The Science of Bioenergy Environmental Impacts

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http://www.porteralliance.org.uk

Outline

- Biodiversity
- Water
- Climate Change

- Differing regional perspectives on ‘what is important’

‘Sustainability’ priorities are different in Africa compared to Europe

	AFRICA (COMPETE, 2009)	UK (RTFO, 2008)
	Principle	Principle
1	Good agro-ecological and forestry practices	Conserve Carbon
2	Not adversely affecting water supply and quality	Conserve Biodiversity
3	No land use change that detrimentally affects food security	Soil Conservation
4	Community / women's participation	Sustainable Water Use
5	Skills transfer (business, agriculture)	Air Quality
6	Community inclusion in business or economic model (Contract with investor or NGO)	Compliance with applicable law (social issues)
7	Added value in the community	Contracts and subcontractors
8	Improvement in services and infrastructure reinvestment of revenue within the community	Freedom of association and right to collective bargaining
9	Compliance with National policy	Working hours
10	Compliance with Local programme or plan	Child labour
11	Respect for Land rights and avoid displacement	Health and safety
12		Wages / compensation
13		Discrimination
14		Forced Labour
15		Land rights issues

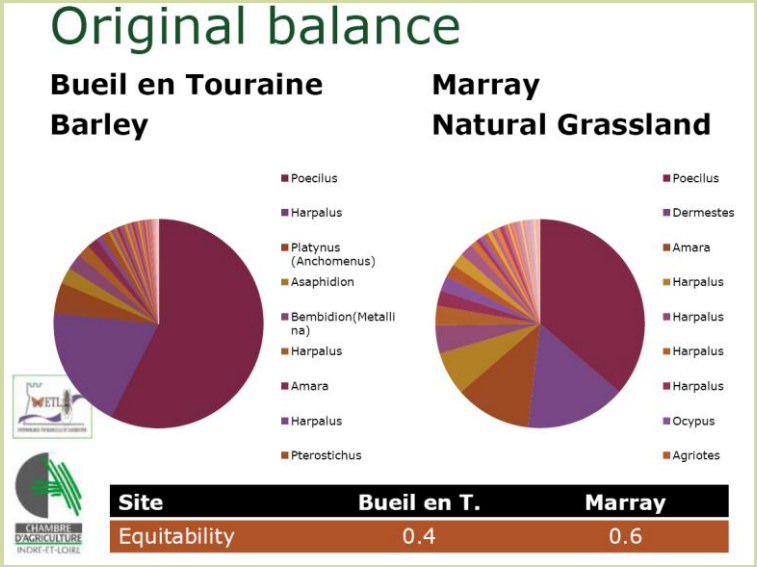
Cropping choices e.g. for biodiversity

In RELU-Biomass, biodiversity was studied in 24 fields of each crop (compared with arable crops).

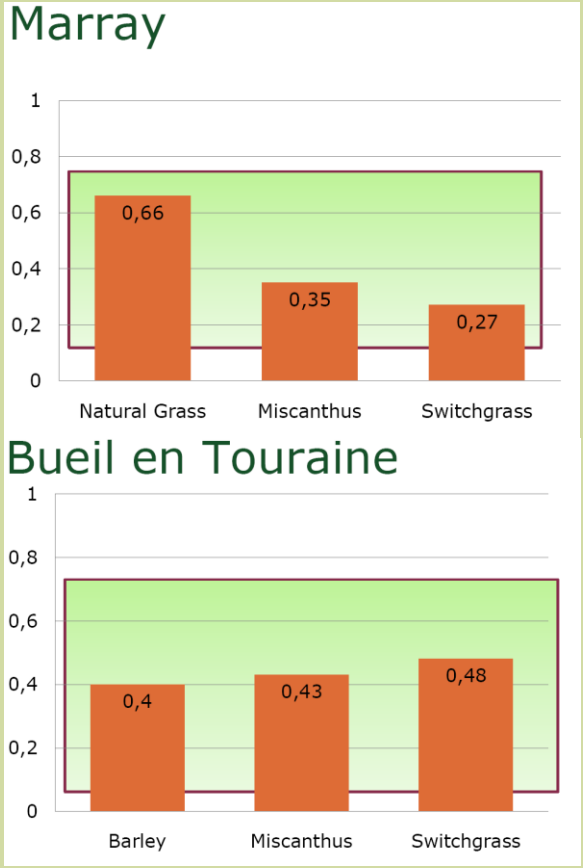
- Weed biomass and the abundance of a range of invertebrates was higher - especially in SRC
- SRC willow and Miscanthus had higher abundance of conservation butterflies
- Pest butterfly species were less abundant
- SRC Willow also showed more farmland and woodland birds but results in Miscanthus were less clear.

Karp, A. www.relu-biomass.org.uk
Haughton et al. 2009. J. Appl Ecol. 46, 323-333

Biodiversity impacts of energy grasses on natural grassland or arable land



Species richness and balance between natural grassland (Marray) and Barley production (Bueil en Touraine) in France (Bersonnet et al, 2010)



Biodiversity impacts of introducing perennial crops, Miscanthus and Switchgrass into natural grassland (Marray) and Barley production areas (Bueil en Touraine) using the Shannon's equitability index (Bersonnet et al, 2010)

Water-use, perennial energy crops

(Karp, 2010; RELU)

SRC willow and Miscanthus roots grow no deeper than deeper rooting annual crops.

SRC willow water use is similar to that of a cereal crop, higher than permanent grass and lower than that of mature woodlands

Miscanthus water-use approaches that of woodlands.

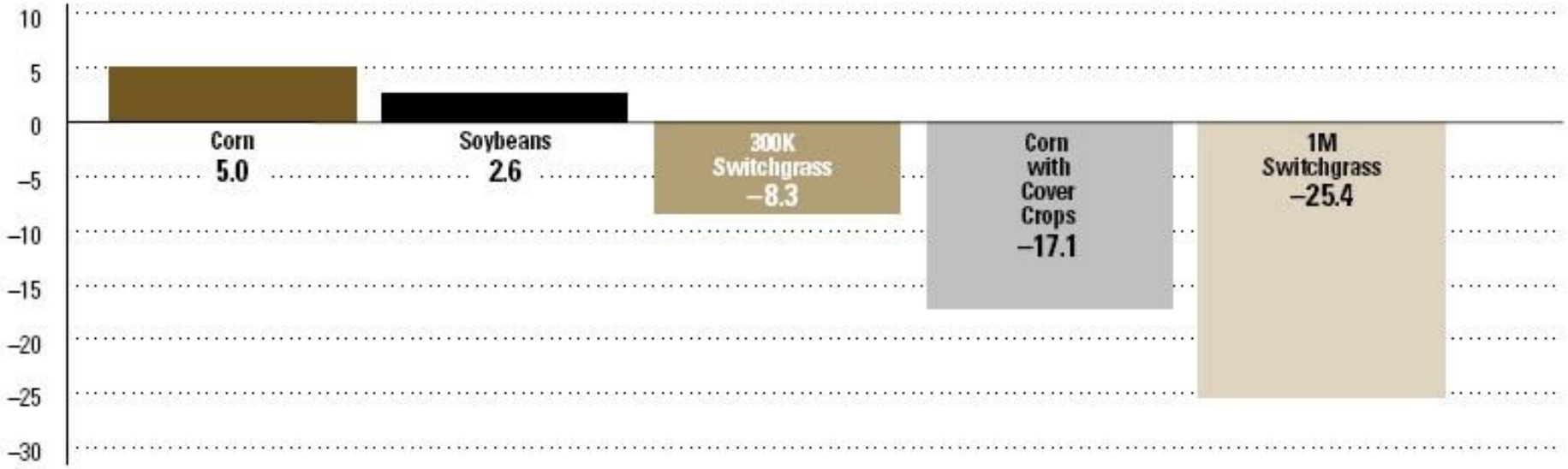
Potential water quality impacts of integrated biofuels (Chesapeake Bay)

Porter Alliance

FIGURE 5

Maximum Nitrogen Load Changes for Biofuels

Millions of pounds per year of nitrogen delivered from the Chesapeake Bay watershed to the Bay under five modeling scenarios.



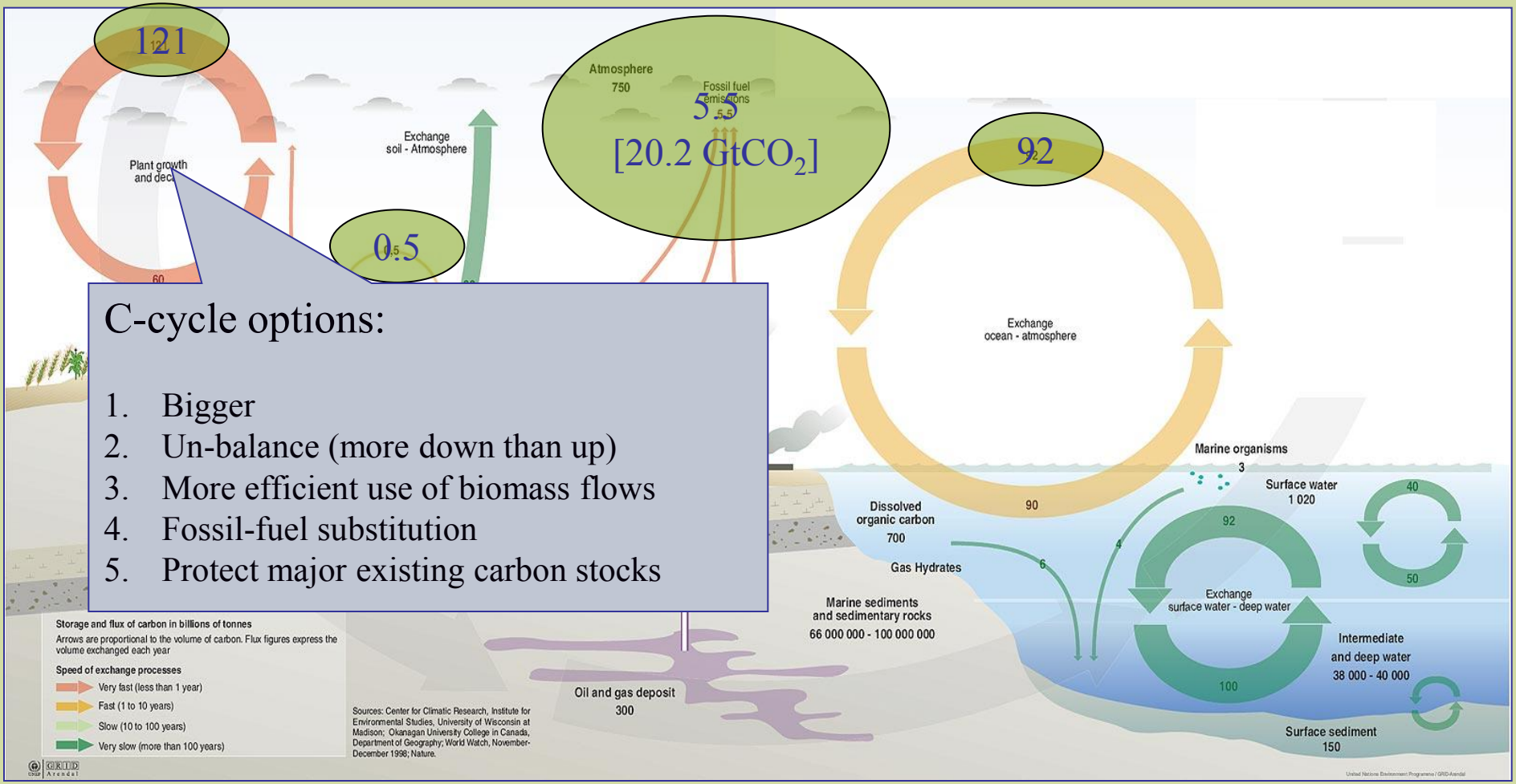
Assumptions for Alternative Scenarios:

- **Corn:** 300,000 additional acres of corn with typical levels of management practices
- **Soybeans:** 300,000 additional acres of soybeans with typical levels of management practices
- **300K Switchgrass:** 300,000 acres of switchgrass, converted primarily from hay and pastureland, with no fertilization
- **Corn with Cover Crops:** Cover crops on all existing and new (additional 300,000) corn acres and one quarter of all other row crops, watershed-wide.
- **1M Switchgrass:** 1 million acres of switchgrass, converted primarily from hay and pastureland, with no fertilization

SOURCE: U.S. EPA CHESAPEAKE BAY PROGRAM OFFICE

Biofuels and the Bay, 2007

Biological mitigation options and the Carbon Cycle (GtC)



C-cycle options:

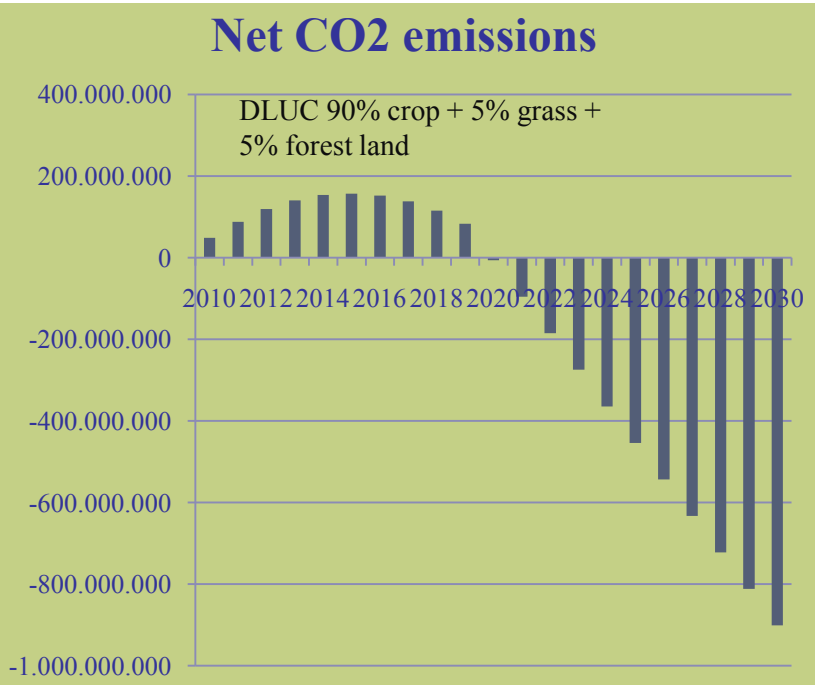
1. Bigger
2. Un-balance (more down than up)
3. More efficient use of biomass flows
4. Fossil-fuel substitution
5. Protect major existing carbon stocks

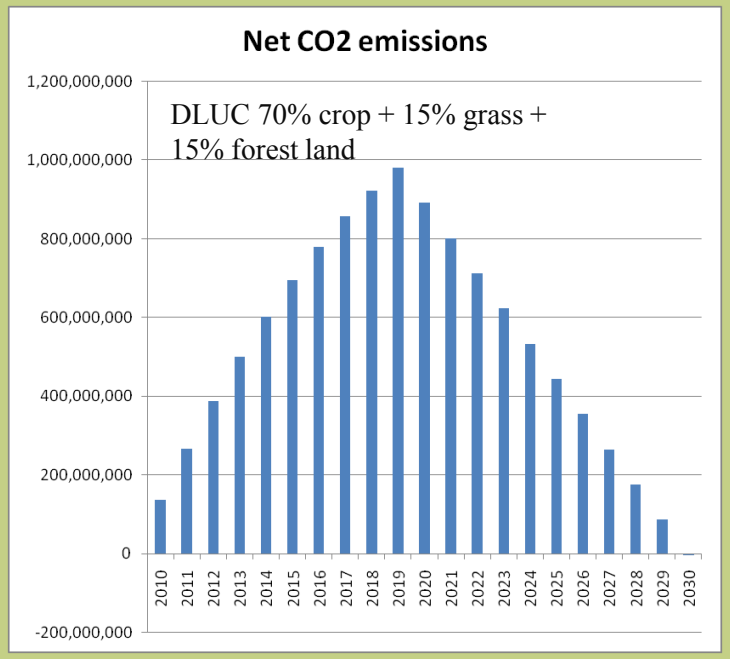
Source: http://www.vitalgraphics.net/graphic.cfm?filename=climate2/large/11.jpg

Biofuel GHG emissions

Source: adapted from: Taken from: DR-TREN: ASSESSMENT OF THE IMPACT OF LAND USE CHANGE ON GREENHOUSE GAS EMISSIONS FROM BIOFUELS AND BIOLIQUIDS. Incomplete draft; version 4 1 10

Possible EU Biofuel GHG emissions trajectory(s) Woods (2009)

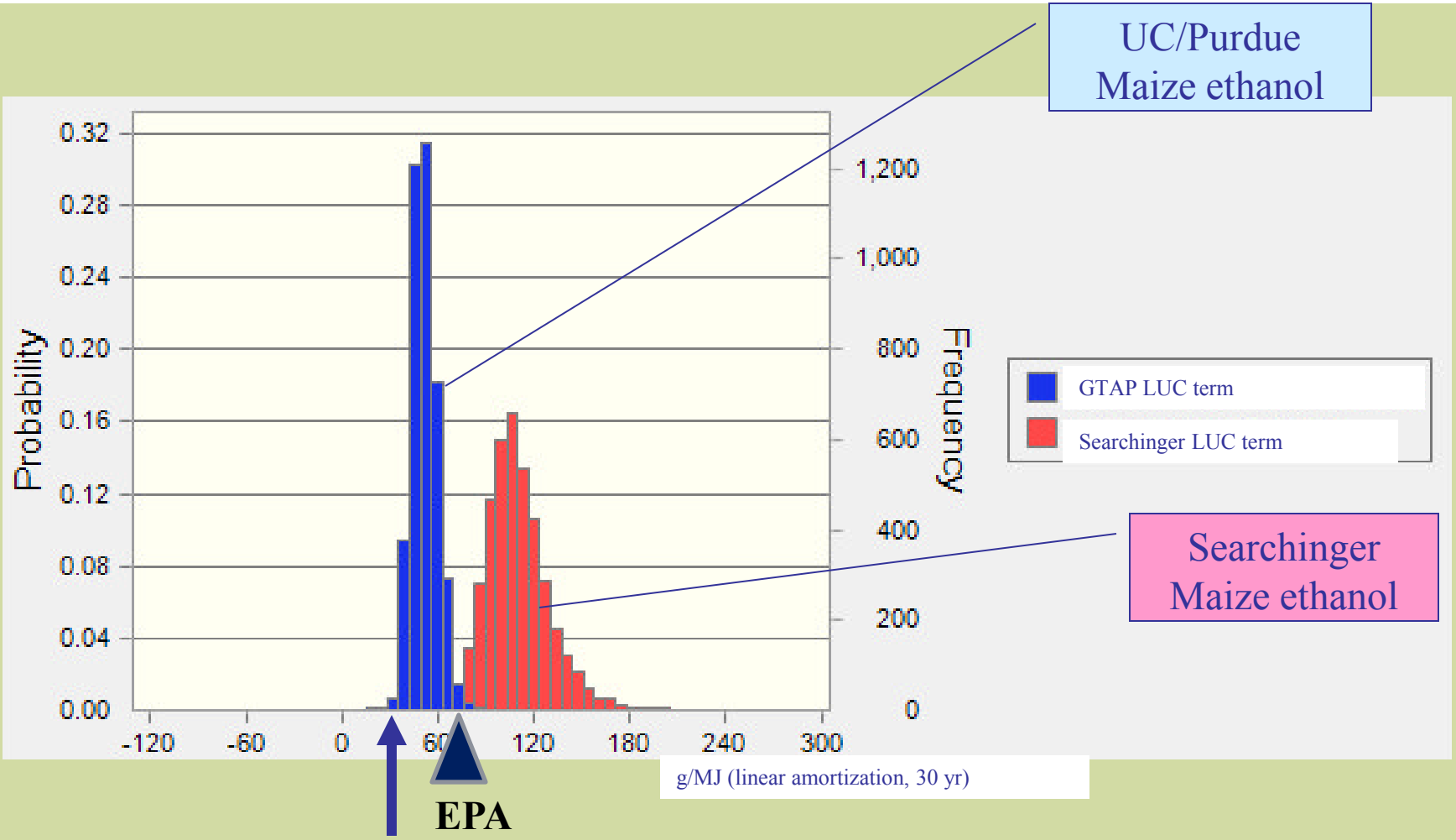




Avoided CO_{2eq} emissions from EU bioethanol production inc ILUC (+30 indirect land required as per Gallagher):

- assumes 50% GHG reduction factor for bioethanol using RTFO methodology
  - Porter cellulosic conversion will achieve 90% to 100%+ GHG reduction
- 16 Mha directly required planted at 1.6Mha/yr for 10 years from 2010
  - 90% on cropland, 5% grassland and 5% forest land
  - Or 70% cropland, 15% grassland and 15% forest land
- 50% wheat, 35% sugar beet and 15% sugarcane based!

Model Uncertainty and Parameter Uncertainty



Michael O'Hare (Berkley and CARB analysis, April 2010

Importance of Land Use Change (IPCC, 2000)

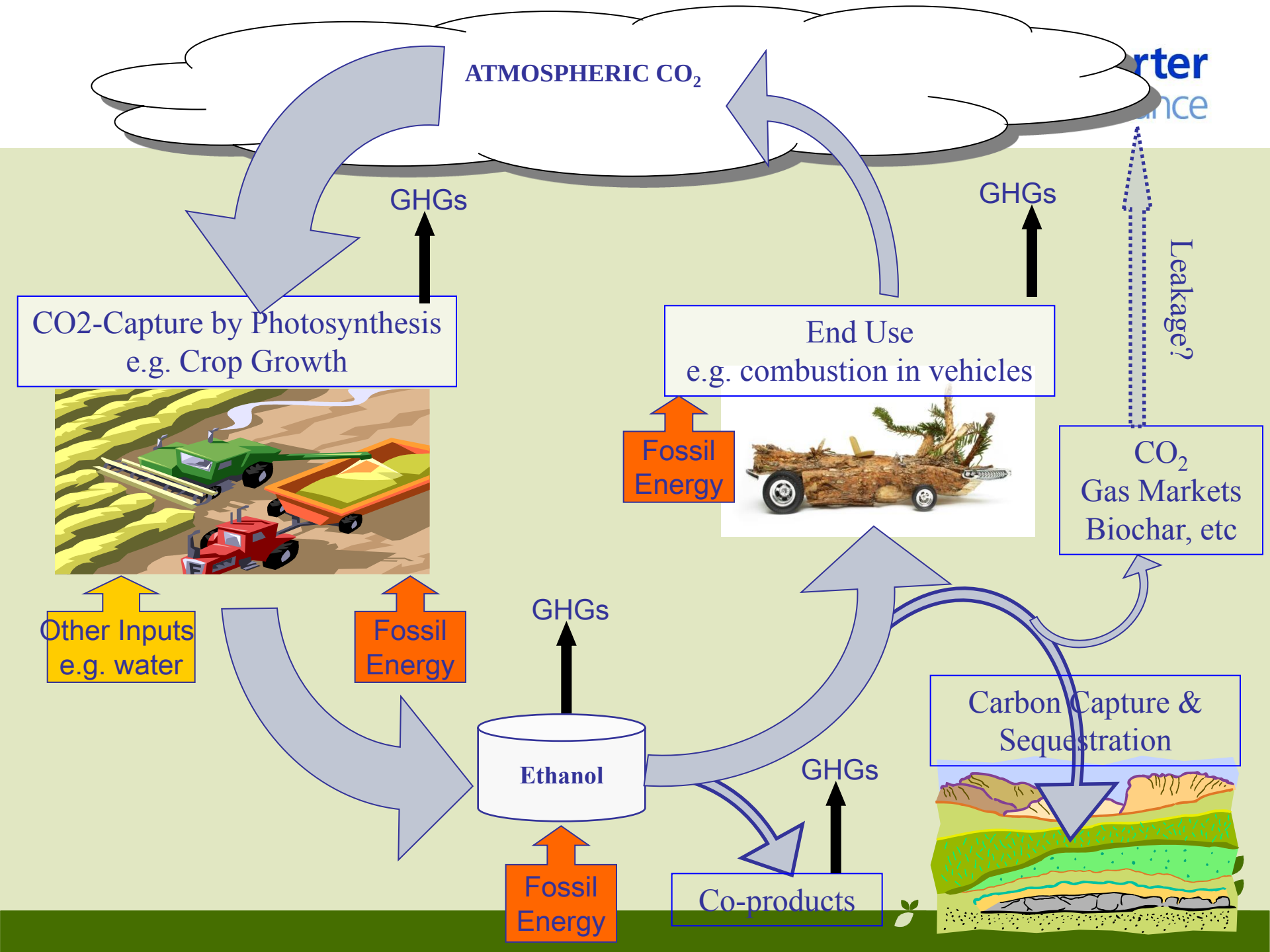
Average annual budget of CO2 for 1980 to 1989 and for 1989 to 1998, expressed in Gt C yr^{-1} (error limits correspond to an estimated 90% confidence interval).

	1989 to 1998 GtC/yr	±
1) Emissions from fossil fuel combustion and cement production	+6.3	0.6[a]
2) Storage in the atmosphere	-3.3	0.2
3) Ocean uptake	-2.3	0.8
4) Net terrestrial uptake = (1)-[(2)+(3)]	-0.7	1
5) Emissions from land-use change	+1.6	0.8[b]
6) Residual terrestrial uptake = (4)+(5)	-2.3	1.3

a Note that there is a one-year overlap (1989) between the two decadal time periods.

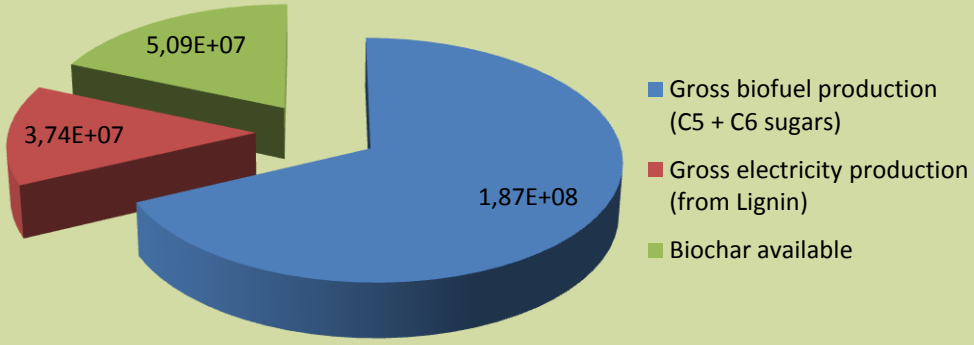
b This number is the average annual emissions for 1989–1995, for which data are available.

Source: IPCC Special Report on Land Use, Land Use Change and Forestry- summary for policy makers (2000)- p5


ATMOSPHERIC CO_2
GHGs
GHGs
Leakage?
CO2-Capture by Photosynthesis
e.g. Crop Growth
End Use
e.g. combustion in vehicles
Fossil
Energy
CO_2
Gas Markets
Biochar, etc
Other Inputs
e.g. water
Fossil
Energy
GHGs
Ethanol
Carbon Capture &
Sequestration
GHGs
Fossil
Energy
Co-products

Starting to play serious games with carbon, land and organic products

Eastern Europe: biorenewables carbon abatement potentials (tC)



53 M ha of European land could give up to 0.3 GtC abatement, through biofuels, bioelectricity and biochar (early estimate)

Global Carbon Fluxes in Products

	GtC/yr	Date
Crops (in food)	1.5	2000
Residues	1.5	2000
Transport	1.5	2010
Chemicals	1.0	2010
Electricity & Heat	3.5	2000
Total	8.0	

Accuracy, precision and uncertainty

"*It is much more important to be able to survey the set of possible systems approximately than to examine the wrong system exactly. It is better to be approximately right than precisely wrong.*"

Tribus and El Sayed (1982). Quoted by Jesper Kløverpris in RSB GHG working group response, 17th May 2010.

Summary

- Climate change mitigation that is based exclusively on capping energy / fossil fuel use will fail
- Biological options are the only productive way to take CO_2 from the atmosphere and counter-balance the inevitable continued fossil fuel leakage
  - ‘how else do we pick up the ‘spilt marbles’?
- Positive contributions will take creativity and care in handling land use change
- Integrated land management will/should enable mixing annuals with perennials to:
  - >100% GHG saving supply chains
  - Positive contributions to biodiversity
  - Positive hydrology management and erosion control
- Policy needs to target direct rather than indirect impacts

Acknowledgements *(contd.)*

NILE
New & Improved
Lignocellulosic Ethanol

IEA Task 40

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