Biomass, bio-energy and terrestrial ecosystems: a global perspective

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Thanks to: A. Bondeau, K.H. Erb, V. Gaube, S. Gingrich, F. Krausmann, W. Lucht, C. Plutzar, M. Fischer-Kowalski et al.

2nd National IEA Bioenergy Task 39 "Liquid Biofuels" Workshop "Transport Biofuels Research in Austria", Vienna, 9 Sept 2008

Global LAND Project

MATISSE

FWF Der Wissenschaftsfonds.

social ecology vienna iff

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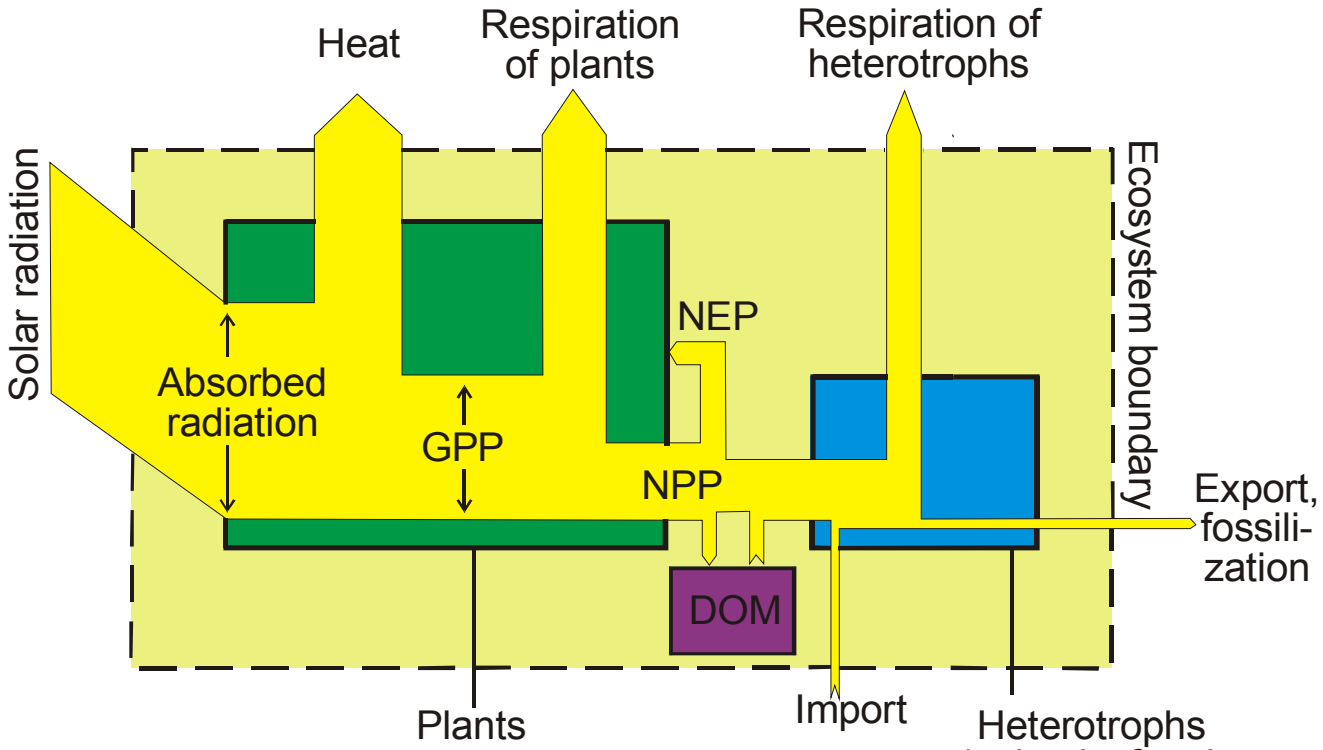
Overview

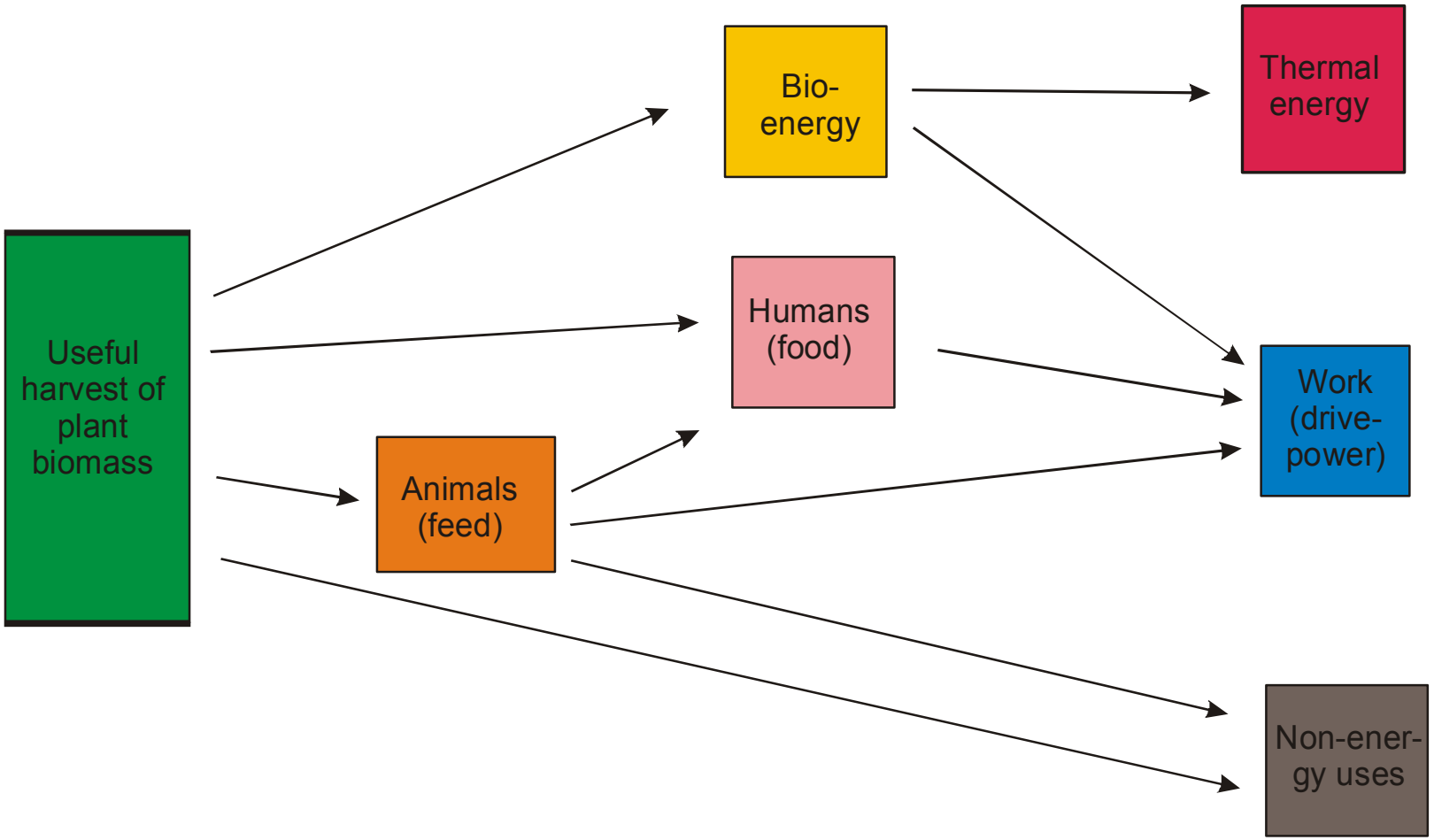
- Biomass: socioeconomic and ecological perspectives
- HANPP: an integrated socio-ecological view on global biomass flows
- Socio-ecological optimization of bio-energy use
- Perspectives and research needs

Ecological energy flows – the trophic-dynamic perspective [Lindemann 1942]

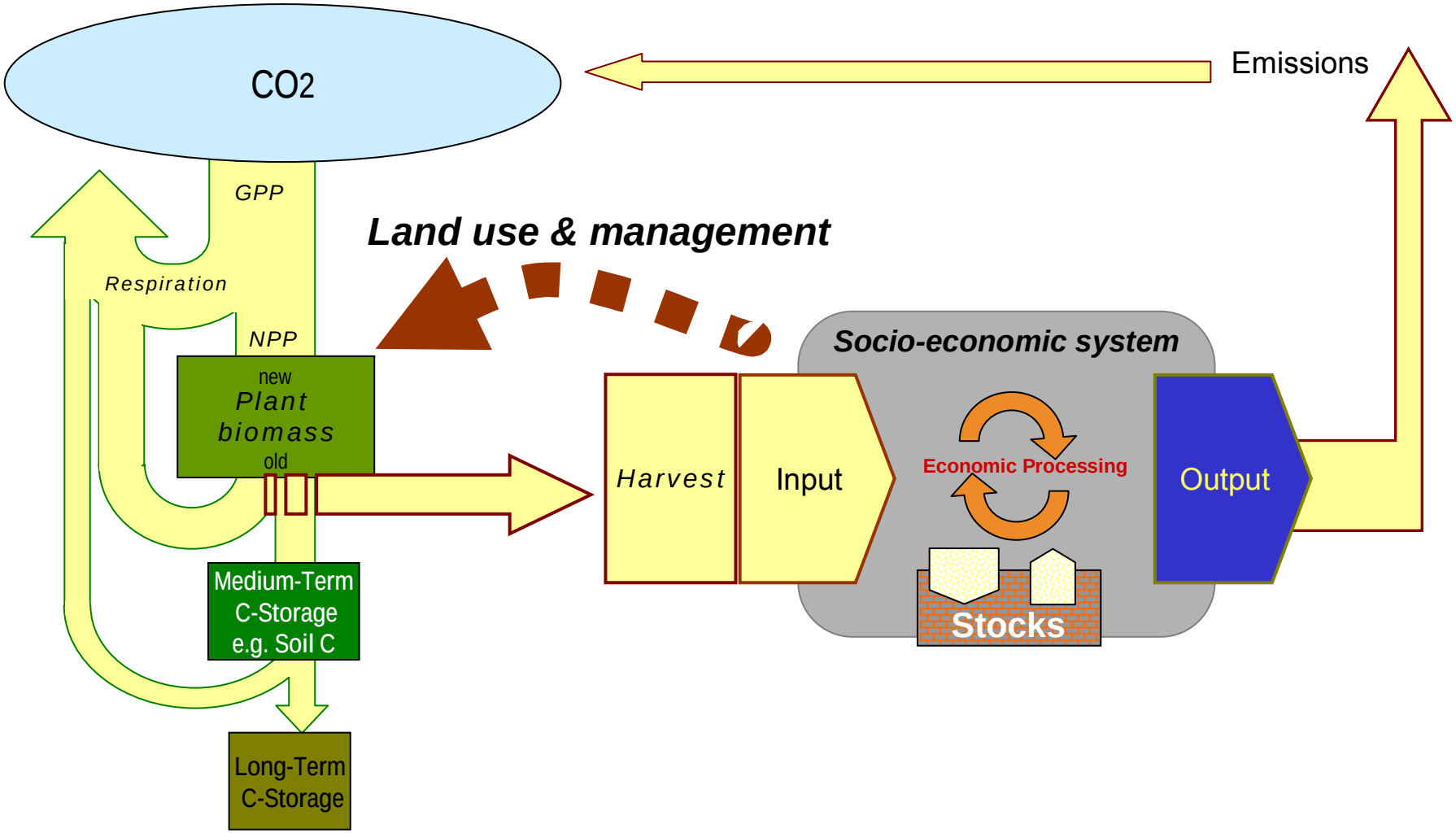


GPP … gross primary production
NPP … net primary production
NEP … net ecosystem production
DOM … dead organic matter

Principal socioeconomic biomass flows

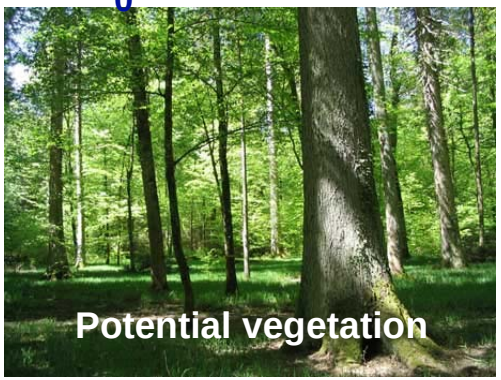


The integrated picture



An integrated socio-ecological perspective on global biomass flows: The HANPP approach

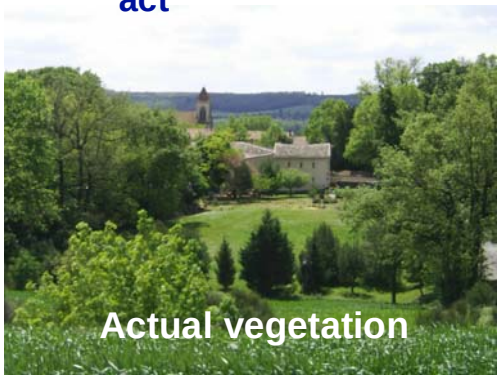
NPP_0



Productivity of potential vegetation

(hypothetical vegetation assumed to prevail in the absence of land use; e.g., forests, grasslands, savannahs, deserts, shrubs, etc.

NPP_{act}



Productivity of actual vegetation

(including croplands, grasslands, built-up area, etc.

NPP_t

Energy remaining in the ecosystem after harvest

An integrated socio-ecological perspective on global biomass flows: The HANPP approach

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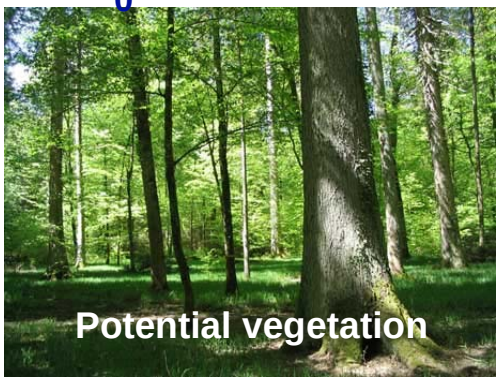

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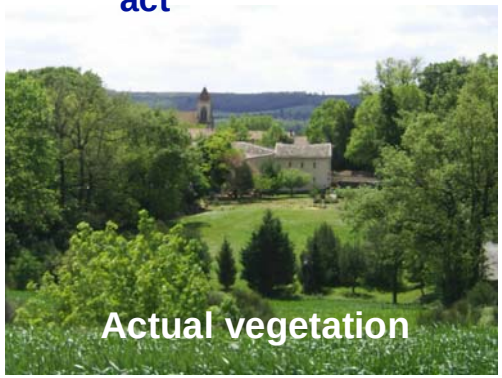

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Productivity of actual vegetation

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Energy remaining in the ecosystem after harvest

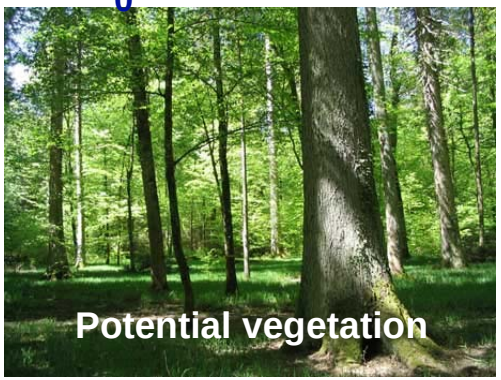
Productivity change (ΔNPP_{LC})

Harvest (NPPh)

Human approriation of NPP (HANPP)

An integrated socio-ecological perspective on global biomass flows: The HANPP approach

NPP_0



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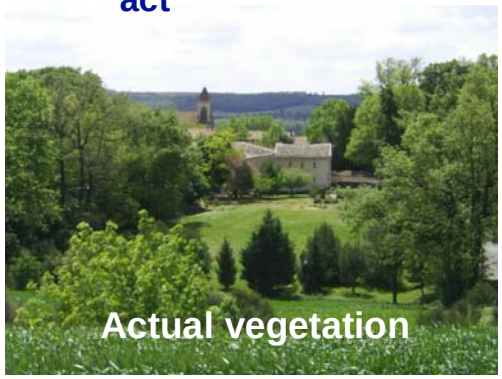

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NPP_t

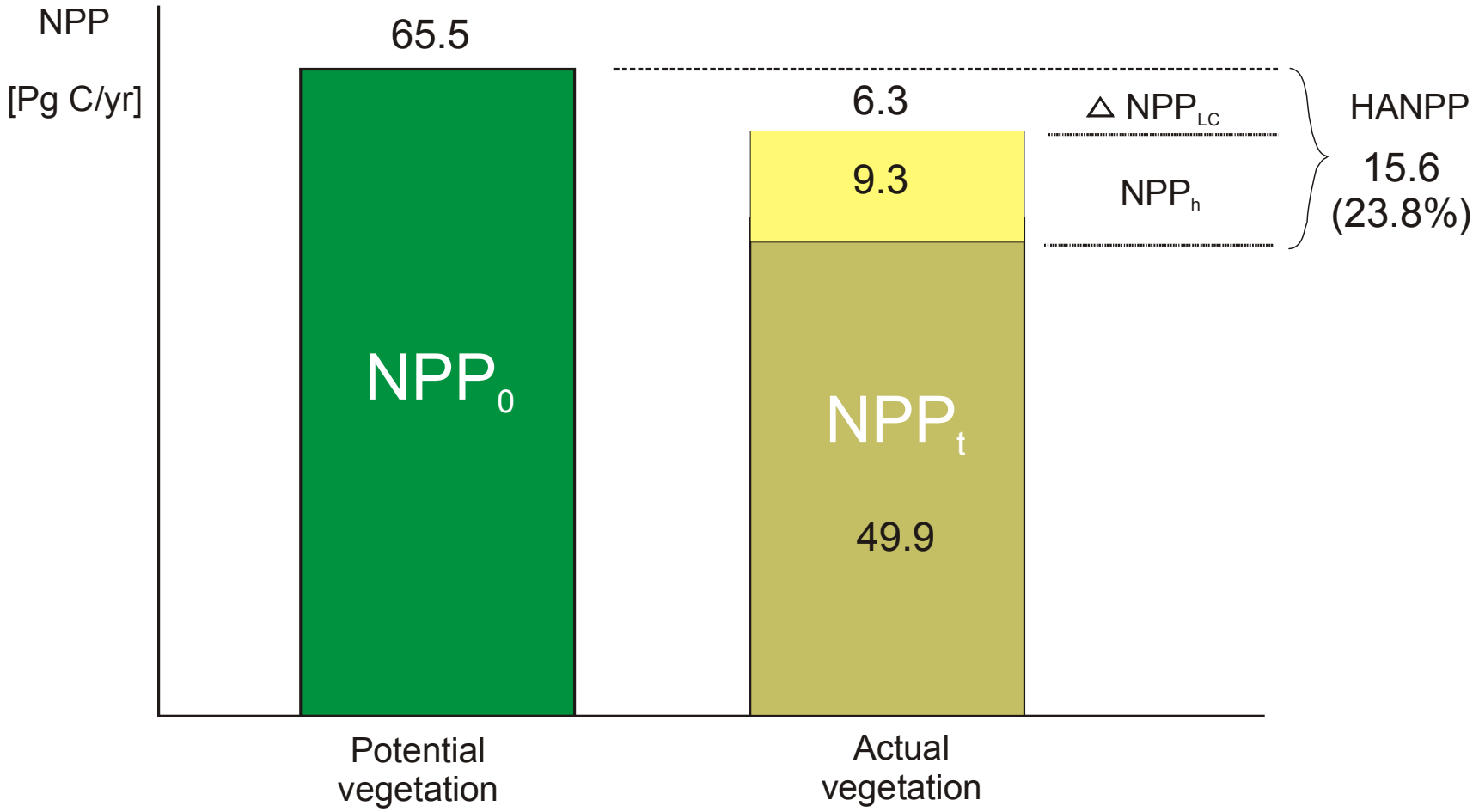
Energy remaining in the ecosystem after harvest

Productivity change

Harvest (NPPh)

- **Indicator of land-use intensity**
- **‚Pressure' indicator, useful to analyze drivers of land use**

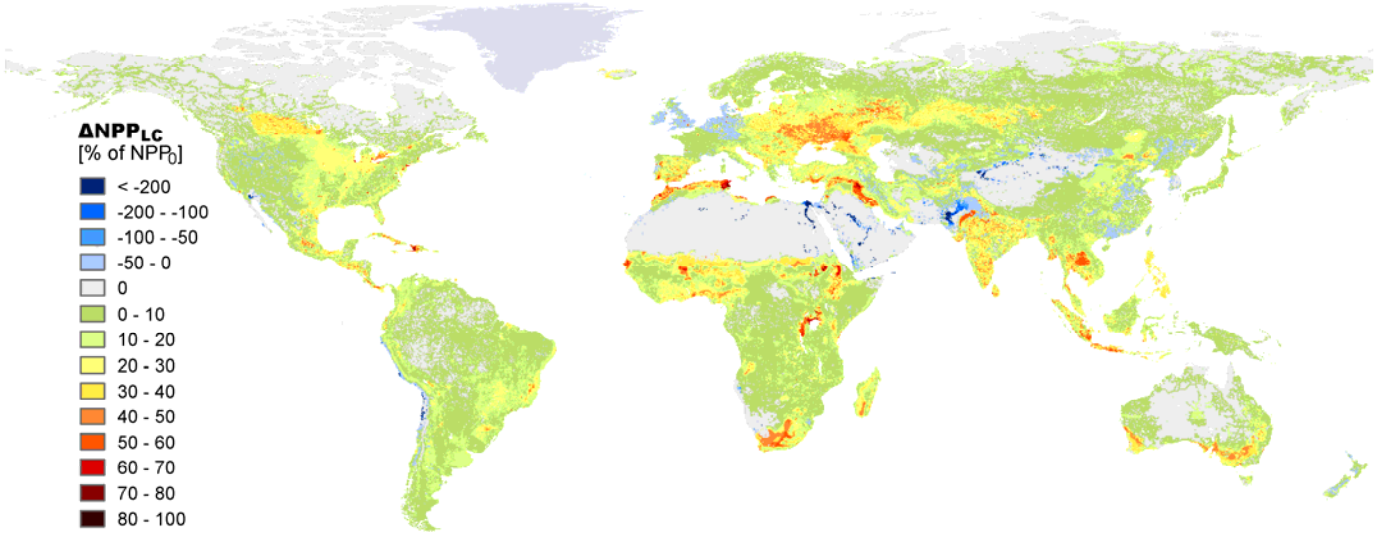
Aggregate global HANPP (year 2000)



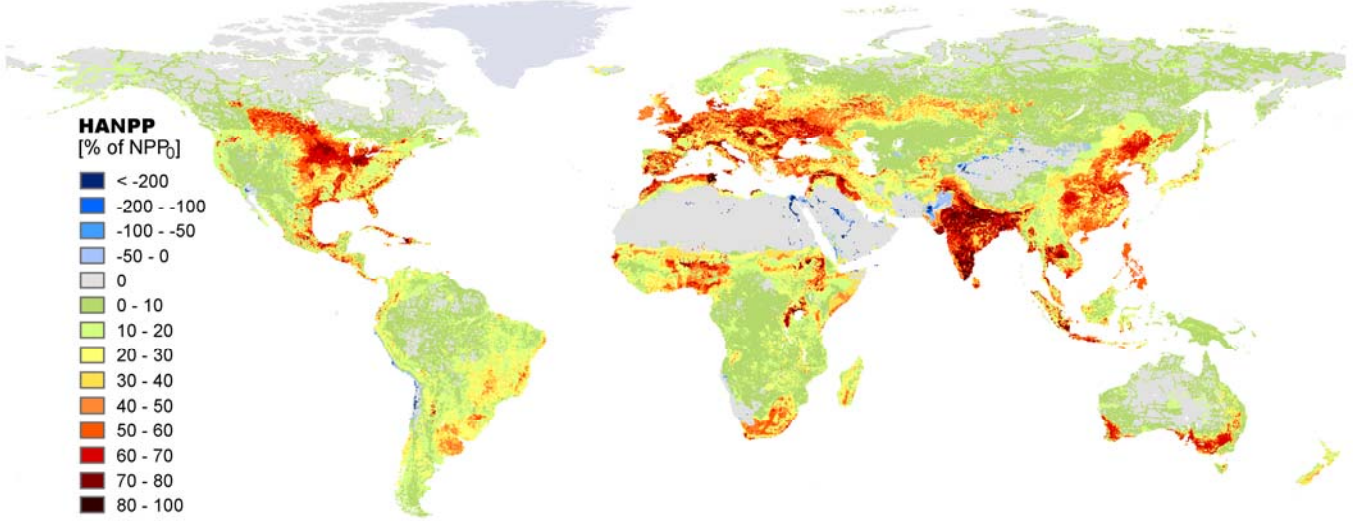
Global HANPP map

year 2000

(a) Land-use induced changes in productivity (ΔNPP_{LC})

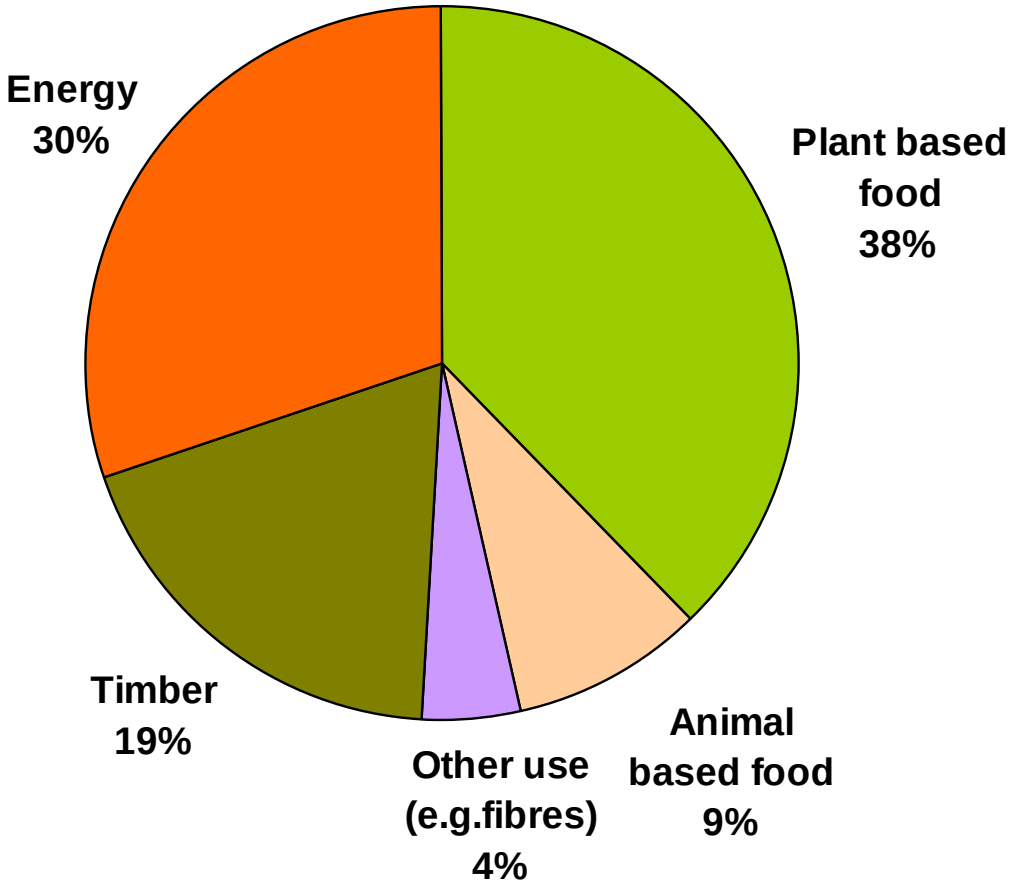


(b) Aggregate HANPP (ΔNPP_{LC} plus harvest)



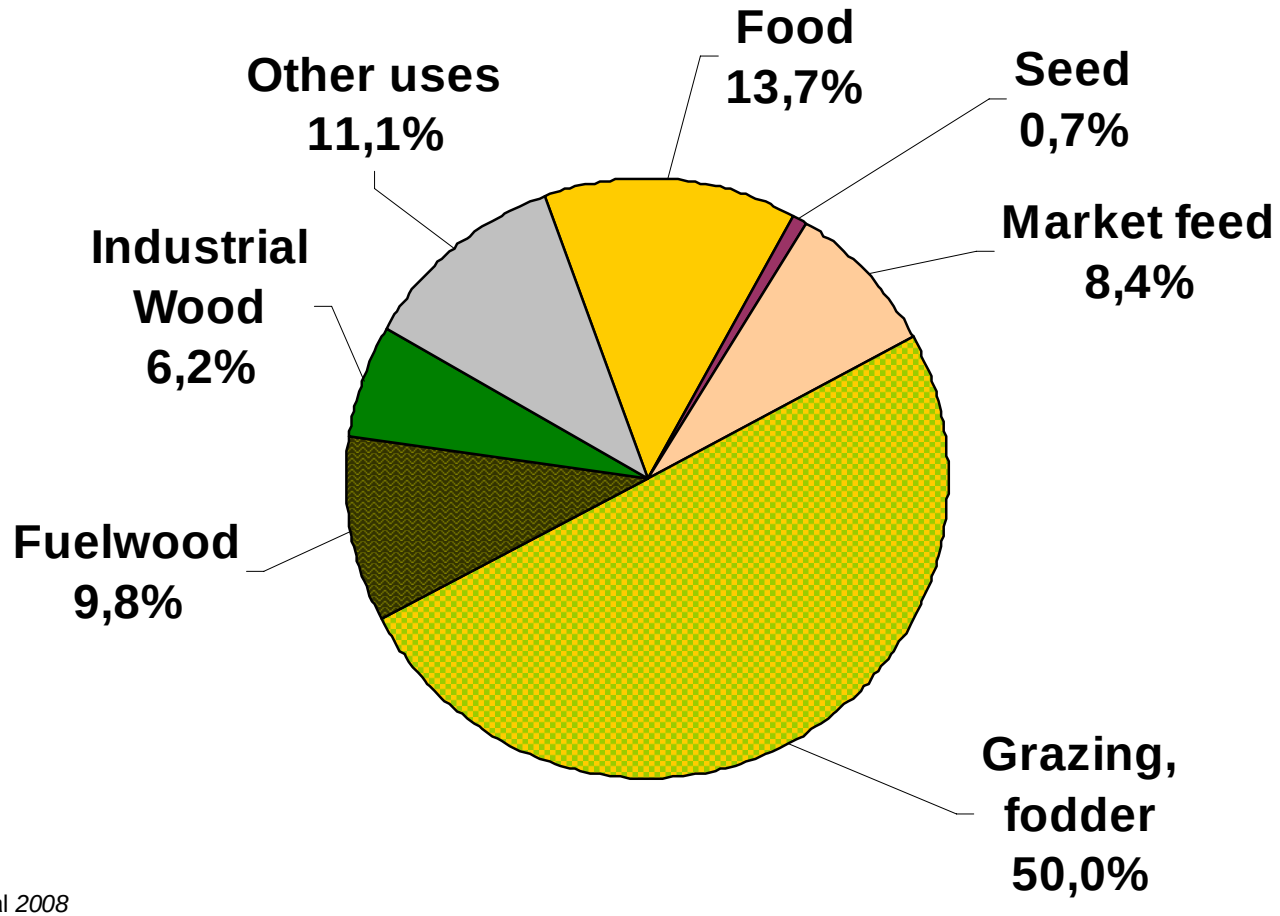
Haberl et al., ***Proc. Natl. Acad. Sci. (USA)*, 104,** 12942-12947 (2007)

Global final biomass demand : 650 kg per capita and year



Source: Krausmann et al *2008*

Used extraction of biomass: 2000 kg per capita and year



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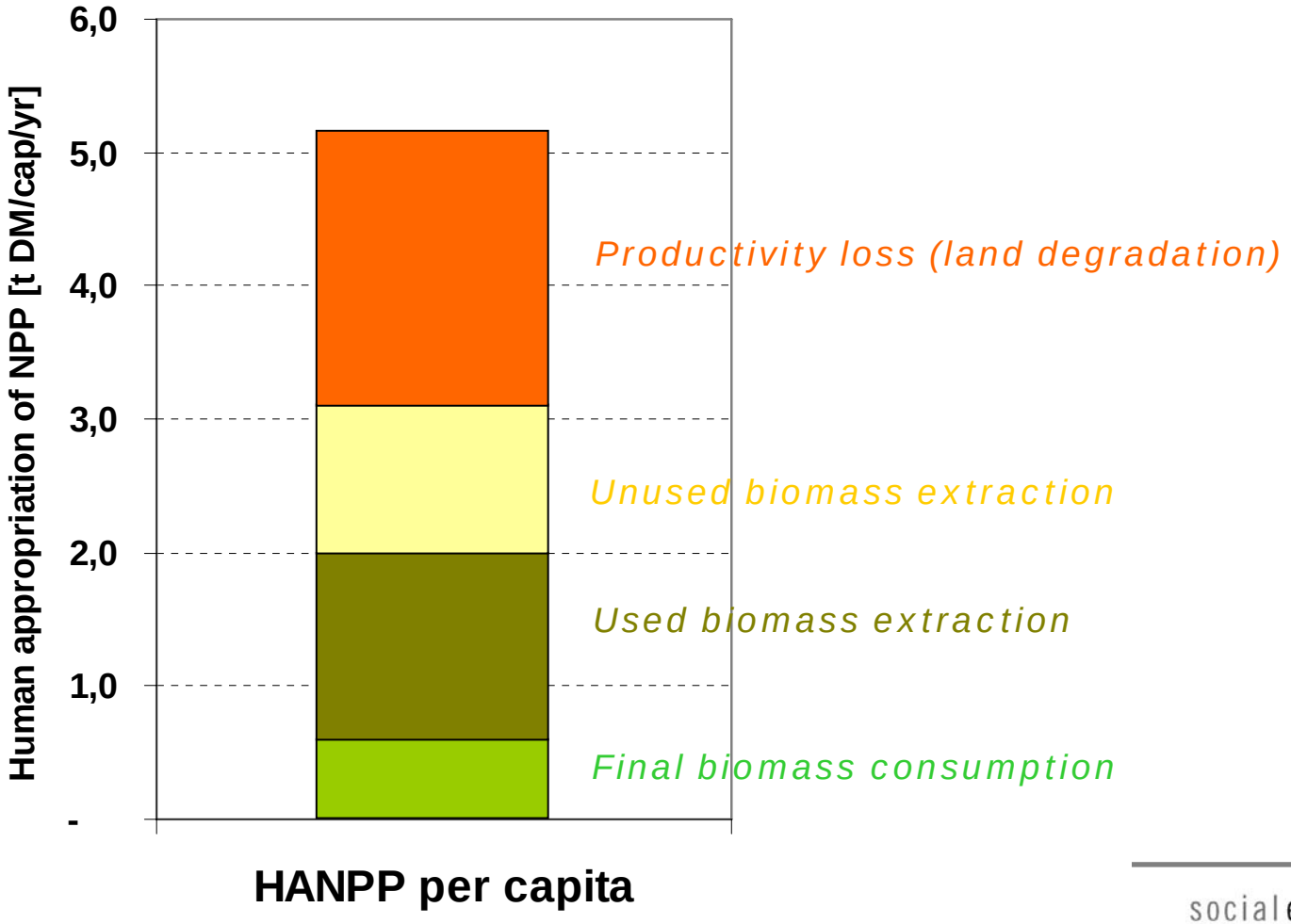
From final demand to HANPP



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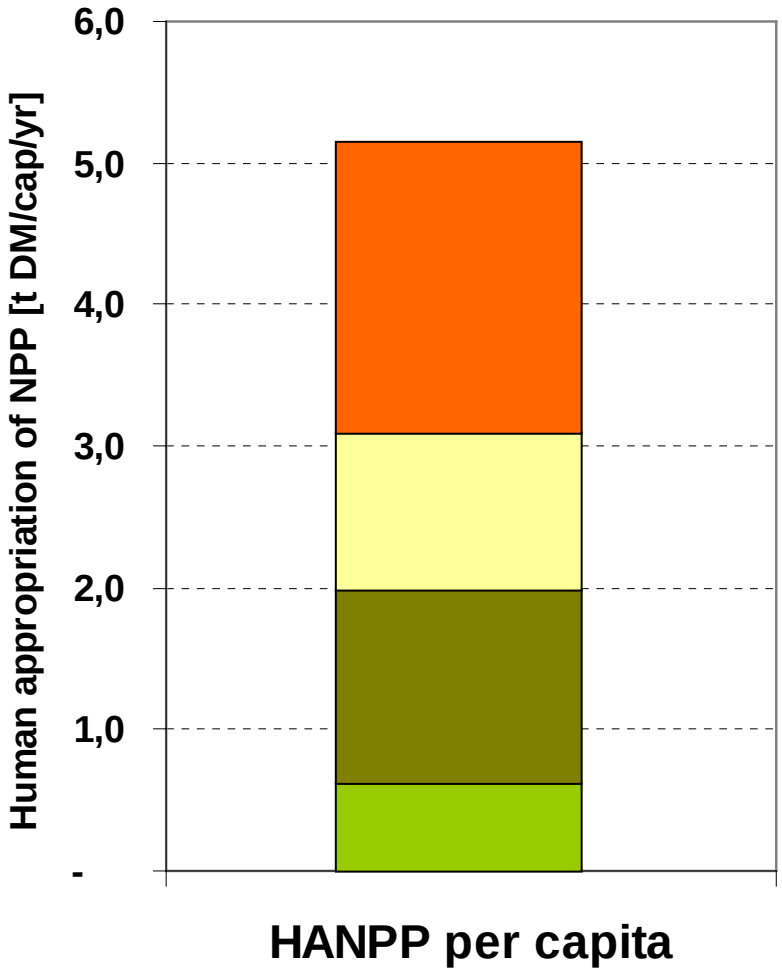
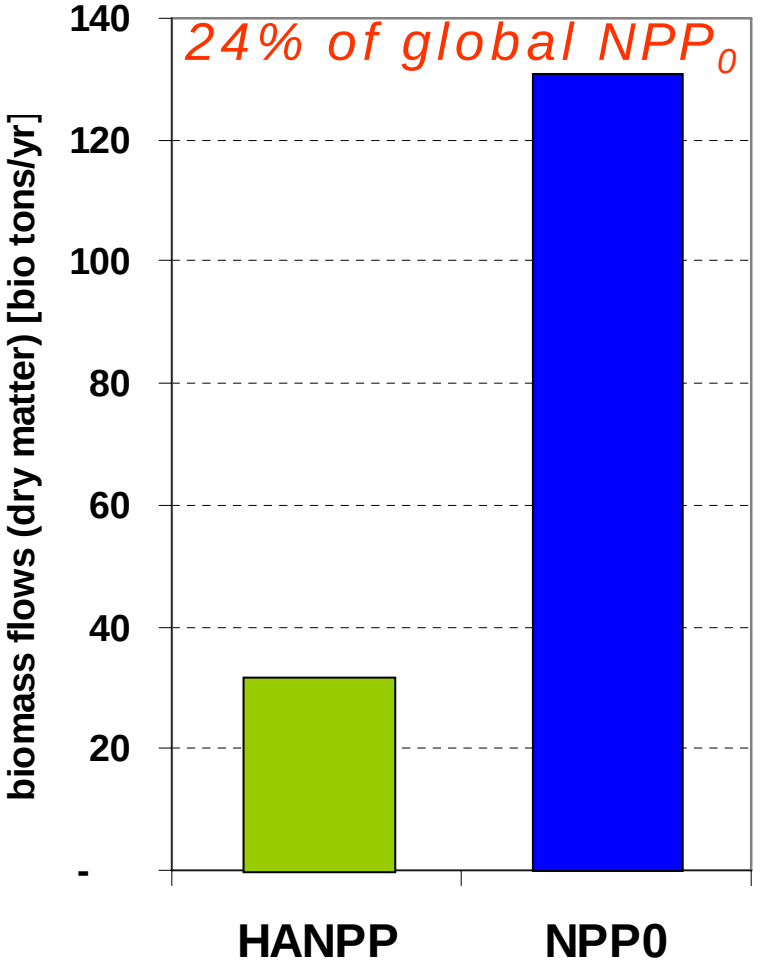


Global HANPP:
36 bio tons biomass
24% of global NPP_0



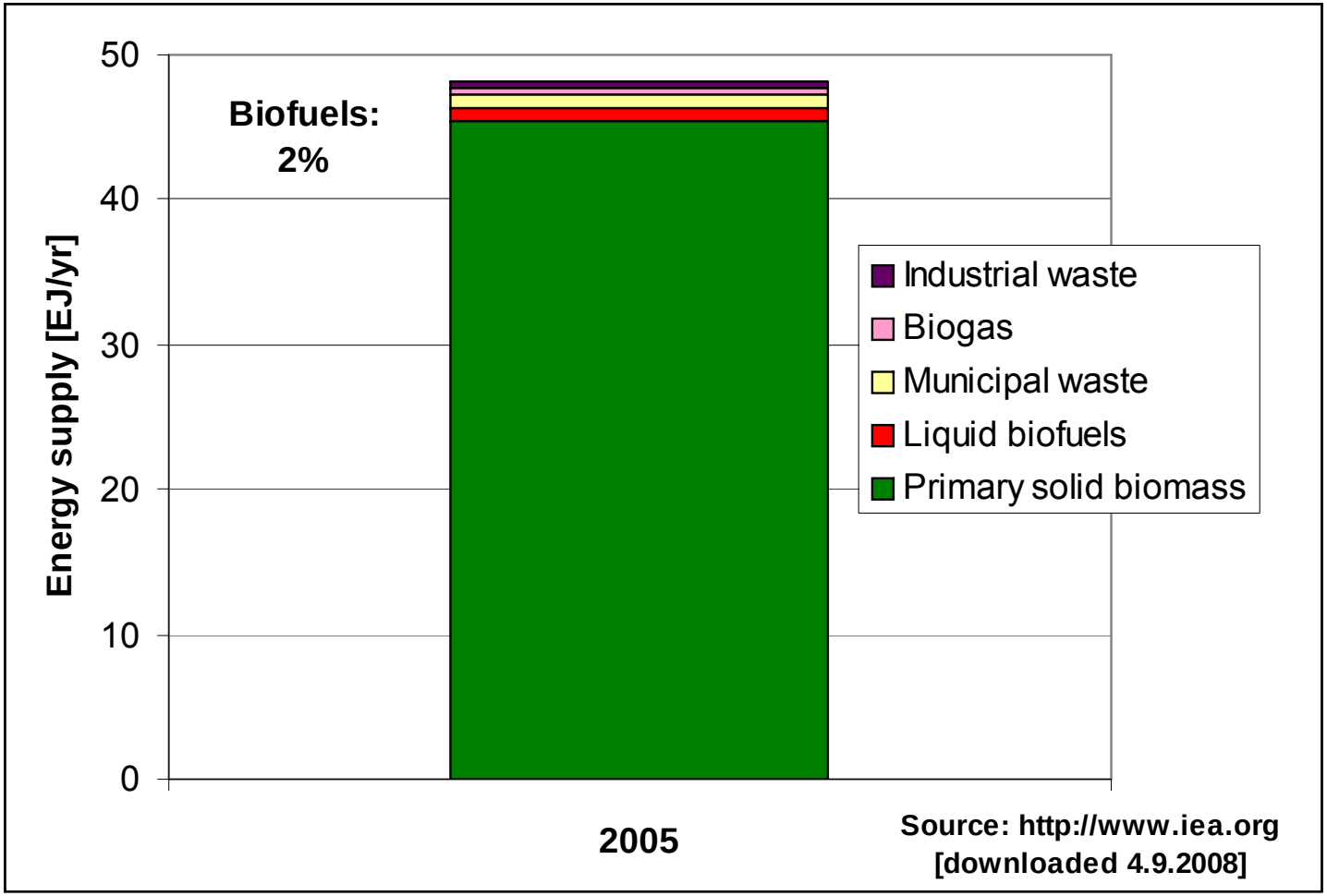
Some figures on current and projected future use of bio-energy

• Current global bio-energy production	48 EJ/yr (±10)
• Potential in 2050 according to the World Energy Assessment [2000]	280 EJ/yr
• World Energy Council/IIASA scenario for 2050	154 EJ/yr
• SRES-IPCC scenarios for 2050	193 EJ/yr
• Long-term potential estimates (various authors)	1 135 EJ/yr

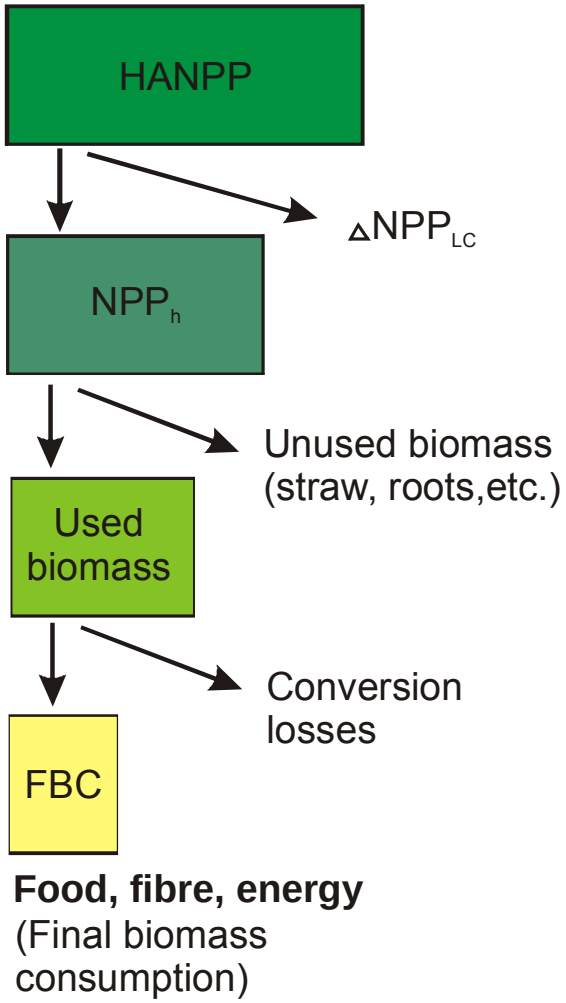
For comparison:

• Current terrestrial NPP (above+belowground)	2 200 EJ/yr
• Current global human fossil fuel use (GCV, 2005)	390 EJ/yr
• Total current human harvest of biomass (NPP_h)	350 EJ/yr
• Total current used biomass harvest	224 EJ/yr

Global use of bio-energy and bio-fuels



Embodied HANPP of final biomass consumption (global average)



1 ton of dry-matter biomass (final use of food, fibre, timber, fuel)

implies (in the global average over all products and regions)

the harvest of **3.6 tons** of primary biomass (NPP$_h$)

a reduction of productivity of **2.4 tons** (Δ NPP$_{LC}$)

i.e. a total HANPP of **6 tons**

Embodied HANPP of bio-energy (rough estimates, should be improved)

„Energetic recycling“ of biomass wastes	No additional HANPP (but limited potential) **0 t HANPP per t of solid biofuel**
Integrated optimization of grain production for food & energy	Increases area-demand for grain production by c10% 50% of straw available for energetic use **0.2 t HANPP per t of solid biofuel**
Rape methyl ester (RME) as agro-fuel (diesel motors)	Assumtions: 0.13 kg RME per m^2 cropland and year HANPP per m^2 cropland and year 1.8 kg 50% of HANPP allocated to RME (remainder to feedstuff produced) **7 t HANPP per t of liquid biofuel (RME)**

Implications

- HANPP efficiency (i.e. largely area-efficiency, i.e. energy yield per unit area and year) should be a highly important indicator for judging the ecological sustainability of bio-energy technologies.
- Agro-fuels are currently roughly 5-10 times less efficient than solid biofuels based on e.g. Miscanthus or short-rotation forests and roughly 25-50 times worse than integrated bioenergy/food schemes (i.e. use of agricultural residues)

$\Rightarrow$ Priority should be given to „cascade utilization“ of biomass and to solid bio-fuels with a high energy yield per unit area (and usually also a good EROI)

Research questions (examples)

- Establish an embodied HANPP database (multiregional, for a large array of biomass-based products: food, fibre, energy)
- Integrated optimization of biomass production (cropping, grazing, livestock) and use (food, fibre and energy cascades)
- Trade issues, in particular with reference to trade between industrialized and developing countries with large importance of agrarian subsistence
- Trade-offs between carbon sequestration, bio-energy production and biodiversity

New: Download HANPP and land use data
http://www.uni-klu.ac.at/socec/inhalt/1088.htm