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Harmonisation and update of the biomass datasets in the context of bioenergy

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Overview

- Introduction
- Update of N emissions
  - Methods
  - Results
- Update of LUC inventories
  - Methods
  - Results
- New biofuel crop inventories
- Conclusions

Background and motivation

- The environmental impact of biofuels from agricultural biomass is dominated by the agricultural phase
- The emission of greenhouse gases is a key criterion for the evaluation of biofuels
- Dynamic context
  - New emission models and factors for nitrous oxide (N_2O), ammonia (NH_3) and nitrate (NO_3)
  - New methods and better data on land use change
  - Emerging sources of biomass like Jatropha, Miscanthus, Salix

→ An update, harmonisation and extension of the data for the assessment of biofuels is required

New nitrogen emission models used

N compound	Applied	Emission model used
Ammonia (NH_3)	Global	AGRAMMON
Nitrate (NO_3)	Europe	SALCA-NO3
	Non-European countries	SQCB / de Willigen (2000)
Nitrous oxide (N_2O)	Global	IPCC 2006, Tier 1

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N_2O emissions according to IPCC 1996/2001 vs. 2006

$$N_2O = \frac{44}{28} \cdot \left(\overbrace{0.0125 \cdot \left(Nav - \frac{14}{17} NH_3 + Ncr + 0.6 \cdot Nbf \right)}^{\text{direct}} + \overbrace{0.01 \cdot \frac{14}{17} NH_3 + 0.025 \cdot \frac{14}{62} \cdot NO_3^-}^{\text{indirect}} \right)$$

N_2O	N_2O emissions (kg N_2O ha^{-1})
Nav	available N (kg N ha^{-1})
Ntot	total N (kg N ha^{-1})
Ncr	N in crop residues (kg N ha^{-1})
Nbf	N from biological N fixation (kg N ha^{-1})
NH_3	ammonia volatilisation (kg NH_3 ha^{-1})
NO_3^-	nitrate leaching (kg NO_3^- ha^{-1})

IPCC Guidelines 2006:

$$N_2O = \frac{44}{28} \left(0.01 \left(N_{tot} + Ncr + 0.0\ Nbf \right) + 0.01 \frac{14}{17} NH_3 + 0.0075 \frac{14}{62} NO_3^- \right)$$

-20% +x% +y% -100% -70%

Ammonia emissions Model AGRAMMON

Organic fertilisers

NH_3–N = TAN * er * c_x

- NH_3–N = Ammoniak-Stickstoff [kg NH3-N/ha]
- TAN = Total ammonium [kg NH3-N/ha]
- er = emission rate [%/100]
- c_x = correction factors for
  - Period and conditions of application
  - Application technique
  - Dilution rate

Mineral fertilisers

NH_3–N = N * er

- er specific for each fertiliser type

Source: Agrammon Group (2009) www.agrammon.ch

Model SALCA-NO3

- Modelling of nitrate leaching in monthly intervals in function of
  - Pedo-climatic conditions
    - Soil characteristics (clay and humus content, rooting depth)
    - Precipitation during winter
    - Temperature
  - Crop management:
    - Crop rotation, sowing and harvest dates
    - Soil tillage
  - Characteristics of the crop:
    - Nitrogen uptake dynamics during the year (in function of the yield, modelled by STICS)
  - Inputs:
    - Mineral and organic fertilisers (including long term-effect of org. fert.)
    - Dates of N fertilisation
- Source: Richner *et al*. (2011)

Nitrate leaching SQCB model

- Regression model according to de Willigen (2000), Roy et al. (2003),Faist Emmenegger *et al.* (2009):

$$N = 21.37 + \frac{P}{c * L}\left[0.0037 * S + 0.0000601 * N_{org} - 0.00362 * U\right]$$

N = nitrate leaching [kg NO_3-N/ha]

P = precipitation + irrigation [mm]

c = clay content [%]

L = rooting depth [m]

S = N fertilisation [kg N/ha]

N_{org} = N in soil organic matter [kg N/ha]

U = N uptake by the vegetation [kg N/ha]

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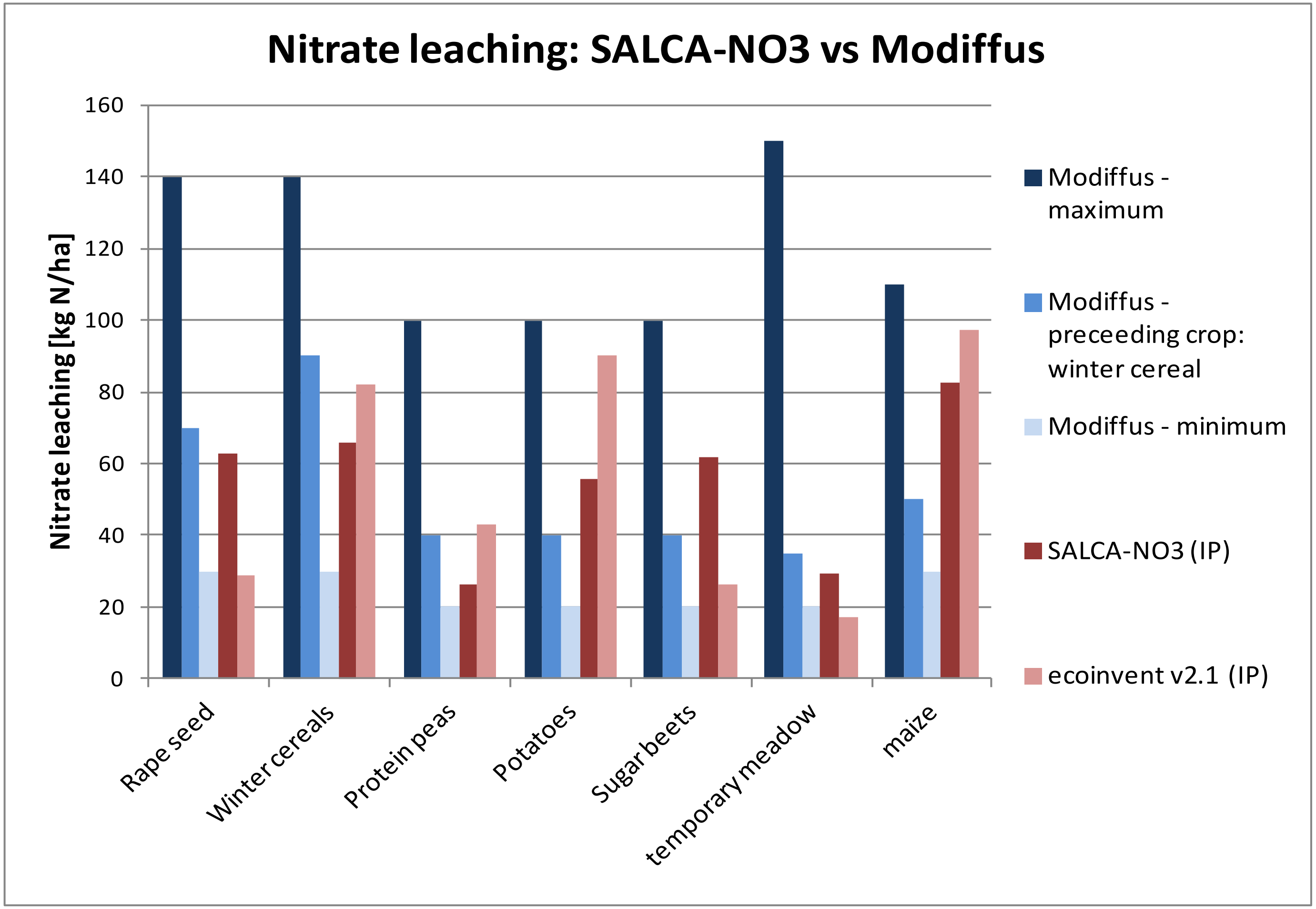
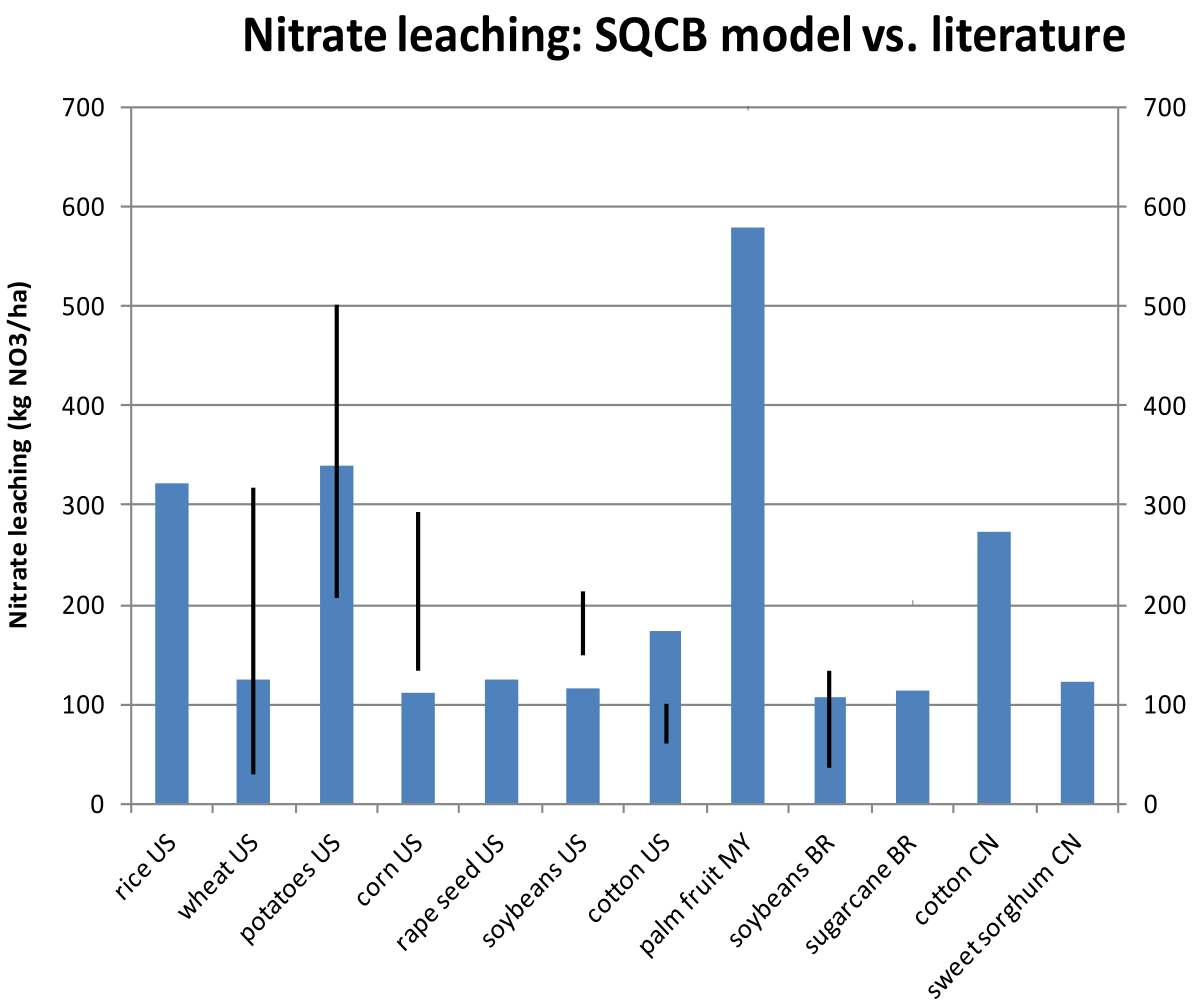
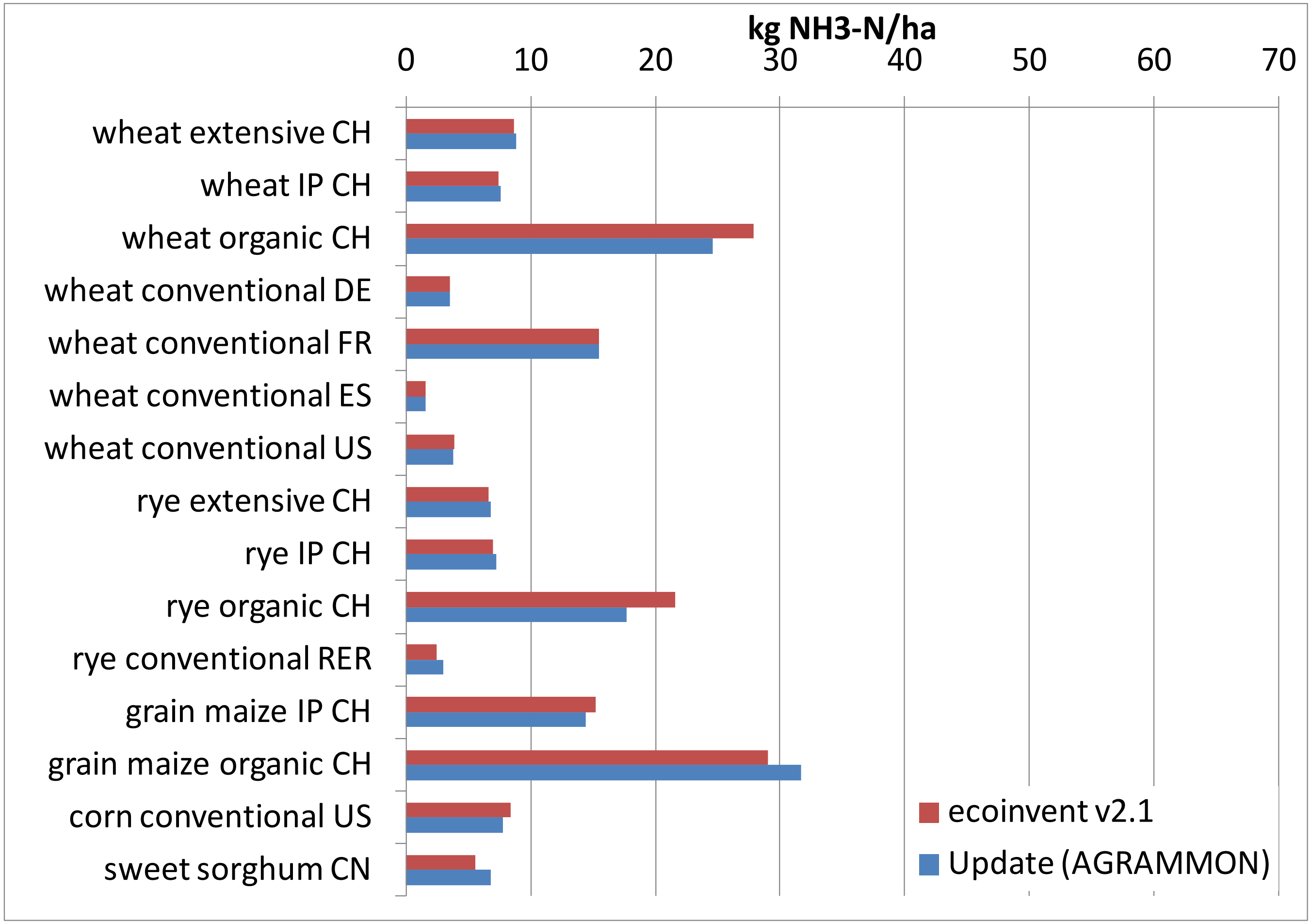
Validation of nitrate leaching for Swiss crops



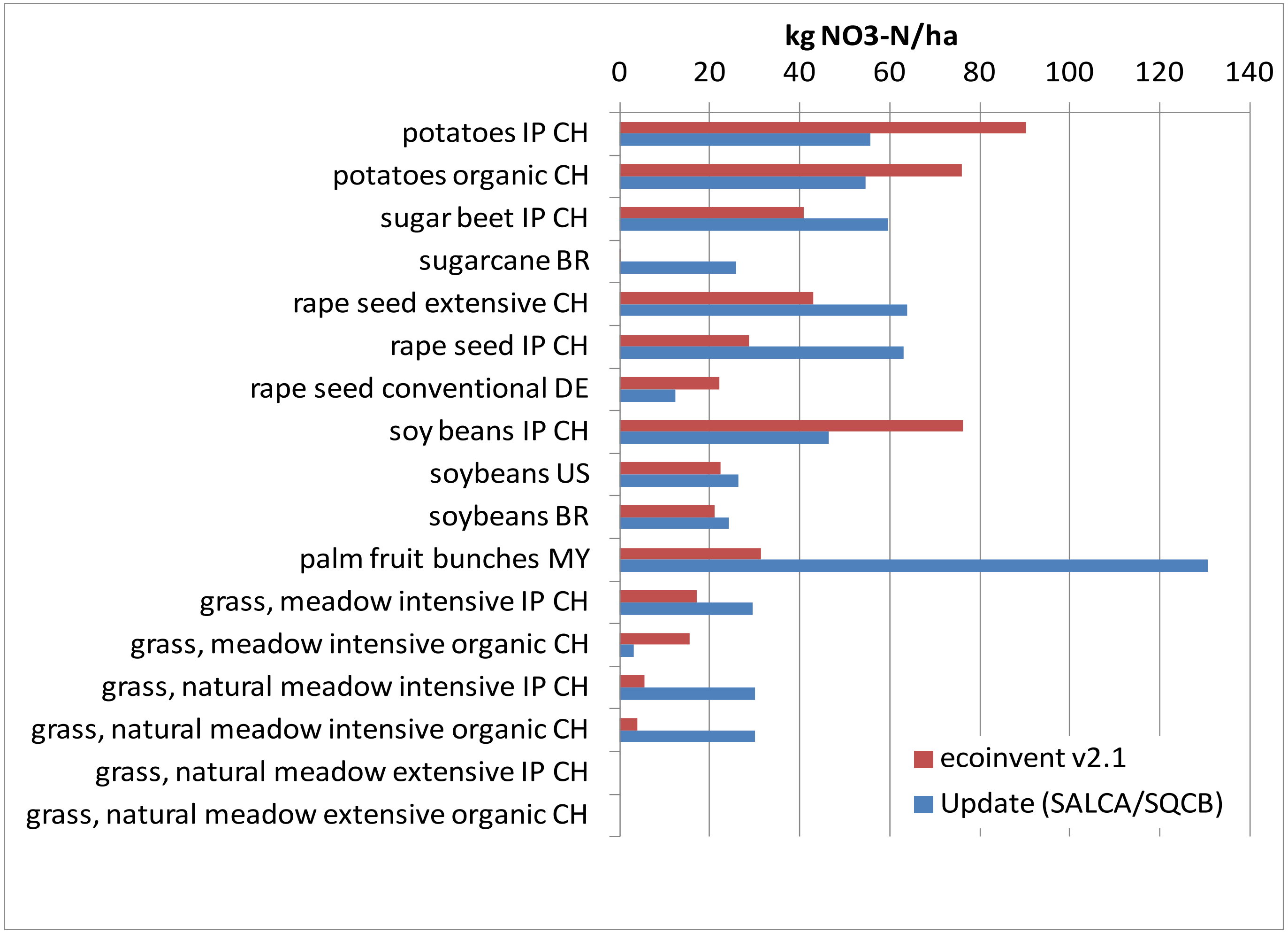
Validation of nitrate leaching for non-European crops



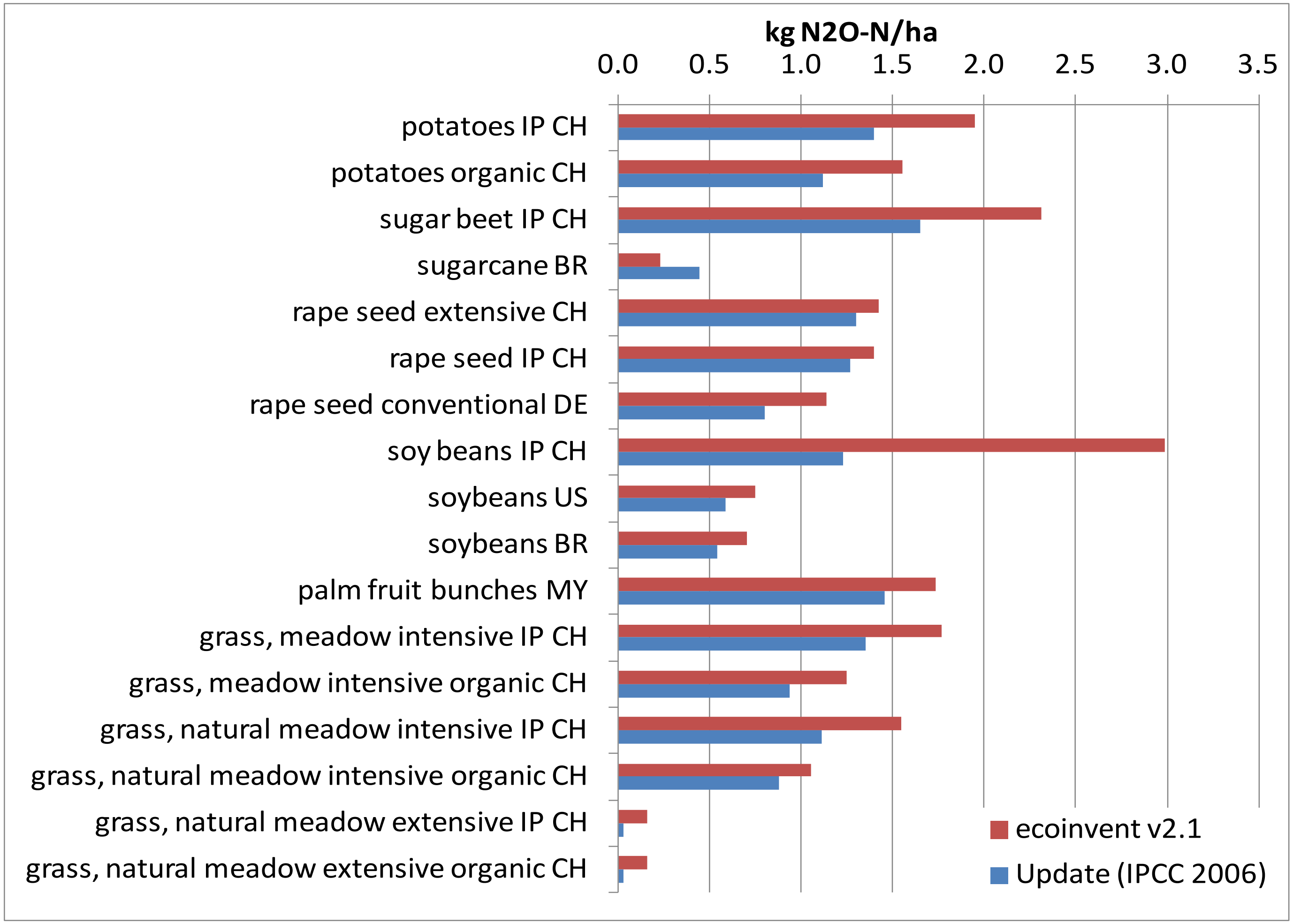
Ammonia emissions: cereals comparison of ecoinvent V2 and V3



Nitrate leaching: other crops comparison of ecoinvent V2 and V3



Nitrous oxide emissions: other crops comparison of ecoinvent V2 and V3



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N emissions: relative changes between ecoinvent V2 and V3

	kg NH_3-N/ha	kg NO_3-N/ha	kg N_2O-N/ha
ecoinvent v2.1	13.69	40.28	1.38
ecoinvent v3	13.04	45.70	1.01
Relative change	**-4.8%**	**+13.4%**	**-26.4%**

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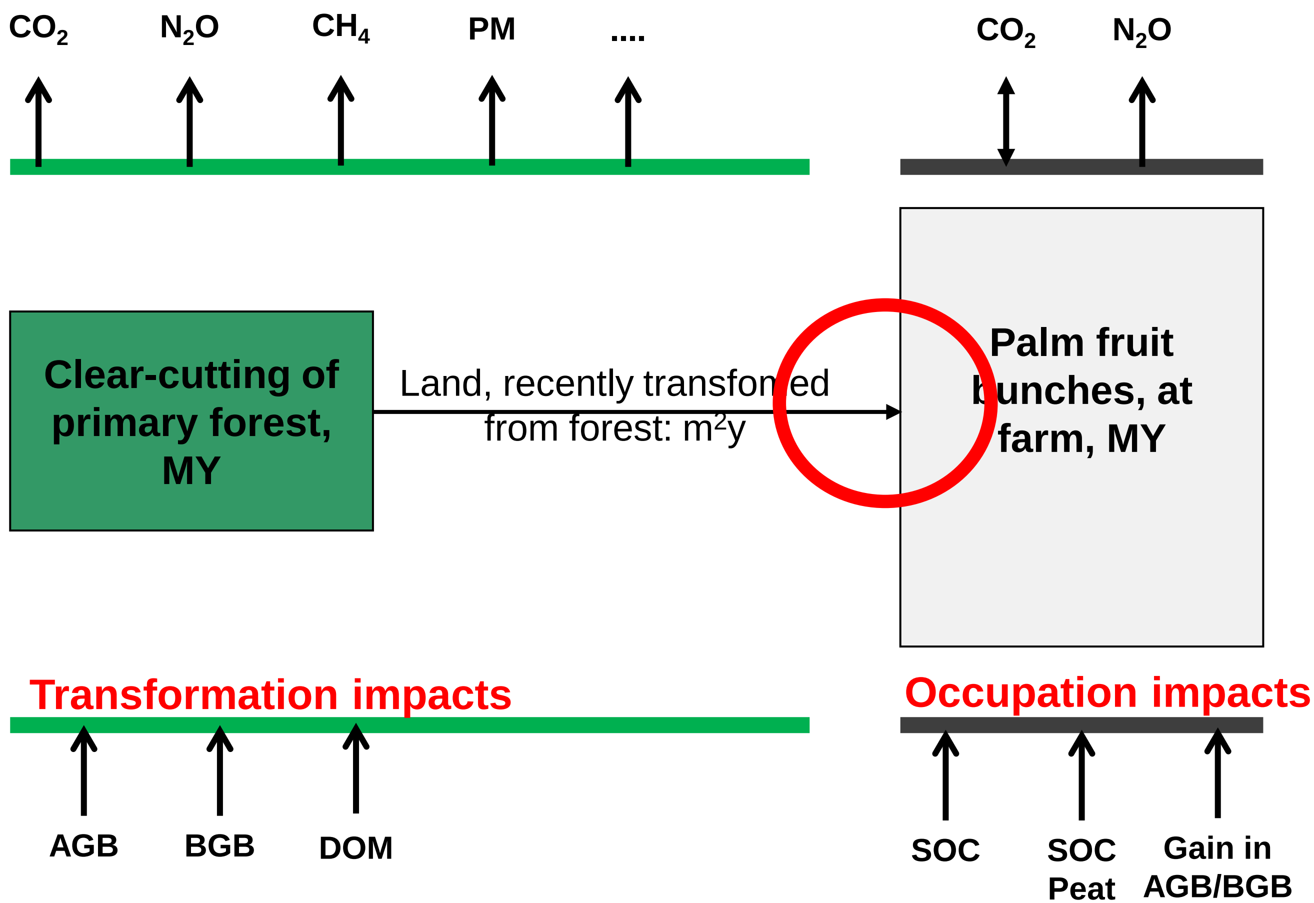
Update LUC inventories

- Goal: update of the emission from direct LUC for all relevant crop activities:
  - Soybean, Brazil (BR)
  - Sugarcane, BR
  - Palm fruit bunches, Malaysia (MY)

- Consistent consideration of all carbon pools (IPCC 2006)
  - Above Ground Biomass (AGB)
  - Below Ground Biomass (BGB)
  - Dead Organic Matter (DOM)
  - Soil Organic Carbon (SOC)

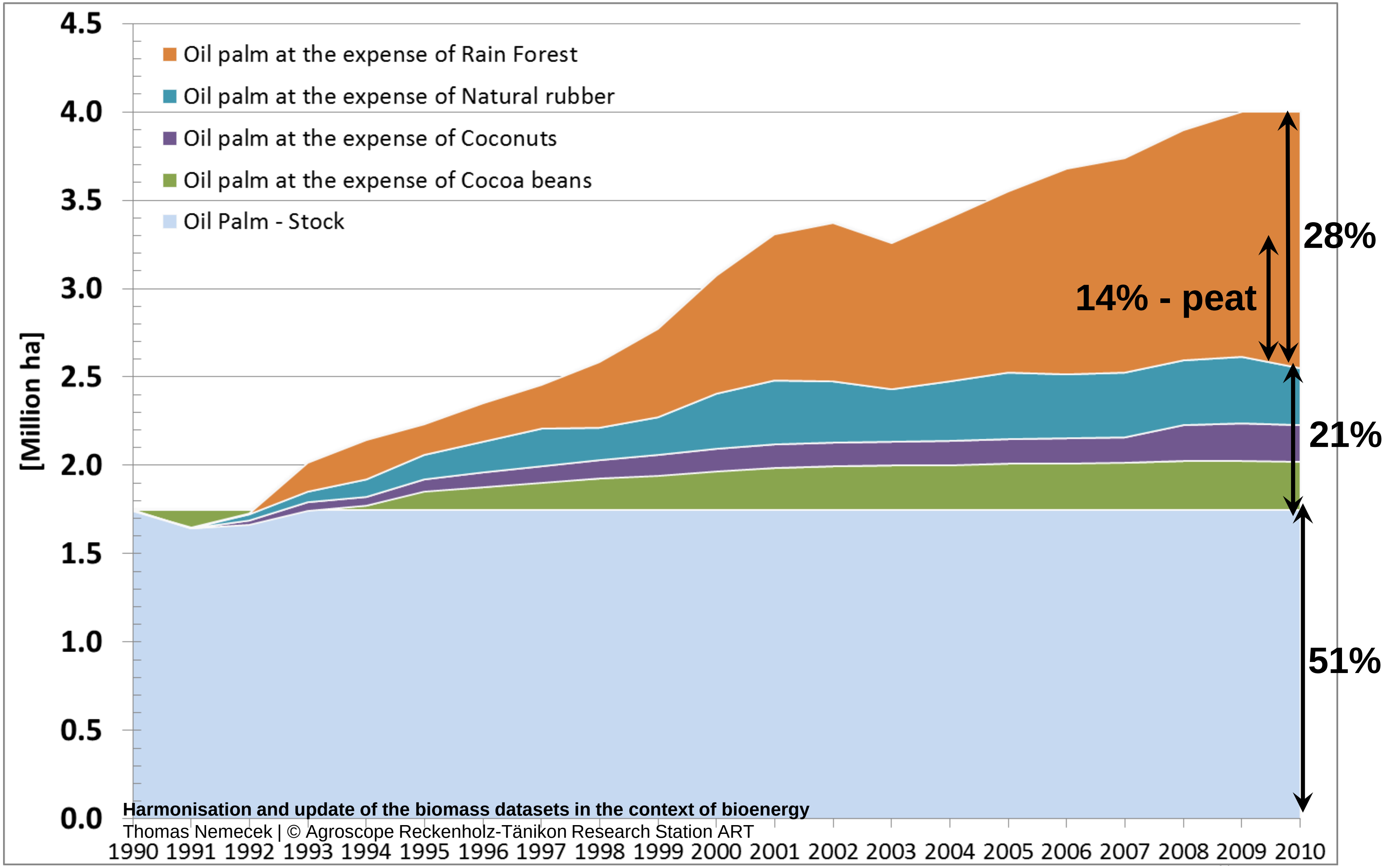
Concept for LCI modelling

➔ Separation according to transformation and occupation impacts



➔ **1. Direct land use change per kg crop?**

Area cultivated with oil palm, MY, 1990-2009



Harmonisation and update of the biomass datasets in the context of bioenergy

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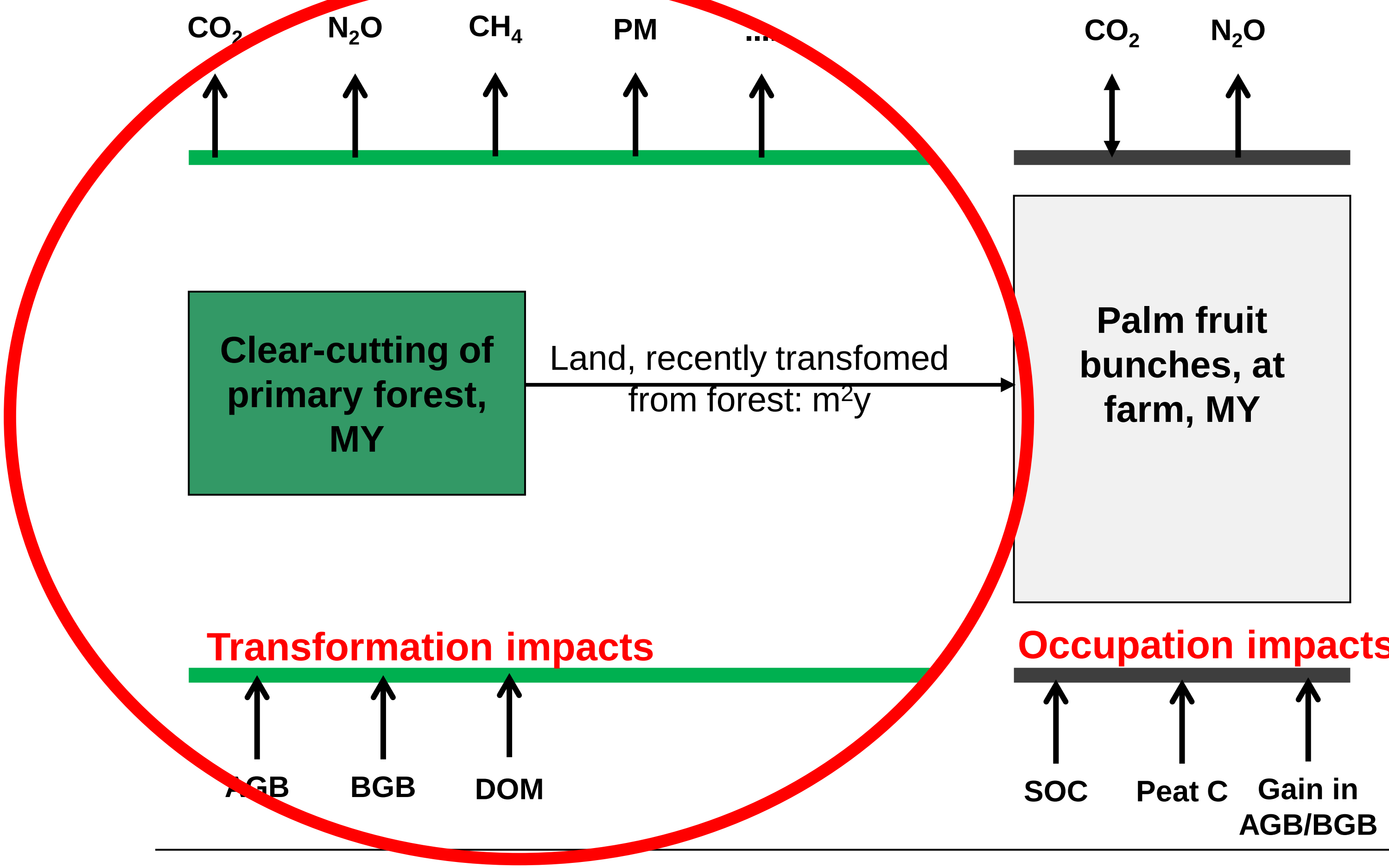
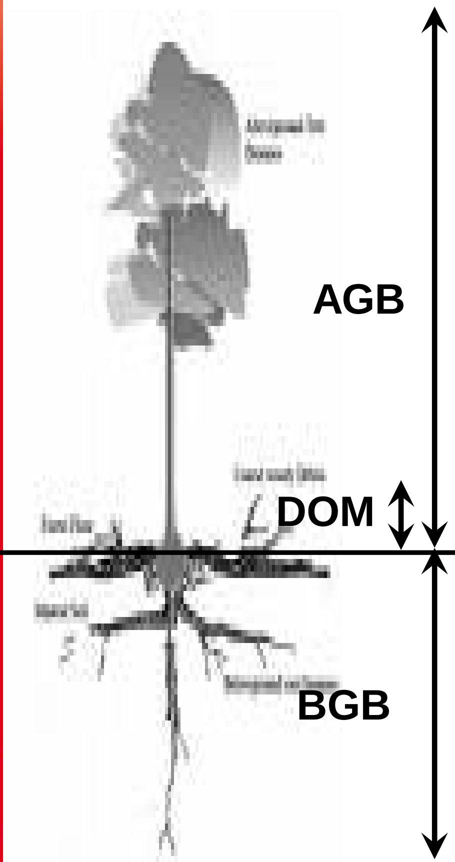
Concept for LCI modelling

➔ Separation according to transformation and occupation impacts



➔ 2. Modelling of land transformation?

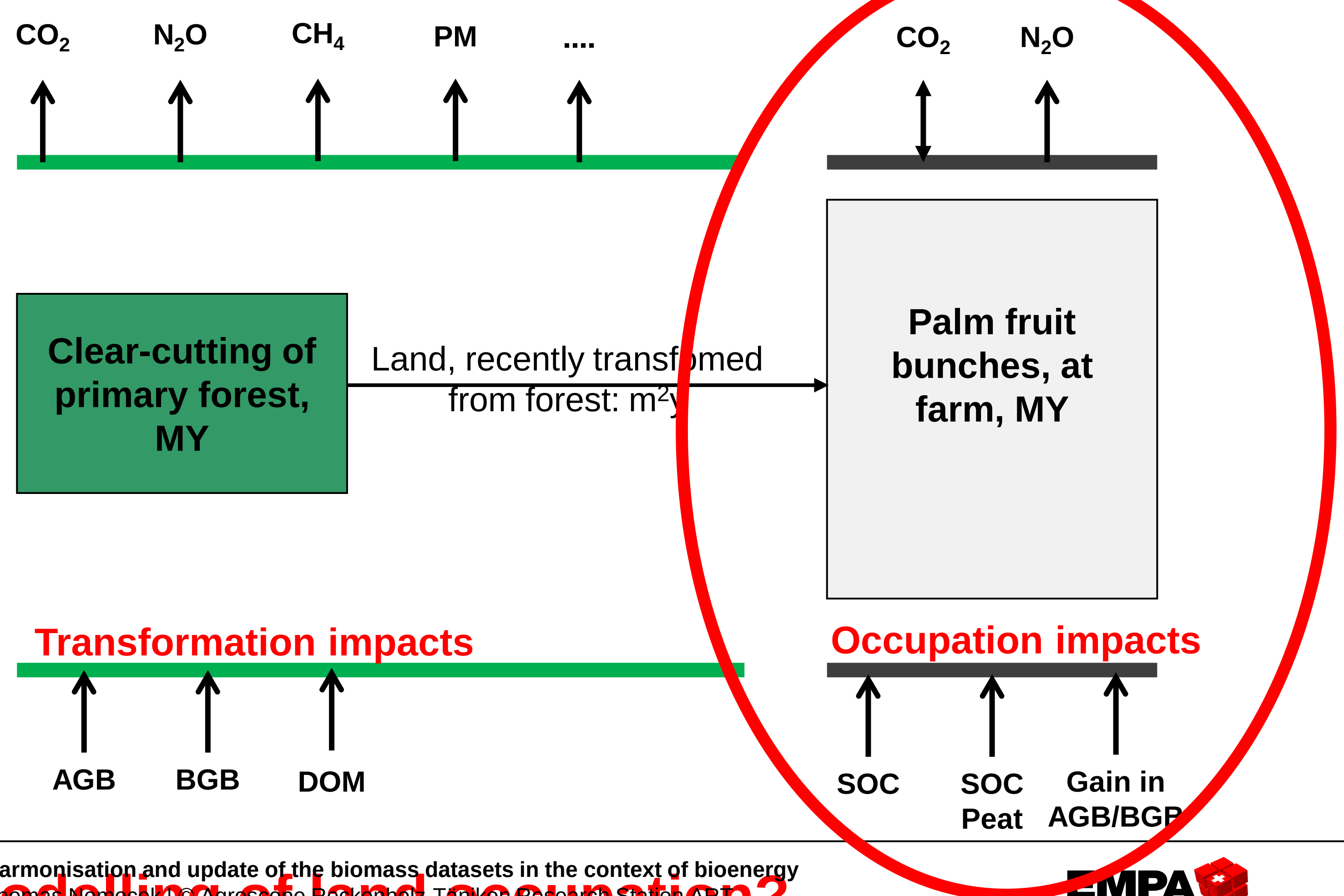
Modelling of land transformation (clear-cutting activities)



Ecoinvent V.2.2	Ecoinvent V.3
AGB, 8% = harvested	AGB, 8% = harvested
AGB, 20% = burned	AGB, 20% = burned
AGB, 72% = (left as slash, n.c.)	AGB, 72% = released as CO_2 (decay of biomass)
BGB, DOM = n.c.	BGB, DOM = released as CO_2 (decay of biomass)

Concept for LCI modelling

➔ Separation according to transformation and occupation impacts



➔ 3. Modelling of land occupation?

LUC emissions from land occupation

- Three main components considered:
- 1. Loss/gain of SOC from/in mineral soil ➔ release of CO_2 and N_2O
  - Factors for land use and management given by IPCC 2006
  - Losses only considered for land transformed from native vegetation
  - Gains only considered for land already in use
- Loss of SOC from peat soil
  - Annual emission factor (29 t C/y)
- Accumulation of C in AGB/BGB
  - Only considered for permanent crops ➔ annual crops = zero
  - NOT considered for land transformations within one land use category, e.g. plantation to plantation.

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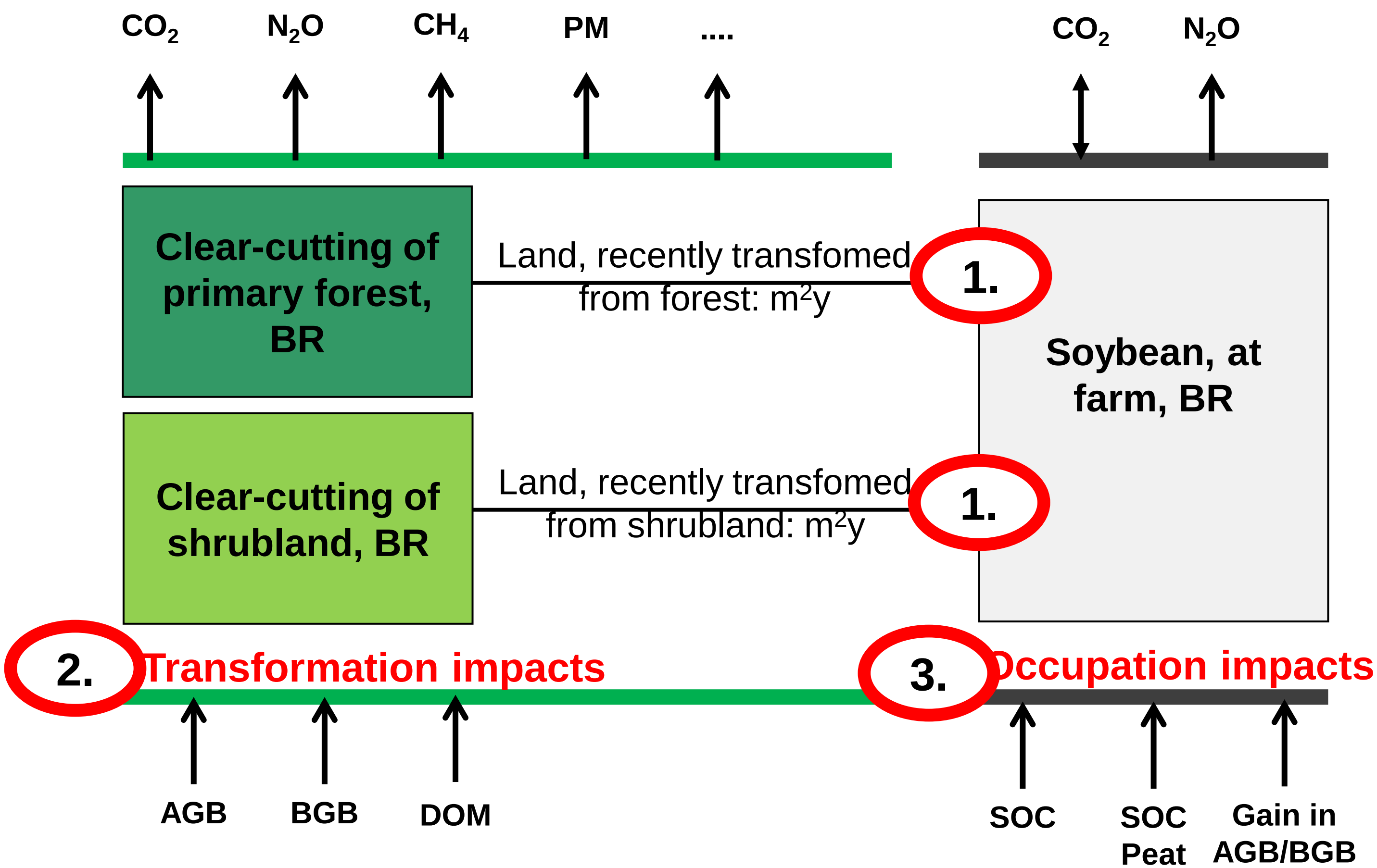
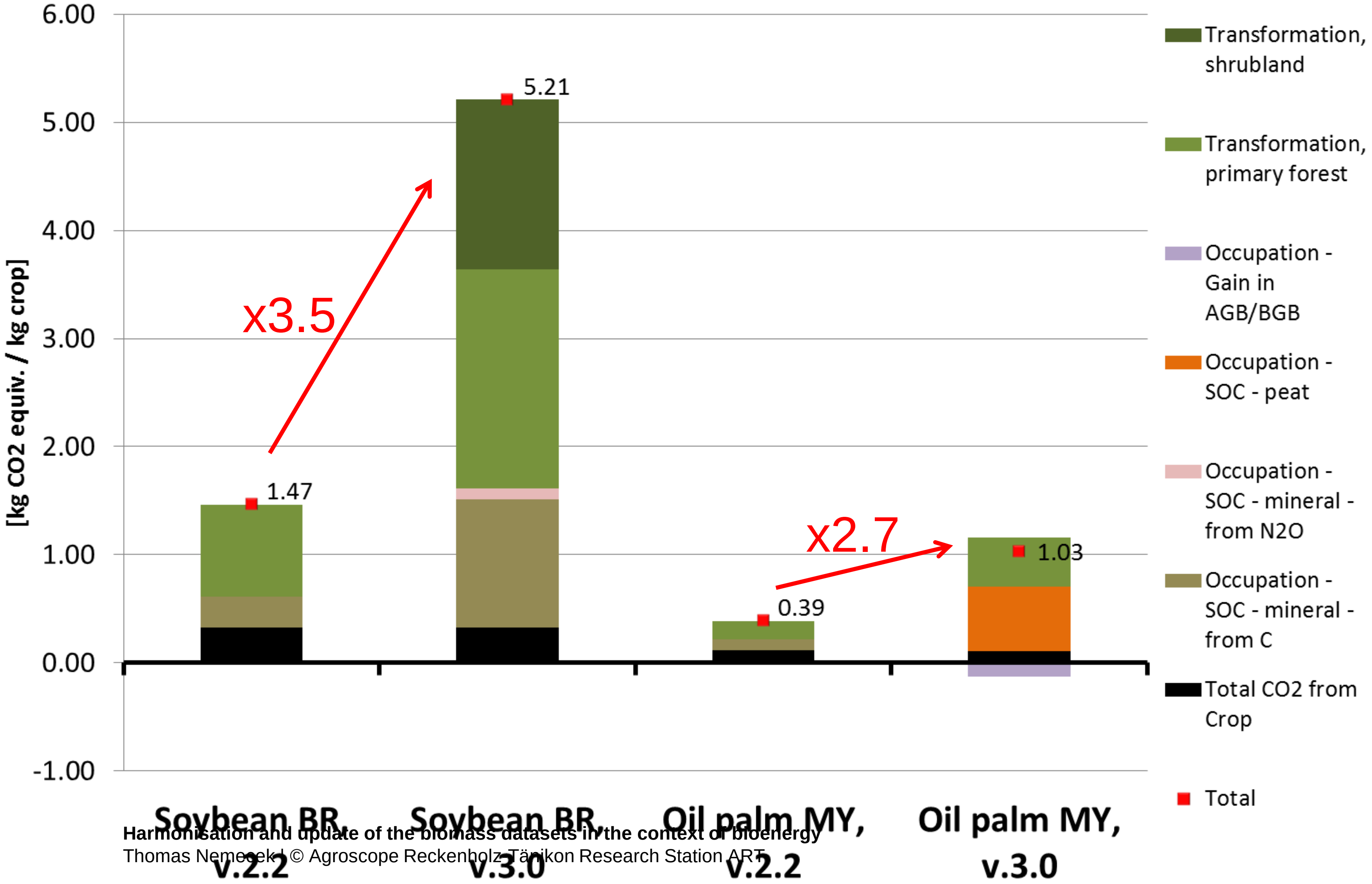
Concept for LCI modelling - Soybean

➔ Separation according to transformation and occupation impacts



Overview: Results



Conclusions

- Updated N emissions:
  - Ammonia: slight reduction
  - Nitrate: Increases and decreases, on average slight increase
  - Nitrous oxide: reduction by ¼
- Updated LUC inventories:
  - Emissions from LUC are highly relevant
  - Attribution of direct LUC = high uncertainties
    - Time period, causality
  - Parameterized activities
    - Fast adaptation to site-specific conditions
- Due to the changes in GHG emissions, a new evaluation of biofuels is required

Thank you!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