Bioenergy and indirect land use change

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Definitions are important

Bioenergy

- Biomass : *any form of organic matter. Generally solid and used for heat and / or electricity*
- *Biofuels: generally liquid (or gaseous) fuels used for transport applications (also for cooking or lighting). Can also be used for electricity and/or heat generation*

Land cover

- *Crop land*
- *Forest*
- *Idle / marginal / resting / wasteland*

'Carbon opportunity cost'

- *impacts of the possible alternative fates of land use?*

Importance of Land Use Change

Table 2: 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).

	1980 to 1989		1989 to 1998	
	GtC/yr	±	GtC/yr	±
1) Emissions from fossil fuel combustion and cement production	5.5	0.5	6.3	0.6[a]
2) Storage in the atmosphere	3.3	0.2	3.3	0.2
3) Ocean uptake	2	0.8	2.3	0.8
4) Net terrestrial uptake = (1)-[(2)+(3)]	0.2	1	0.7	1
5) Emissions from land-use change	1.7	0.8	1.6	0.8[b]
6) Residual terrestrial uptake = (4)+(5)	1.9	1.3	2.3	1.3

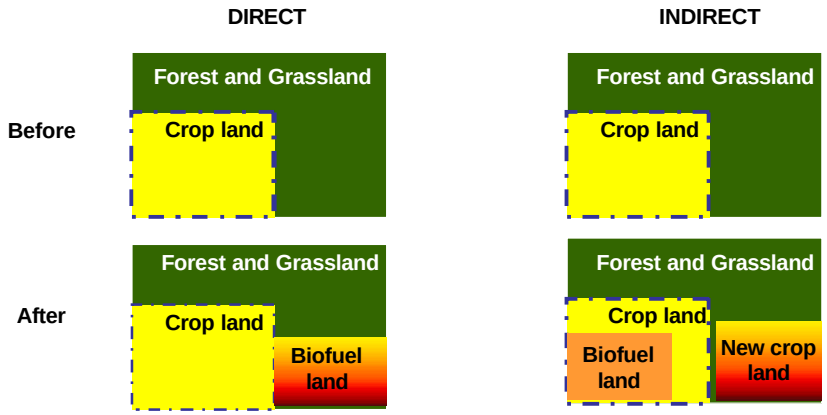
a Note that there is a one-year overlap (1989) between the two decadal time periods.

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

Indirect land use change leads to GHG emissions (Bauen & Howes, 2008)

Porter Alliance



Gallagher Review 2008: for every ha of biofuel production c. 0.3 ha of indirect land may result. [Highly uncertain and crop specific with strong linkages to animal feed]

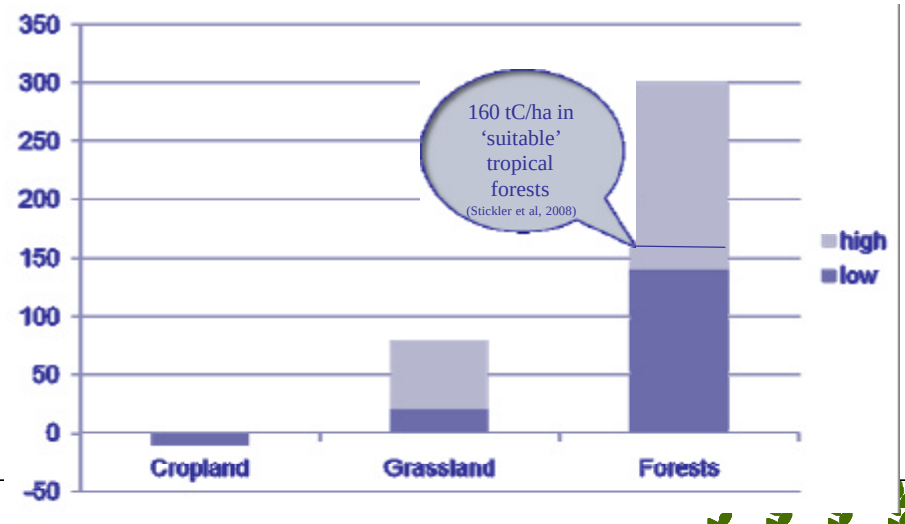
Terrestrial Carbon stocks

Table 1: Global carbon stocks in vegetation and soil carbon pools down to a depth of 1 m.

Biome	Area Bha	Global Carbon Stocks (Gt C) Vegetation	Soil	Total	Biome average *tC/ha*	*tCO2/ha*
Tropical forests	1.76	212	216	428	***243***	***892***
Temperate forests	1.04	59	100	159	***153***	***561***
Boreal forests	1.37	88	471	559	***408***	***1496***
Tropical savannas	2.25	66	264	330	***147***	***538***
Temperate grasslands	1.25	9	295	304	***243***	***892***
Deserts and semideserts	4.55	8	191	199	***44***	***160***
Tundra	0.95	6	121	127	***134***	***490***
Wetlands	0.35	15	225	240	***686***	***2514***
Croplands	1.60	3	128	131	***82***	***300***
Total	15.12	466	2011	2477	***164***	***601***
Total (avg) without croplands	13.52	463	1883	2346	***174***	***636***

Source: IPCC Special Report on Land Use, Land Use Change and Forestry - summary for policy makers (2000)- p4

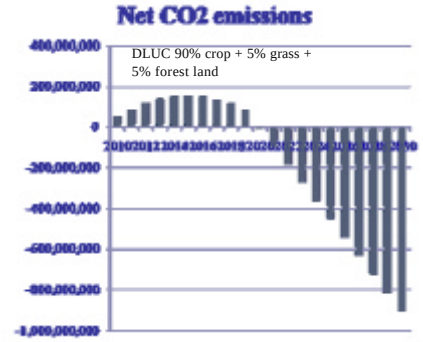
IPCC Land Use – Land Use Change (stocks / loss; tC/ha)

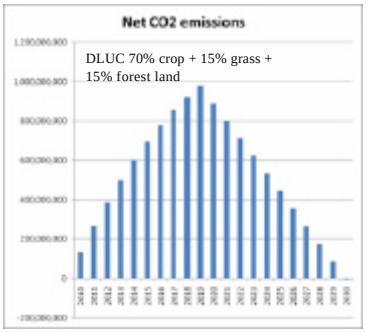


Key sensitivity parameters and uncertainty

- Net biofuel yield per ha (GJ/ha)- beware co-products!
- 'Direct' GHG reduction achieved by each biofuel ('attributional' LCA basis)
- Co-products (particularly animal feed, electricity, heat but also food, chemicals and materials)
- Allocation methods for those co-products
  - Mass? Energy? Substitution? Economic?
- Share of responsibility for deforestation assigned to biofuel production (direct and indirect) and type of forestry impacted
- Change in carbon stocks as result of LUC (direct and to a lesser extent indirect)

GHG emissions trajectory(s)



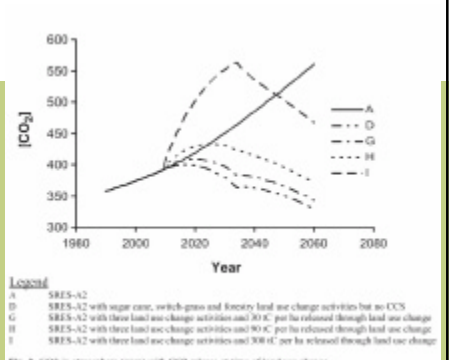


Avoided CO_{2eq} emissions from EU bioethanol production inc ILUC (+30 indirect land required as per Gallagher):

- 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!

Mitigating Climate Change

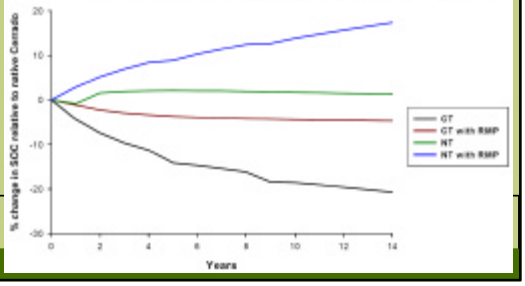
- Economics (Stern, 2007)
  - Capital costs
  - Operation & Maintenance costs
  - Land 'rental' costs / social costs
- Understanding 'Direct' & 'Indirect Effects'
  - Read (2007)
  - Searchinger et al + Fargione et al (2008)
  - Galbraith (2005)



Legend
A SRES-A2
D SRES-A2 with sugar cane, switch-grass and forestry land use change activities but no CCS
G SRES-A2 with three land use change activities and 30 tC per ha released through land use change
H SRES-A2 with three land use change activities and 90 tC per ha released through land use change
I SRES-A2 with three land use change activities and 300 tC per ha released through land use change

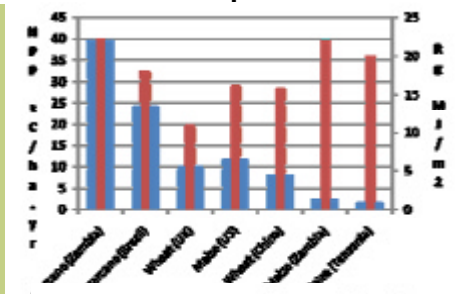
Fig. 2 CO2 in atmosphere (ppm) with CO2 release at time of land use change

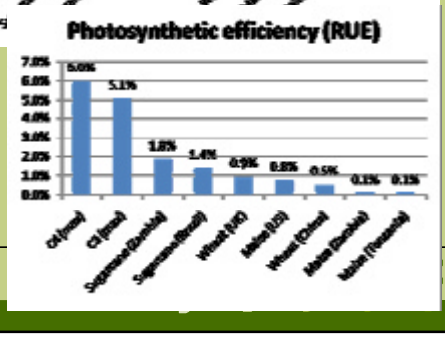
Figure 4.3: Mean modelled change in SOC for each management scenario (0-20 cm) for the first 14 years following conversion from Cerrado.



Much will depend on future yields for food, energy, materials and chemicals crops

- Theoretical maximum radiation use efficiencies of c. 5%
- In practice sugarcane in Zambia = 2% whilst average maize = 0.1%

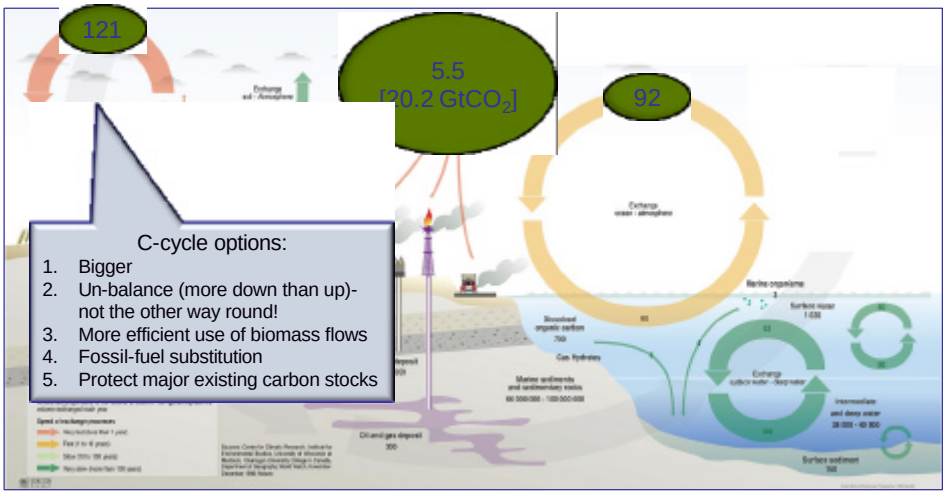




Summary

- Very large amount of uncertainty in the scale and spatial dispersion of future land use change
- Some aspects may be too difficult / complex to adequately cover in systems models
- Indirect land use change is not unique to biofuels but covers all activities that affect land including e.g. set-aside / CRP
- Options (not exclusive)
  - Increasing complex (scale/resolution and methodology) global land use models coupled to market models coupled to atmospheric models
  - Development and implementation of 'sustainability criteria' implemented through assurance and certification
  - Resolution of boundary conflicts e.g. geographic (winners and losers; links with REDD), and methodological covering 'leakage', double accounting, etc

The Carbon Cycle (GtC)



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