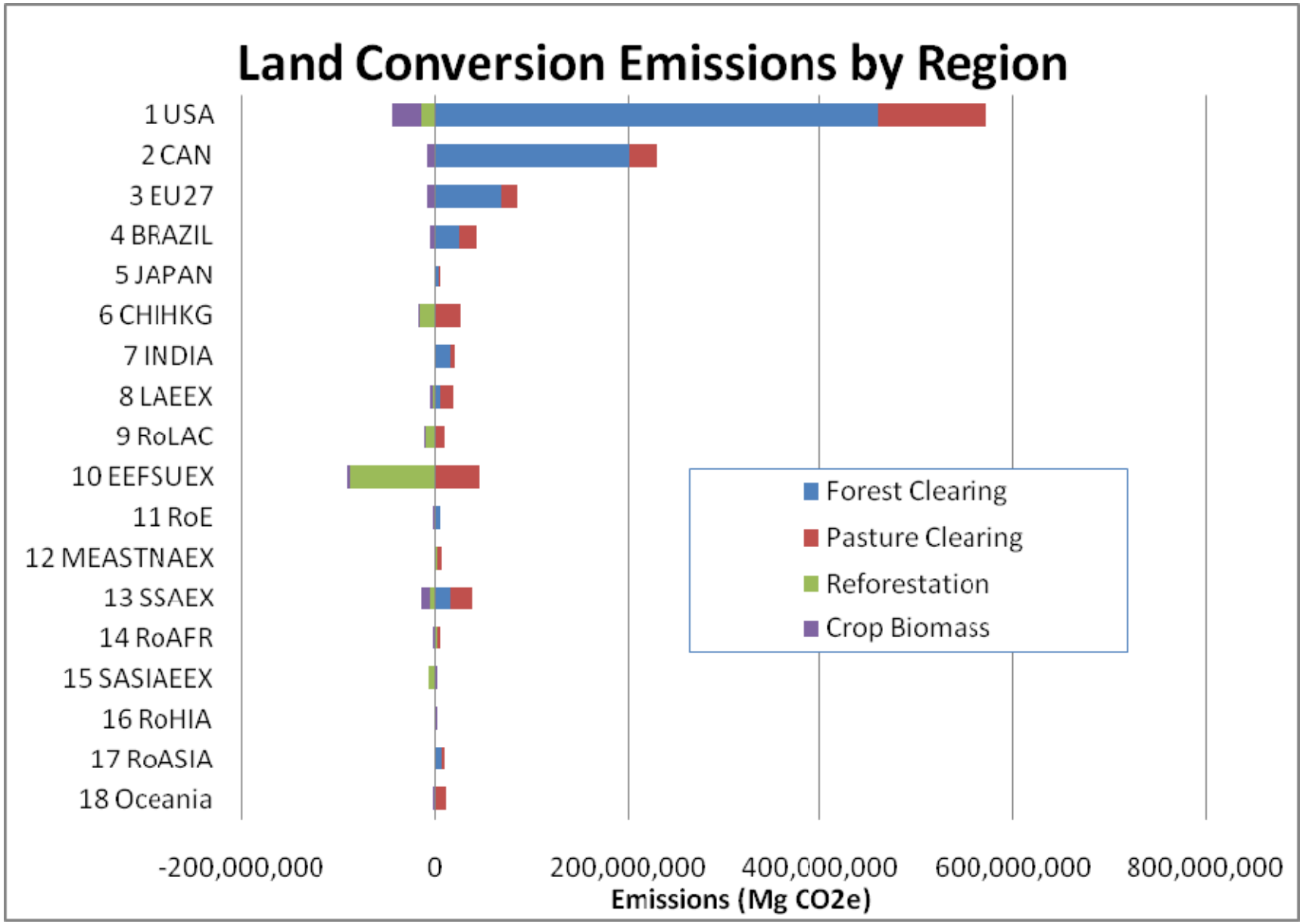
–of which: from other crops: 4.4 mha
from forest & pasture 1.6 mha

Increased cultivation outside US: 2.6 mha

Total conversion to cultivation: 4.2 mha

BUT: grain prices increase 8% (other crops less)
grain consumption decreases 0.35%, other food less

Holding food consumption constant increases LUC by about 50%


Land Conversion Emissions by Region
1 USA
2 CAN
3 EU27
4 BRAZIL
5 JAPAN
6 CHIHKG
7 INDIA
8 LAEEX
9 RoLAC
10 EEFSUEX
11 RoE
12 MEASTNAEX
13 SSAEX
14 RoAFR
15 SASIAEEX
16 RoHIA
17 RoASIA
18 Oceania
Forest Clearing
Pasture Clearing
Reforestation
Crop Biomass
-200,000,000
0
200,000,000
400,000,000
600,000,000
800,000,000
Emissions (Mg CO2e)

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 (eg, snow on former boreal/temperate forest land)
- Nitrogen cycle
- Other greenhouse gases (eg, cattle, rice methane)
- Extremely low-AFCI biofuel crops (e.g mixed perennials for biomass conversion)
- More conversion from lower-C land types (pasture)
- Increased cattle intensity/better practice

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:

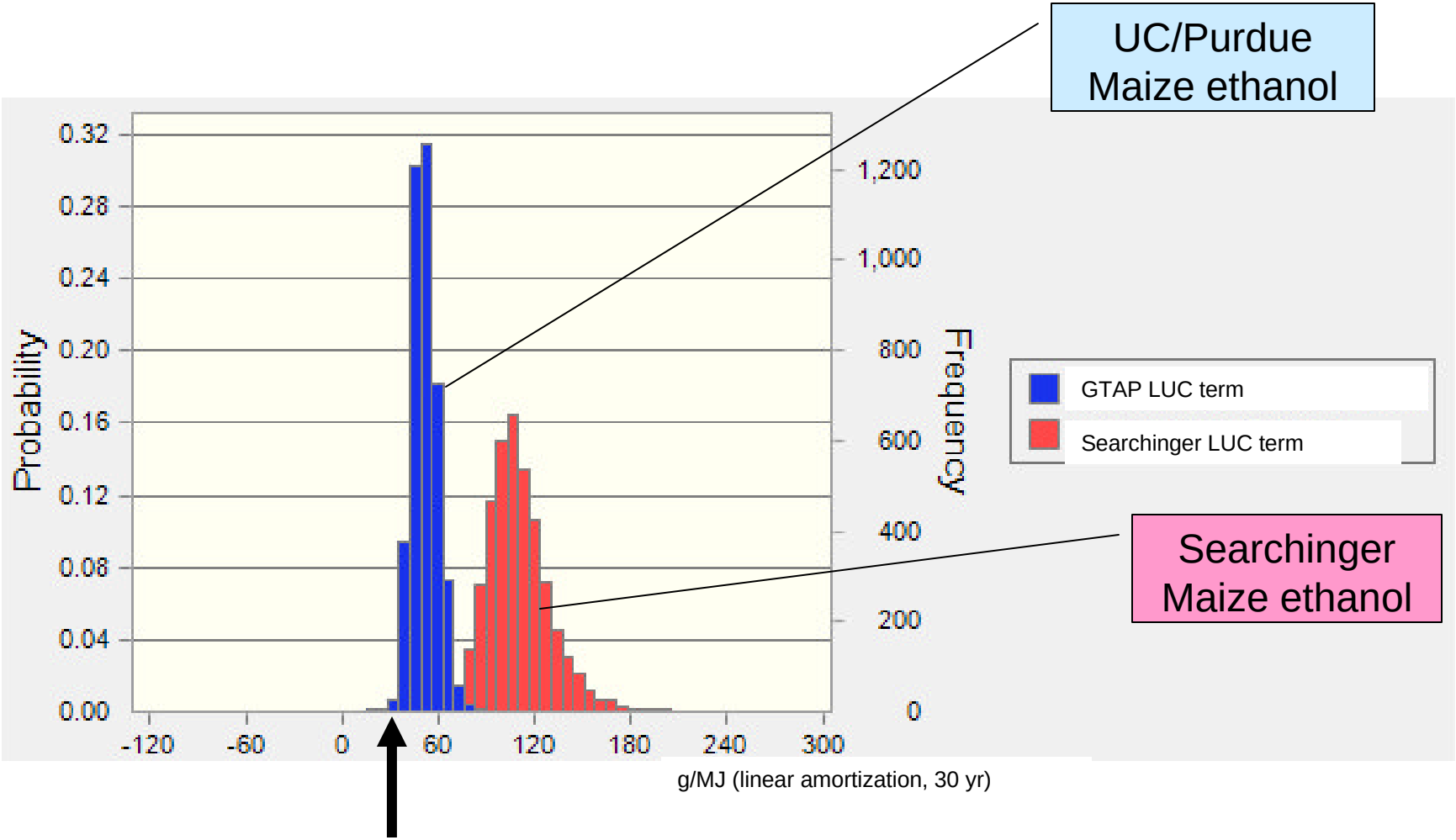
(1) Increase yields, or find 'idle' land with low C stock: a notional empty field.

(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?

Model Uncertainty and Parameter Uncertainty



Gasoline – direct ethanol

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.

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

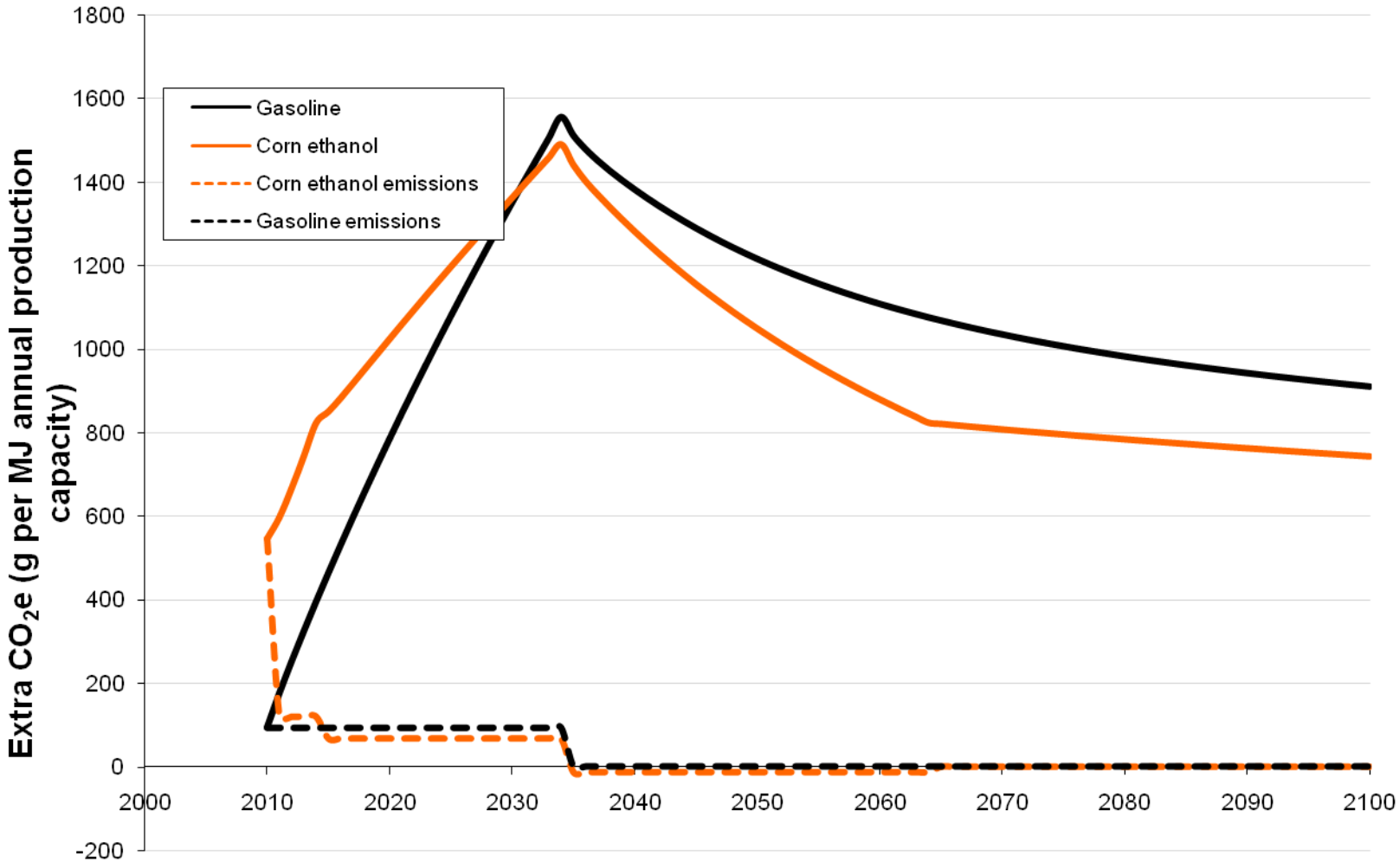
Key time issues

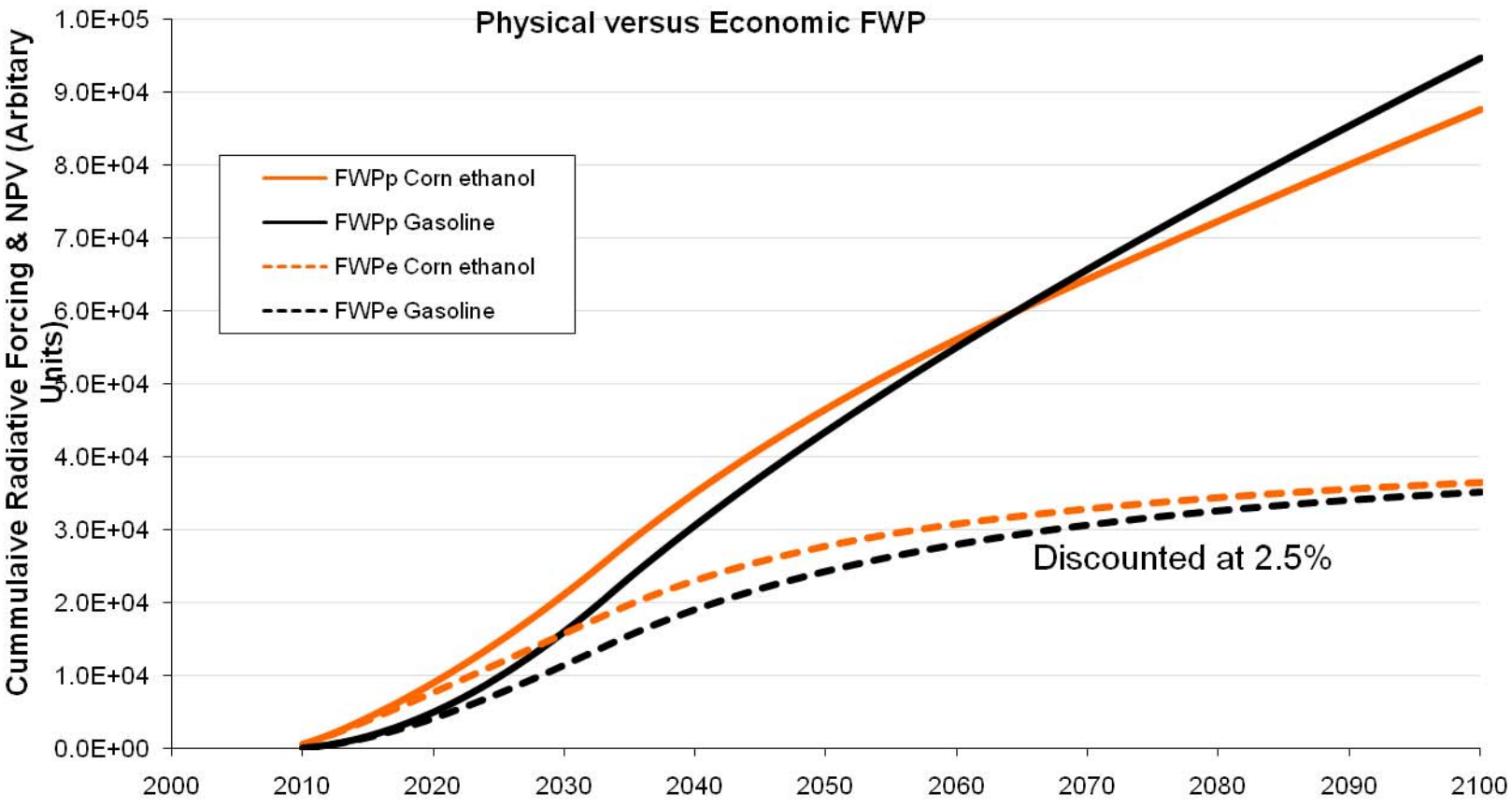
- Production period
- Analytic horizon
- Policy horizon
- Policy goal choice:
  - Fuel carbon content
  - Atmospheric carbon at target time
  - Integral of carbon release
  - Warming
  - Social cost

Discharges to costs

- **Discharge(t)**
  - Decay
- **Atmospheric concentration(t)**
  - Forcing(concentration)
- **Temperature(t)**
  - Climate, water, adaptation, etc.
- **Costs(t)**
  - Discounting
- **NPV**

Corn ethanol: 25 yrs production, 60g direct emissions, 776 g LUC, 30 yrs recovery of 50% of LUC





FWP(t) is total warming up to time t

Implications

- These models still don't include diminishing warming effect with increasing atmospheric C
- …but even with a very low initial discharge (800 gm/MJ-y capacity), 25 years' production, and a low *r, 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
- Local policy is critical (cattle management, forest protection)
- 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/

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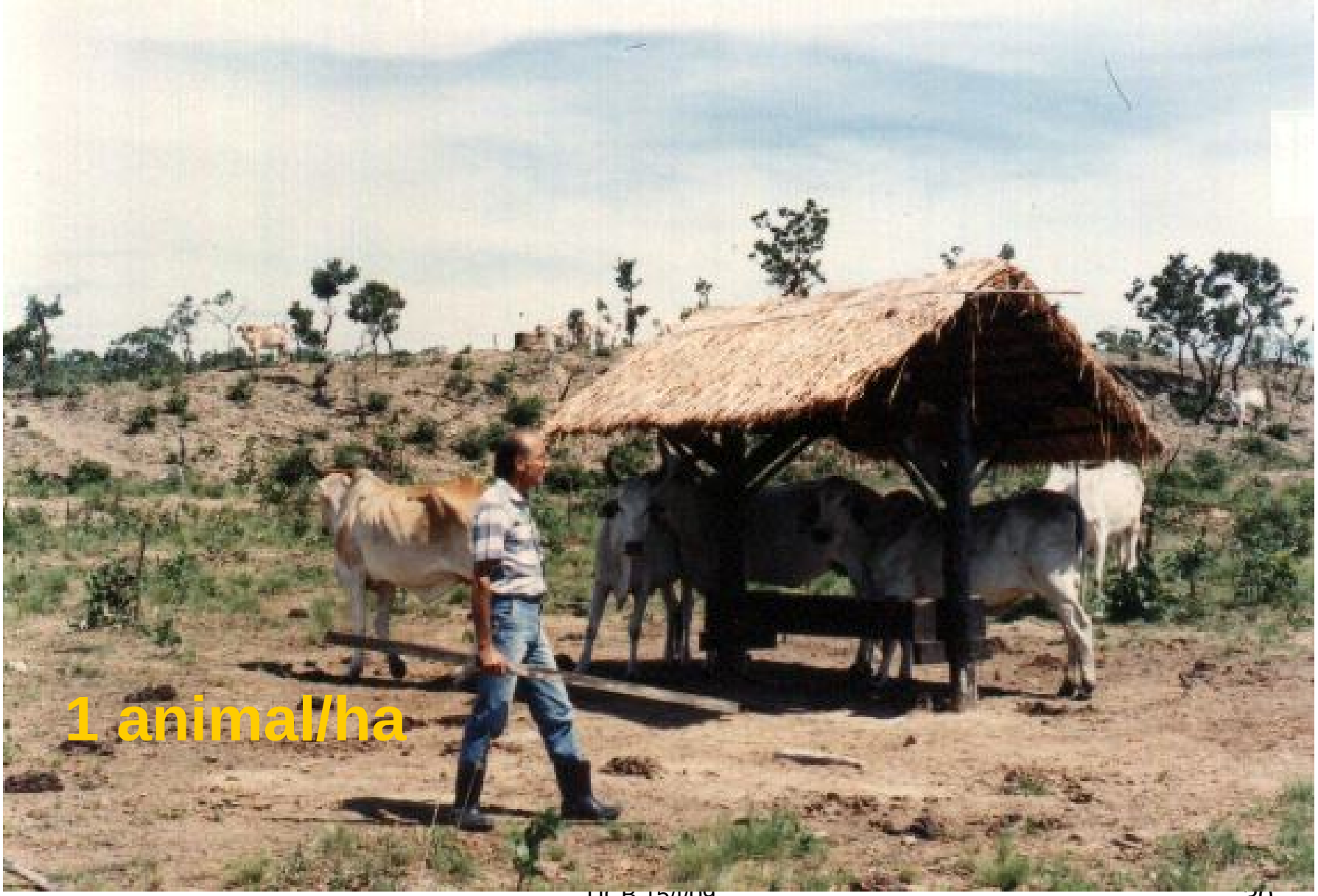


PASTOREIO RACIONAL VOISIN

Formalizado por André Voisin (1.957)

SISTEMA DE MANEJO QUE PERMITE

O EQUIÍBRIO 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

LUC 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 and not included
- Need CGE models
- WTO rules will matter for policy

Some biofuels will not have LUC effects

- MSW
- Forestry waste
- Used food oils
- Agricultural ‘waste’
- Algae
- Biomass crops on waste land

BUT these are scarce, or years away…

Non-climate issues

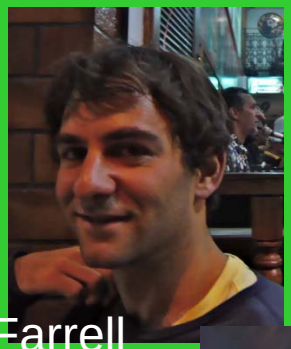
- Biofuel crops are mostly
  - Low labor input
  - Industrial monocrop agriculture
  - Land-hungry
  - Water-thirsty

- Next issues will be “sustainability” considerations
  - Species diversity
  - Rural sociology and economics
  - Etc.

“Sustainability” is another whole can of worms!

- Assessment of effects
- Association with ‘batches’ of fuel
- Local enforcement capacity
- Commensuration
- 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

Thanks!



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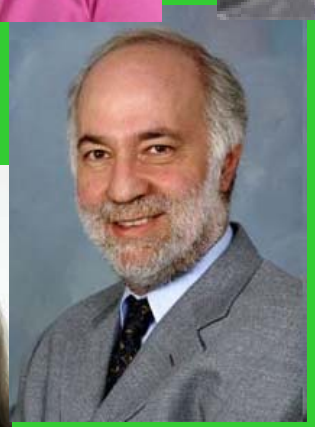

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Your thoughts?