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Global human appropriation of net primary production

Population, affluence, technology, trade - and biodiversity.

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Overview

- The „human appropriation of net primary production“ (HANPP)
- Global and regional results
- The next steps: Analysing drivers and determinants of HANPP
 - The role of trade
- Analysing impacts of HANPP: biodiversity
- Conclusions and Outlook: Challenges

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Land - a socio-ecological system

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The HANPP approach

NPP0

Potential vegetation

Annual energy flow of the potential vegetation (without human land use, e.g. Forests, Grasslands, Savannas, etc.)

NPPact

Actual vegetation

Annual energy flow of the actual vegetation, including secondary vegetation, fields, built-up areas, etc.

NPPt

NPP remaining after harvest

Energy flow available annually after the extraction of biomass through harvest

ΔNPP_{LC}

HANPP

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Human Appropriation of Net Primary Production (Definition)

- A measure for the reduction of trophic (=food) energy available for all other species than humans and their livestock
- Indicator for land use intensity
- HANPP can be directly related to socio-economic activities, thus allowing preventive measures to lower human pressures on ecosystems

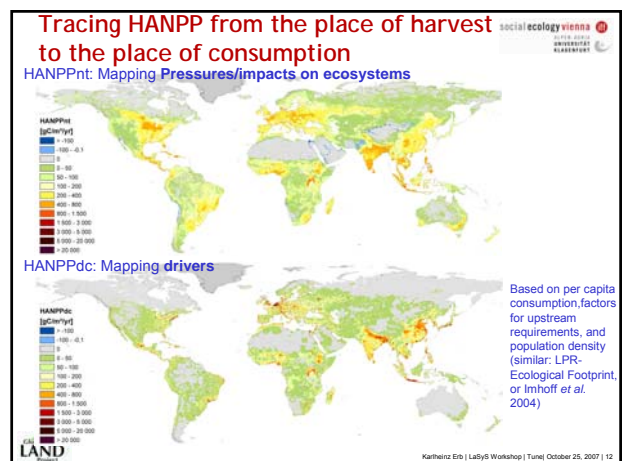
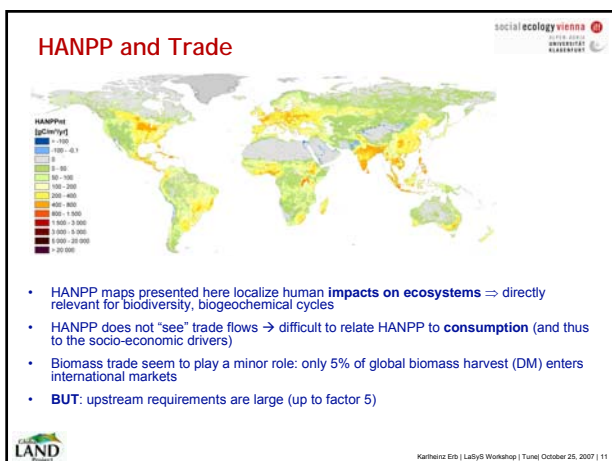
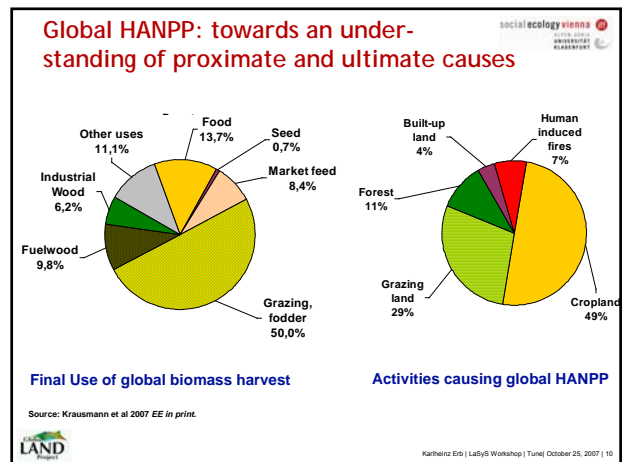
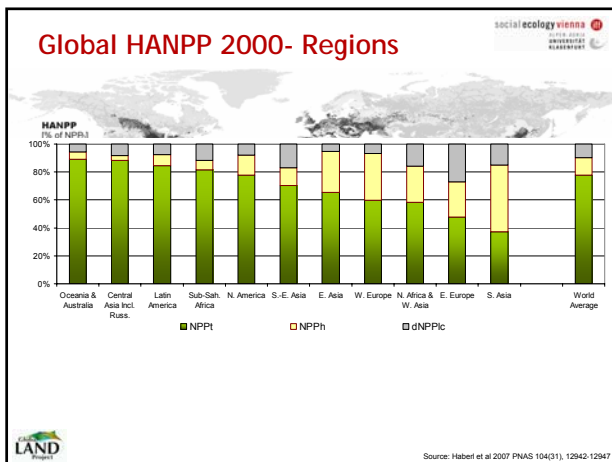
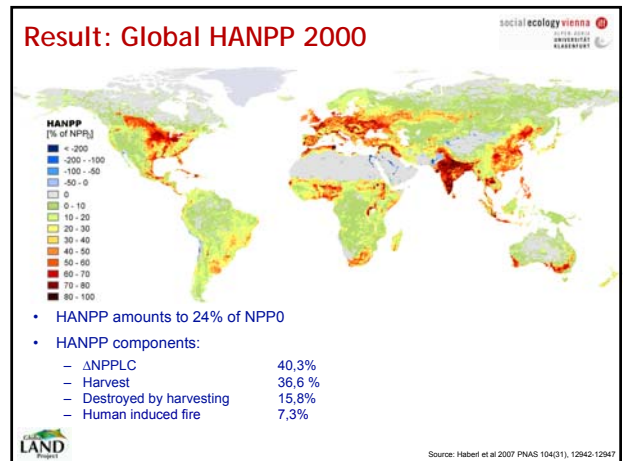
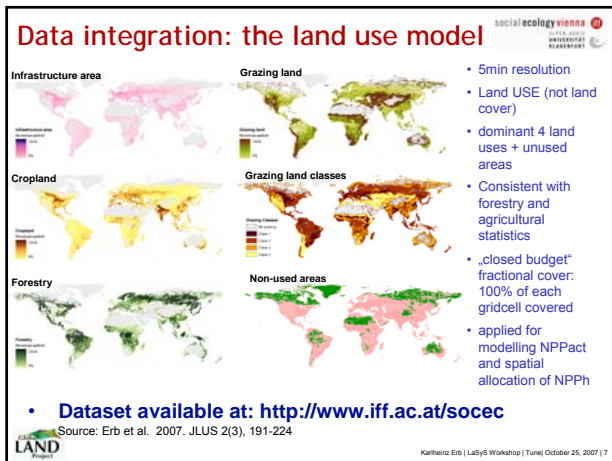
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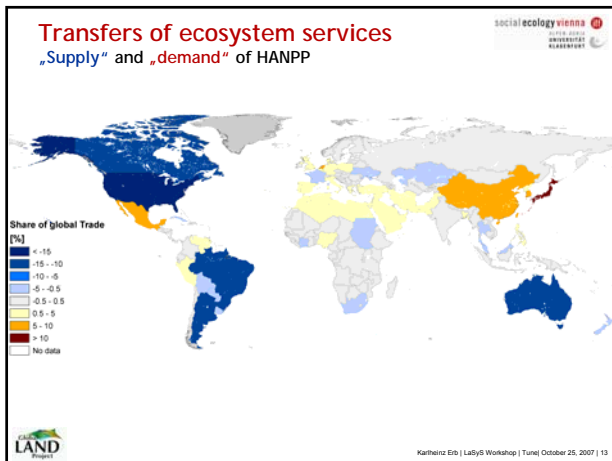
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Method: Calculation approach

- **NPP_h**:
 - statistics on the national and sub-national level (standards of MEFA – compatibility with economic accounts).
 - modelling approaches for flows not covered or underestimated by international statistics (e.g. biomass grazed by livestock).
- **NPP₀**: LPJ-DGVM results
- **NPPact**
 - mixed approaches, combining statistics and modelling approaches.
 - Effects/data considered: Fertilization (FAO), Irrigation (Döll-Siebert-FAO), Soil Degradation (GLASOD)
 - Conservative approach: in the absence of data, **NPPact = NPP₀**

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Interpretations...

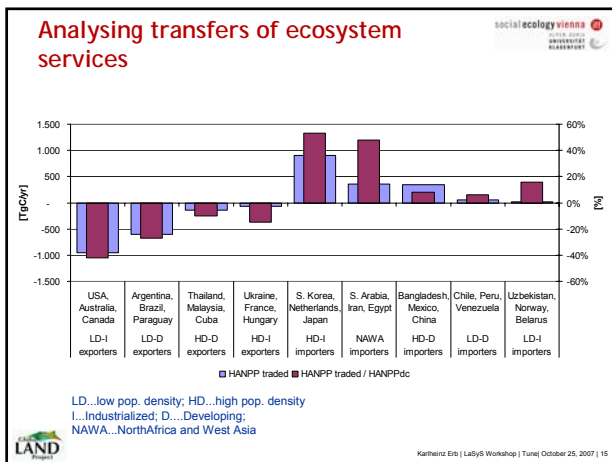
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Regional deficits have to be solved. But how?

- Biodiesel is a newcomer and renewable fuel in Brazil.
- However, it seems that the development of the Brazilian Biodiesel Program is slow.
- Brazil may need help from outside to move faster.

Source: J.D. Ferrés, ABOVE (Brazilian Vegetable Oil Industries Association), 2005

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HANPP and biodiversity: The species-energy hypothesis

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HANPP and biodiversity: The species-energy hypothesis

- Basic claim:** The number of species is positively related to the flow of energy in an ecosystem.
- Corollary:** If humans reduce energy flow (e.g., through HANPP), then species richness will decline.
- Why is it relevant:** pressure indicator, unambiguously related to human activities. causal chain: drivers-pressures-states-impacts
- Notes**
 - Can explain species diversity gradient from equator to poles.
 - Not undisputed. Competing (complementary) hypotheses exist (e.g., intermediate disturbance hypothesis).

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Empirical studies: species richness is well correlated with NPP_t - indirect support for HANPP/biodiversity hypothesis

all heterotrophs
 $Y = -1.975 + 0.485X$
 $R^2 = 0.546$, $p < 0.0001$

breeding bird species richness
 $Y = 1.32916 + 0.05916X - 0.00292X^2$
 $R^2 = 0.89$

Number of species
 $p = 0.708$

Case study 1: Correlation between NPP, and autotroph species richness (5 taxa) on 38 plots sized 600x600 m, East Austria
Haberl et al., 2004, *Agric., Ecosyst. & Envir.* 102, p213ff

Case study 2: Correlation between NPP, and breeding bird richness in Austria, 328 randomly chosen 1x1 km squares.
Haberl et al., 2005, *Agric., Ecosyst. & Envir.* 110, p119ff

Case study 3: Correlation between NPP, and vertebrate richness in the Americas, 10,000 randomly chosen 5m gridcells
Haberl et al., forthcoming

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Summary

- What have we learned since Vitousek et al. 1986 (Bioscience)
 - Straightforward, consistent definition, applicable in time series analysis, not too inclusive (allows for analysing the link NPPt ~ biodiversity)
 - Global HANPP is considerable (24% of NPP0); agriculture is the most important driver. Livestock plays a crucial role
 - Relation NPPh and HANPP is complex: more NPPh does not necessarily mean more HANPP (agricultural intensification)
 - Spatially explicit assessment reveals considerable regional variations
 - HANPP localizing impacts, HANPP localizing drivers
- Large transfers in ecosystem services: net biomass trade: 21% of global HANPP in 2000
 - not dominated by net flows from developing to industrialised countries; population density plays a stronger role (Low density → high density countries)
 - Large regions do not (yet) participate in this transfer of ecosystem services



Challenges I

Lack in data/understanding

- Global land use data: beyond dominant LU classes: multiple land use, mosaics, land use intensity; spatial accuracy
 - Land Use Data Intercomparison Workshop, May 2008, Vienna (Inst. Social Ecology & MNP [K.Klein-Goldewijk])
- Grazing: intensity, amount and spatial pattern of grazing biomass; effects of grazing
- Forestry: used-unused forests
- soil/vegetation degradation: where? how much? effects on NPP?

HANPP and biodiversity

- More case studies (more habitats, more biomes, more ecosystems, more species groups)
- Alternative biodiv data (e.g. species abundance data) needed
- Direct tests: lack of biodiversity-change data



Challenges II

- Understanding drivers and trajectories of HANPP
 - socioeconomic drivers and determinants in agriculture, food, and energy systems
 - Climate change trajectories
- Impacts of HANPP on ecosystem services/functioning
 - interrelations with N-cycle, water cycle
- Spatial segregation between appropriation and consumption: Issues of scale, governance
- Future biomass demand-supply: Options/potentials for sustainable biomass utilization
 - biomass demand is bound to increase: population growth, techn. energy demand
 - Options: Land use expansion - Intensification of production - Increasing land-use efficiency. All of them may come at high ecological costs.
 - Regional optimization/international cooperation. Sustainability criteria



The End

Thank you for your attention!

Further information & data:
<http://www.iff.ac.at/socec>

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Next steps

- Ongoing work (collaboration with PIK & MNP) to integrate GTAP/LEITAP, IMAGE and LPJ-DGVM to forge a coupled model capable of producing HANPP scenarios depending on climate trajectories, biomass demand scenarios
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