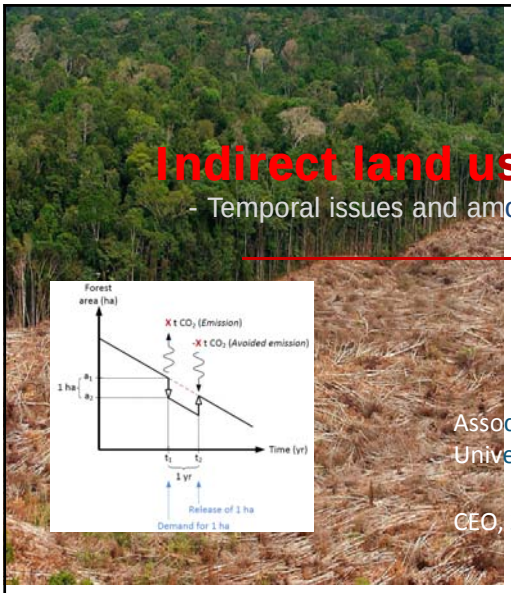


Indirect land use changes (iLUC)

- Temporal issues and amortisation, time-dependent Global Warming Potential (GWP)

Jannick H Schmidt

Aalborg 5th September 2013

Associate Professor, PhD, Aalborg University, Denmark | DCEA | DET DANSKE CENTER FOR MILJØVURDERING

CEO, 2.-0 LCA consultants

DCEA | DET DANSKE CENTER FOR MILJØVURDERING — ILCA International Life Cycle Academy — AALBORG UNIVERSITET

The challenge of temporal issues and amortisation

- Land use:
  - Unit: ha yr
  - Most often proportional with the functional unit, e.g. yield
- Land use change
  - Unit: ha transformation from X to Y
  - Unit is not proportional with functional unit

DCEA | DET DANSKE CENTER FOR MILJØVURDERING — ILCA International Life Cycle Academy — AALBORG UNIVERSITET 2

How can the problem be solved?

1. Amortisation
   - transformation "supports" a fixed number of functional units, OR
   - define a number of years to be attributed to occupation
2. Carbon Debt
   - Results not reported as impacts, but pay-back time (years)
   - Applicable to biofuels that substitute fossil alternative
   - Years before cumulative annual savings exceed transformation impact
3. Accelerated deforestation
   - Assuming that total deforestation (long term) is not affected by current demand for products
   - The effect of demanding products now is accelerated deforestation
   - GHG-effect calculated via Bern Carbon Cycle and IPCC's GWP

Amortisation (1 of 2)

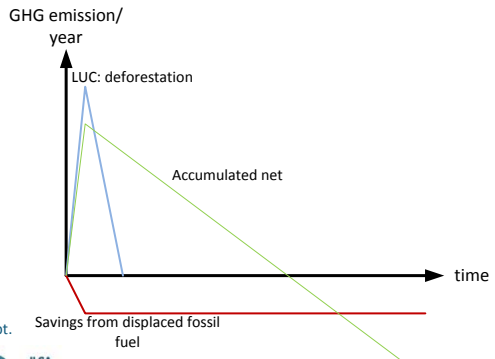
- Used in:
  - PAS2050
  - GHG-protocol
  - The EU Commission's PEF (product environmental footprint) guide
- How:
  - Occupation of 1 ha yr
  - Choose amortisation period – typically 20 years
  - Decide to include or exclude LUC
  - If LUC is included, identify C stock before and after LUC
  - GHG-emissions from LUC = $\Delta C \times (44/12) \times (1/20)$

Amortisation (2 of 2)

- Interpretation
  - Current demand for land causes:
    - deforestation up to 20 years ago, or
    - deforestation the next 20 years
  - Amortisation period is arbitrary
  - Choice to include or exclude LUC (based on historical data):
    - ignores trade with crops/animal products
    - inherently assumes that crop-displacement takes place
- Lack of causality and several arbitrary choices!

Carbon debt (1 of 2)

- Used in various biofuel studies
- Carbon debt = CO_2 release from converting natural habitat for biofuel production
- Over time biofuels can repay this carbon debt



- Fagionne et al. (2008), Land Clearing and the Biofuel Carbon Debt. Science Vol 319, pp 1235-1238

Carbon debt (2 of 2)

- Interpretation
  - Assumptions on baseline important: often untouched forest in very long period of time
  - Any interaction with surroundings (iLUC) ignored, i.e. very local market for land
  - Intensification ignored and difficult/not possible to include because in another unit/other methodology
- Limited usability!!
  - comparison parameter (GHG from alternative fuel) build-in as impact category
  - non-compliance with other impact categories

DCEA | DET DANSKE CENTER FOR MILJØVURDERING ILCA International Life Cycle Academy AALBORG UNIVERSITET 7

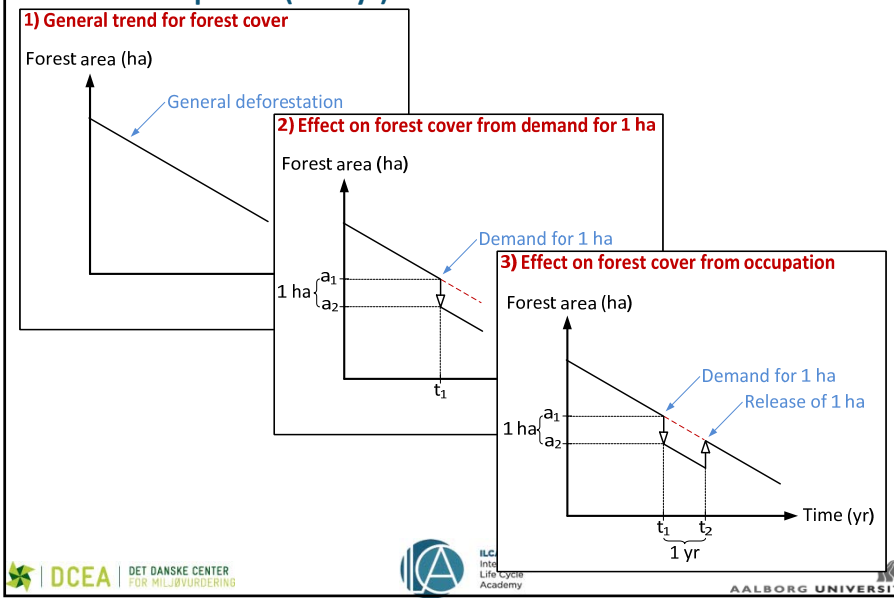
Accelerated deforestation

- Used in:
  - the 2.-0 LCA iLUC model
  - Kløverpris J and Mueller S (2012), Baseline time accounting - Considering global land use dynamics when estimating the climate impact of indirect land use change caused by biofuels
- Assumptions
  - Aim to establish relationship between demand for land and deforestation (effects)
  - Total deforestation not affected by demand for products
  - when 1 ha yr is needed this causes 1 ha accelerated deforestation by 1 yr (or 1 ha delayed naturalisation by 1 yr)
  - IPCC's GWP is used to quantify GHG-effects

DCEA | DET DANSKE CENTER FOR MILJØVURDERING ILCA International Life Cycle Academy AALBORG UNIVERSITET 8

Accelerated deforestation

Effect of occupation (1 ha yr)



DCEA | DET DANSKE CENTER FOR MILJØVURDERING

ILCA International Life Cycle Academy

AALBORG UNIVERSITET

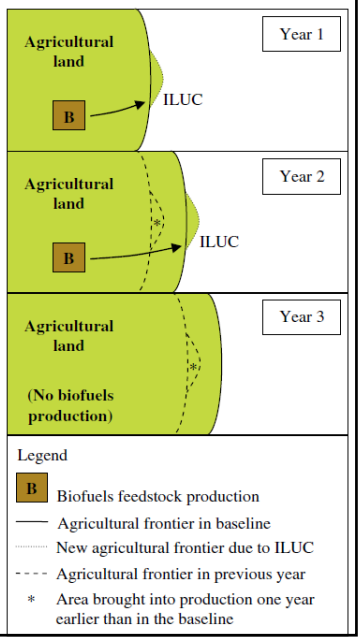
9

Accelerating deforestation

Kløverpris J and Mueller S (2012), Baseline time accounting - Considering global land use dynamics when estimating the climate impact of indirect land use change caused by biofuels. Int J Life Cycle Assess, DOI 10.1007/s11367-012-0488-6

Is the assumption that total deforestation is not affected desirable:

- What determines when deforestation stops?
- If assumption does not hold, then the approach underestimates deforestation effects



DCEA | DET DANSKE CENTER FOR MILJØVURDERING

ILCA International Life Cycle Academy

IPCC's global warming potential (GWP)

- The global warming potential
  - Originally used to differentiate different GHG-emissions (unit: CO_2-eq)

$$GWP_i = \frac{\int_0^{TH} RF_i(t)dt}{\int_0^{TH} RF_{CO_2}(t)dt}$$

  - TH = time horizon
  - RF = Radiative forcing (W/m^2)

IPCC's global warming potential (GWP)

- The global warming potential
  - Non-CO_2 GHG are removed via degradation (exp via life time)
  - CO_2 is removed via assimilation in the sea and in biomass. This can be expressed via Bern Carbon Cycle (IPCC 2007)

fraction (t) = 0.217+0.259*exp(-t/172.9)+0.338*exp(-t/18.51)+0.186*exp(-t/1.186).

  - The effect of CO_2 emitted at different times can be calculated
  - No need for considering RF when CO_2 is compared by CO_2 at different time

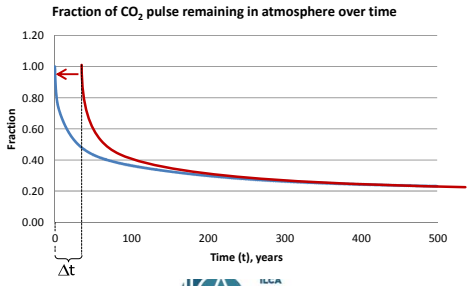
Industrial Designation or Common Name (years)	Chemical Formula	Lifetime (years)	RadiativeEfficiency (W m^{-2} ppb^{-1})	Global Warming Potential for Given Time Horizon			
				SAR‡ (100-yr)	20-yr	100-yr	500-yr
Carbon dioxide	CO_2	See below[a]	[b]1.4x10^{-5}	1	1	1	1
Methane[c]	CH_4	12[c]	3.7x10^{-4}	21	72	25	7.6
Nitrous oxide	N_2O	114	3.03x10^{-3}	310	289	298	153
Substances controlled by the Montreal Protocol							
CFC-11	CCl_3F	45	0.25	3,800	6,730	4,750	1,620
CFC-12	CCl_2F_2	100	0.32	8,100	11,000	10,900	5,200
CFC-13	$CClF_3$	640	0.25		10,800	14,400	16,400
			.3	4,800	6,540	6,130	2,700

http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html

IPCC's global warming potential (GWP)

- The global warming potential
  - CO_2 is removed via assimilation in the sea and in biomass
  - This can be expressed via the Bern Carbon Cycle (IPCC 2007)

    fraction (t) = 0.217+0.259*exp(-t/172.9)+0.338*exp(-t/18.51)+0.186*exp(-t/1.186).
  - The effect of CO_2 emitted at different times can be calculated
  - No need for considering RF when CO_2 is compared by CO_2 at different time



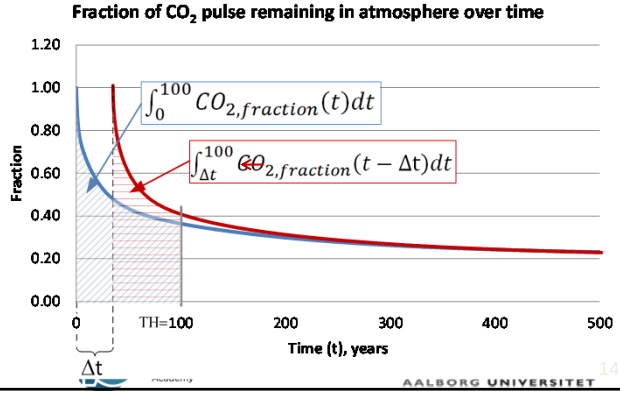
IPCC's global warming potential (GWP)

- Effect of accelerating deforestation = emitting CO_2 emissions in yr 0 instead of yr 1:

$$GWP_{CO2,\Delta t} = \frac{\int_{\Delta t}^{100} CO_{2,fraction}(t-\Delta t)dt}{\int_{0}^{100} CO_{2,fraction}(t)dt} \qquad GWP_{CO2,\Delta t=0} = 1 \qquad GWP_{CO2,\Delta t=1} = 0.9924$$

Effect of emitting 1 kg CO_2 in year 0 instead of year 1:

$GWP_{CO2,t=1\rightarrow 0}$
= 1 – 0.9924
= 0.0076 kg CO_2-eq.



GWP20 and GWP100 for CO2-emissions at different times

Δt	$GWP20_{CO2}(\Delta t)$	$GWP100_{CO2}(\Delta t)$
0	1.00	1.00
1	0.96	0.99
2	0.92	0.98
3	0.87	0.98
4	0.83	0.97
5	0.79	0.96
6	0.74	0.95
7	0.70	0.95
8	0.65	0.94
9	0.60	0.93
10	0.55	0.92
11	0.50	0.92
12	0.45	0.91
13	0.40	0.90
14	0.35	0.89
15	0.30	0.88
16	0.24	0.88
17	0.19	0.87
18	0.13	0.86
19	0.07	0.85
20	0	0.84
21	0	0.84
22	0	0.83
23	0	0.82
24	0	0.81
25	0	0.80

	GWP20	GWP100
CH_4	72	25
N_2O	289	298

DCEA | DET DANSKE CENTER FOR MILJØVURDERING

AALBORG UNIVERSITET 15

The effect of time horizon on iLUC GHG emissions

- the 2.-0 LCA iLUC model v4.0

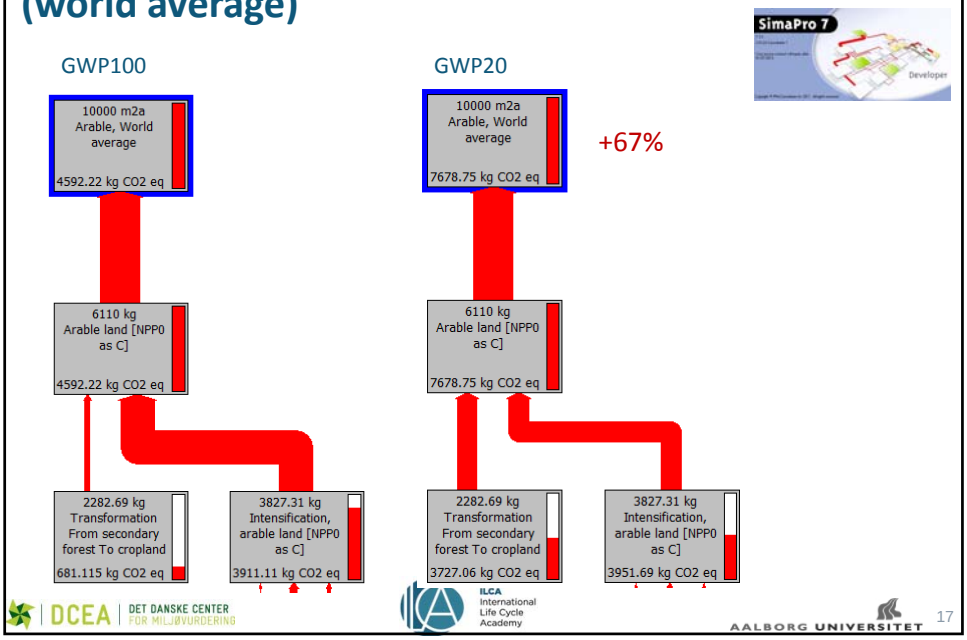
Time horizon

DCEA | DET DANSKE CENTER FOR MILJØVURDERING

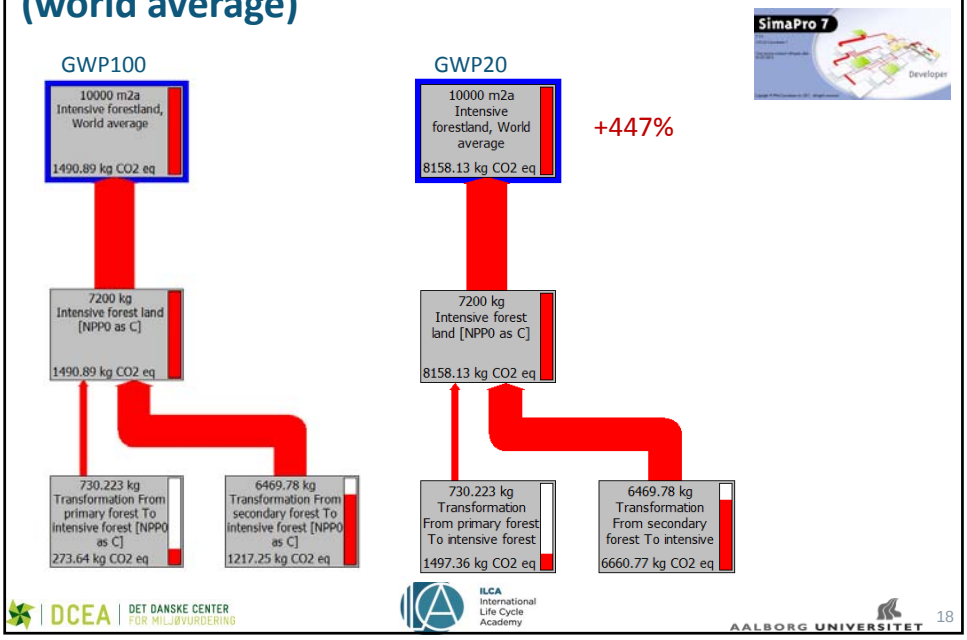
ILCA International Life Cycle Academy

AALBORG UNIVERSITET

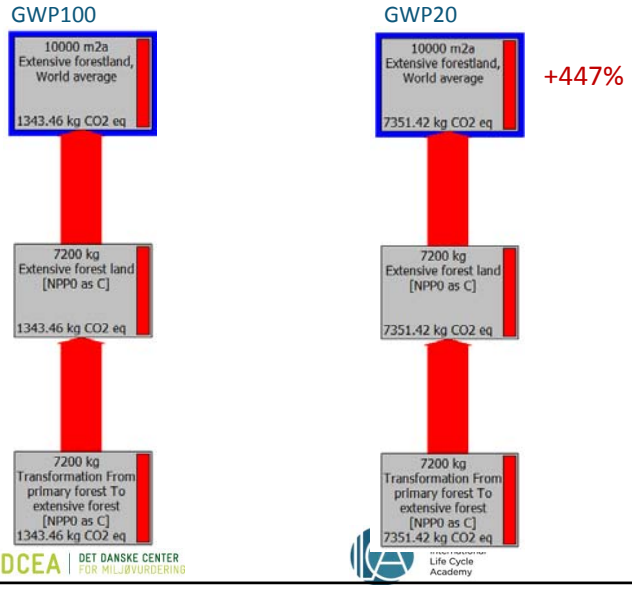
Market for land tenure: 1 ha yr arable land (world average)



Market for land tenure: 1 ha yr intensive forest land (world average)



Market for land tenure: 1 ha yr extensive forest land (world average)

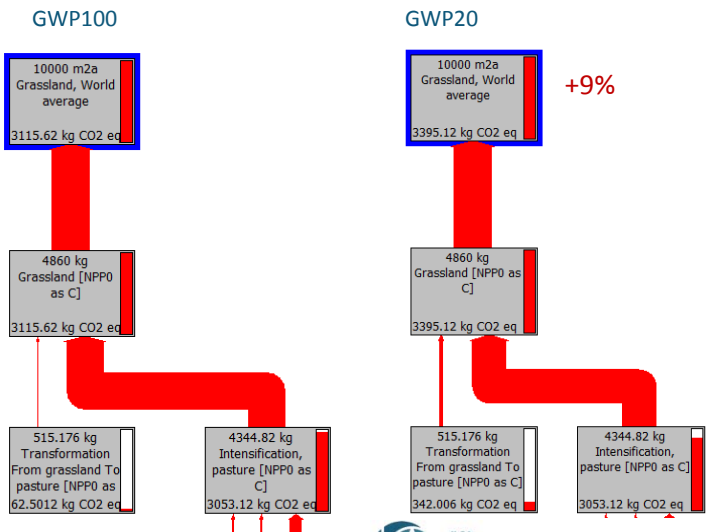


DCEA | DET DANSKE CENTER FOR MILJØVURDERING

ILCA International Life Cycle Academy

AALBORG UNIVERSITET 19

Market for land tenure: 1 ha yr grass land (world average)



DCEA | DET DANSKE CENTER FOR MILJØVURDERING

ILCA International Life Cycle Academy

AALBORG UNIVERSITET 20

If you want to know more…

Choose among our courses at:

www.ilca.es

ILCA
International
Life Cycle
Academy

DCEA | DET DANSKE CENTER FOR MILJØVURDERING

ILCA International Life Cycle Academy

AALBORG UNIVERSITET