The Food-Energy Nexus

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Main points:

- Biomass production > global energy consumption
- Multiple demands on biomass: food, fiber, ecosystem services, energy
- Biomass can be an important, but not dominant, part of the energy system
- The value of biomass energy depends strongly on the details

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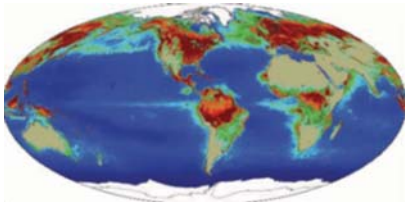
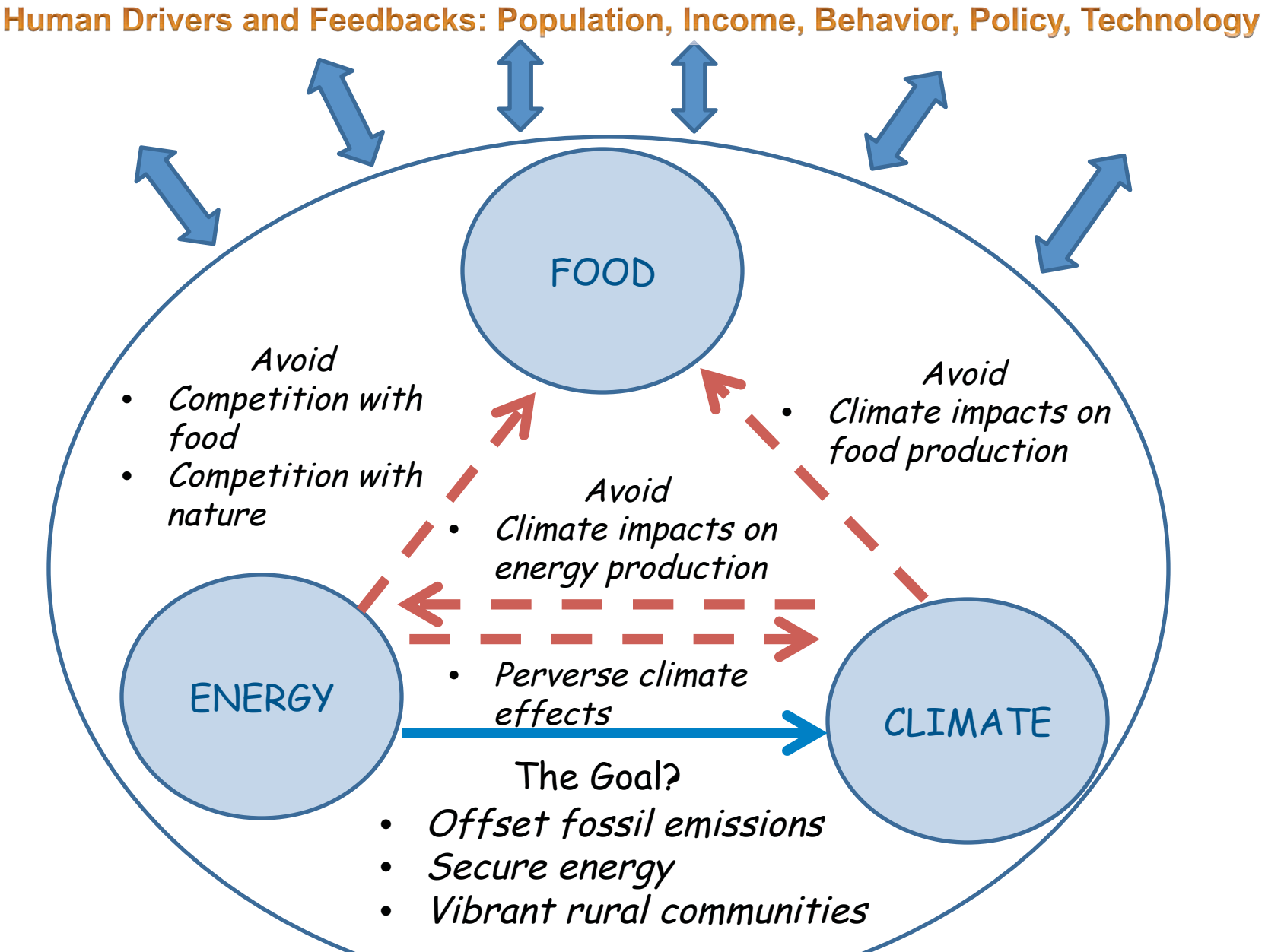


The Food-Energy Nexus

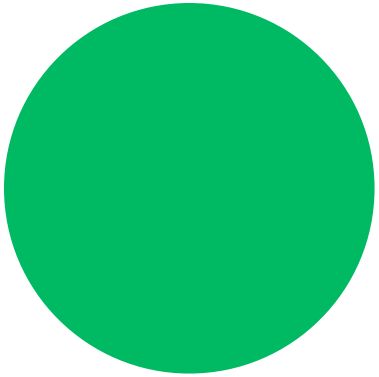


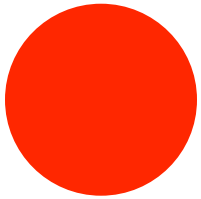
The Food-Energy Nexus

- How much biomass energy can the world produce?
- How much of this biomass energy might be available to the energy system?
- How important is the form of biomass energy?

How much biomass energy can the world produce?

Total energy content of aboveground
Plant growth on land = 1,756 EJ/y





Total global primary energy
In 2009 = 469 EJ/y

How much biomass energy can the world produce?

Total solar energy absorbed by
land and oceans = 2,809,000 EJ/y

Total energy content of aboveground
Plant growth on land = 1,756 EJ/y

Total global primary energy
In 2009 = 469 EJ/y

Protecting food & nature, Avoiding perverse climate effects:

Possible approaches

- Biomass energy from:
  - Abandoned lands
  - Waste
  - Unproductive lands
  - Sustainably managed forest or prairie

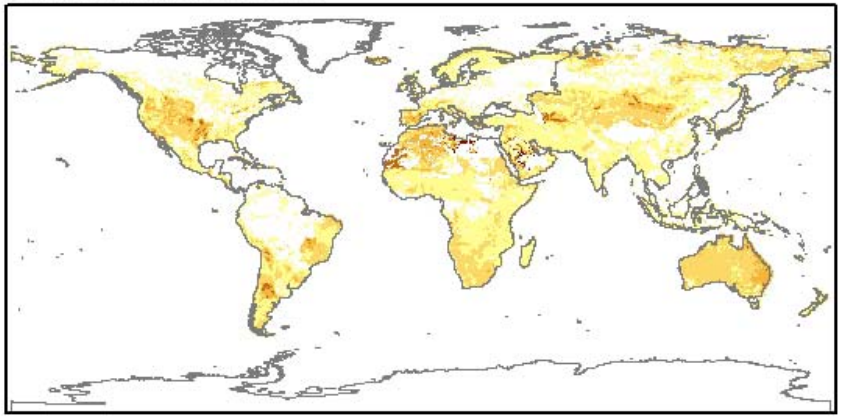
Setting the scale

- Food for 1 person for one year
  - ~ 250 kg corn

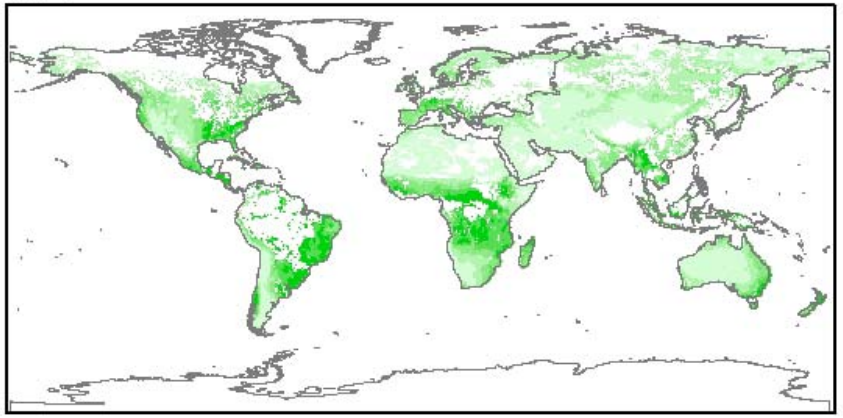
    = ethanol for one fill-up

    (~ 80 l (20 gal))
- At 25 mpg and 10,000 miles/y
  - The corn required to fuel one car on corn ethanol
  - Would feed 20 people
  - Would require 1 Ha of farmland

a) Total Abandoned Area



b) NPP



Area (%)

- 0% - 5%
- 6% - 14%
- 15% - 31%
- 32% - 59%
- 60% - 100%

NPP (Mg C / ha)

- 0.0 - 1.6
- 1.7 - 3.7
- 3.8 - 6.2
- 6.3 - 8.9
- 9.0 - 18.3

Field et al TREE 2008

From available abandoned land

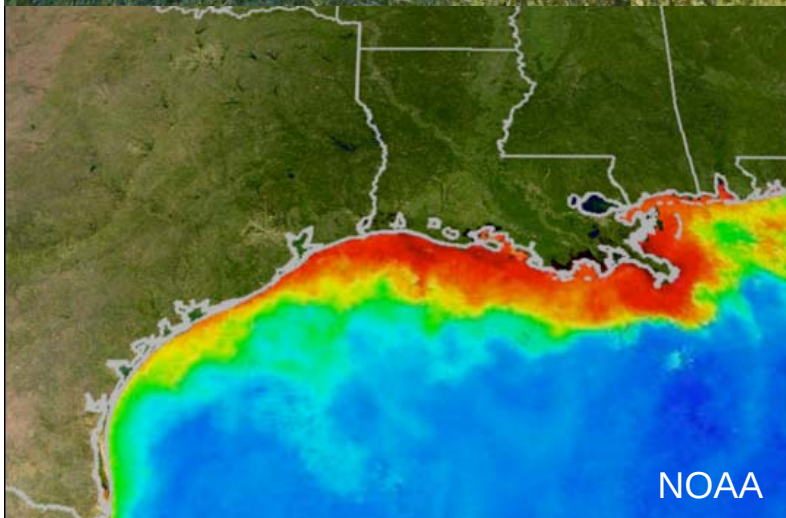
Land Type		Area (Mha)	Mean NPP (ton C / ha / yr)	Total NPP (Pg C / yr)
Global	Crop	1,445	4.6	6.7
	Pasture	3,321	3.4	11.3
	Abandoned	474-579	4.7	2.2-2.7

1.6 – 2.1 Pg C x 2 g Plant/g C x 0.5 g top/g plant x 20 EJ/Pg = 32 - 41 EJ
= 7-8% of current global energy system

Field et al TREE 2008

Is the answer boosting productivity?

- Agricultural technology
  - Ag/NPP -- Globally about 65%
- Fertilizer
  - Energetically expensive
  - Pollution/GHG risk
- Irrigation
  - Energetically expensive
  - Competing demands
- Advanced crops
  - In nature's portfolio?
- Algae
  - Capital cost
  - Water cost



How important is the form of biomass energy?

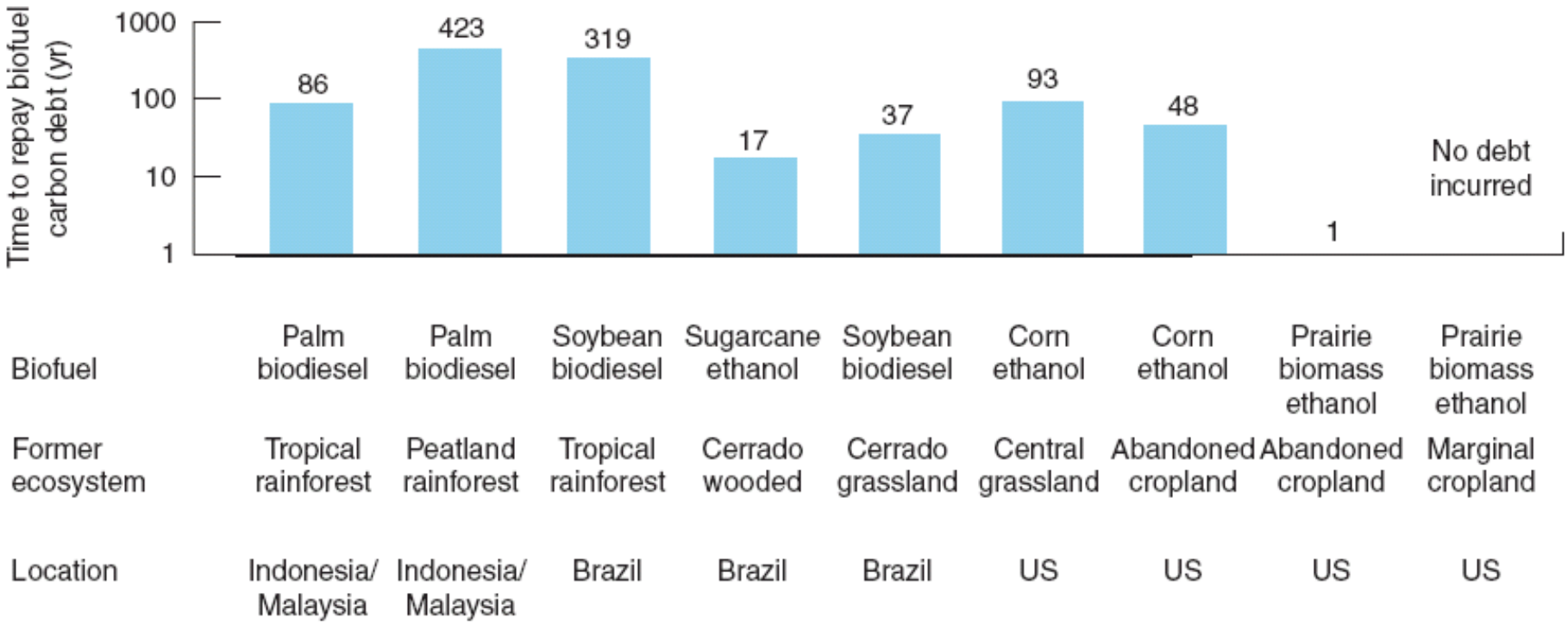
- Fossil fuel required for production
- Carbon debt
- Services per unit of biomass

Net energy balance ratio

(biomass energy out/fossil energy in)

- Corn ethanol ~1.2
  - (USDA 9/2010 Nebraska = 2.3)
- Sugarcane ethanol ~ 8
- Soy biodiesel ~ 2
- Palm biodiesel ~ 9
- Cellulosic ~5(?)

Carbon "debt" from land clearing



Fargione et al. Science 2008

"Indirect deforestation"

(cropland to biofuels leads to increased croplands in other parts of the world)

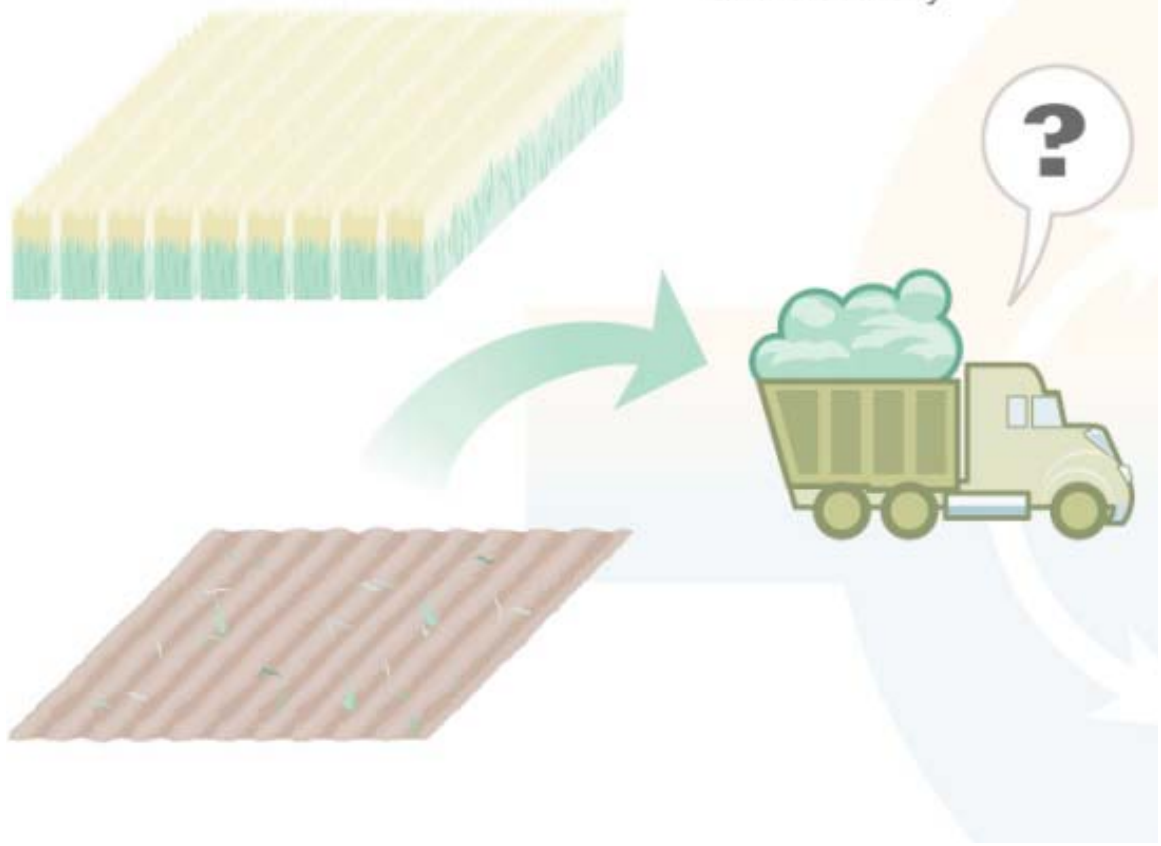
Ethanol vs. Electricity

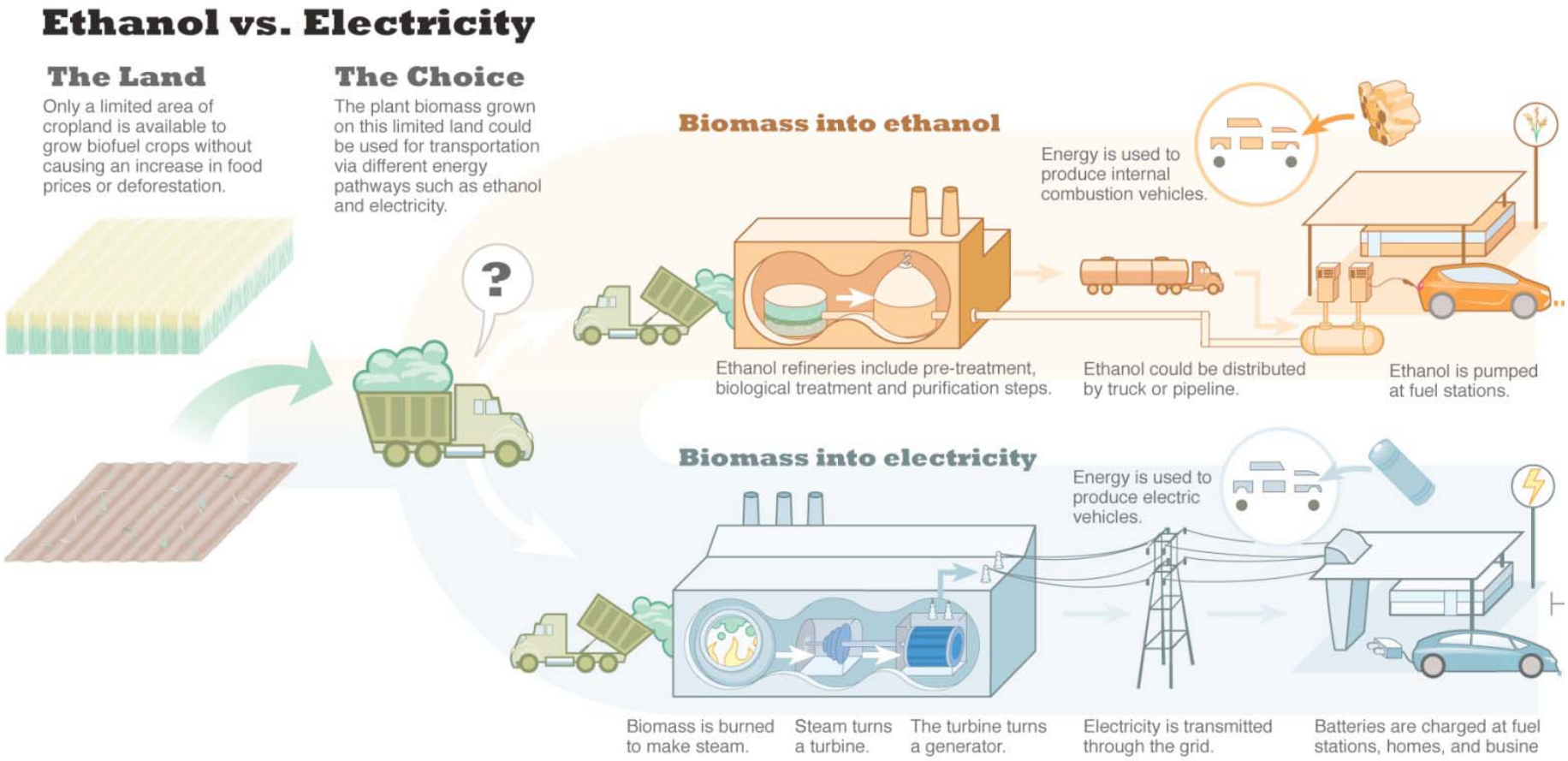
The Land

Only a limited area of cropland is available to grow biofuel crops without causing an increase in food prices or deforestation.

The Choice

The plant biomass grown on this limited land could be used for transportation via different energy pathways such as ethanol and electricity.





Electricity wins

- 81% more services (distance) per unit of land area
- 108% more HG offsets per unit of land area

Campbell et al. Science, 2008

The Economist, 10/28/2010

Biomass energy

• Corn		$252/ton
• Coal	Power River	$15/ton
	Central Appalachia	$78/ton
• Crude oil		$752/ton

Prices 2/2011

Bioenergy

- Land, water, & fertilizer constraints
  - Maximum from abandoned lands < 10% primary energy
  - Big potential in absolute terms
  - But a small slice of present or future demand
- Climate impact depends on pre-existing ecosystem
- Indirect as well as direct paths to carbon loss
- Form matters
- Thanks:
  - Stanford Global Climate & Energy Project - GCEP