# Land Use Change and LCFS/RFS Policy

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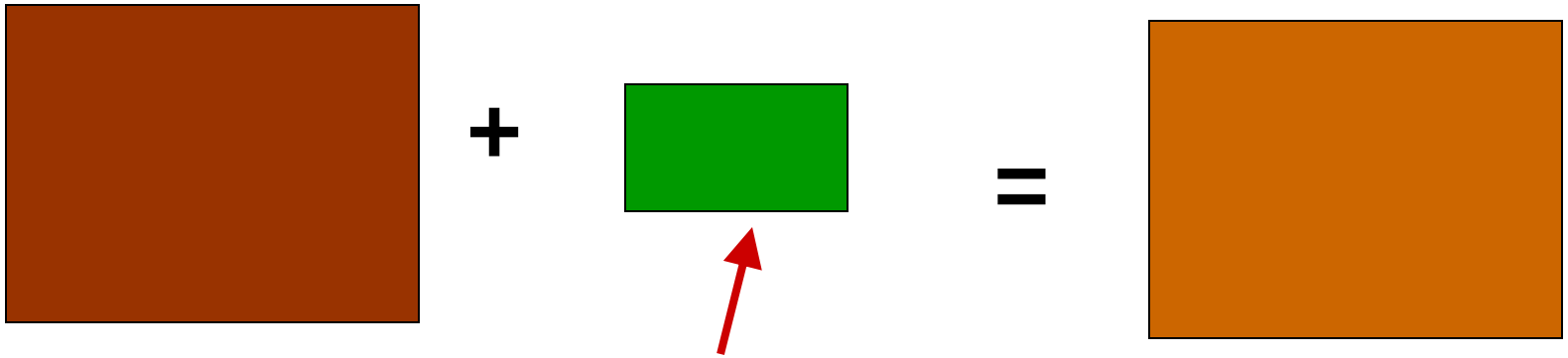
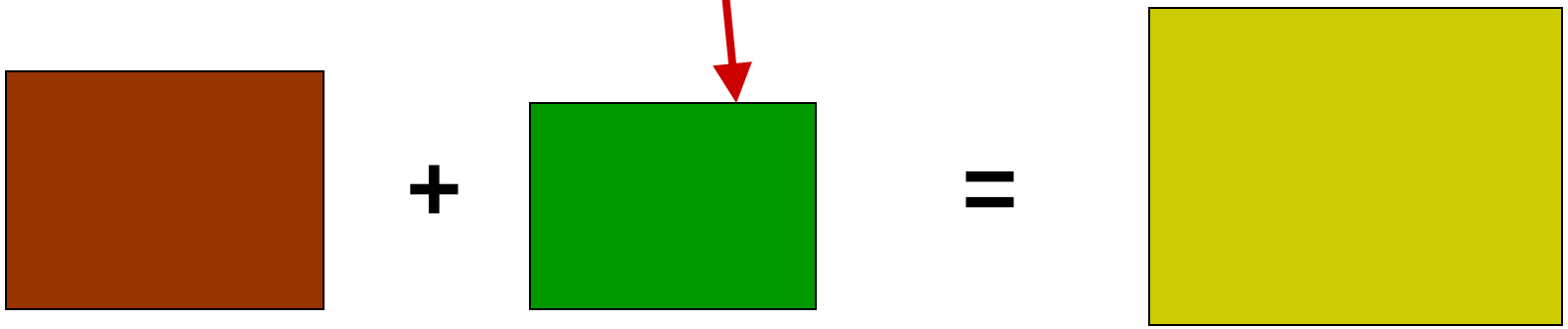
# LCFS liquid fuel concept




If this is a biofuel,
how green is it?

**2010**




**2020**

# Cookbook

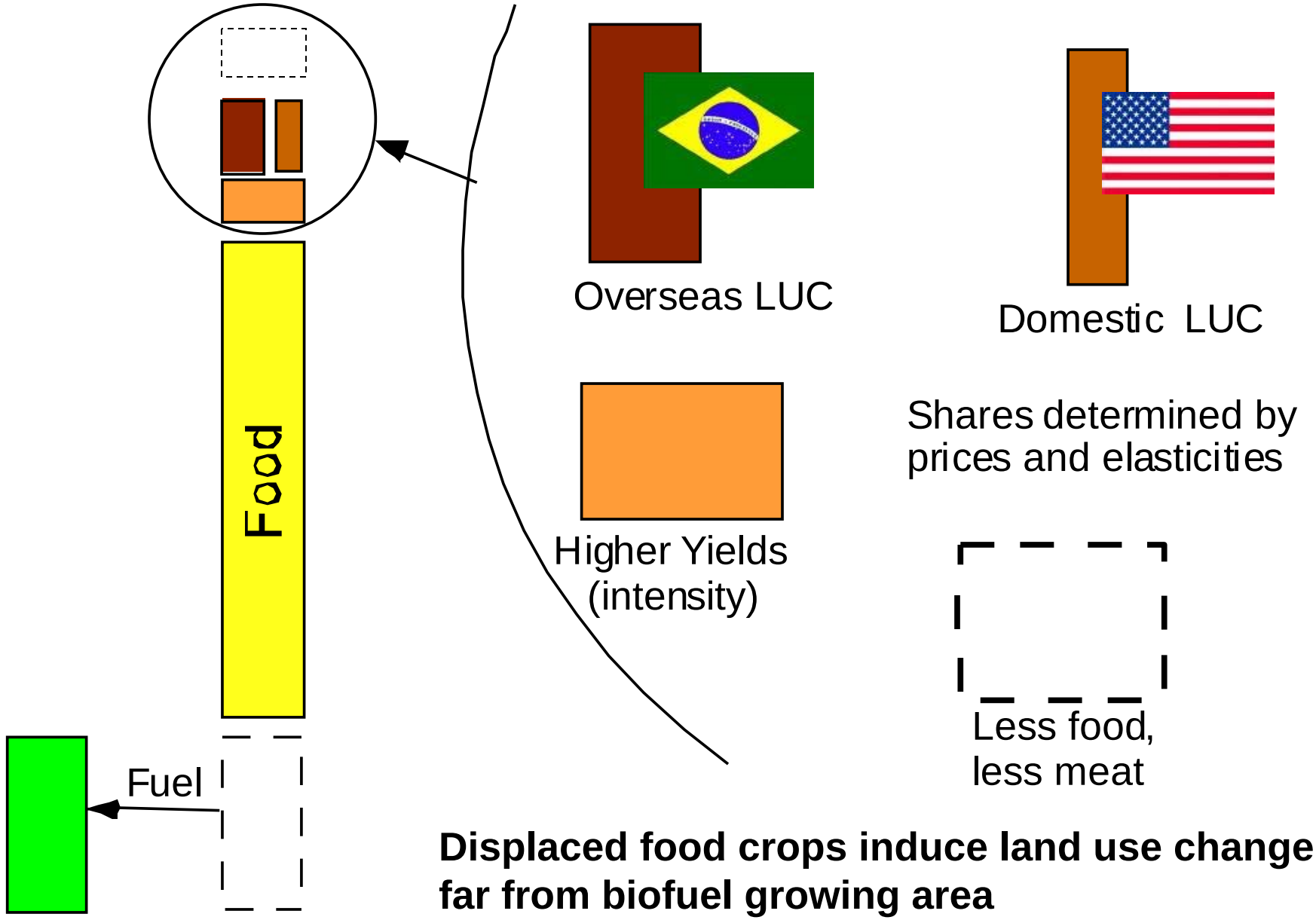
| Feedstock | Product | | | |
|---|---|---|---|---|
| | Ethanol | Otherols | Diesel | Mass |
| Maize | (Now) | | | |
| Wastes | (Coming) | | | |
| Perennials | | (Long-term) | | |
| Sugar crops | | | | |
| Other crops | | | | |
| Algae | | | | |

# LCA/CTW

- Considering any two exclusive policies/practices A and B:
- How would the world be different in the future under A compared to under B?
  - Things with money prices, and things not traded in markets
  - Things we can see (tractor fuel on corn farm), and things we can't see (soil and plant C sequestration, N cycle)

    Current example of the latter: faraway land use change effected through worldwide food markets

*What do we count? How do we measure them? How do we weight them into a scalar measure of merit?*




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

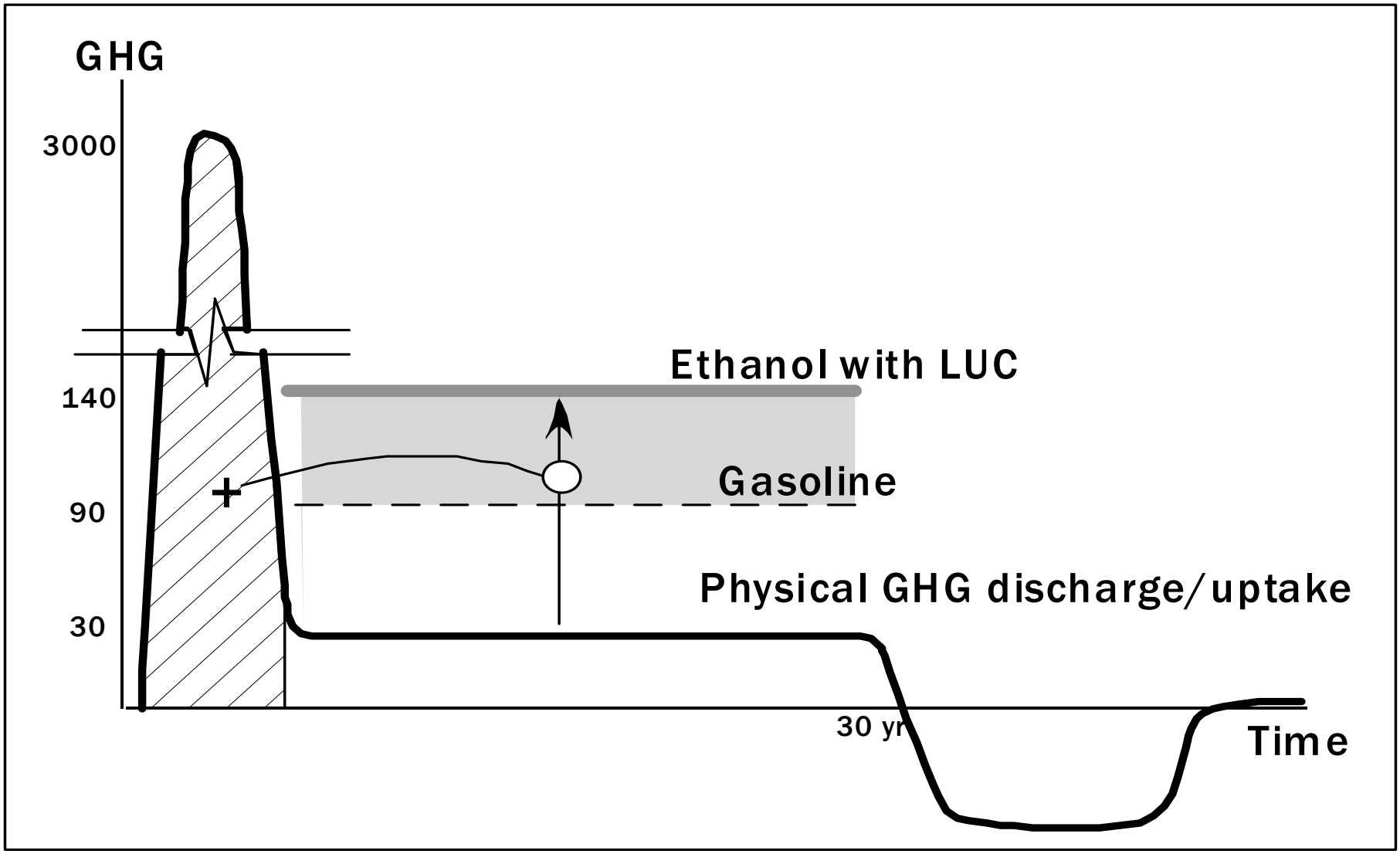



Figure 1: Physical discharge of GHG and land use change. Values rounded from Searchinger *et al*.

**Table 1.** Comparison of corn ethanol and gasoline greenhouse gasses with and without land use change by stage of production and use (Grams of GHGs $CO_2$ eq. per MJ of energy in fuel) (*29*).

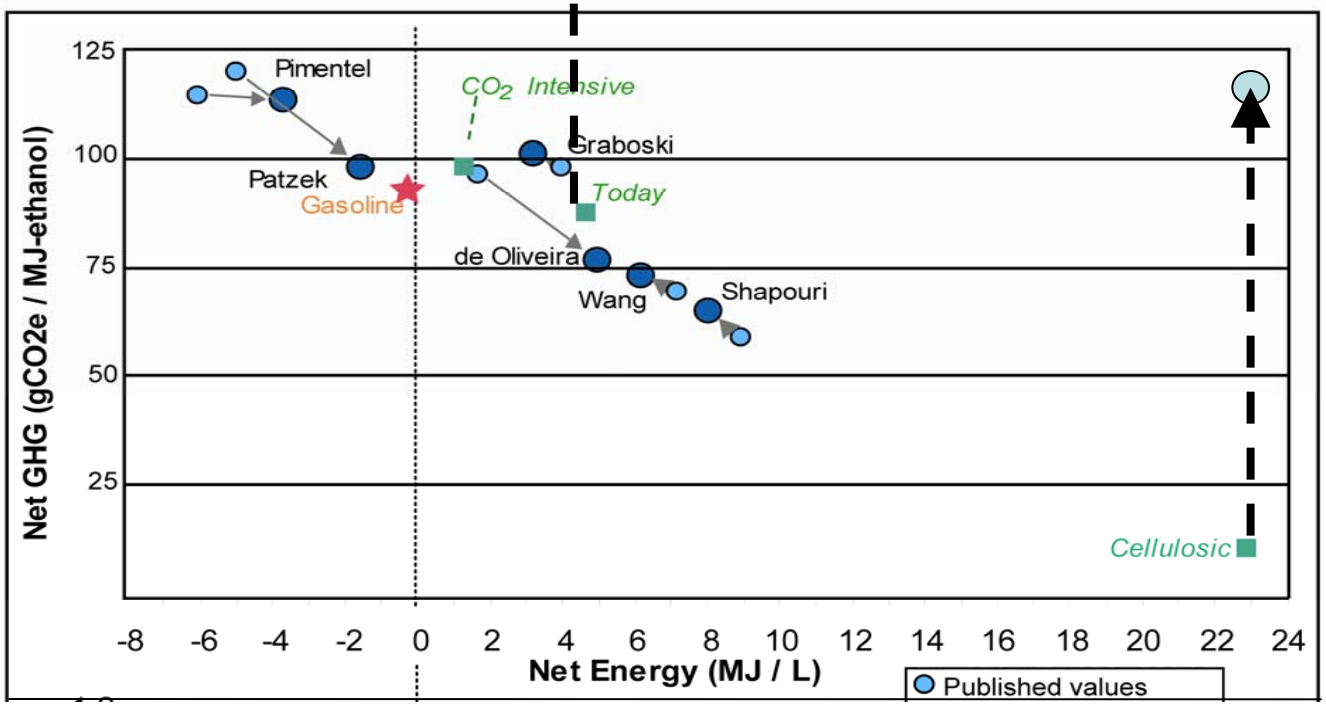
| Source of Fuel* | Making Feedstock | Refining Fuel | Vehicle Operation (Burning Fuel) | Net Land Use Effects | | Total GHGs* | % Change in Net GHGs vs. Gasoline |
|---|---|---|---|---|---|---|---|
| | | | | Feedstock Uptake from Atmosphere (GREET) | Land Use Change † | | |
| Gasoline | +4 | +15 | +72 | 0 | – | +92 | – |
| Corn Ethanol (GREET) | +24 | +40 | +71 | -62 | – | +74<br>+135 without feedstock credit | -20%<br>+47% without feedstock credit |
| Corn Ethanol + Land Use Change | +24 | +40 | +71 | -62 | +104 | +177 | +93% |
| Biomass Ethanol (GREET) | +10 | +9 | +71 | -62 | – | +27 | -70% |
| Biomass Ethanol + Land Use Change | +10 | +9 | +71 | -62 | +111 | +138 | +50% |

*Figures in total may not sum perfectly due to rounding in each column.
†Amortized over 30 years

From Searchinger 2008

# Farrell et al 06 redux

Considering land use change (LUC)

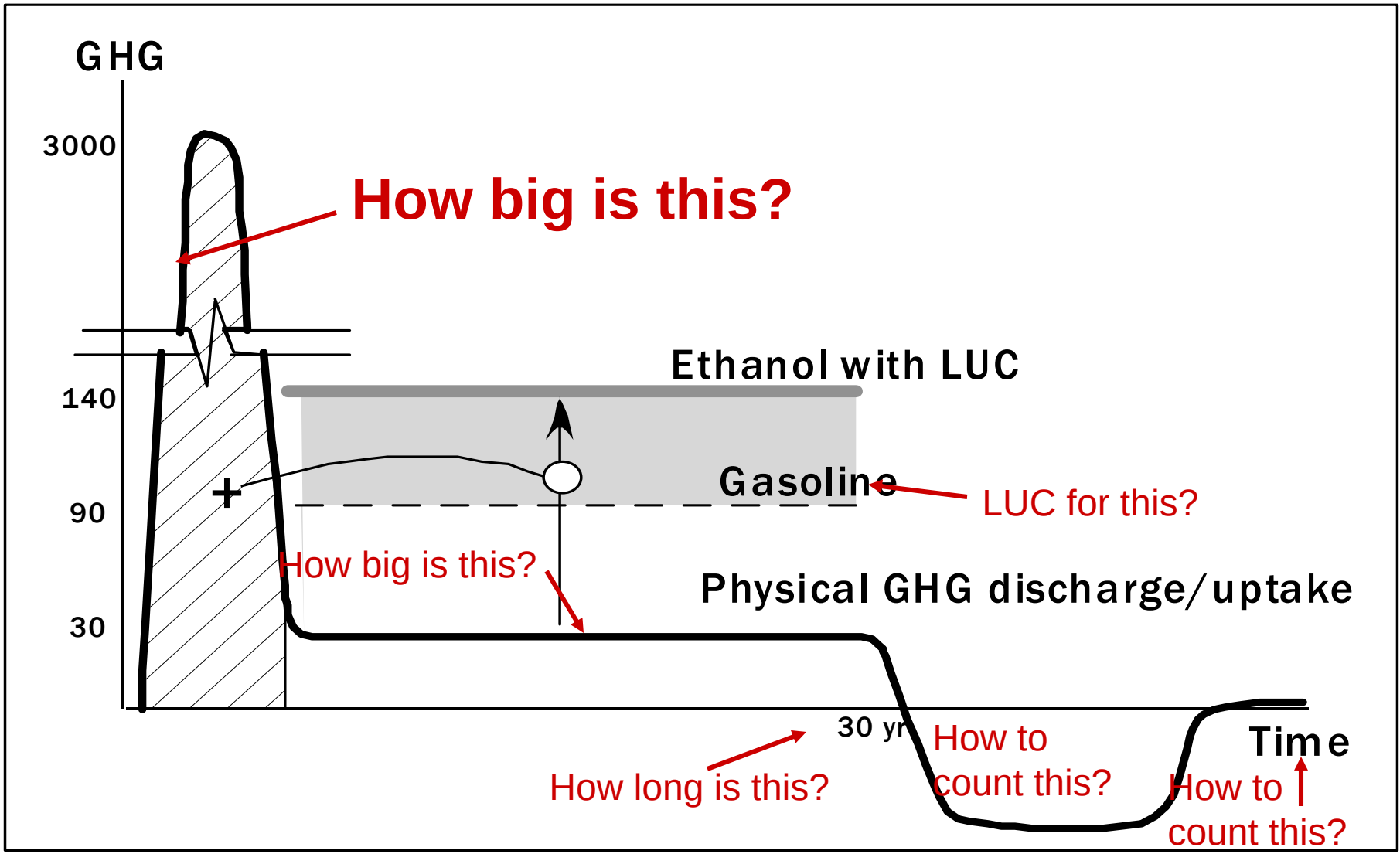



Net energy and net GHG estimates for 6 studies of corn ethanol, as well as 3 cases. Gasoline is shown for reference. The cellulosic case is switchgrass grown on prime crop land. Adapted from - Farrell et al, 2006 and Searchinger et al, 2008

# Key points

- It doesn’t matter what the biofuel crop is (except for yield)
- It doesn’t matter where you grow it (as long as its on land that could grow food)

- *“Previously cultivated land” provisions (US, Germany, RTFO, Indonesia) are inconsequential.*

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# Ethanol

- From maize
  - Conventional, rudimentary, close to gasoline cost
  - **Probably not RF**
- From cellulose crops
  - Waiting for technology
  - **May not be RF**
- From waste
  - Waiting for technology
  - **Probably RF**
- Usability issues

# Advanced biofuel technologies will be needed to produce fuels without causing LUC

- Most biofuel feedstocks that do not cause LUC are cellulosic
- Other feedstocks are even more advanced

# What's left?

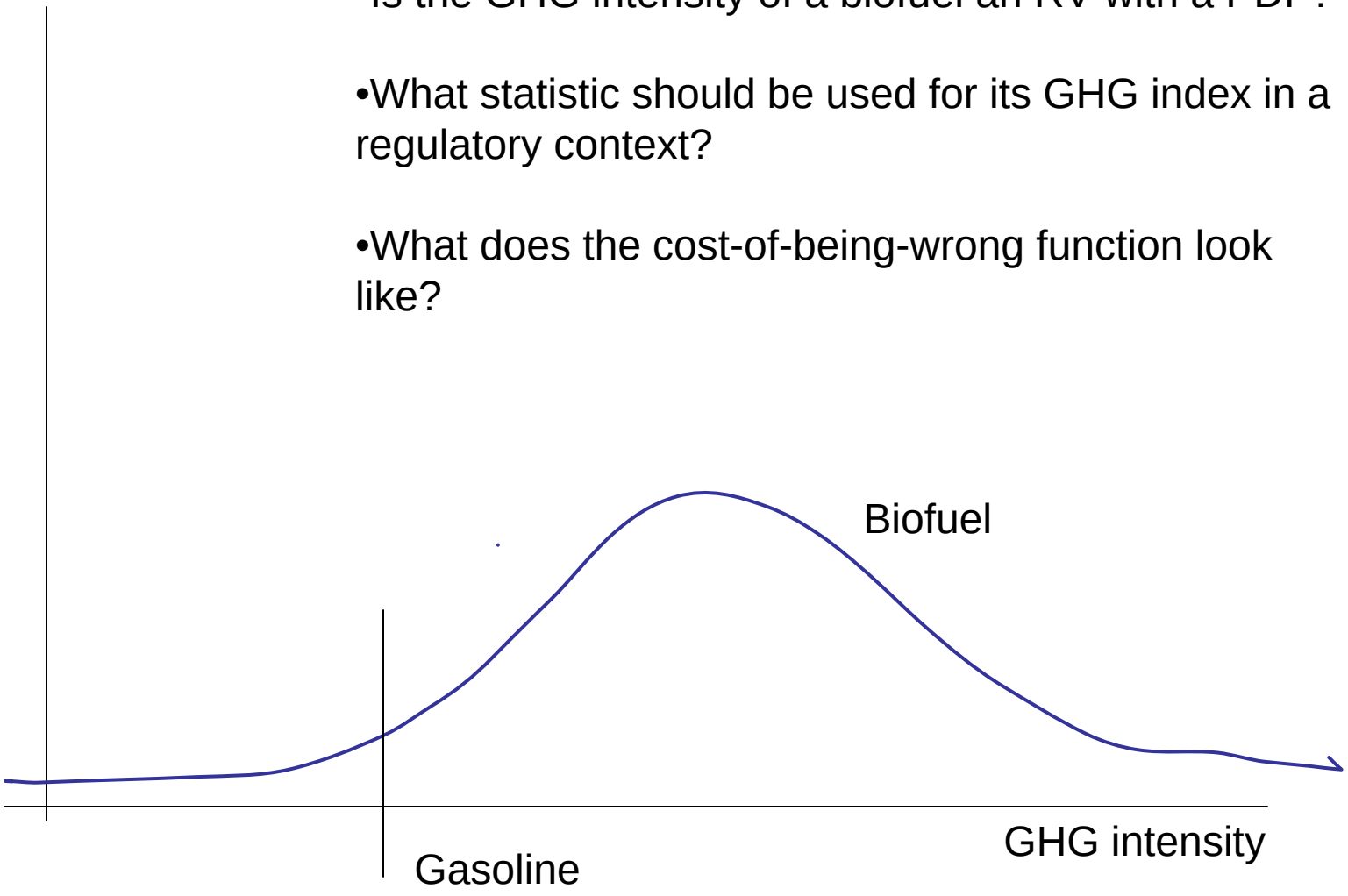
- From waste: ~8% of gasoline
  - Enzymes to crack cellulose
  - Thermal gasification + microbes + membrane separation (eg, Coskata)
  - Mass burn
- Mixed perennials on waste land
- Cane, variousols
- Algae: too soon to tell, but very expensive now. Must be on desert (closed system) or open water.

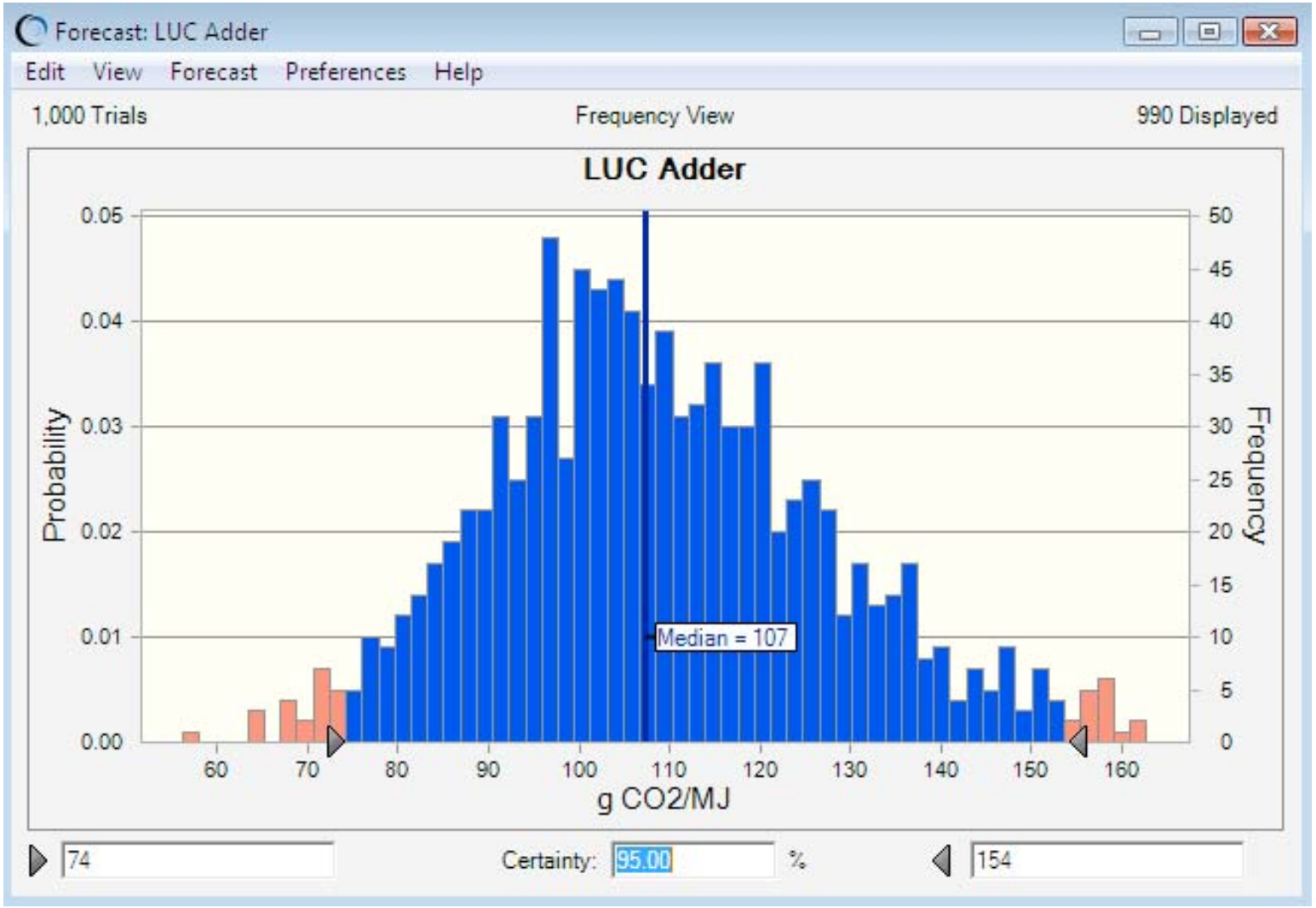
# Other considerations for crop biofuels

- Industrial monocrops
- Biodiversity, economic diversity
- Capital intensive, low-wage labor
- Biofuel curse?
- Water
- Etc.

*“Sustainability” comprises a variety of non-GW issues*

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






(Draft) Monte Carlo Analysis of Searchinger: Plevin & Jones

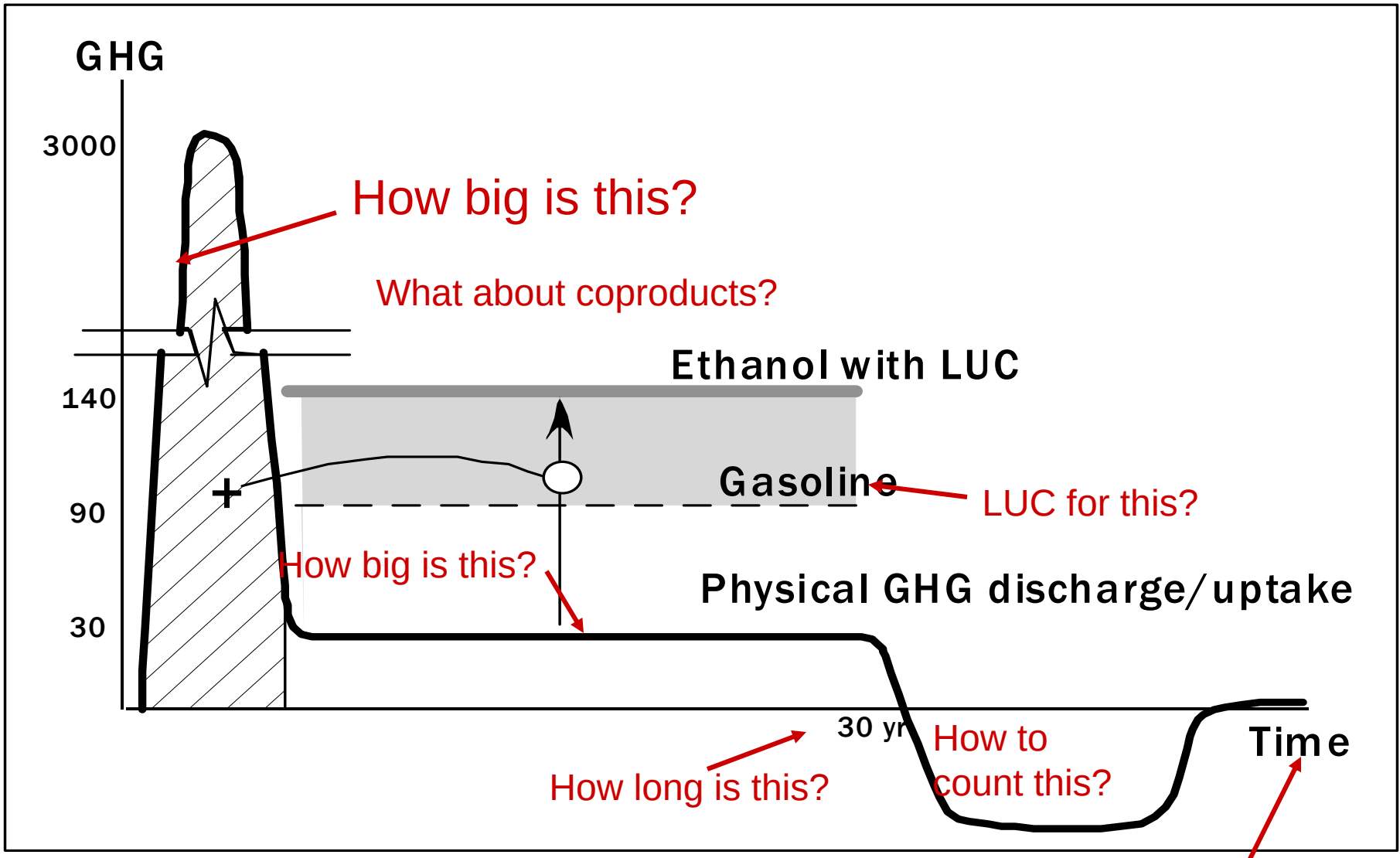



Figure 1: Physical discharge of GHG and land use change. Values rounded from Searchinger *et al*.

# What about time?

- Searchinger (and others) do not discount
- Discounting is a complicated issue:
  - Economic discounting of events involving goods traded in markets
  - “Derating” of physical phenomena
- *Any recognition of time value* increases currently estimated deficits of crop biofuels relative to fossil fuel.

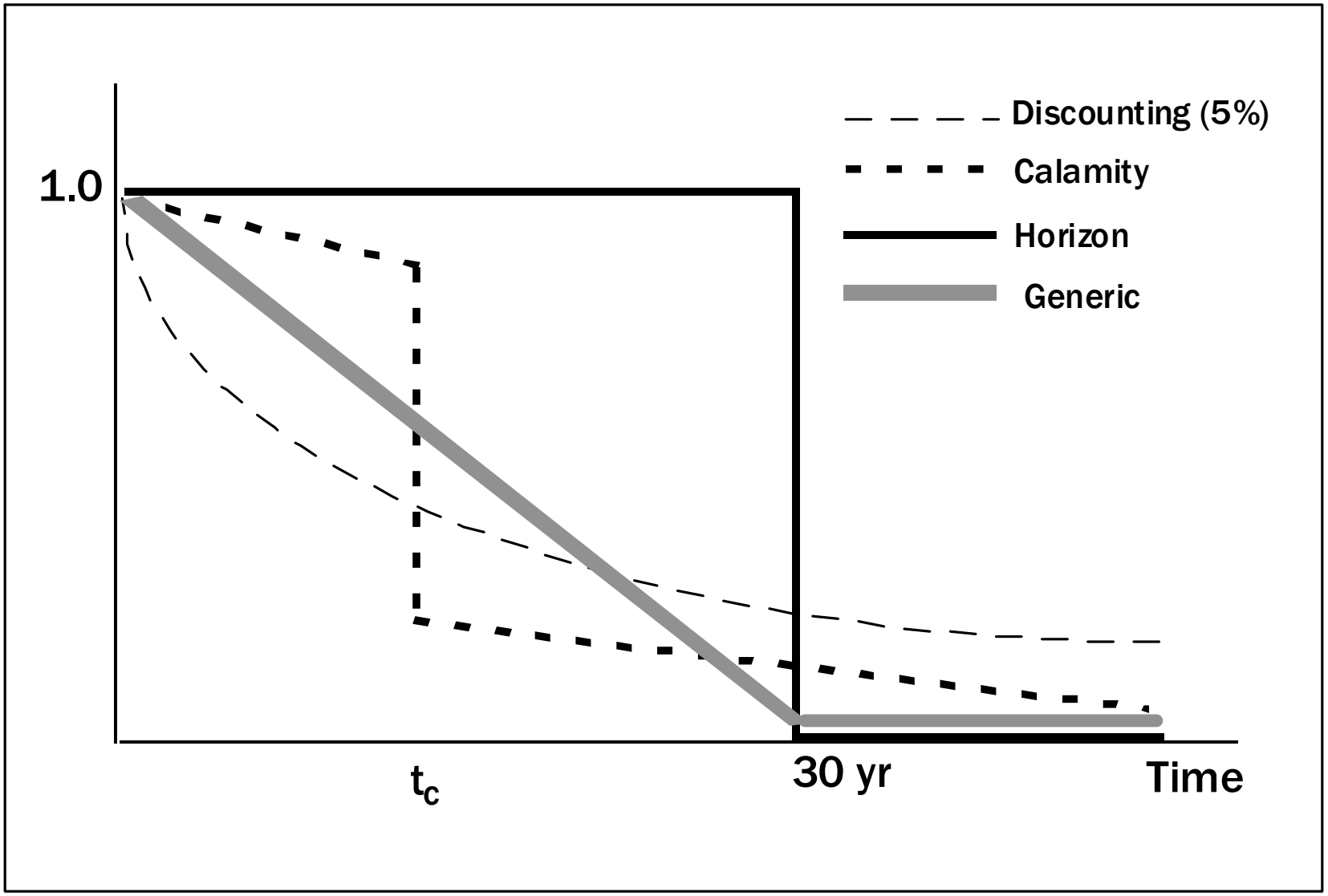



Figure 2: Possible social cost of physical GHG release functions. Conventional economic discounting is shown for comparison (see text)

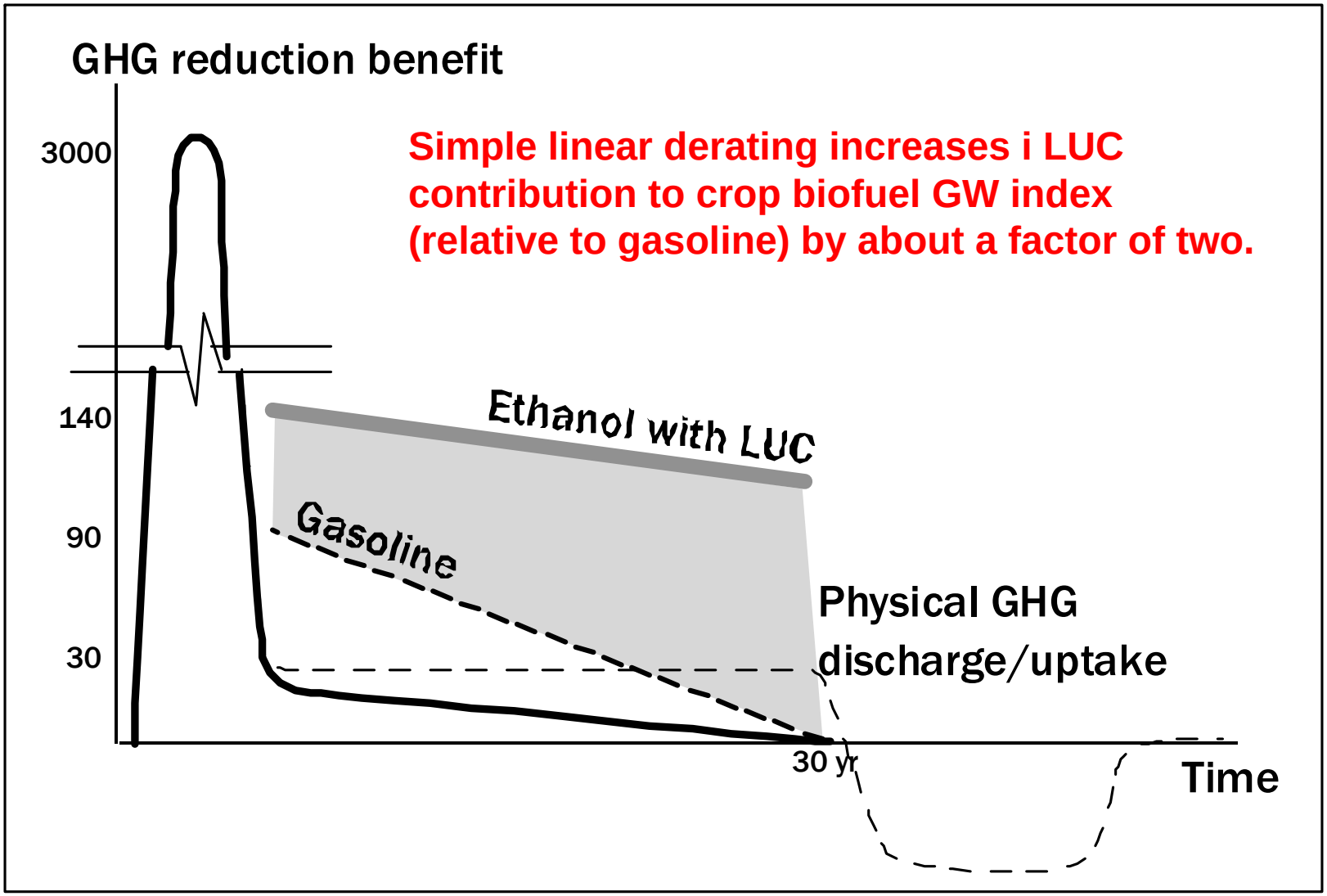



Figure 3: Social benefit of reducing physical discharge of GHG including land use changes, with derating according to the Generic function (see Figure 2). Values rounded from Searchinger *et al*.

“Sustainability” is [are] 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 is a GW policy

# Thanks

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