Biofuels and LUC in multiple policy setting: Integrated modelling approach

Petr Havlík, Michael Obersteiner, Erwin Schmid, Uwe A. Schneider

AND MANY OTHER COLLABORATORS

International Institute for Applied Systems Analysis (IIASA),
Forestry Program, Austria
University of Natural Resources and Applied Life Sciences, Vienna (BOKU),
Department of Economics and Social Sciences, Austria
University of Hamburg, Sustainability and Global Change (FNU), Germany

IEA Bioenergy Task38 Workshop , Helsinki, Finland, March 30th – April 1st, 2009

I. Introduction

LAND – fixed production factor

- links several sectors

(agriculture, forestry, bioenergy,…)

- fixity appears at local, but especially global scale

No constant link between biofuels and GHG emissionions from iLUC

- policies play a role: **biofuel policies (scale of production)**
trade policies
environmental policies (REDD)

Not only GHG emissions – also other sustainability requirements

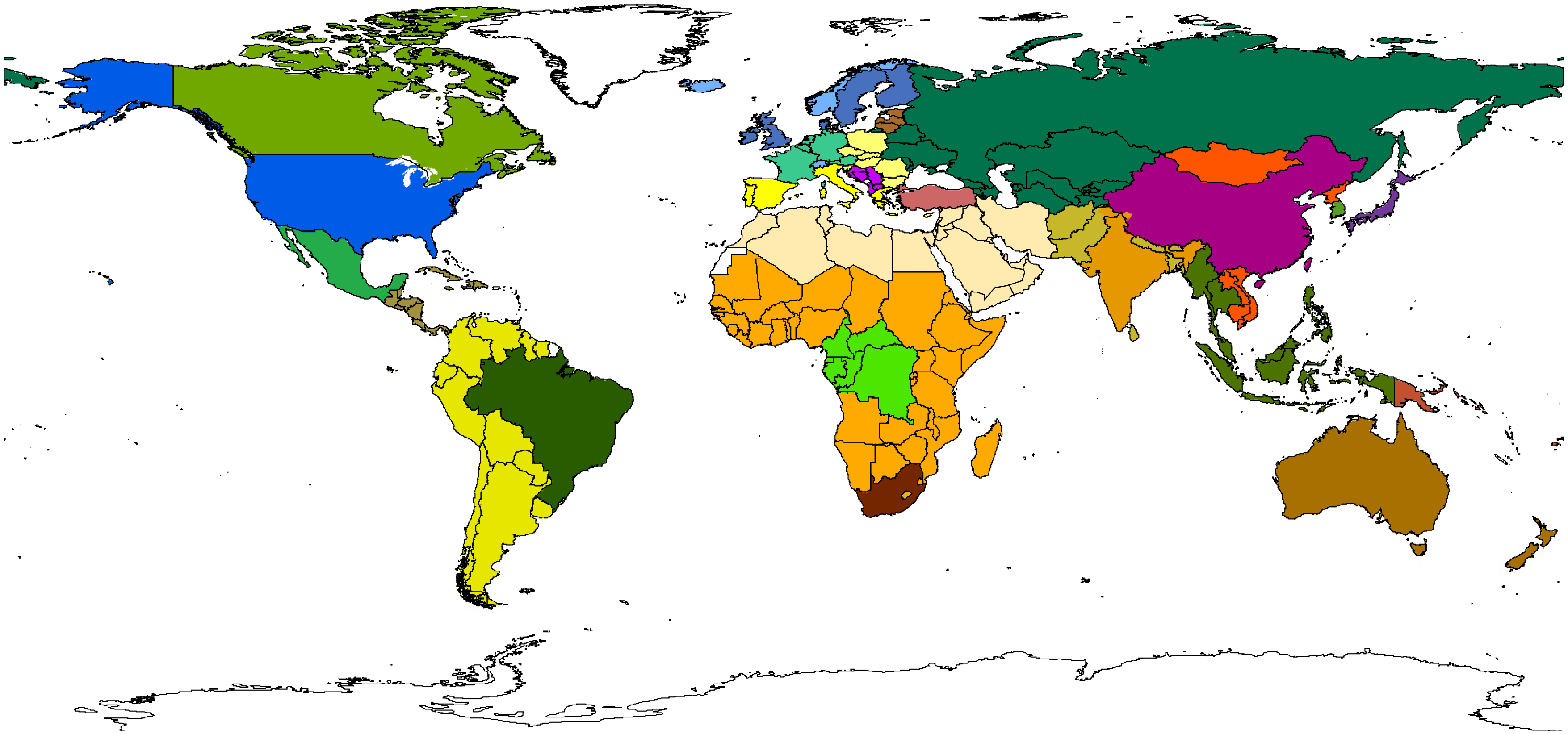
→ Integrated and global modeling approaches useful/necessary for biofuels' iLUC assessment

II. Model: GLOBIOM

Global Biomass Optimization Model

Coverage: the Earth

Basic resolution: 28 regions



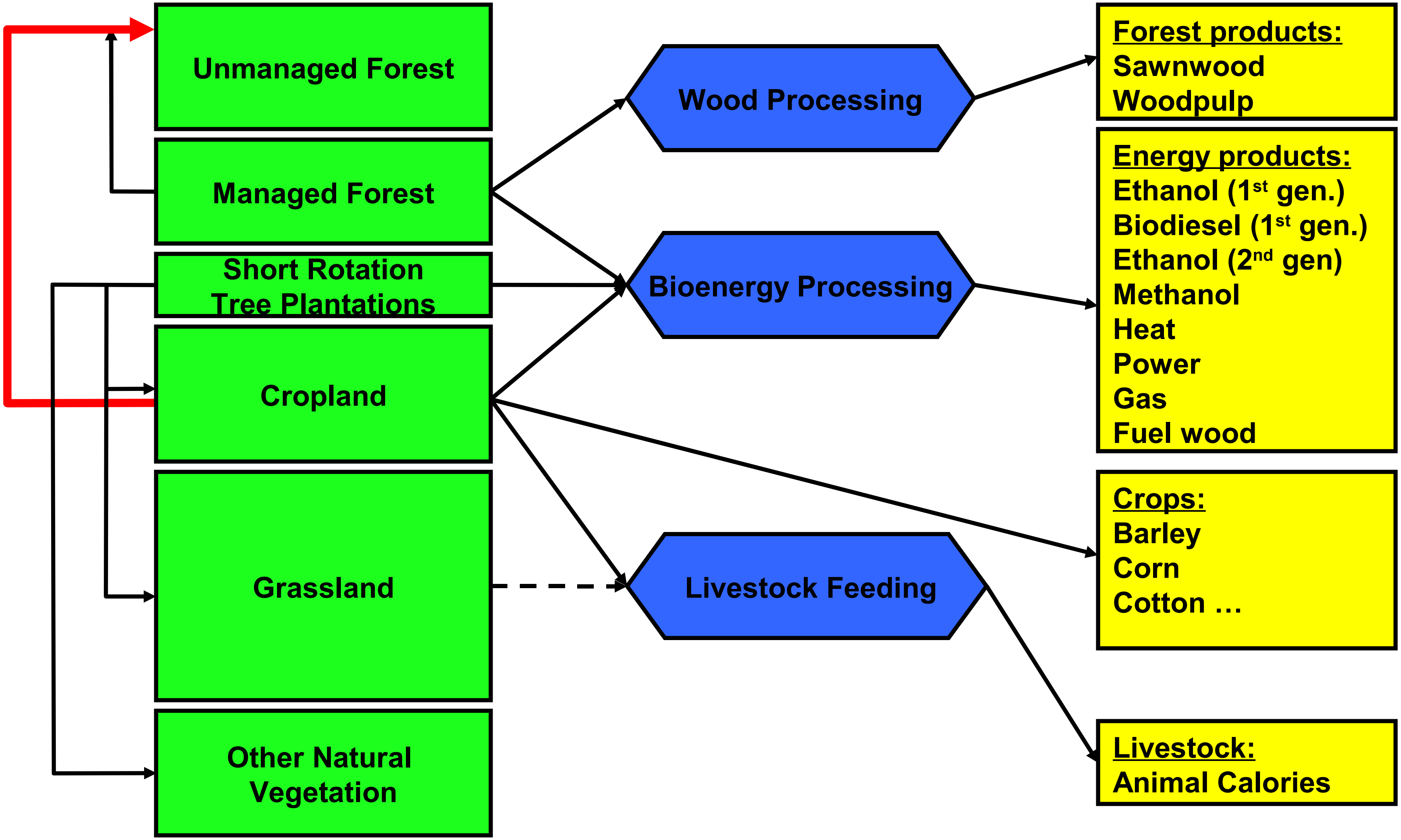
II. Model presentation

Biomass

3 land based sectors:

- **Forestry:** traditional forests for sawnwood, and pulp and paper production
- **Agriculture:** major agricultural crops, and generalized livestock production
- **Bioenergy:** conventional crops and dedicated forest plantations

II. Model presentation: Supply chains



II. Model presentation

Optimization Model (FASOM structure)

Recursive dynamic spatial equilibrium model

Partial equilibrium model: endogenous prices

Maximization of the social welfare (PS + CS)

Supply functions

implicit:

technology 1 (rainfed) → yield 1 + constant cost 1

technology 2 (irrigated) → yield 2 + constant cost 2

Demand functions

explicit: linearized non-linear functions $p = \hat{p} * (q / \hat{q})^{1/e}$

II. Model presentation

Resource constraints: Land and Water

- fixed total quantity and/or increasing resource supply functions

Output:

production Q → land use, water use, environment

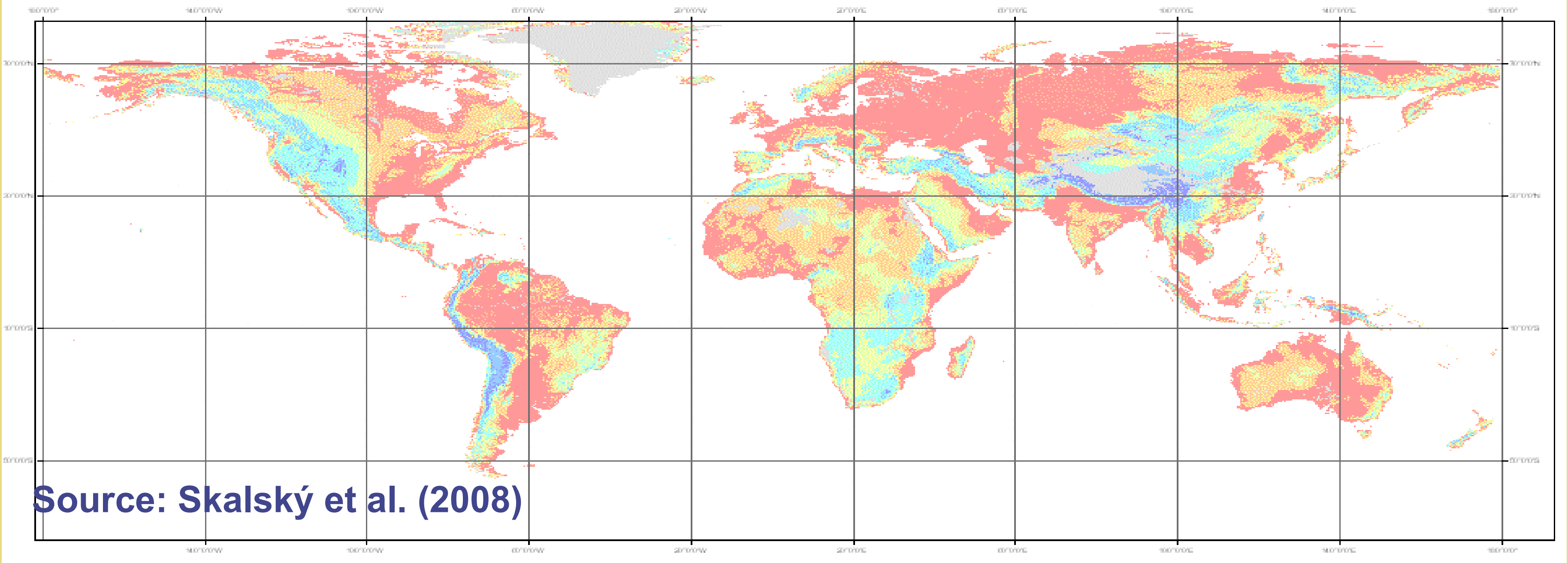
consumption Q → undernourishment indicators

trade flows

prices

II. Model presentation: Land

Homogeneous response units (HRU) – altitude, slope, soil (157)



Source: Skalský et al. (2008)

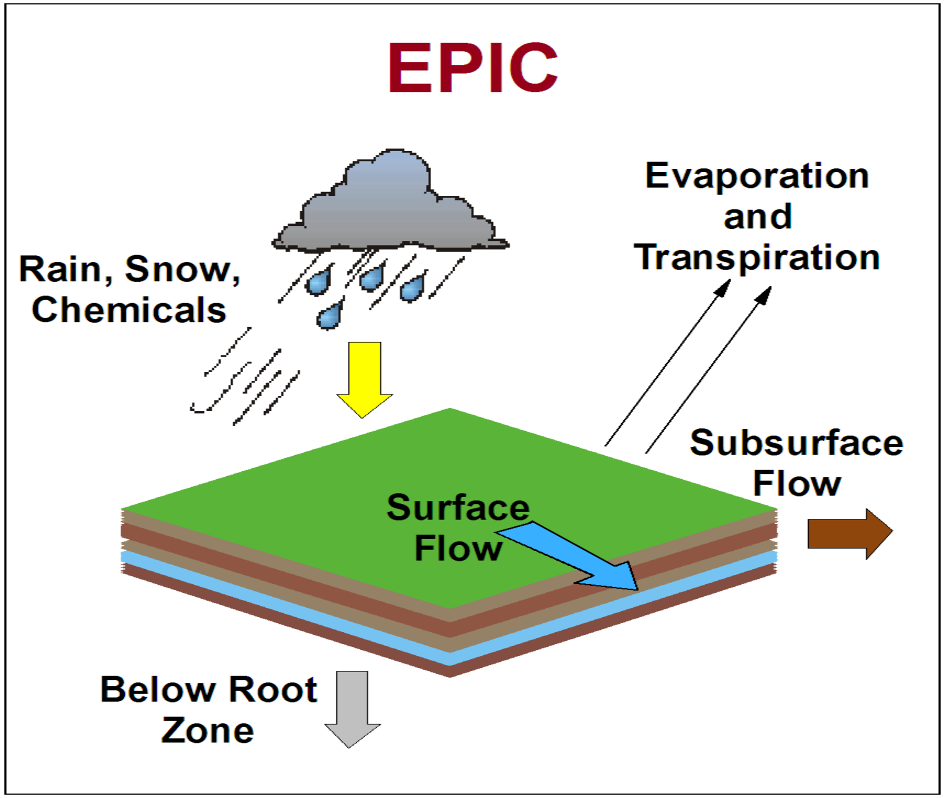
HRU & 30 min grid & Country zone → 200 000 Simulation Units

= **BASIS FOR BIOPHYSICAL MODELS** (EPIC,…)

II. Model presentation: Cropland - EPIC

Processes

- Weather
- Hydrology
- Erosion
- Carbon sequestration
- Crop growth
- Crop rotations
- Fertilization
- Tillage
- Irrigation
- Drainage
- Pesticide
- Grazing
- Manure



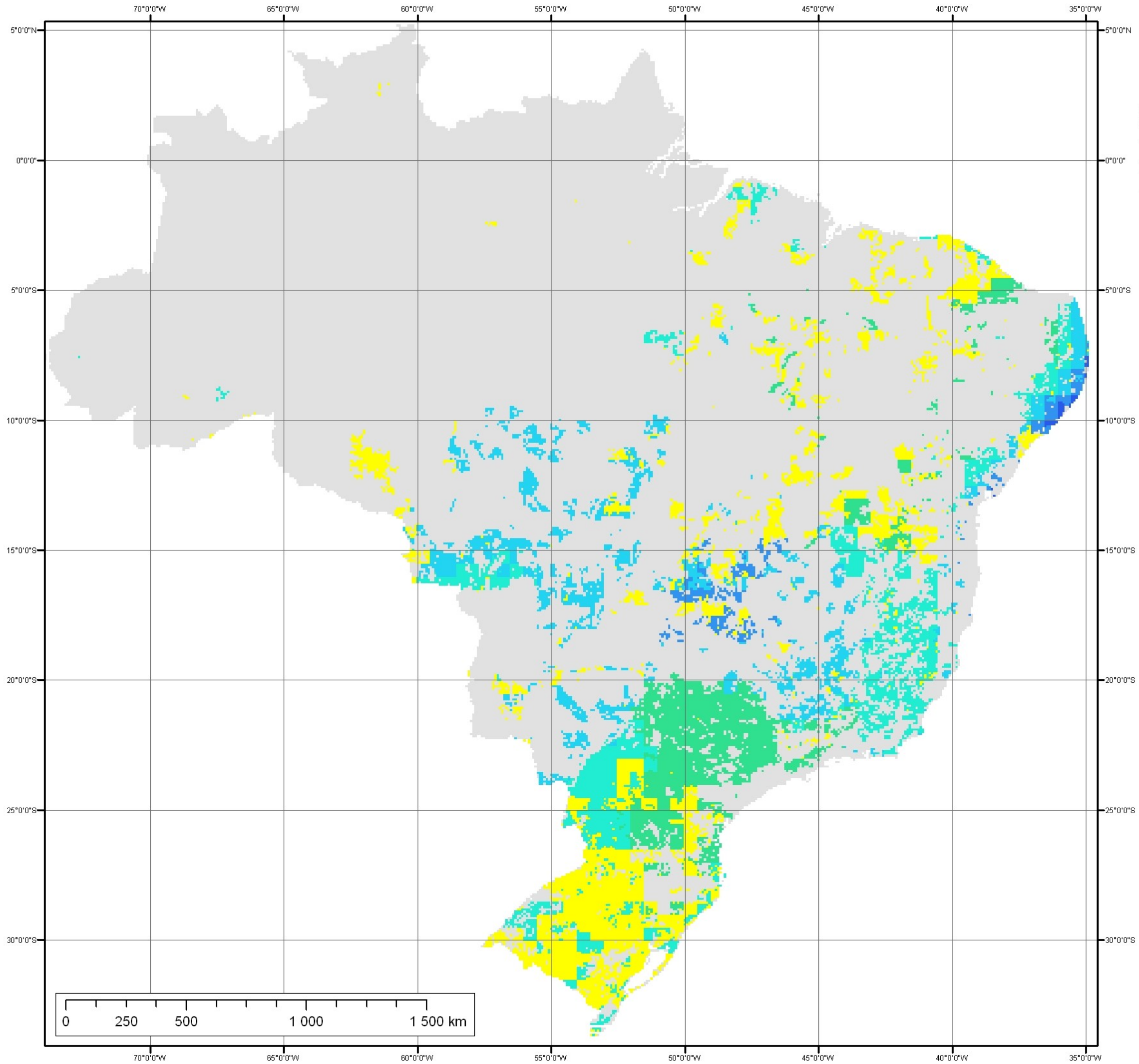
Major outputs:

Crop yields, Environmental effects (e.g. soil carbon,)

17 crops (>75% of harvested area)

4 management systems: High input, Low input, Irrigated, Subsistence

II. Model presentation: EPIC - Yields



Brazil:

Sugar cane yield,
IFPRI allocated area,
high input system

Legend:

Sugar cane Yield (t/ha)

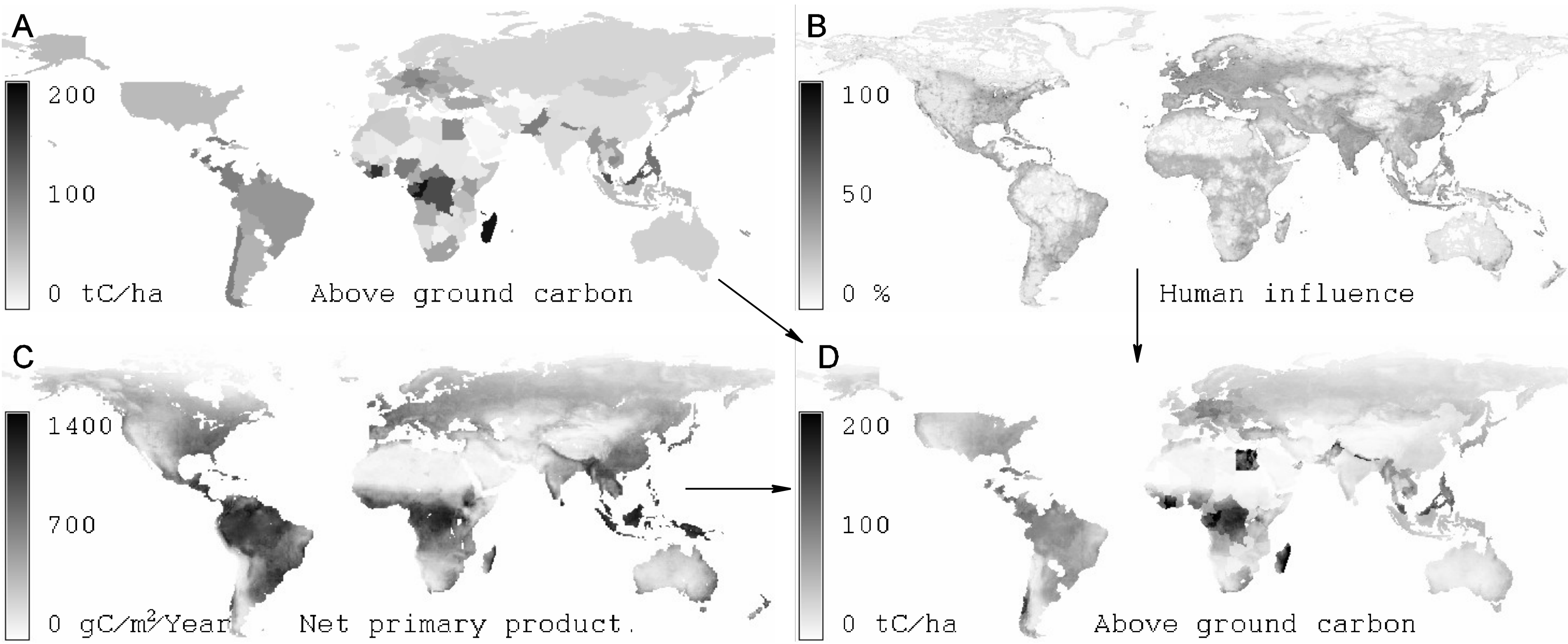
- 0
- 0 - 5
- 5 - 10
- 10 - 15
- 15 - 20
- 20 - 25
- 25 - 30
- 30 - 35

- no cropland
- other cropland (no sugar cane cultivated)

GEOBENE

II. Model presentation: Forests – G4M

Step 1: Downscaling FAO country level information on above ground carbon in forests (FRA 2005) to 30 min grid



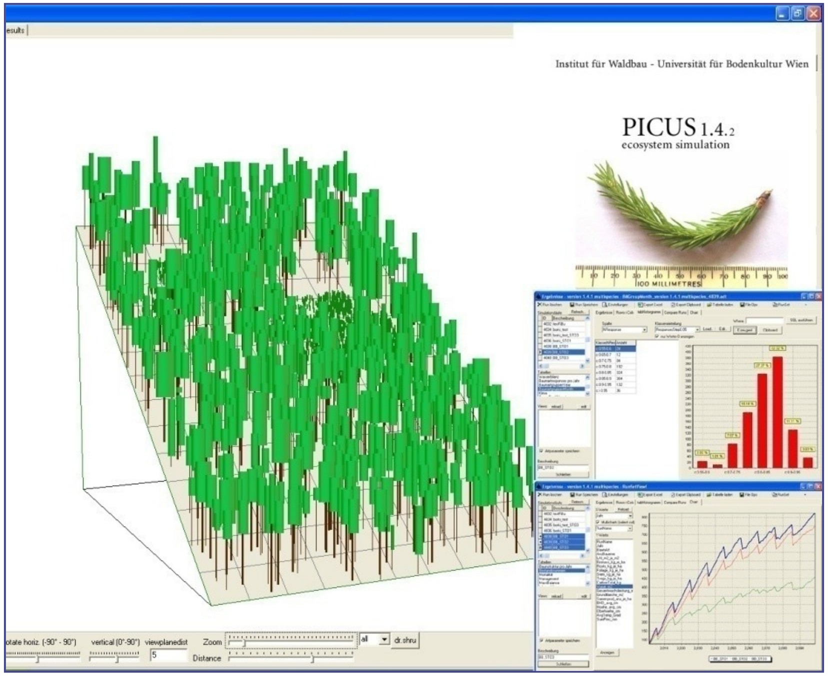
Source: Kindermann et al. (2008)

II. Model presentation: Forests – G4M

Step 2: Forest growth functions estimated from yield tables

Major outputs:

- Mean annual increment
- Tree size
- Sawn wood suitability
- Harvesting cost



II. Model presentation: Forest plantations

Short rotation plantations

- poplar, willow, eucalyptus

Land availability (approach inspired by Zomer et al., 2008)

- eliminates unsuitable area on the basis of:

aridity, temperature, elevation, population density

Category	Afforestation Potential [Mha]
Forest	3 151
Agriculture/Cropland	1 171
Grassland	299
Other Natural Vegetation	510

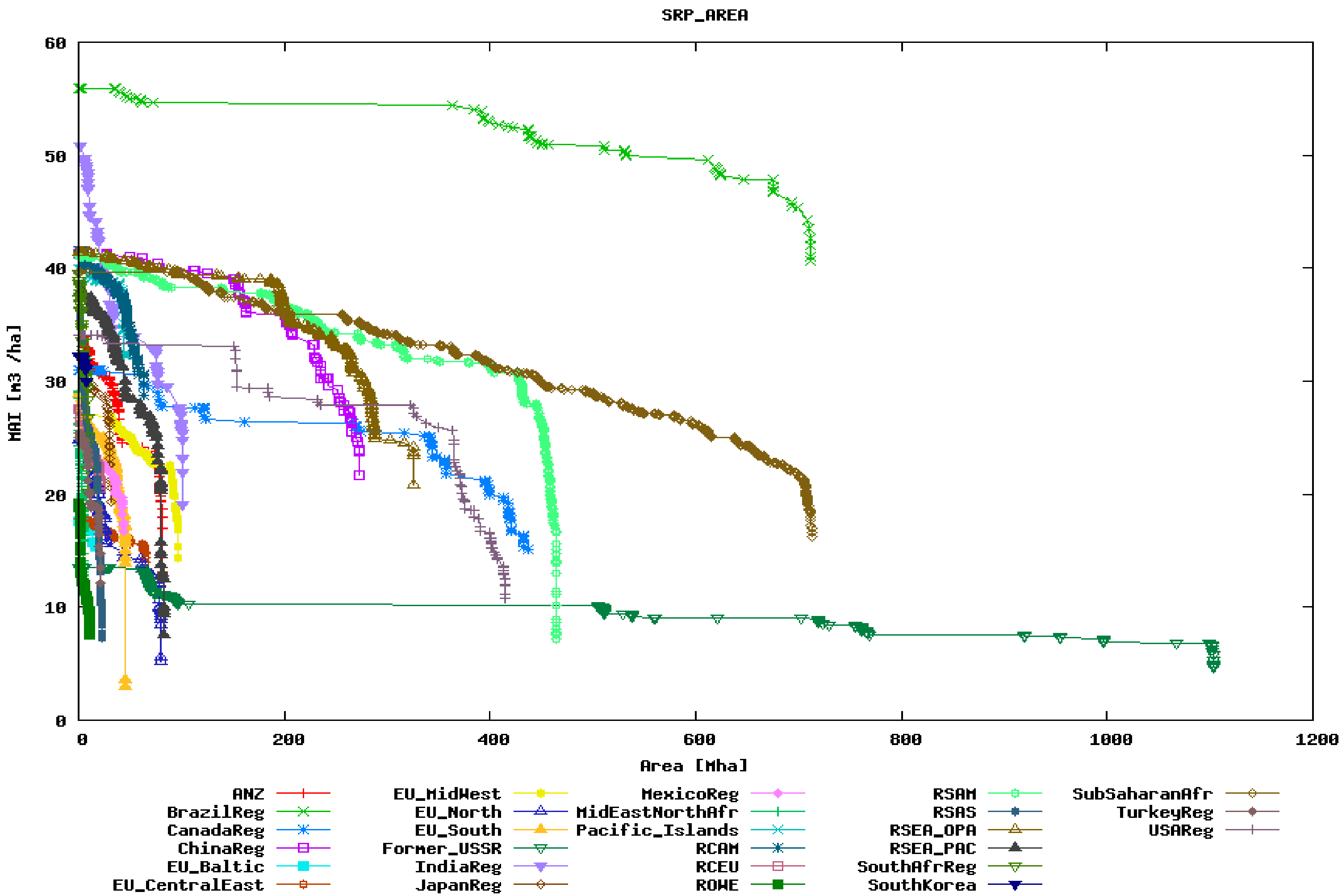
Land productivity

- regional potentials from literature review

- scaled by NPP (Cramer *et al*, 1999)

II. Model presentation: Forest plantations

Productivity distribution



III. Model application

Simulation horizon: 2000–2020

Main drivers: Population (IIASA SRES projections)
Diets (FAO, 2006)
Bio-energy demand (POLES team, JRC Seville, and WEO, 2008)
(GDP, technological change,…)

Scenarios

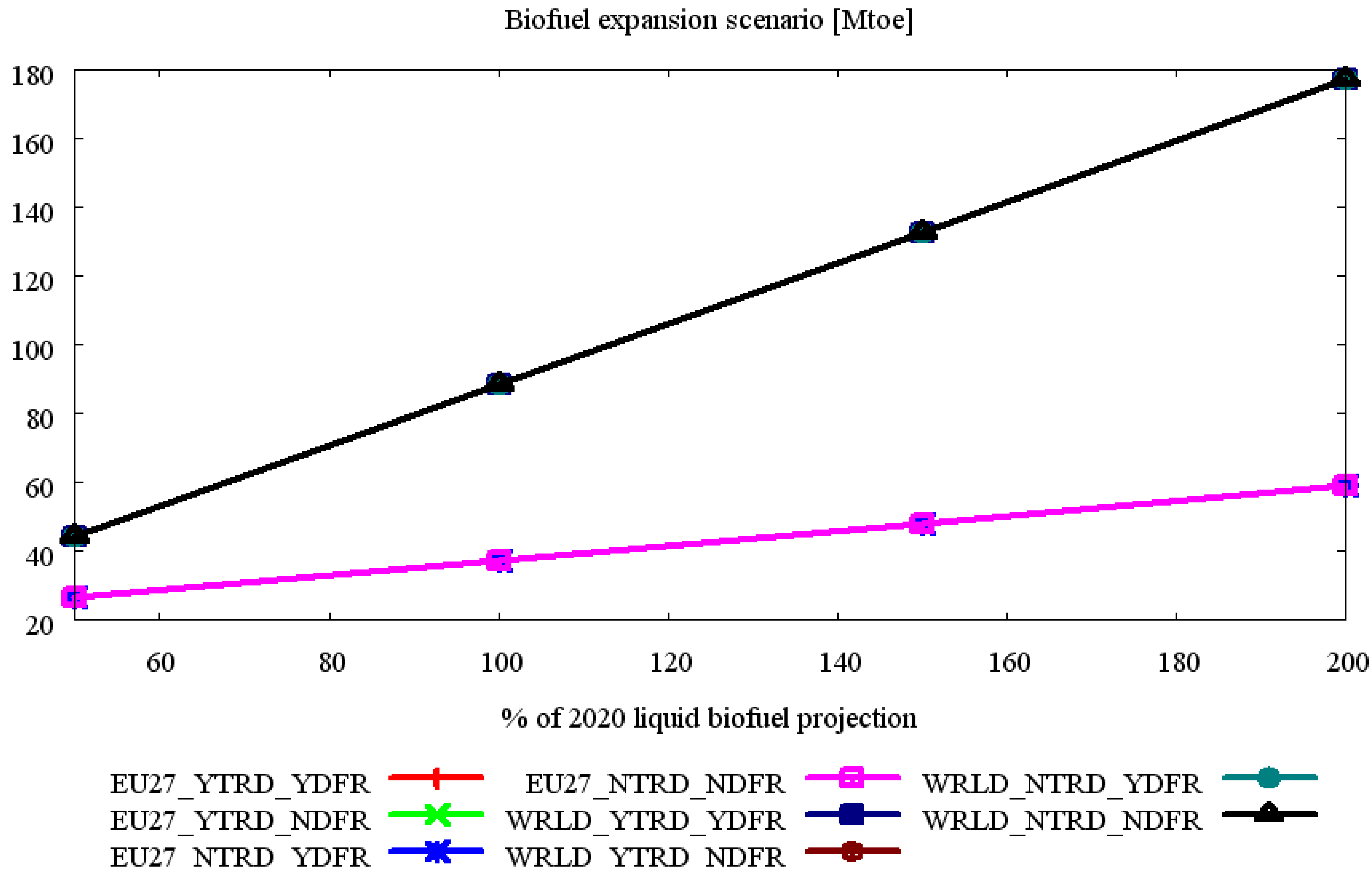
1st dimension:

+/- 100% first gen. biofuel mandates WEO 2020 reference

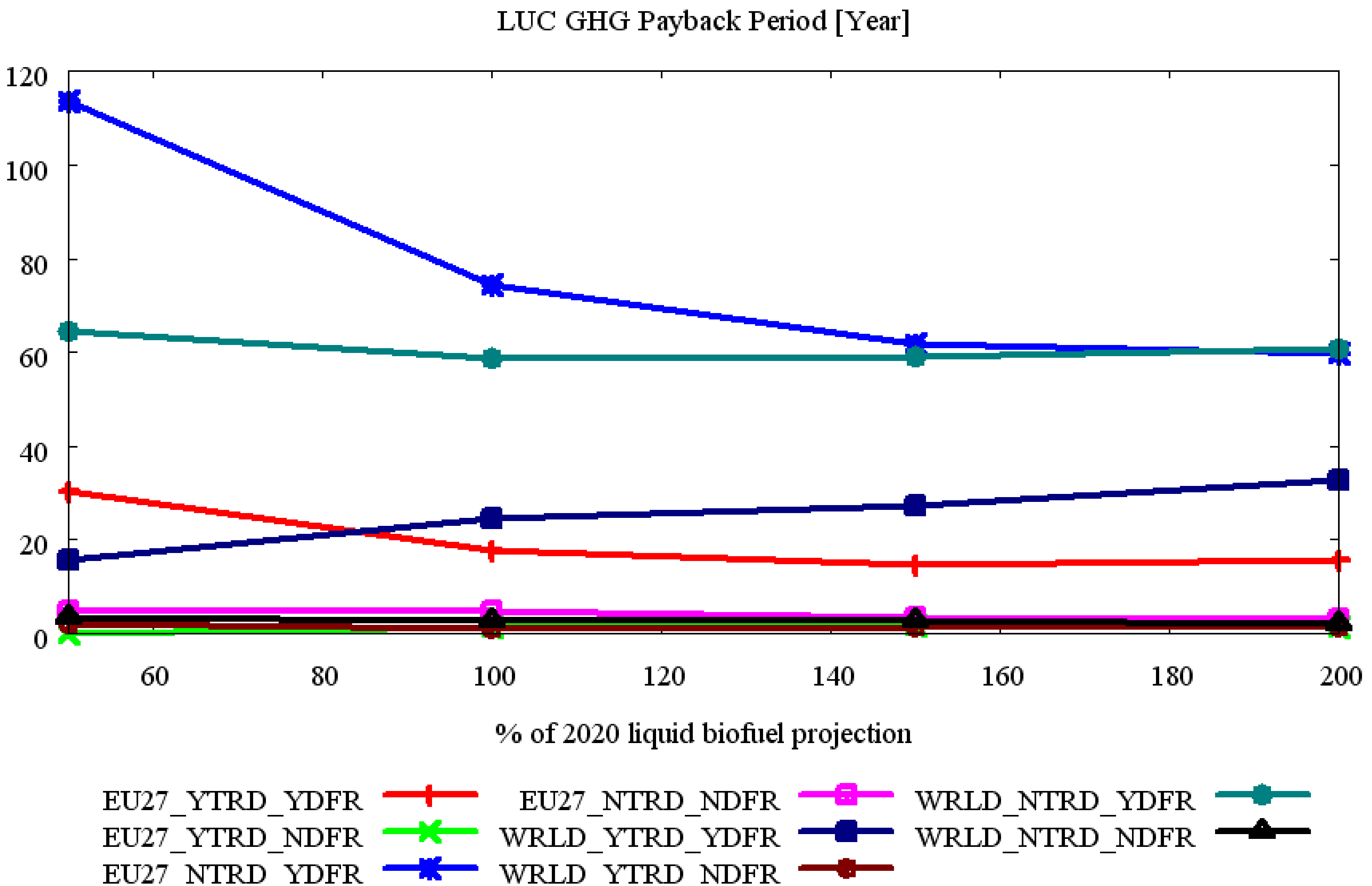
2nd dimension: POLICIES

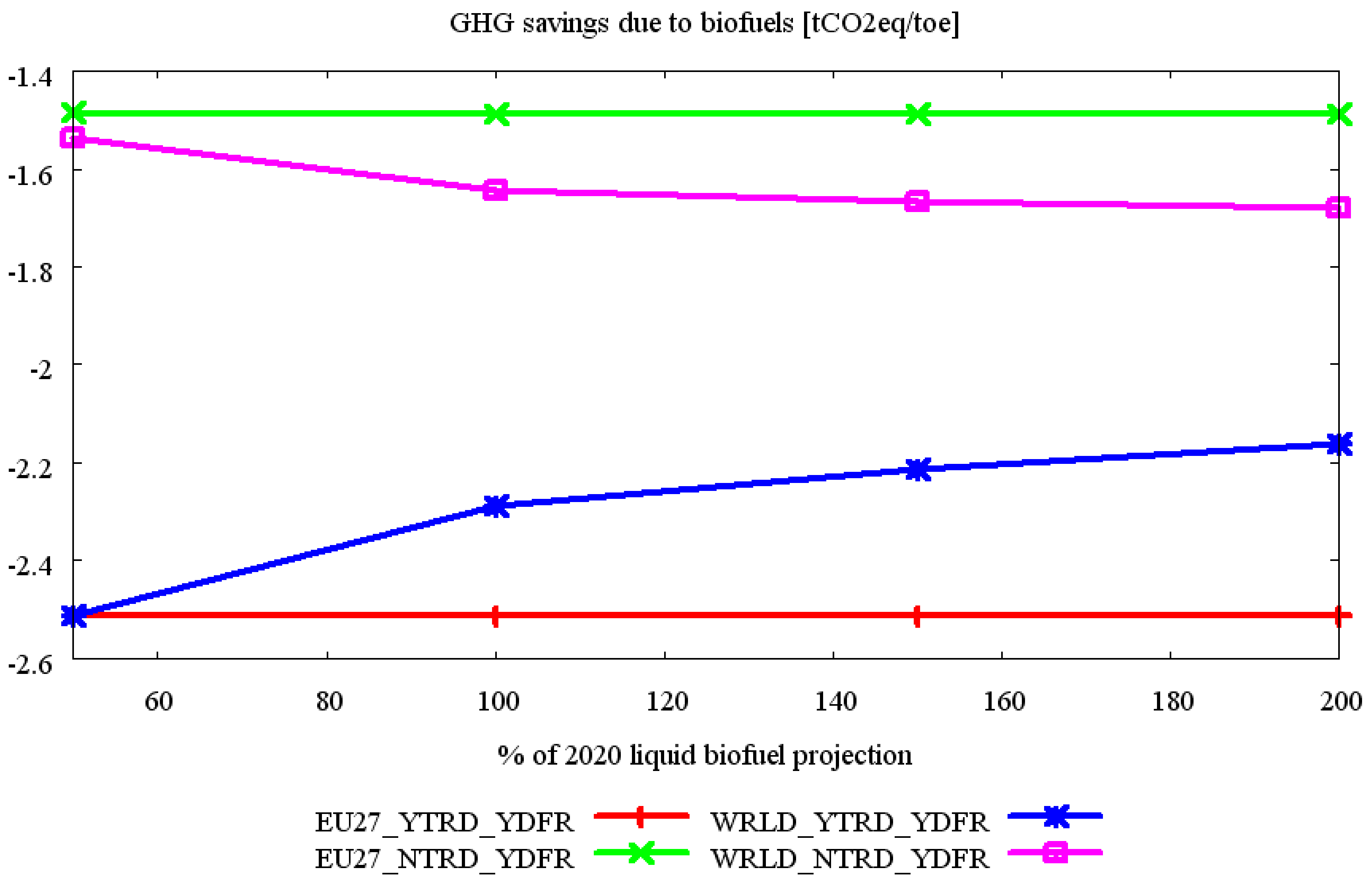
1. **Global scale of mandates – EU27 x World**
2. **Trade with biofuels – YES x NO**
3. **Deforestation allowed – YES x NO**

III. Model application: Scenarios setting

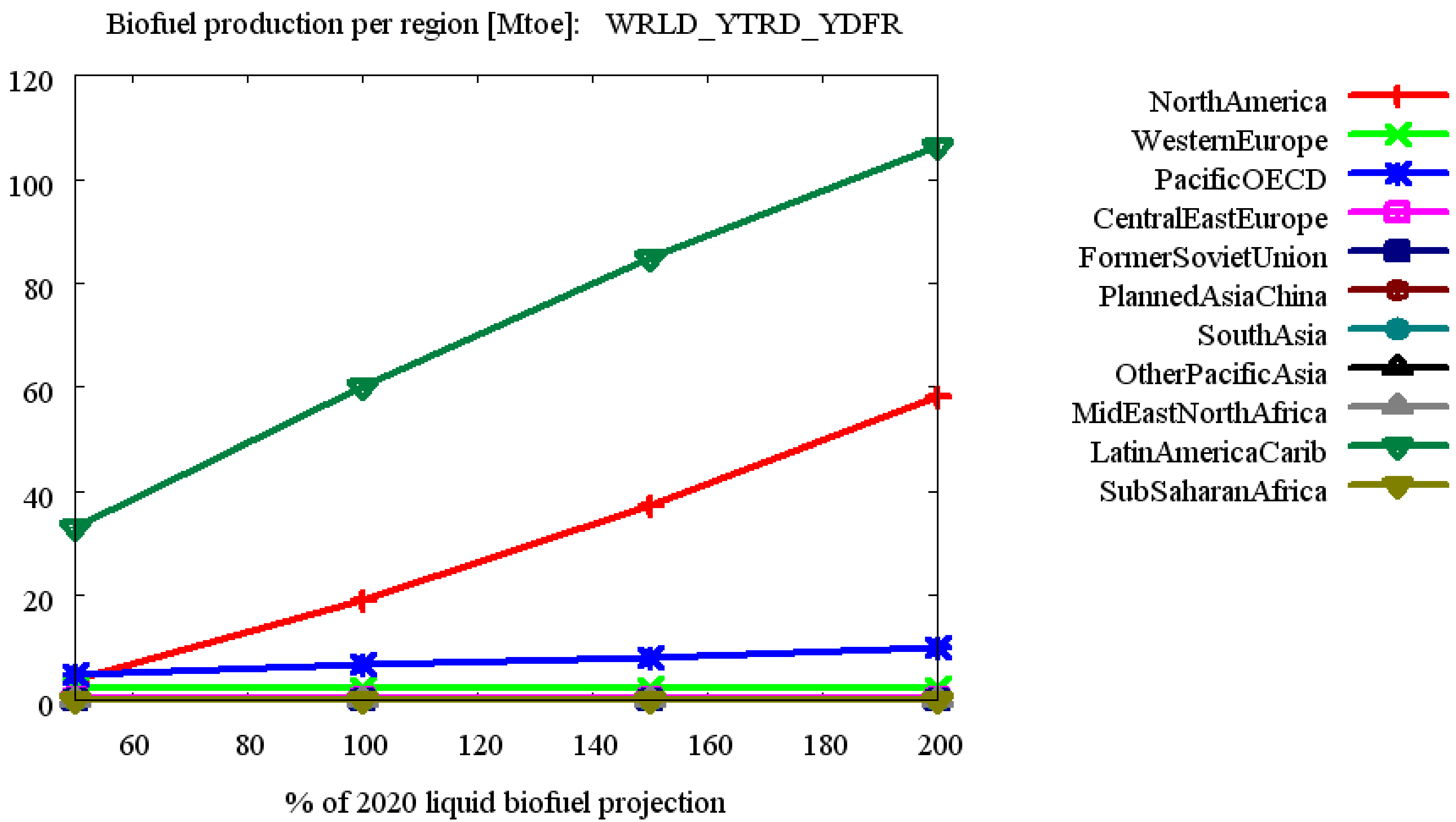


III. Model application: Results

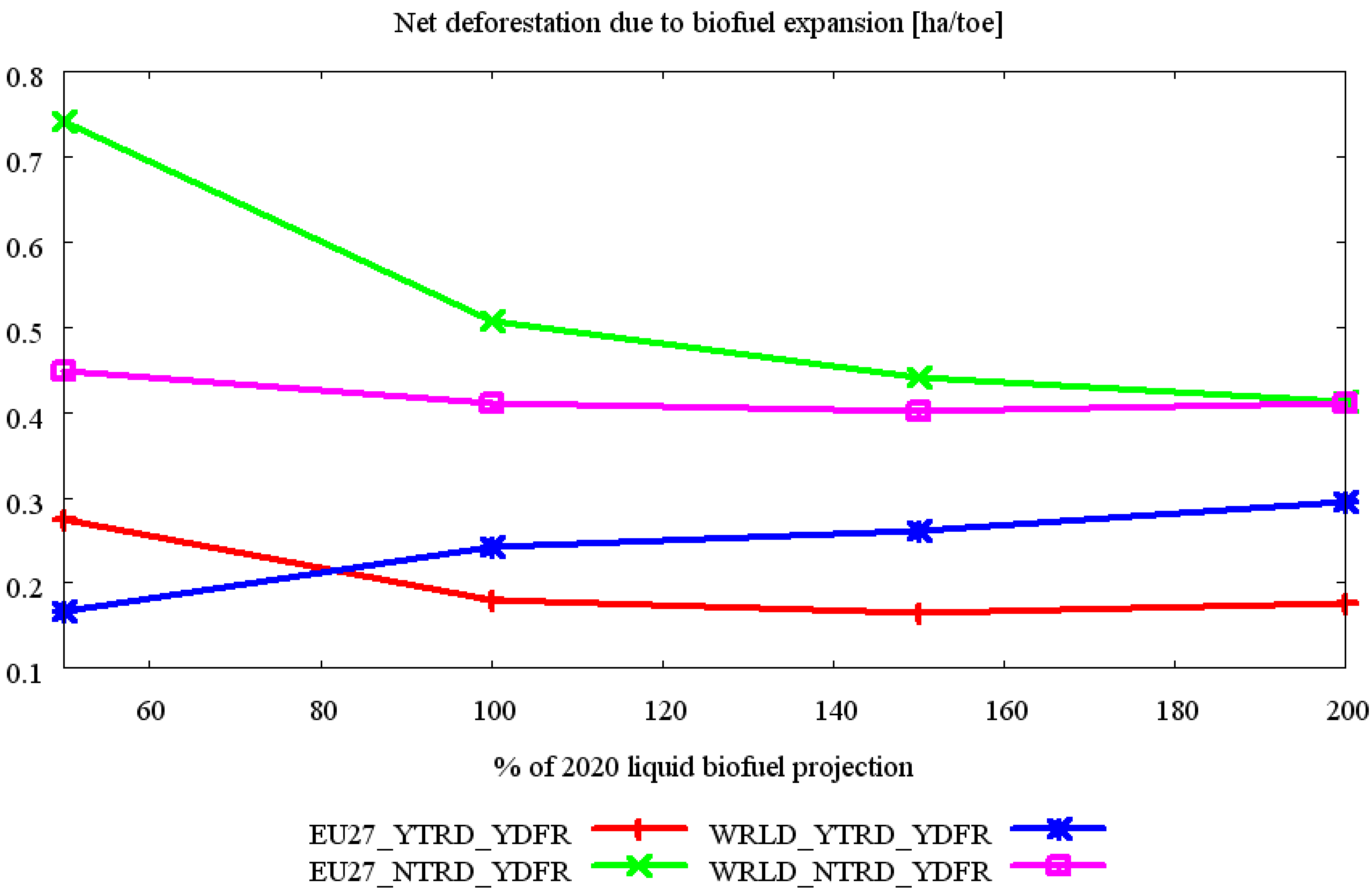




LCA GHG savings relatively stable – changes due to shifts in biofuel portfolio

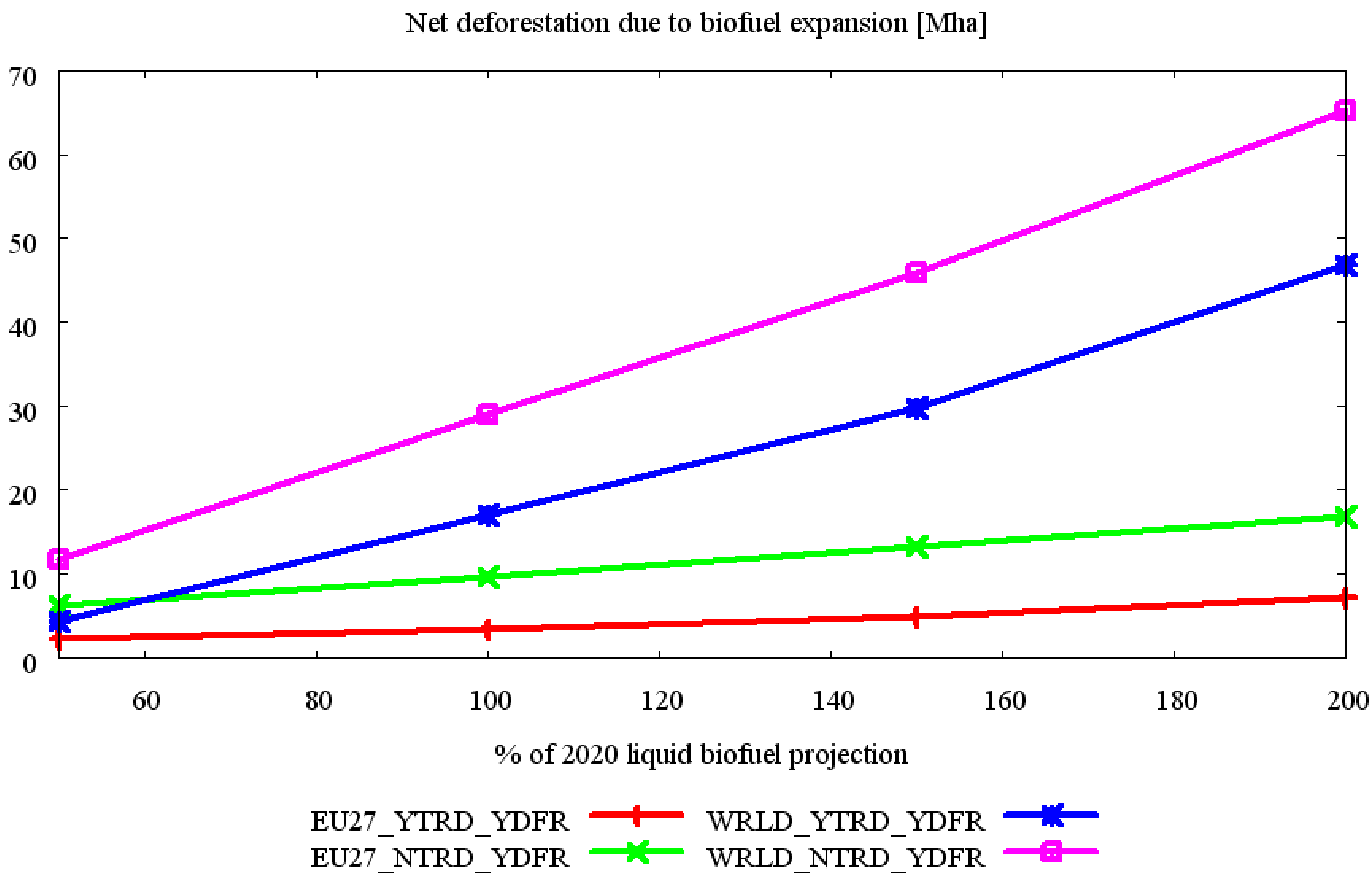


E.g. increasing share of ethanol produced from corn

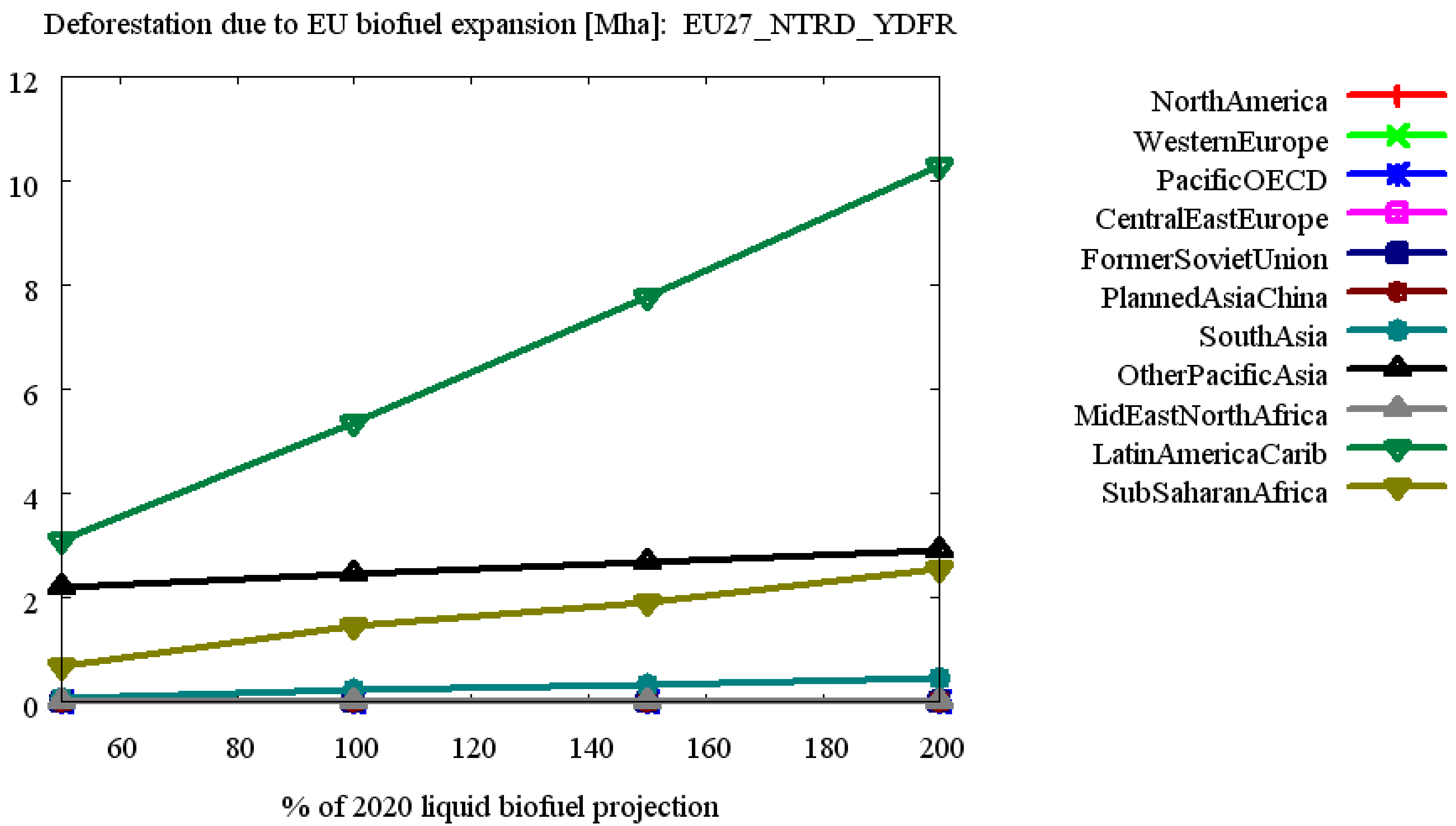


Trade acts to lower global net deforestation per energy unit.

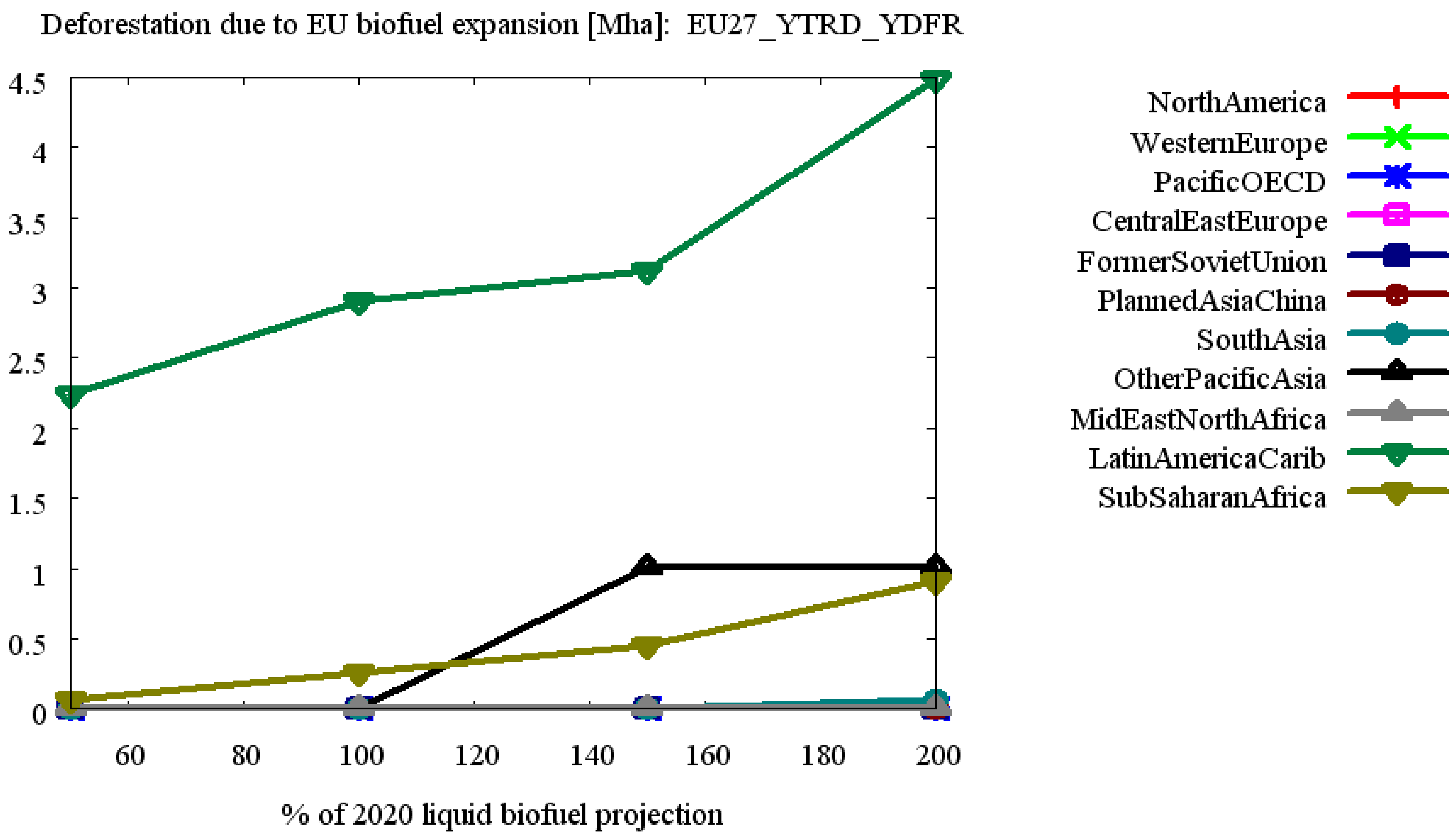
With higher mandates, deforestation per energy unit tends to increase.



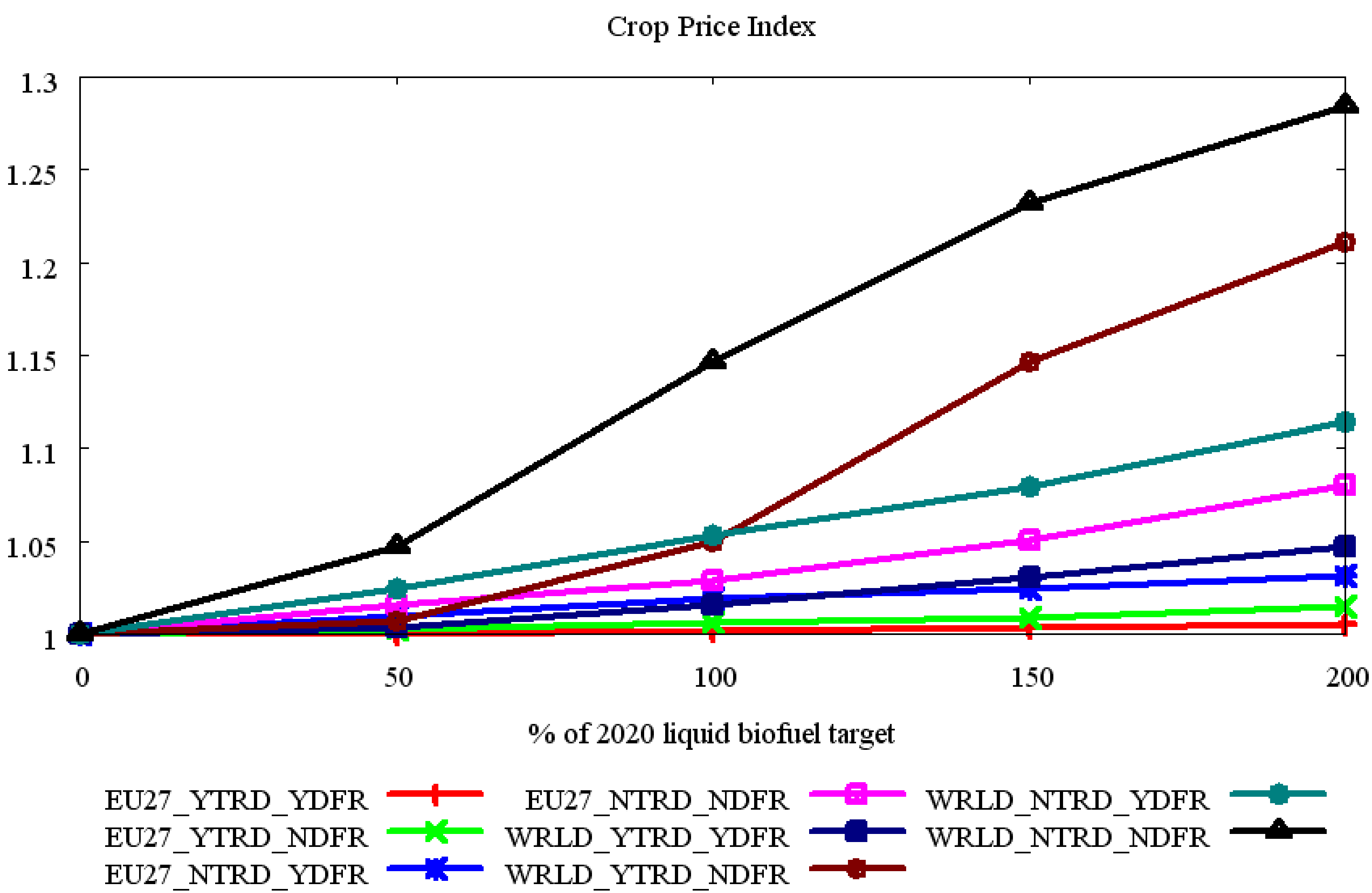
If not constrained (e.g. by REDD) important deforestation occurs.



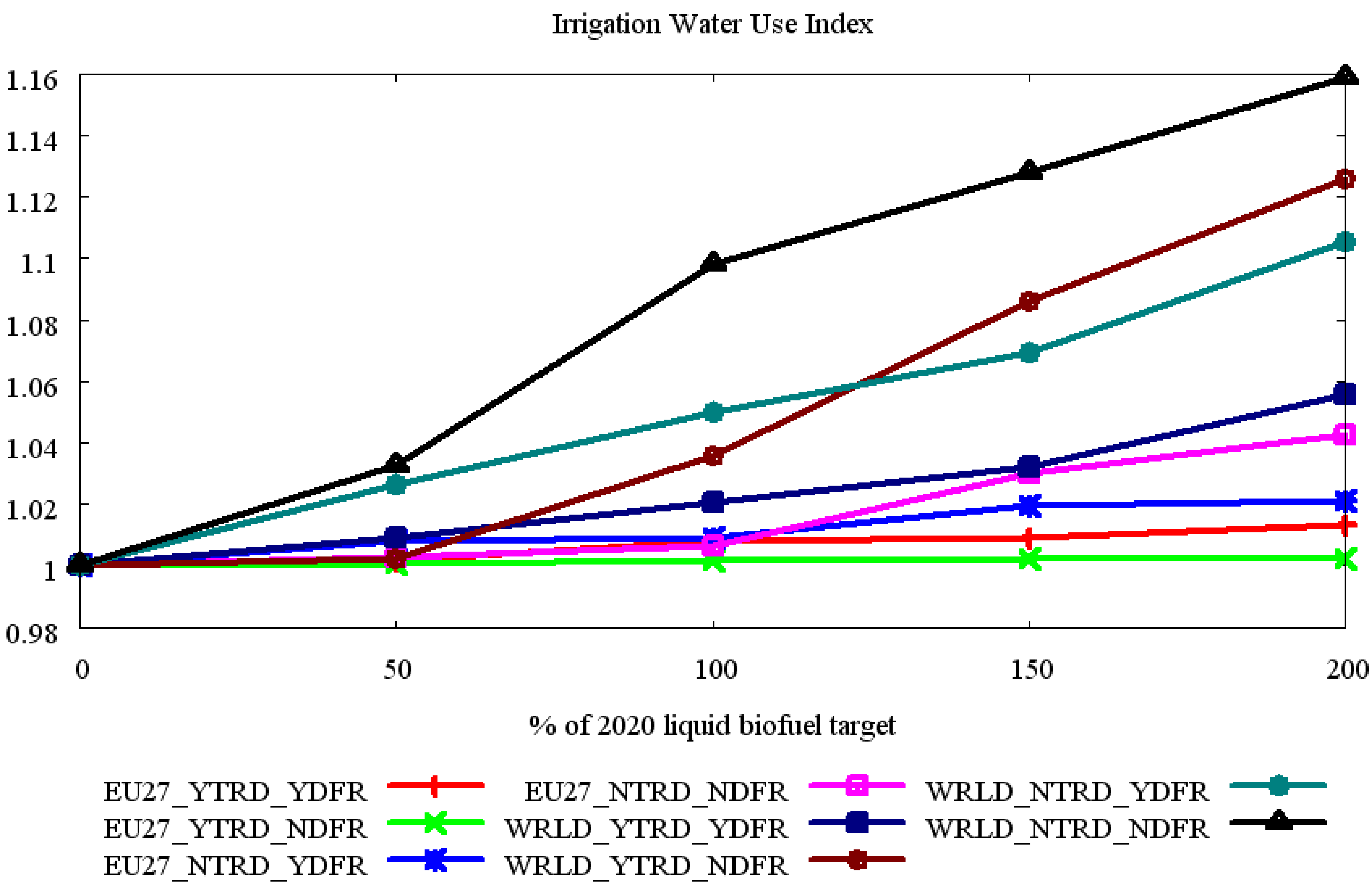
EU mandates put pressure on deforestation elsewhere even without trade – iLUC!



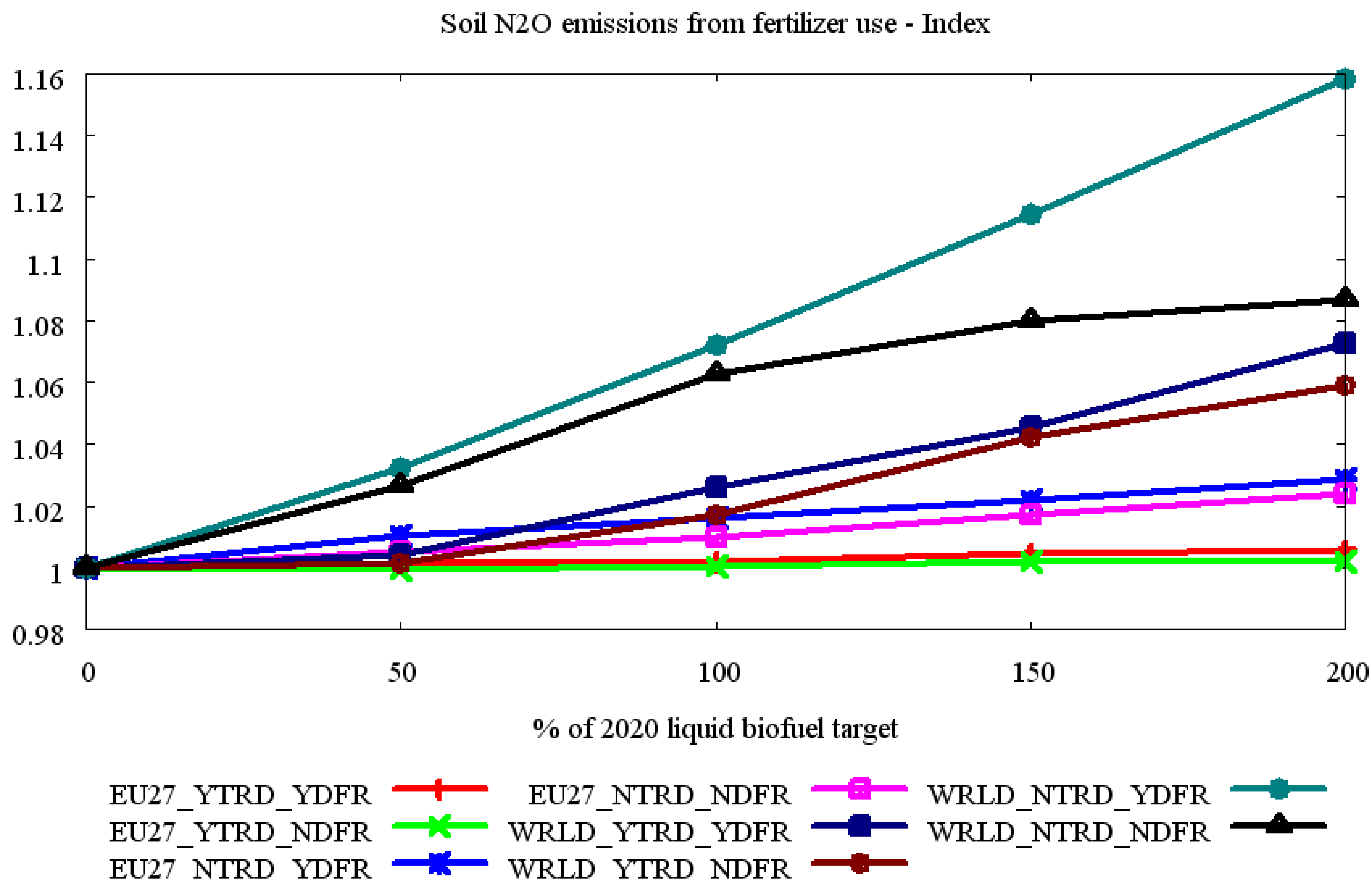
Trade in biofuels lowers the iLUC effect!



Avoiding deforestation further increases the effect of biofuels on crop prices.



Crop management adjustments necessary to avoid higher price increases.



Biofuel mandates lead to increases of Soil N2O emissions.

REDD policies may slow them down.

V. Conclusions

- Biofuel expansion generates important iLUC GHG emissions.

- iLUC depends more on the possibility to source biofuels efficiently at international markets then on the global scale of production,

  ALTHOUGH for the larger scale iLUC per energy unit increases.

- Policies (like REDD) aiming at reducing the negative (i)LUC effects

  will fortify the pressure on crop prices,

  UNLESS management systems adapted (feasible?)

- Unit iLUC effects contingent on the global multiple policy setting

  to be taken into account if iLUC factors should be calculated

Thank you!

havlikpt@iiasa.ac.at