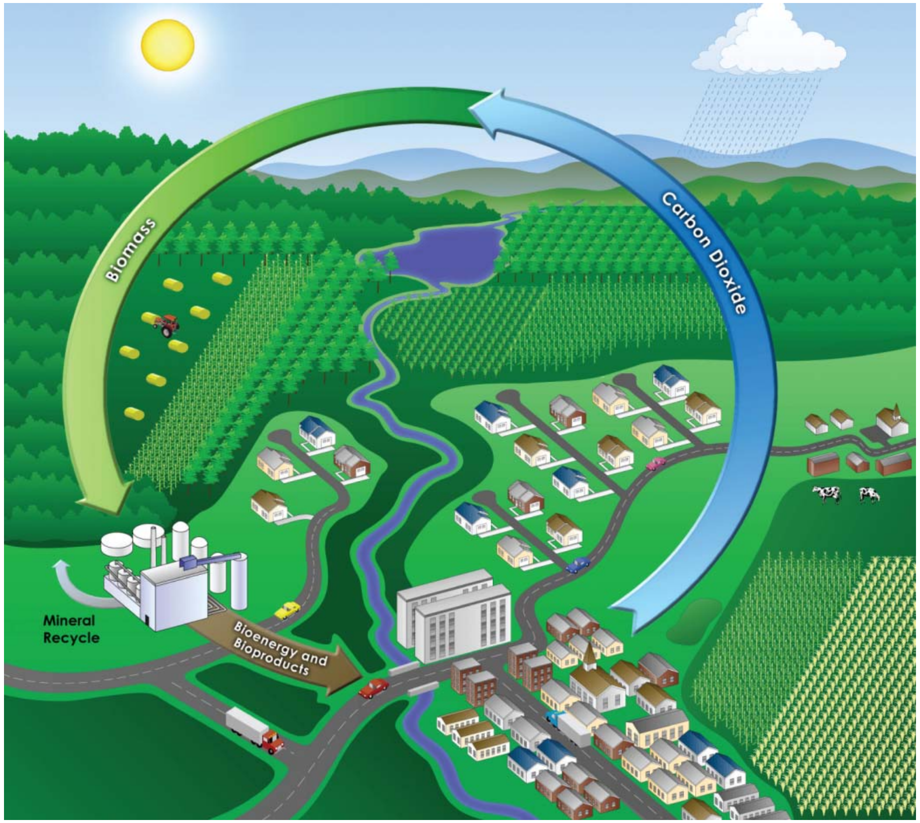
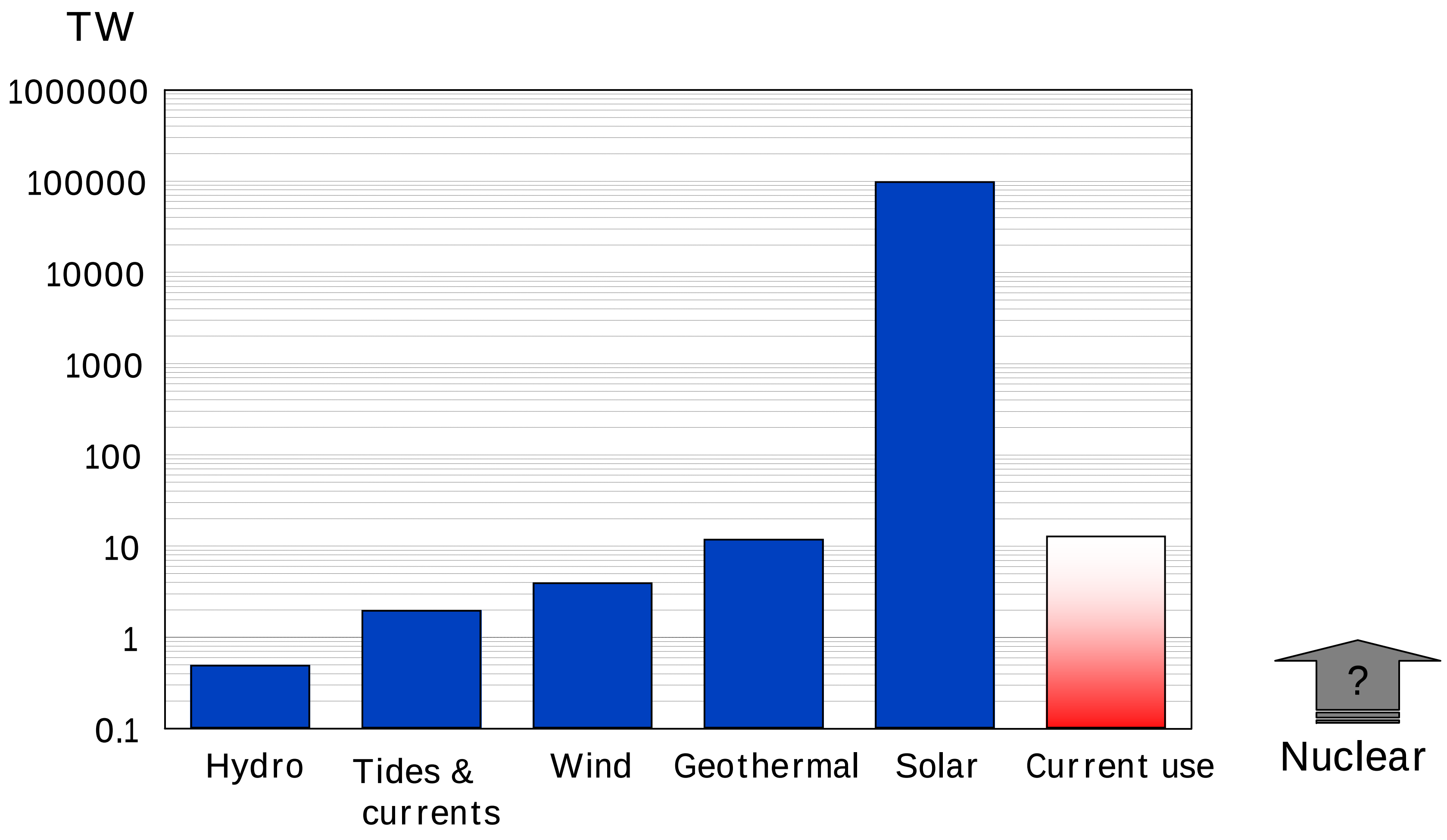
Development of Cellulosic Biofuels



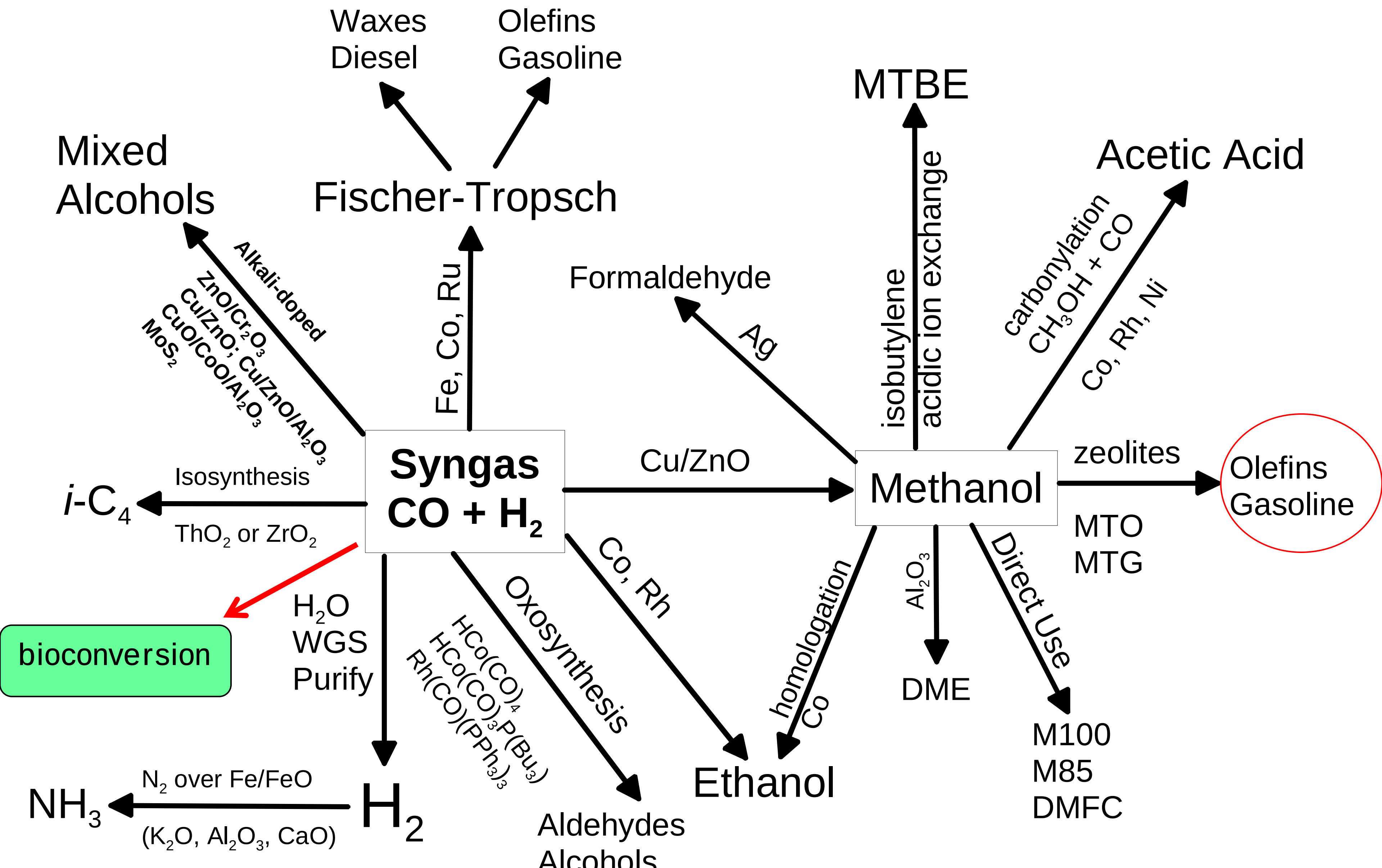
Chris Somerville
Energy Biosciences Institute
UC Berkeley, LBL, University of Illinois

Potential of carbon-free energy sources



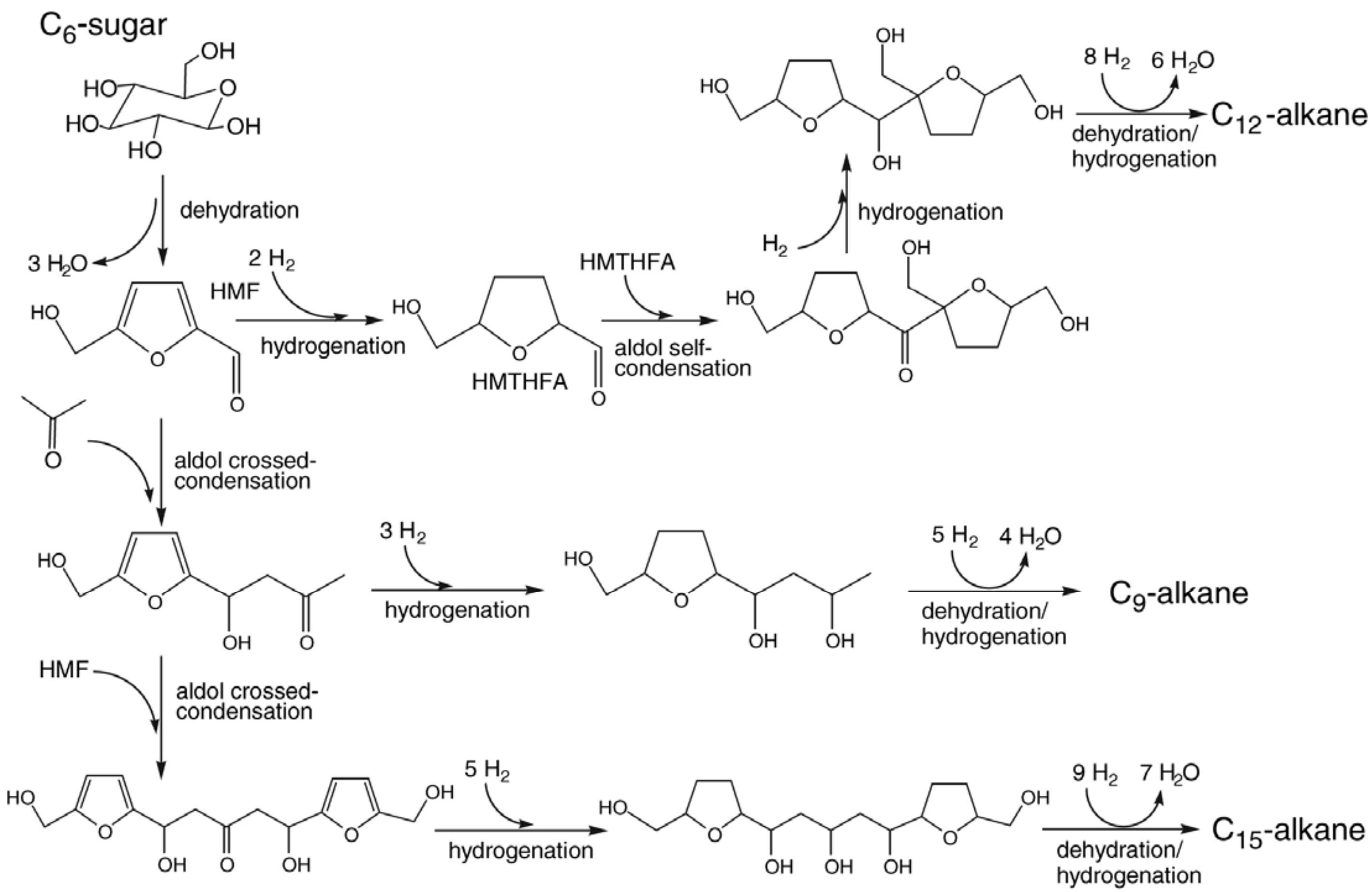
From: Basic Research Needs for Solar Energy Utilization, DOE 2005

Summary of Syngas-Liquids Processes



Richard Bain, NREL

Conversion of sugar to alkanes

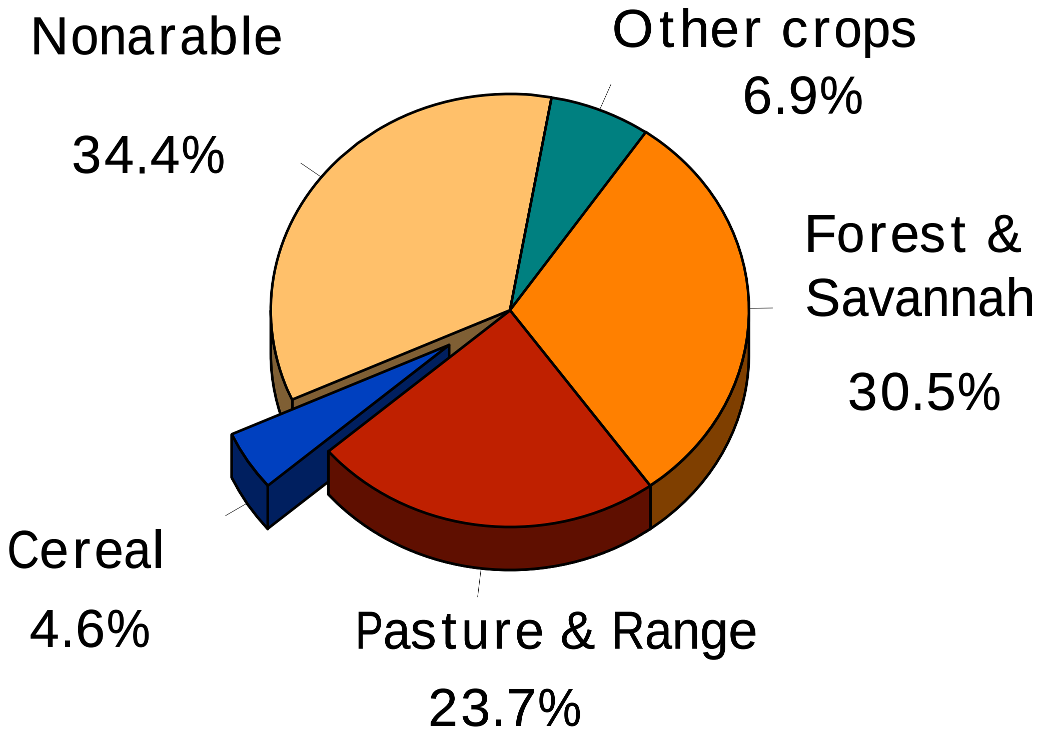


Huber et al., (2005) Science 308,1446

Perspective

- Economists are helpful for evaluating the feasibility and consequences of alternative scenarios
- Social scientists are helpful for flagging social issues that can block adoption of technology

World Land Use

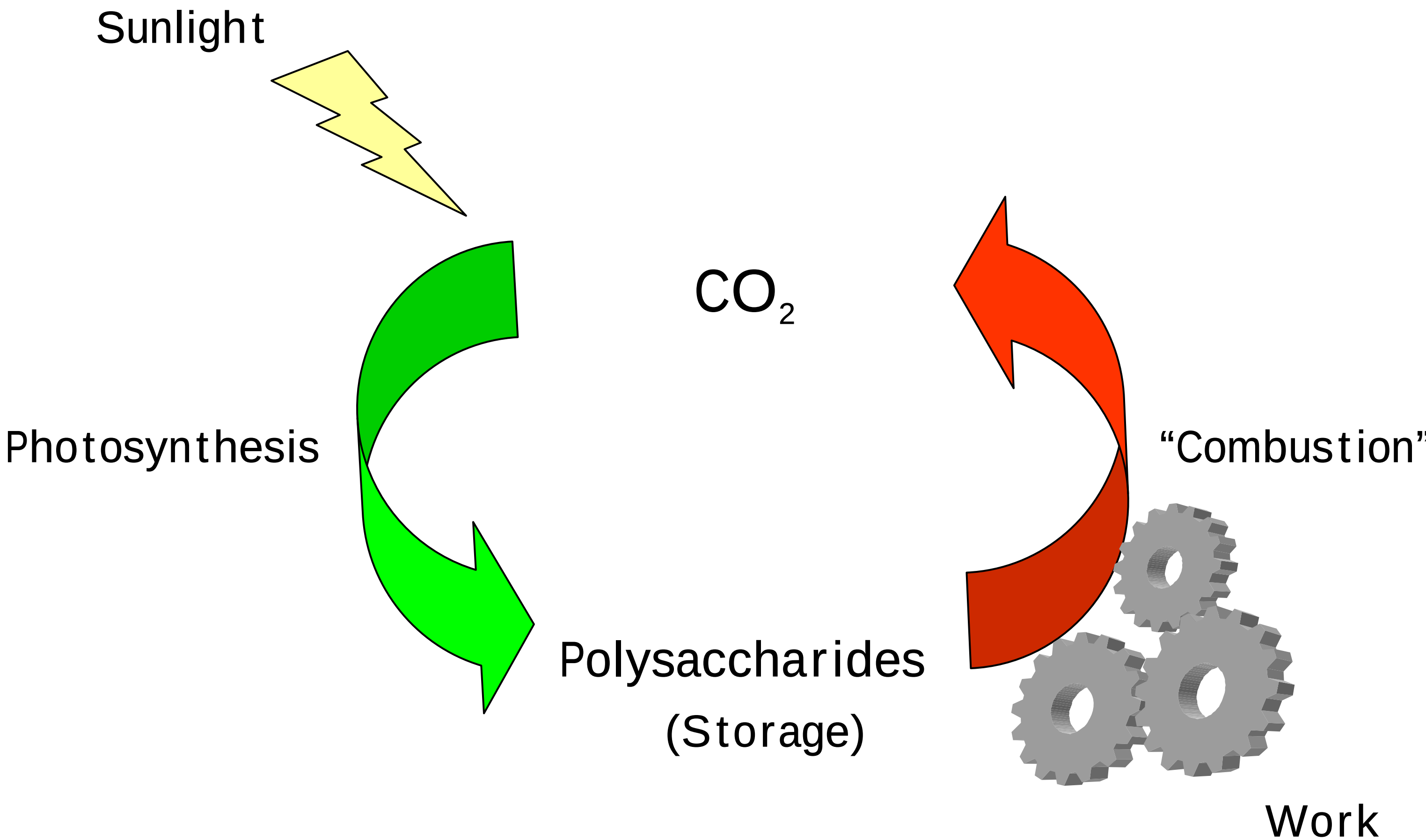


AMBIO 23,198 (Total Land surface 13,000 M Ha)

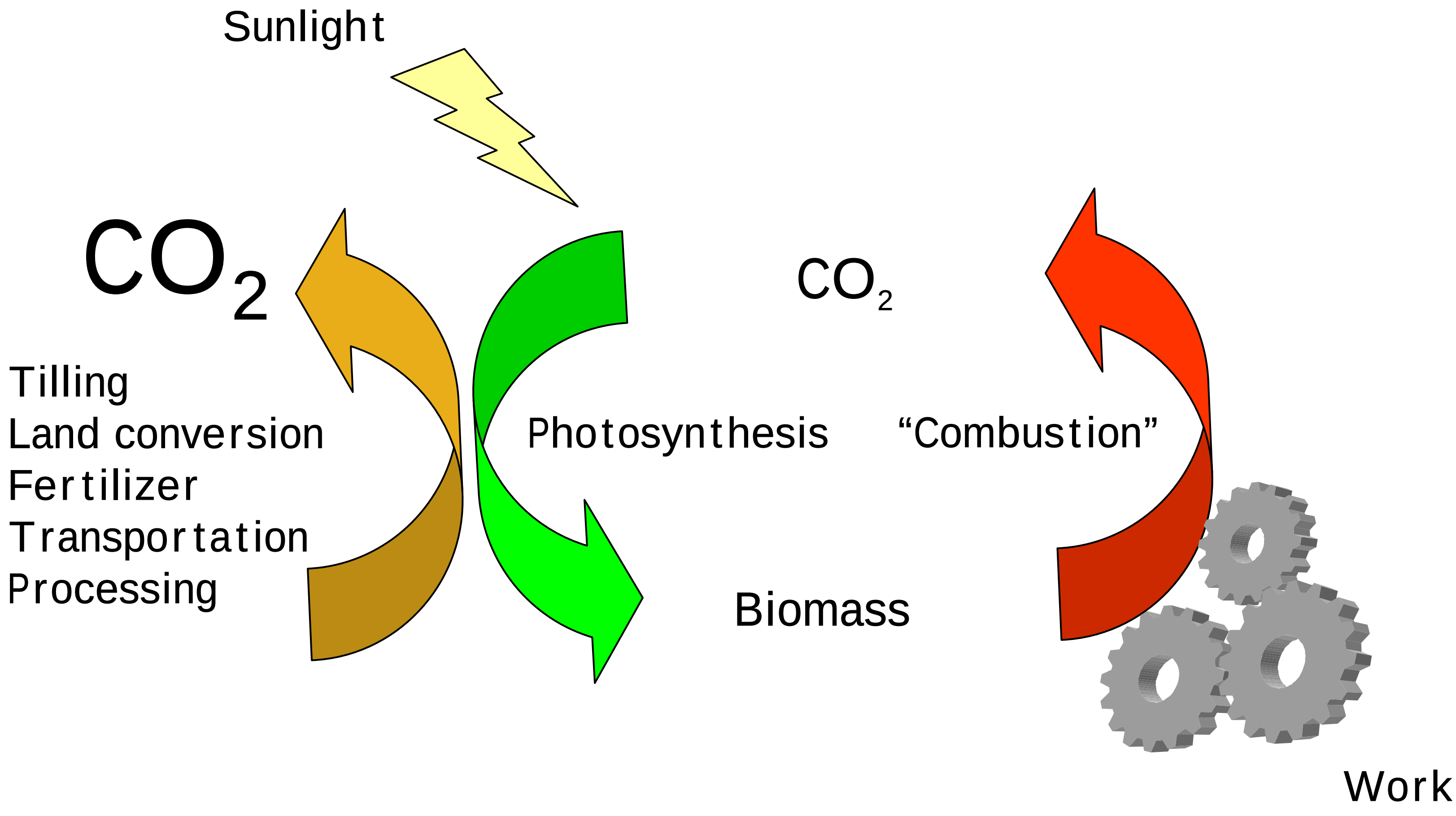
Thinking beyond tofu

- Emissions from meat production equivalent to all transportation fuels
- Cattle are major threats to many ecologically sensitive regions
- Ruminants are a very inefficient source of nutrition
- Can we create acceptable alternatives?

Combustion of biomass ***can*** provide carbon neutral energy



Combustion of biomass ***can*** provide carbon neutral energy

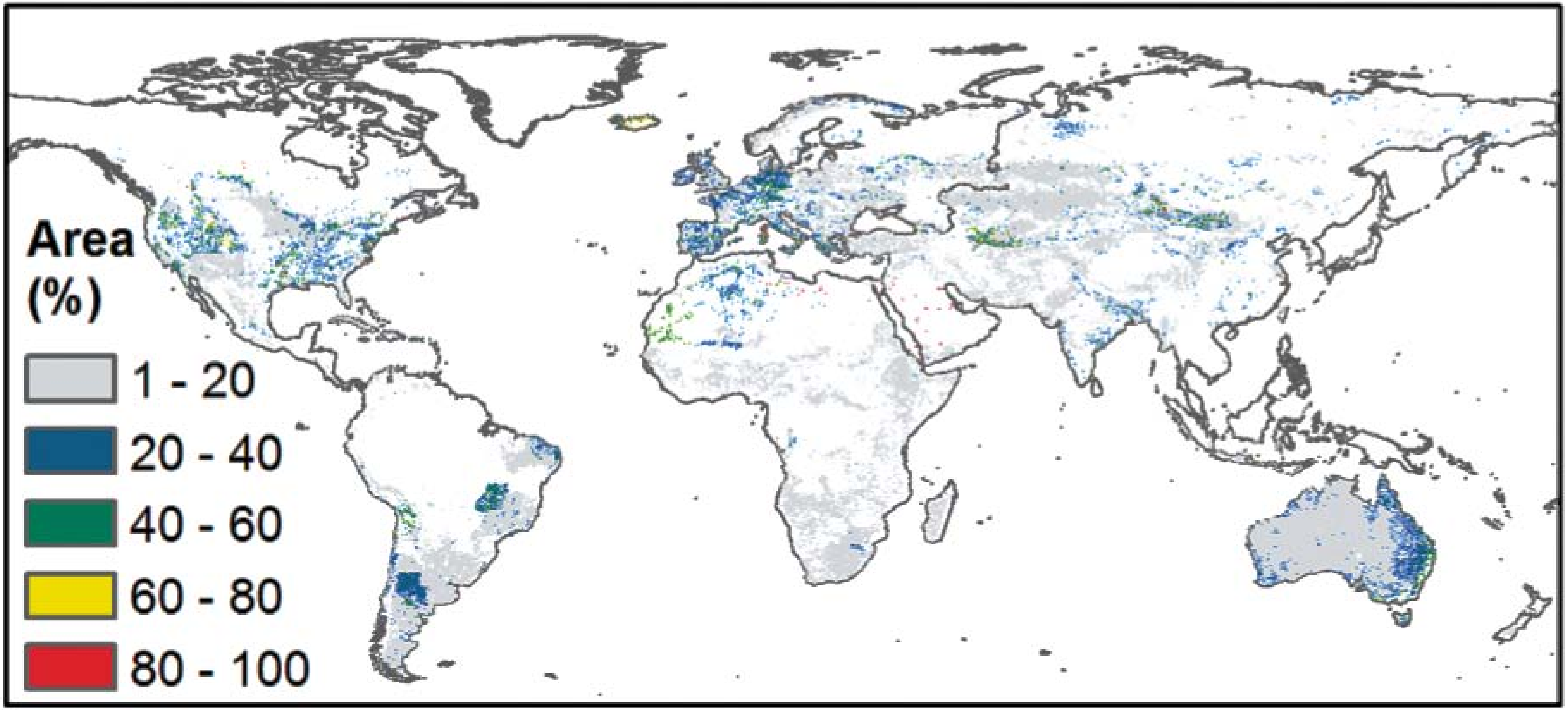


But it depends on how the biomass is produced and processed

Problems with corn, soy, rapeseed for biofuels

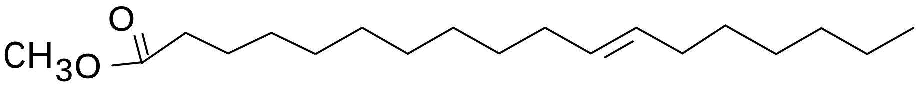
- Annual crop production leads to soil erosion, fertilizer runoff, loss of soil carbon, nitrous oxide emissions, pesticide effects ...
- Weakly positive for GHG emissions
- Increased feed and food price
- May stimulate production of food on ecologically sensitive acres (indirect effects)

>>A billion acres of agricultural land have been abandoned

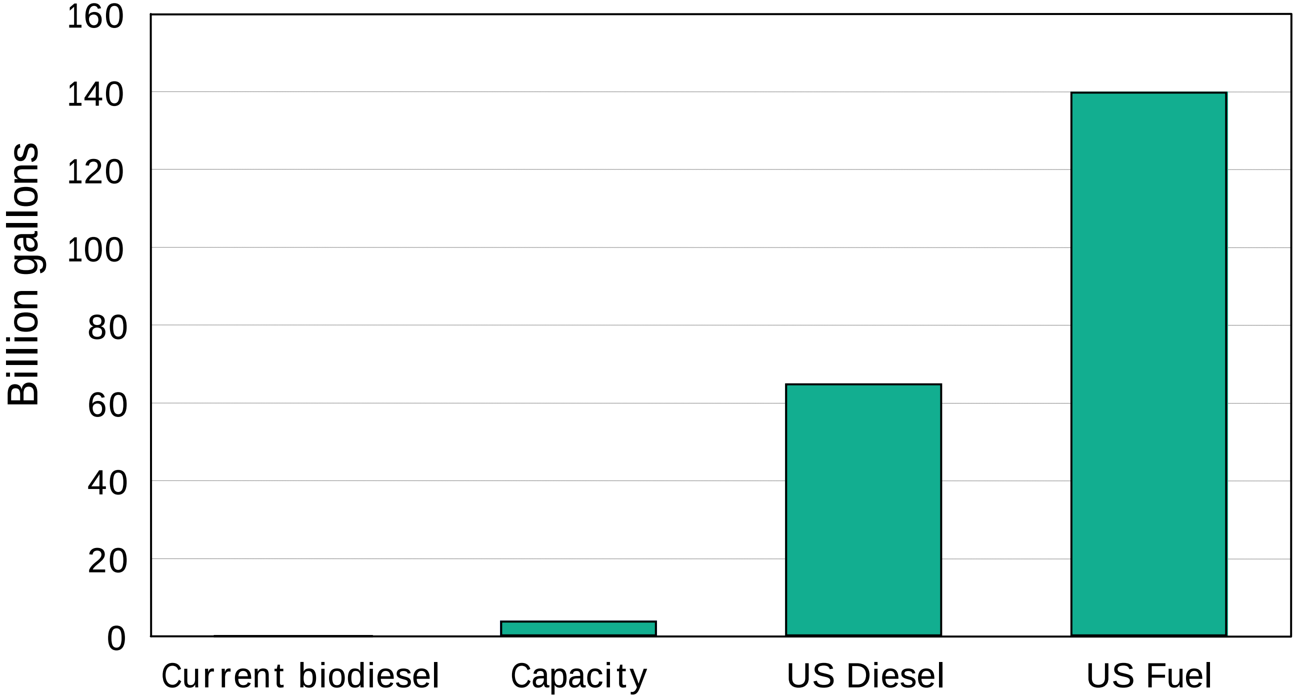


Campbell et al., Env. Sci. Technol. (2008) **ASAP Article**, 10.1021/es800052w

Limited potential of biodiesel



Biodiesel

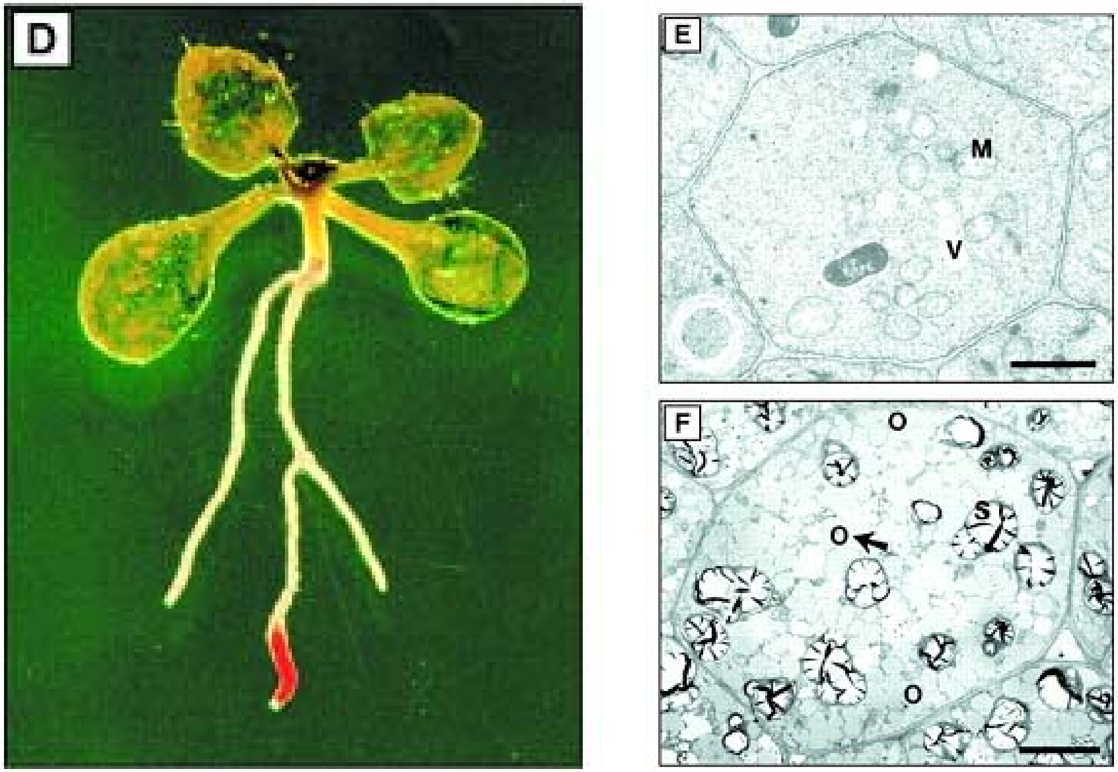


65 biodiesel companies in operation, 50 in construction 2006

Oil potato, oil cane, oilfalfa...

- Accumulate terpenes or alkanes in vegetative tissues
  - Increased solar efficiency
- Cold press tissue in field
  - Environmental benefits
  - Transportation and storage costs decrease
- Costs of conversion to fuels minimal
  - Engineering costs greatly decrease

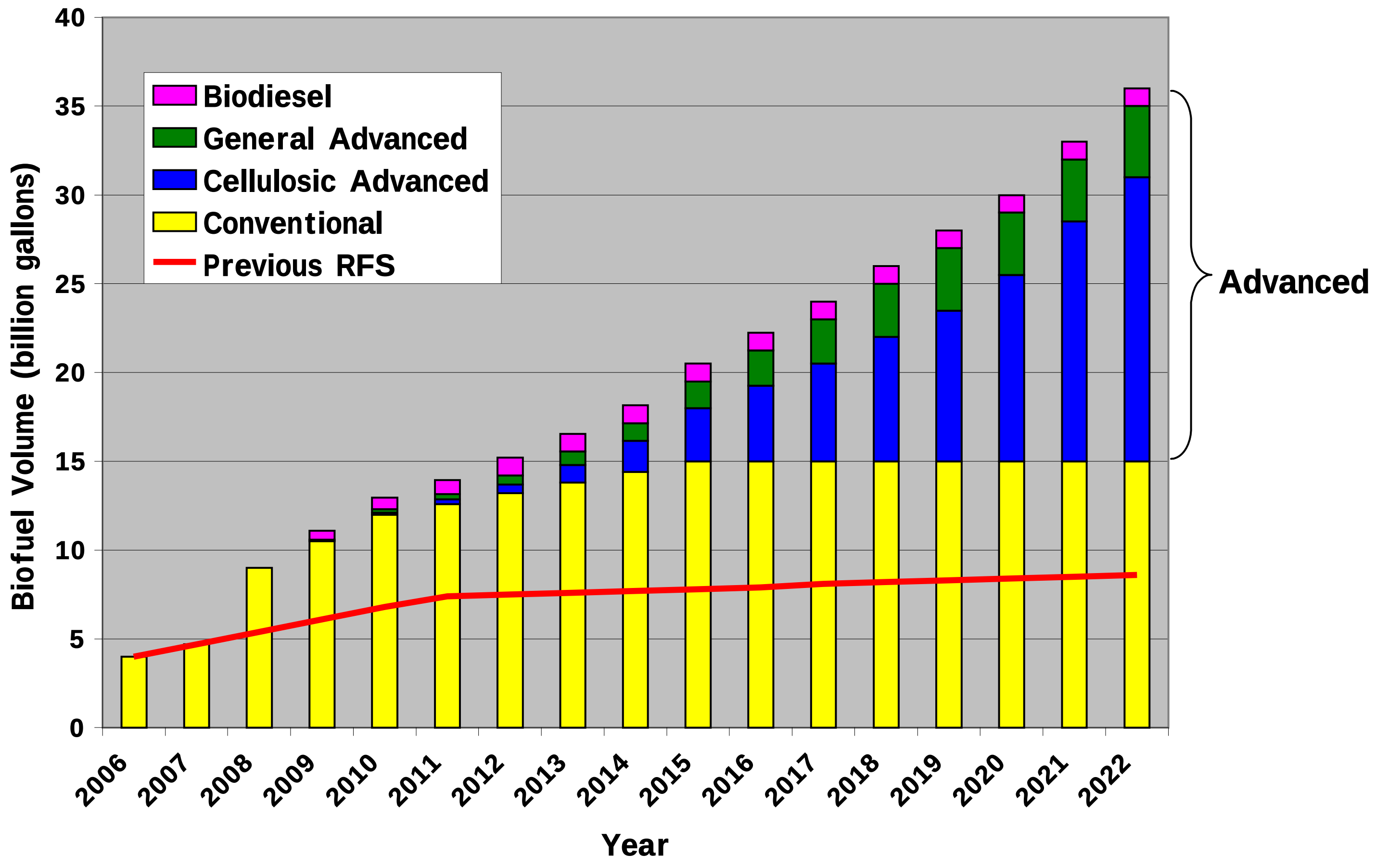
Knowledge of developmental mechanisms will create entirely new opportunities for producing biomaterials



Ogas et al., Science 277,91

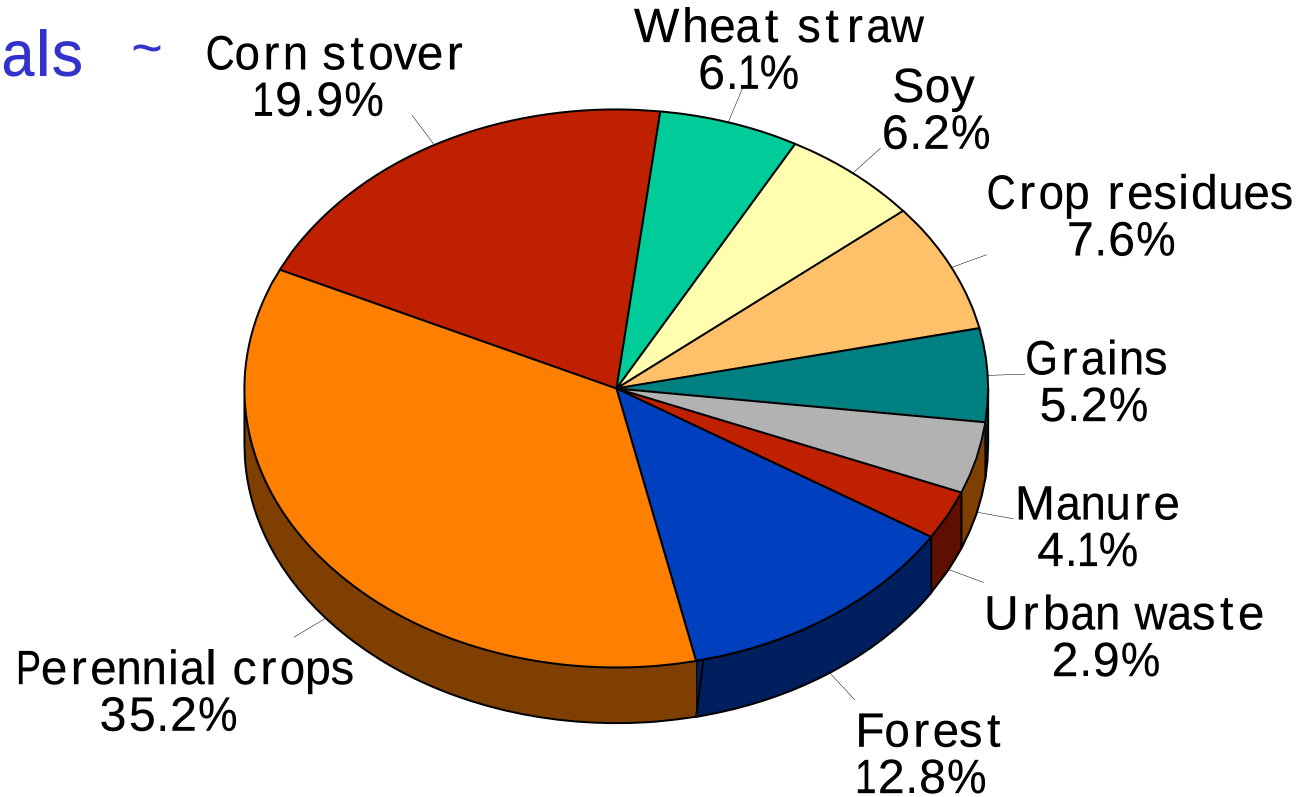
Renewable Fuel Standard

(Energy Independence and Security Act of 2007)



US Biomass inventory = 1.3 billion tons

26 B gals ~



From: Billion ton Vision, DOE & USDA 2005

Potential bioenergy crops tested in the US

English name	Latin name	Photo- synthetic pathway	Yields reported [t DM ha^{-1} a^{-1}][a]
Crested wheatgrass	*Agropyron desertorum* (Fisch ex Link) Schult.	C_3	16.3
Redtop	*Agrostis gigantea* Roth	C_3	Not available
Big bluestem	*Andropogon gerardii* Vitman	C_4	6.8–11.9
Smooth bromegrass	*Bromus inermis* Leyss.	C_3	3.3–6.7
Bermudagrass	*Cynodon dactylon* L.	C_4	1.0–1.9
Intermediate wheatgrass	*Elytrigia intermedia* [Host] Nevski	C_3	Not available
Tall wheatgrass	*Elytrigia pontica* [Podp.] Holub	C_3	Not available
Weeping lovegrass	*Eragrostis curvula* (Schrad.) Nees	C_4	6.8–13.7
Tall Fescue	*Festuca arundinacea* Schreb.	C_3	3.6–11.0
Switchgrass	*Panicum virgatum* L.	C_4	0.9–34.6
Western wheatgrass	*Pascopyrum smithii* (Rydb.) A. Love	C_3	Not available
Bahiagrass	*Paspalum notatum* Flugge	C_4	Not available
Napiergrass (elephant grass)	*Pennisetum purpureum* Schum	C_4	22.0–31.0
Reed canary grass	*Phalaris arundinacea* L.	C_3	1.6–12.2
Timothy	*Phleum pratense* L.	C_3	1.6-6.0
Energy cane	*Saccharum* spp.	C_4	32.5
Johnsongrass	*Sorghum halepense* (L.) Pers.	C_4	14.0–17.0
Eastern gammagrass	*Tripsacum dactyloides* (L.) L.	C_4	3.1–8.0

[a] t = Mg.

From Lewandowski et al., Biomass & Bioenergy 25,335

>1% yield is feasible

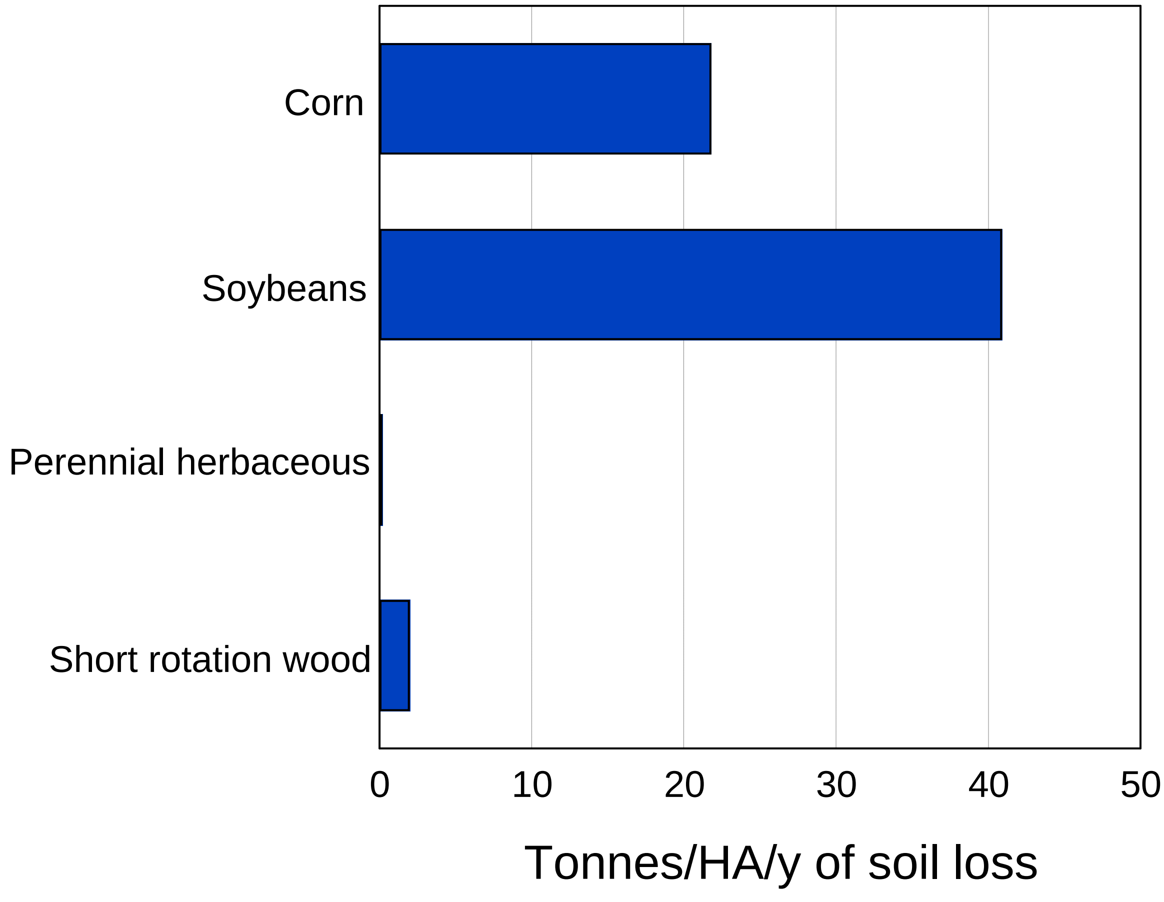
Yield of 26.5 tons/acre observed by Young & colleagues in Illinois, without irrigation

Courtesy of Steve Long et al

Harvesting Miscanthus

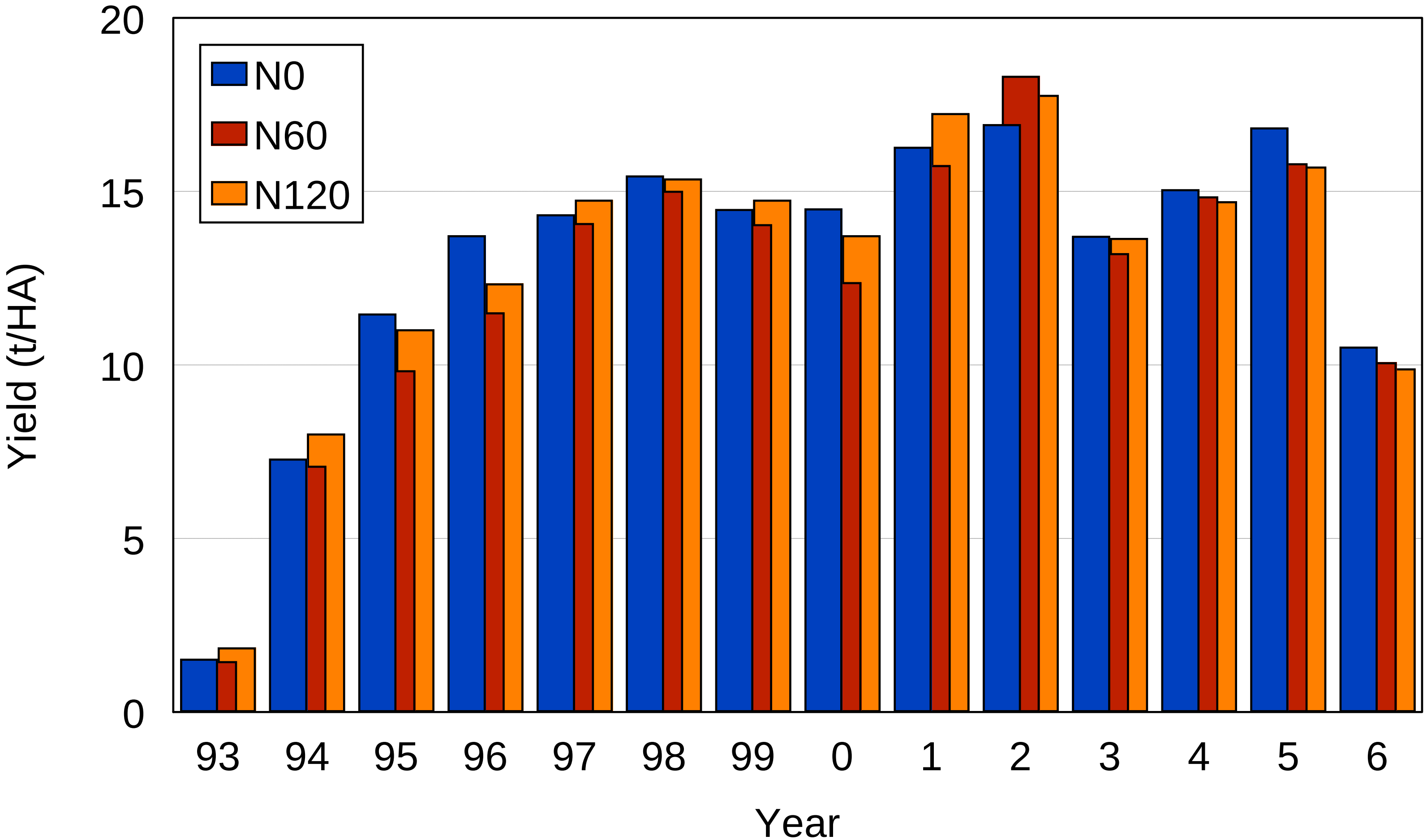
http://bioenergy.ornl.gov/gallery/index.html

Perennials have little or no erosion



From Oliveira et al in: Jones and Walsh (eds) Miscanthus for Energy and Fibre, 2001

Response of Miscanthus to nitrogen fertilizer

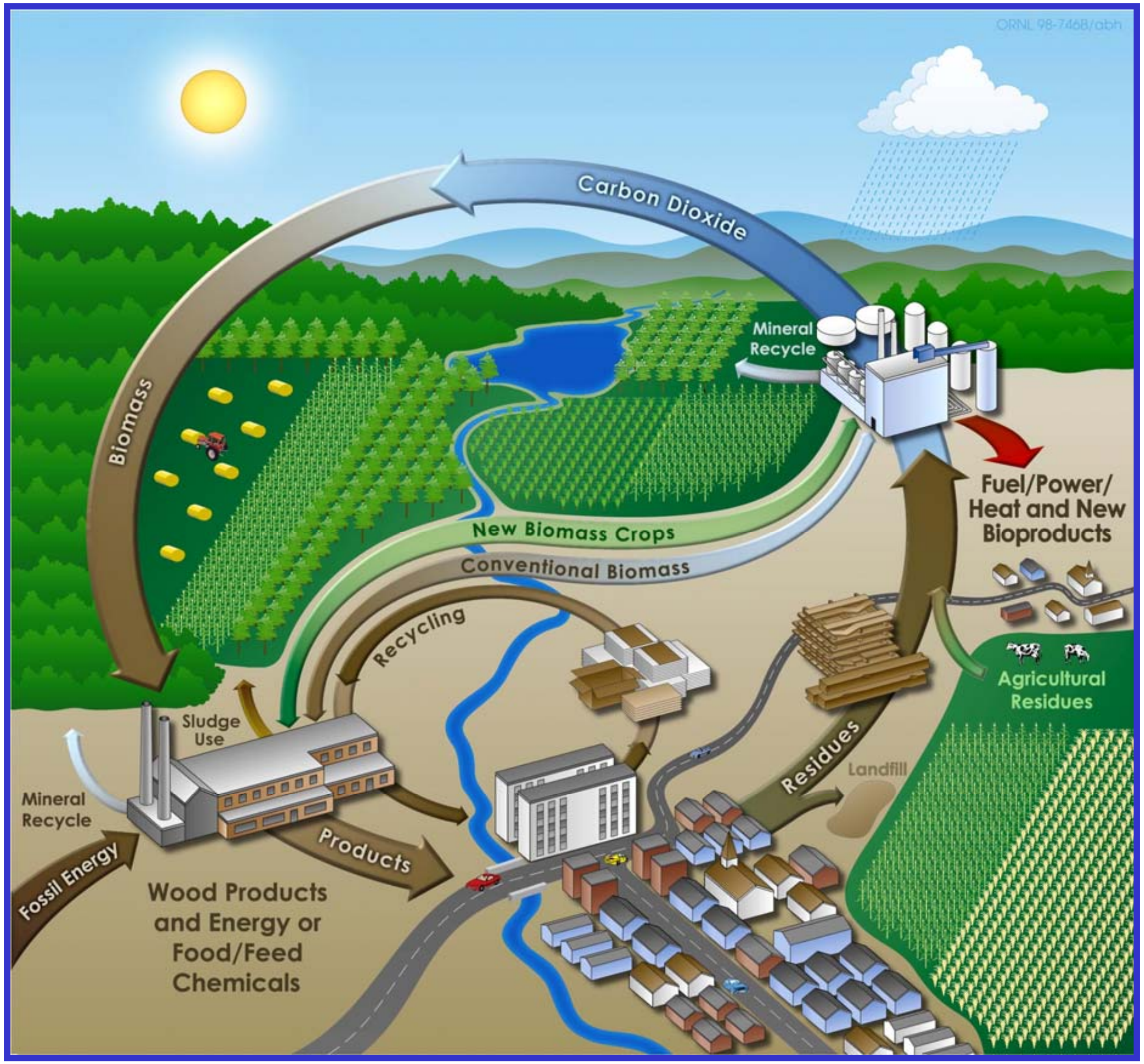


Christian, Riche & Yates Ind. Crops Prod. (2008)

Some research topics in crop production

- Self-incompatibility
  - Breeding challenging
- Biotic and abiotic stress
  - A lot of dry or saline land available
- Identification of useful species
  - Non-invasive, high productivity, low input
- Identification of useful variation
- Nutrient recycling and efficiency
- Nitrogen fixation

The Future



http://genomicsgtl.energy.gov/biofuels/index.shtml