

Socioeconomic drivers of biodiversity

The HANPP approach

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**Ecosystem services and Biodiversity: what is the link
between the two?**

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Overview

- Resource use, indicators and biodiversity: the material and energy flow accounting (MEFA) framework
- Global patterns of human appropriation of net primary production (HANPP)
- HANPP and biodiversity
- How to use material flow analysis to link HANPP with economic activities
- Outlook and conclusions

Two mutually reinforcing approaches for reducing biodiversity loss

- **Protection:**

Goal: protect valuable populations, species or habitats from adverse human impacts

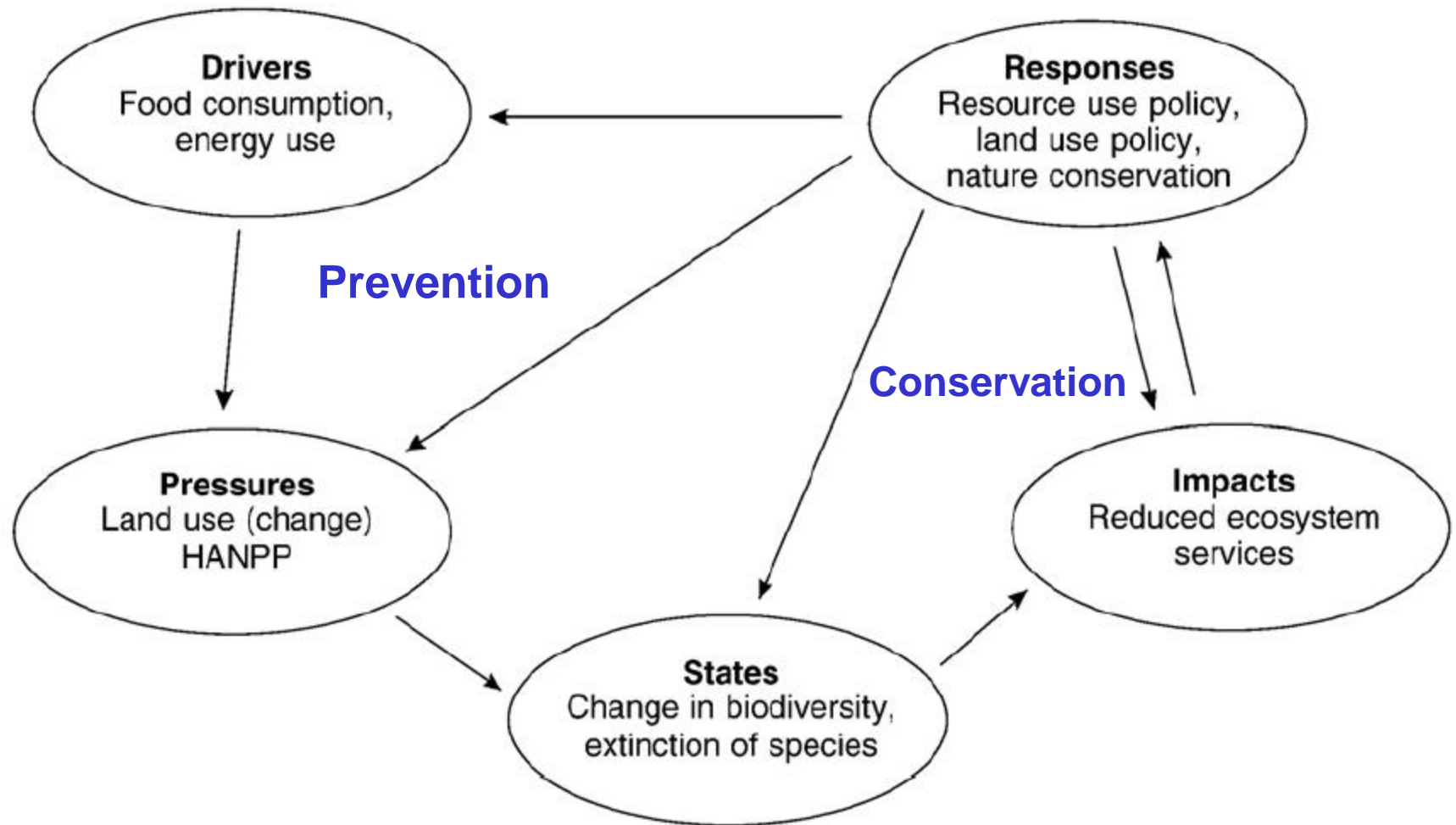
Mechanism: protect „red list“ species from hunting/use, establish nature reserves, national parks, etc.

- **Prevention:**

Goal: reduce pressures on biodiversity by influencing their drivers – alter socioeconomic trajectories into a more biodiversity-friendly direction

Mechanism: reduce/alter the socioeconomic use of natural resources (area, biomass, energy, materials, etc.)

The DPSIR approach applied to biodiversity



Resource use is connected to pressures on biodiversity

- Reducing resource consumption will be beneficial for biodiversity:
 - Mitigate climate change
 - Reduce direct pressures from land use
 - Etc.

Table 1 – The interrelations between main pressures on biodiversity and resource flows as assessed in the MEFA (material and energy flow accounting) framework

Main categories of pressures on biodiversity	Parameters/flows accounted for in the MEFA framework
Direct impacts of exploitation (e.g., hunting or poaching of rare/endangered animals, collection of rare/endangered plants)	Domestic extraction of biomass NPP _h ... an important component of HANPP
Habitat loss and fragmentation due to land use (change)	Land demand, HANPP
Intentional and unintentional release of chemicals (fertilizers, pesticides, pollutants)	Outflows from socioeconomic metabolism (part of the “Domestic Processes Output”, DPO, as accounted for in Material Flow Analysis MFA)
Introduction of alien species	Related to trade flows as accounted for in MFA (e.g., import/export of living animals and biomass)
Climate change	Results to a large extent from fossil fuel combustion (accounted for in MFA and Energy Flow Analysis, EFA)

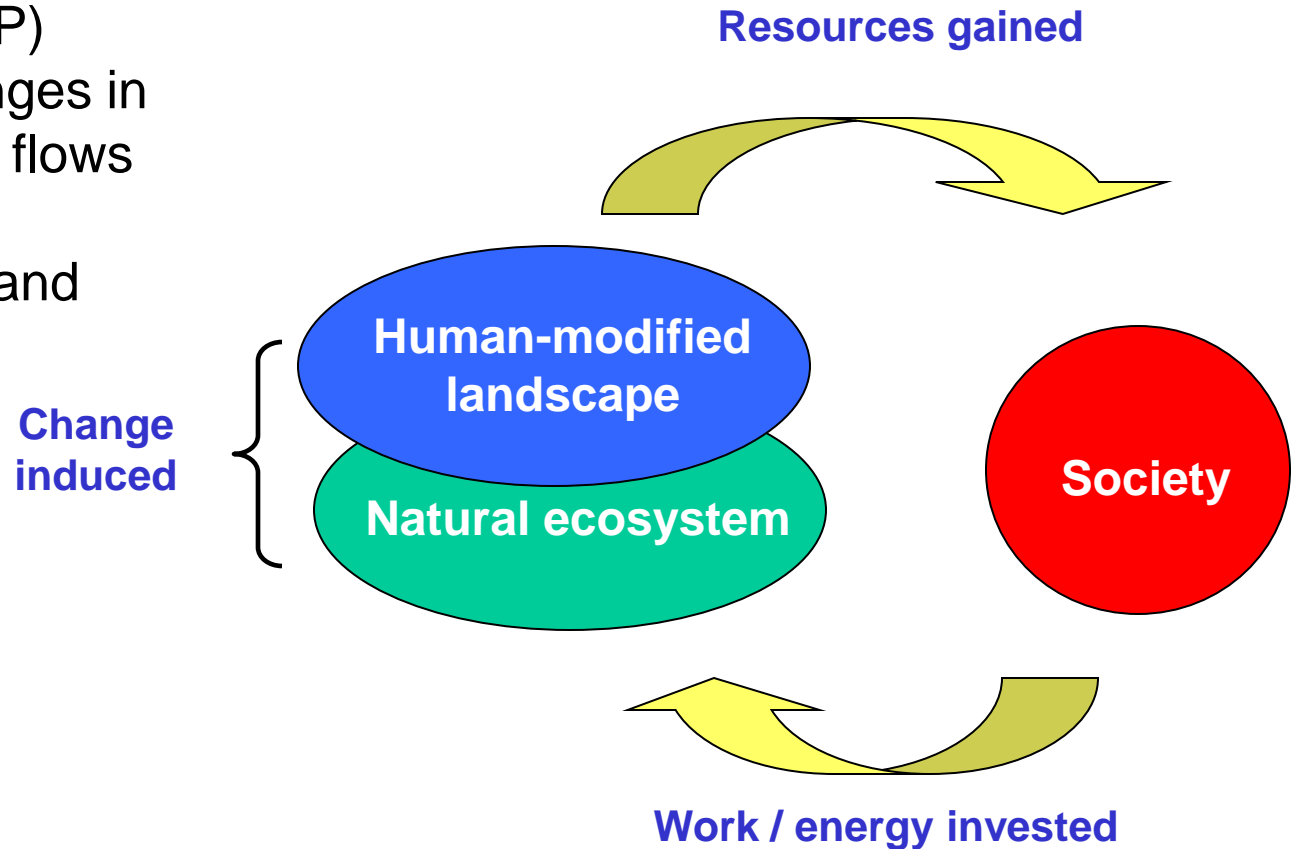
The „Material and Energy Flow Accounting“ (MEFA) framework

- **Rationale**
Monitor/assess the „physical economy“ – a basis for strategies to reduce socioeconomic use of natural resources („dematerialization“)
- **Socioeconomic material and energy flow indicators:**
 - Material flow analysis (MFA)
 - Energy flow analysis (EFA)
 - Carbon, nitrogen, etc. flow analyses
- **Socioecological material/energy flow indicators:**
 - Human appropriation of net primary production (HANPP)
 - Related approaches, e.g. virtual water, ecological footprint

Ecological Economics, Industrial Ecology, Social Ecology

HANPP: an integrated indicator of land use intensity

Human appropriation of NPP (HANPP) measures changes in yearly biomass flows in ecosystems resulting from land use



An integrated socio-ecological perspective on terrestrial ecosystems: The HANPP approach

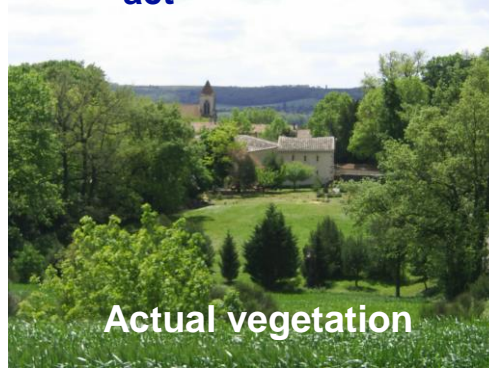
NPP_0



Productivity of potential vegetation

(hypothetical vegetation assumed to prevail in the absence of land use; e.g., forests, grasslands, savannas, 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

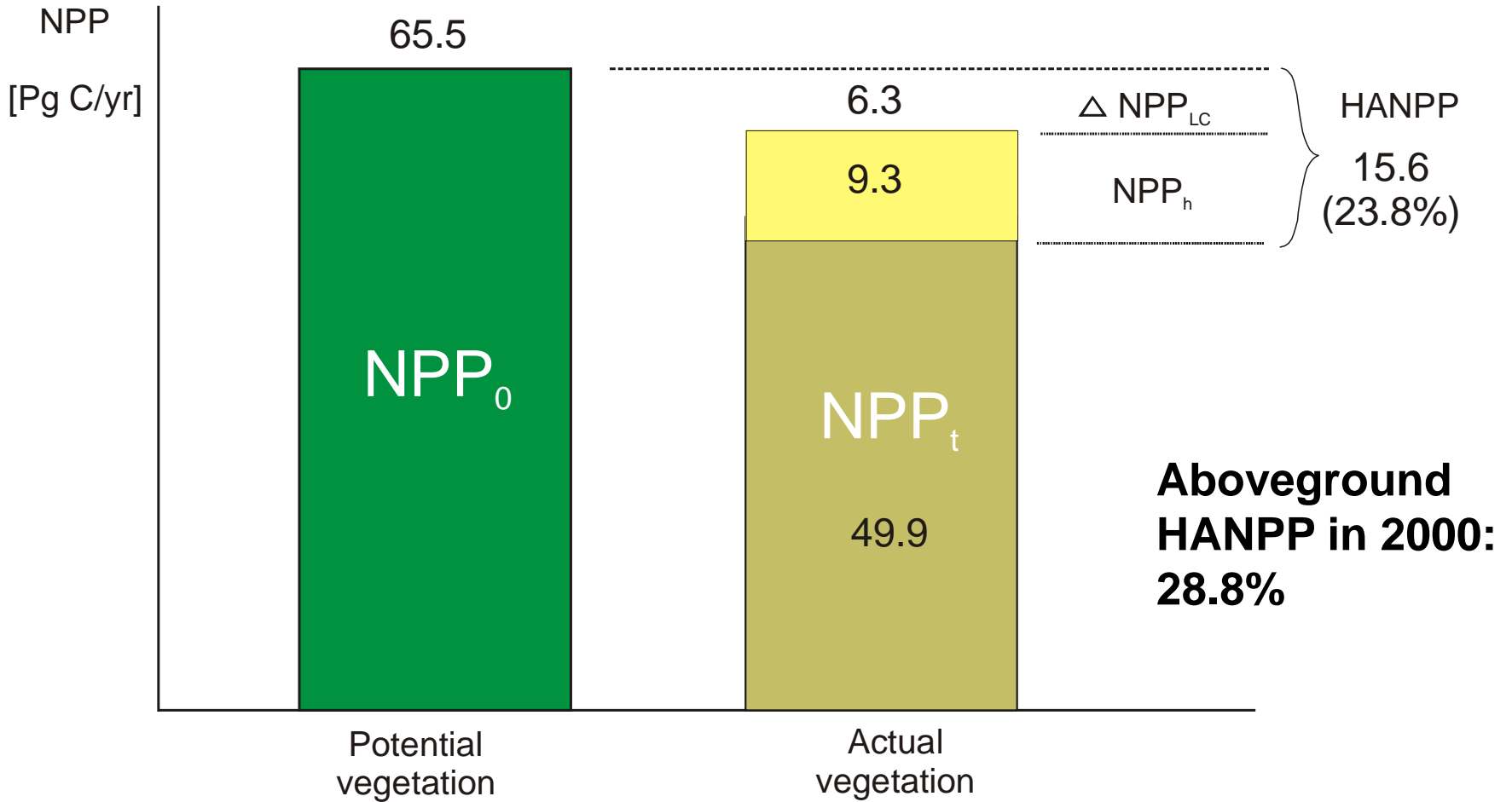
Productivity change

(ΔNPP)

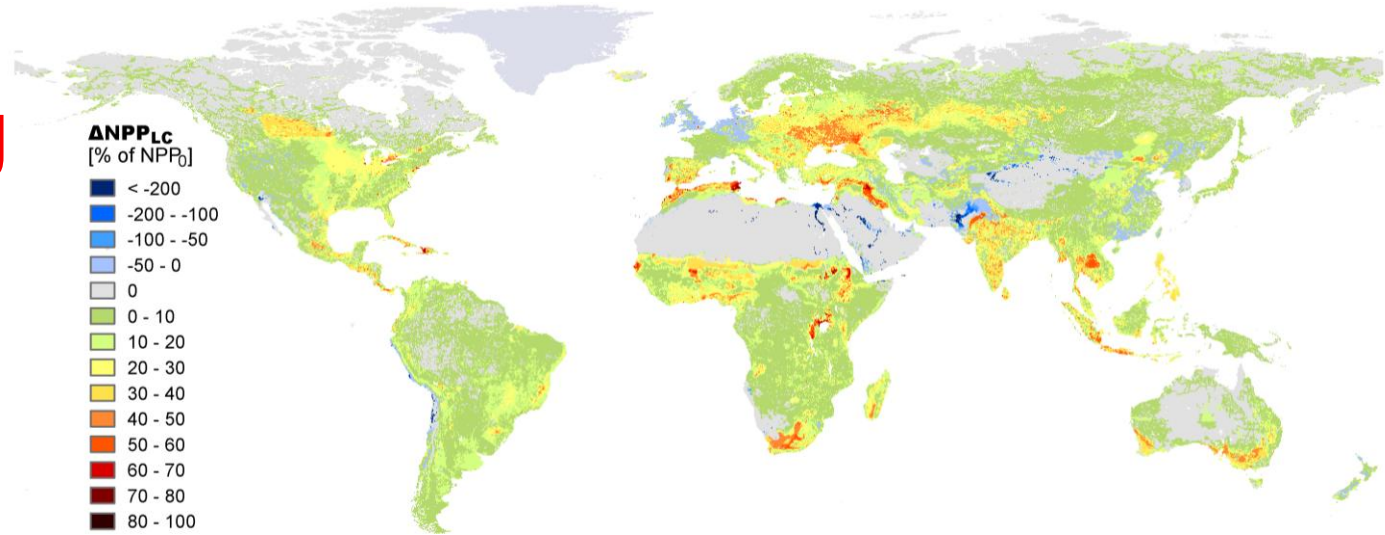
Harvest (NPP_h)

- Indicator of land-use intensity
- ‚Pressure‘ indicator
- Human domination of ecosystems

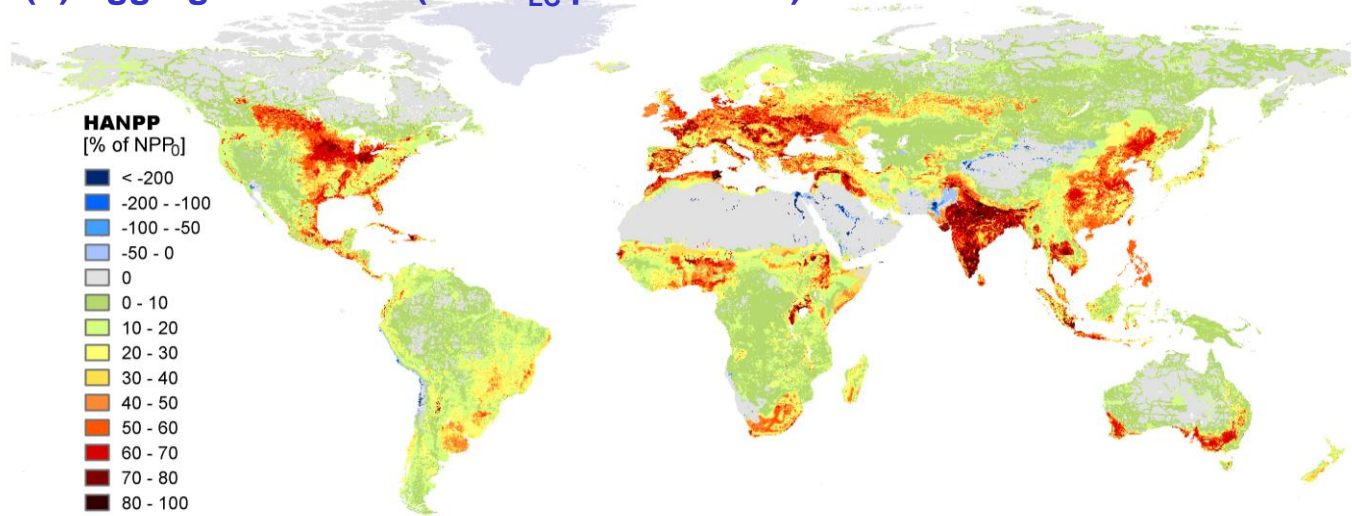
Aggregate global HANPP (year 2000)



(a) Land-use induced changes in productivity ($\Delta\text{NPP}_{\text{LC}}$)



(b) Aggregate HANPP ($\Delta\text{NPP}_{\text{LC}}$ plus harvest)

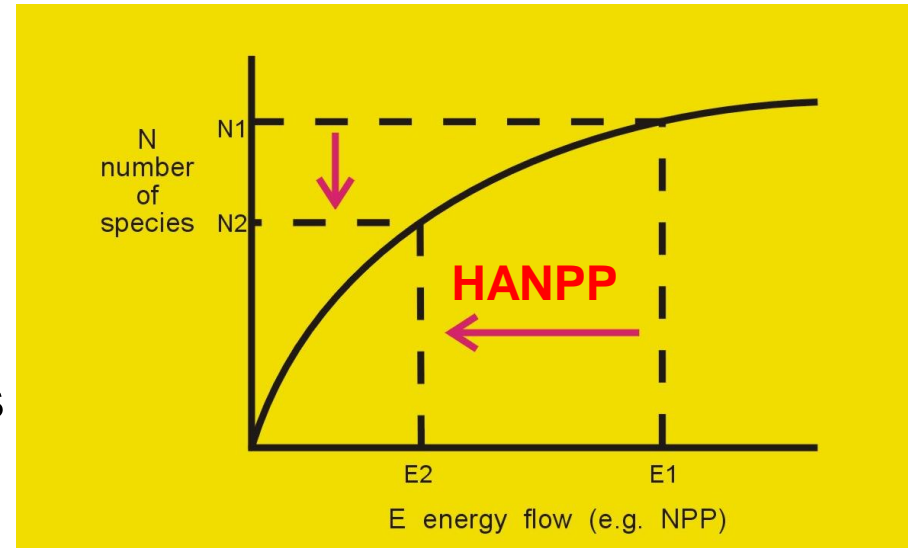


Mapping global HANPP 2000

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

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.
- **Notes**
 - Can explain species diversity gradient from equator to poles.
 - Not undisputed. Competing (complementary) hypotheses exist (e.g., intermediate disturbance hypothesis).

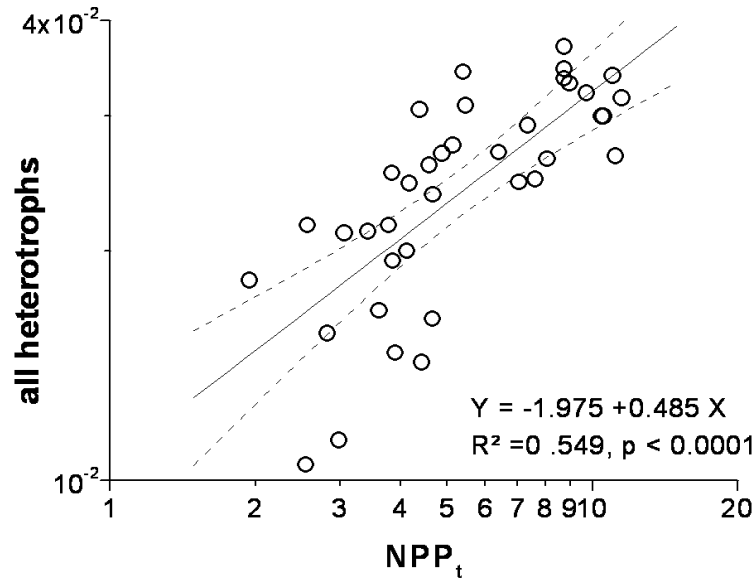


- Brown, J.H. (1981) *Am. Zool.* **21**, 877-888.
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Waide, R.B. et al. (1999) *Ann. Rev. Ecol. Syst.* **30**, 257-300.
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Wright, D.H. (1990) *Ambio* **19**, 189-194.

Difficulties of observing HANPP-related reductions in biodiversity

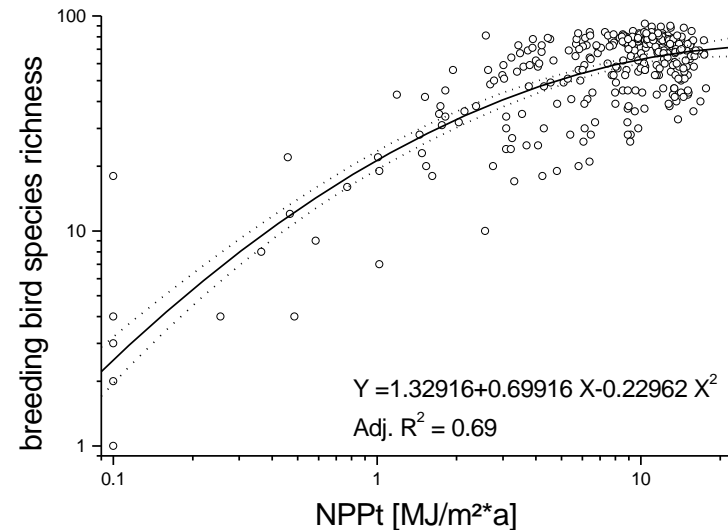
- HANPP may favour some species at the expense of others \Rightarrow broad taxonomic groups required \Rightarrow problems of biodiversity data availability
- HANPP reduces trophic energy flows (ΔE) which is hypothesized to result in a reduction of species richness ($\Delta S = S_0 - S_t$), but data on ΔS are lacking because S_0 is unknown.
- Only indirect tests are possible, i.e. relating S_t (current species richness) to NPP_t (NPP remaining in ecosystem after harvest)
- Consistent time series of species richness are lacking \Rightarrow time-series analyses are almost impossible

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



Case study 1: Correlation between NPP_t and autotroph species richness (5 taxa) on 38 plots sized 600x600 m, East Austria

Haberl et al., 2004, *Agric., Ecosyst. & Envir.* 102, p213ff



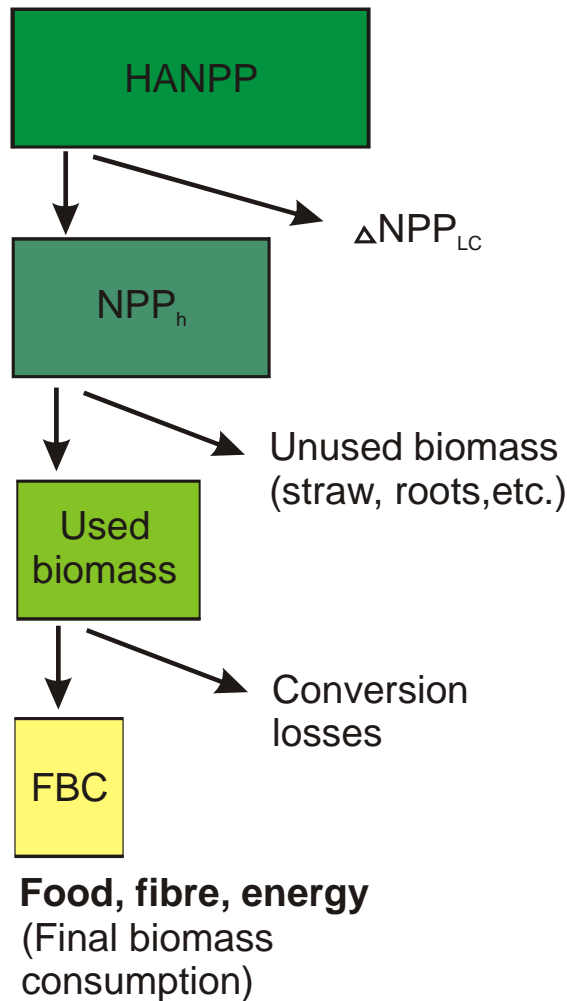
Case study 2: Correlation between NPP_t and breeding bird richness in Austria, 328 randomly chosen 1x1 km squares.

Haberl et al., 2005. *Agric., Ecosyst. & Envir.* 110, p119ff

HANPP as an indicator of pressures on biodiversity

- Evidence does not contradict the hypothesis that increasing HANPP results in a decline in biodiversity
- Evidence is unsatisfactory:
 - Restricted to Austria
 - Only indirect tests possible due to lacking data
 - Effect of HANPP on abundance could not be analyzed
- BUT:
 - There is no other pressure indicator with similar level of generality
 - No other pressure indicator has undergone as much empirical testing as HANPP

Embodied HANPP of final biomass consumption (global average)



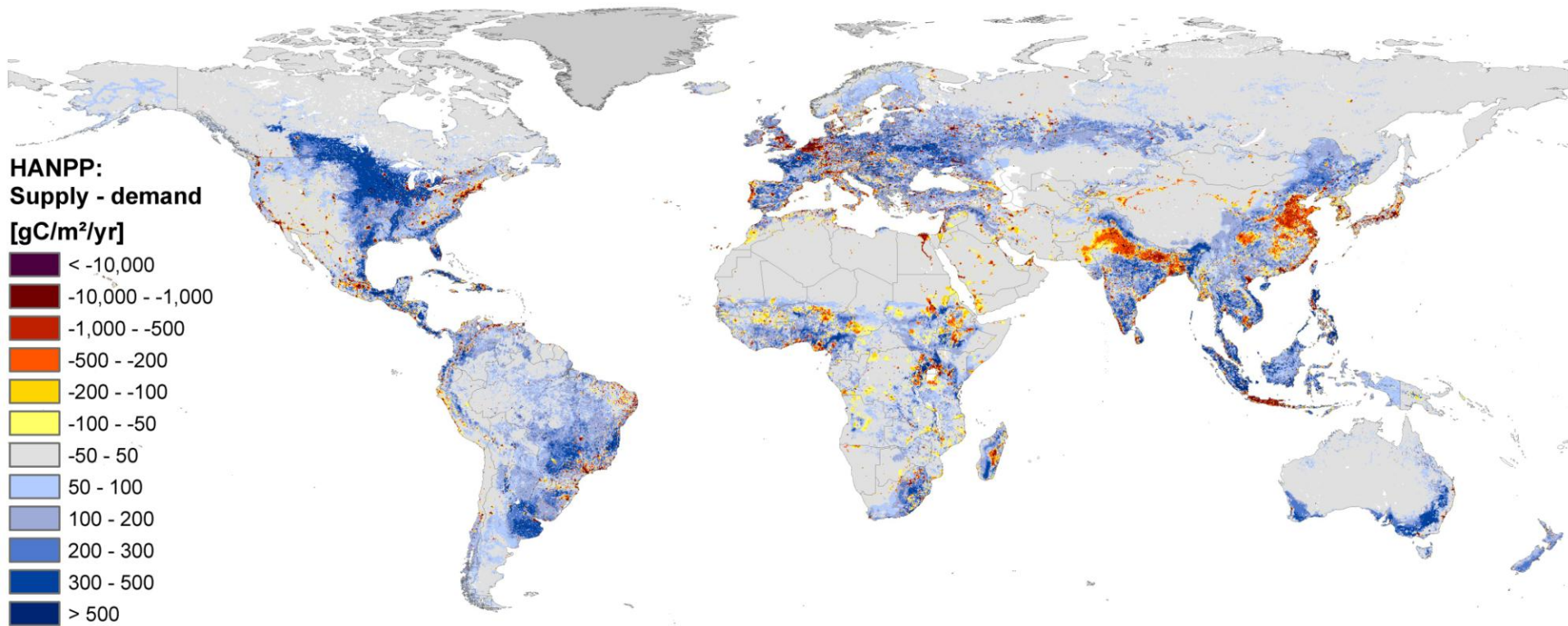
1 ton of dry-matter biomass (final use of food, fibre, timber, fuel)

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

- o the harvest of **3.6 tons** of primary biomass (NPP_h)
- o a reduction of productivity of **2.4 tons** (ΔNPP_{LC})

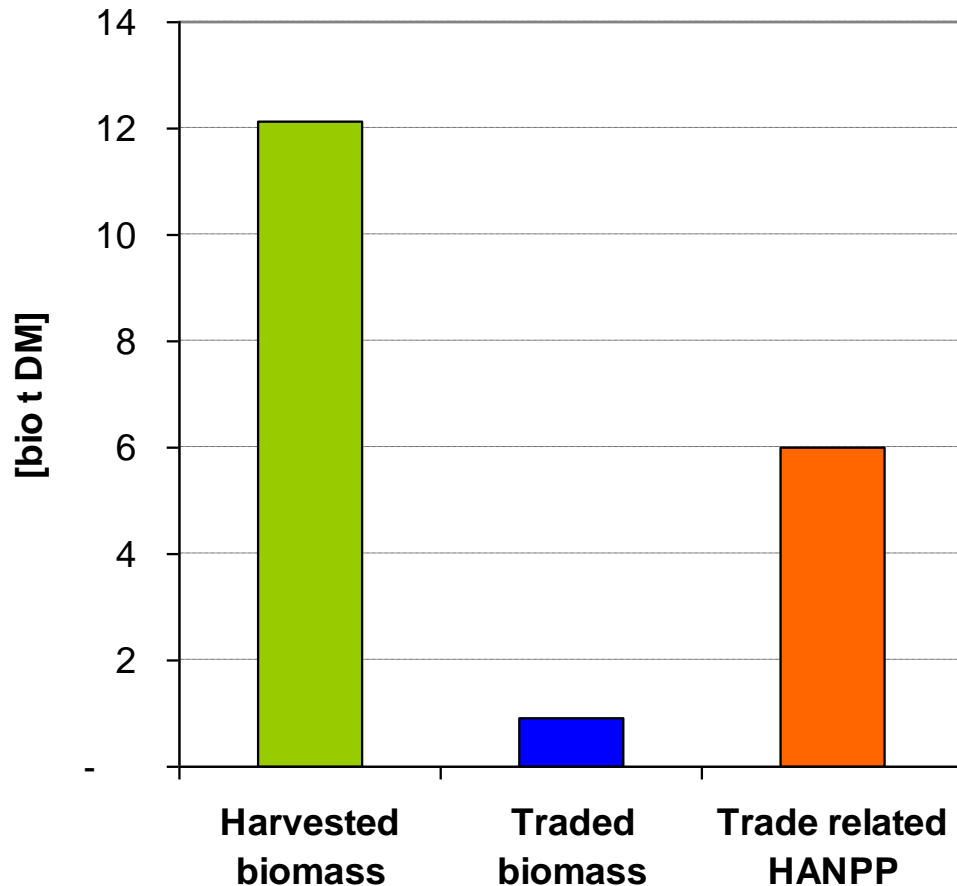
i.e. a total HANPP of **6 tons**

Embodied HANPP: „Supply“ and „Demand“ of biomass



Erb, Krausmann et al. 2009 *Ecol. Econ.*,
doi: [10.1016/j.ecolecon.2009.06.025](https://doi.org/10.1016/j.ecolecon.2009.06.025)

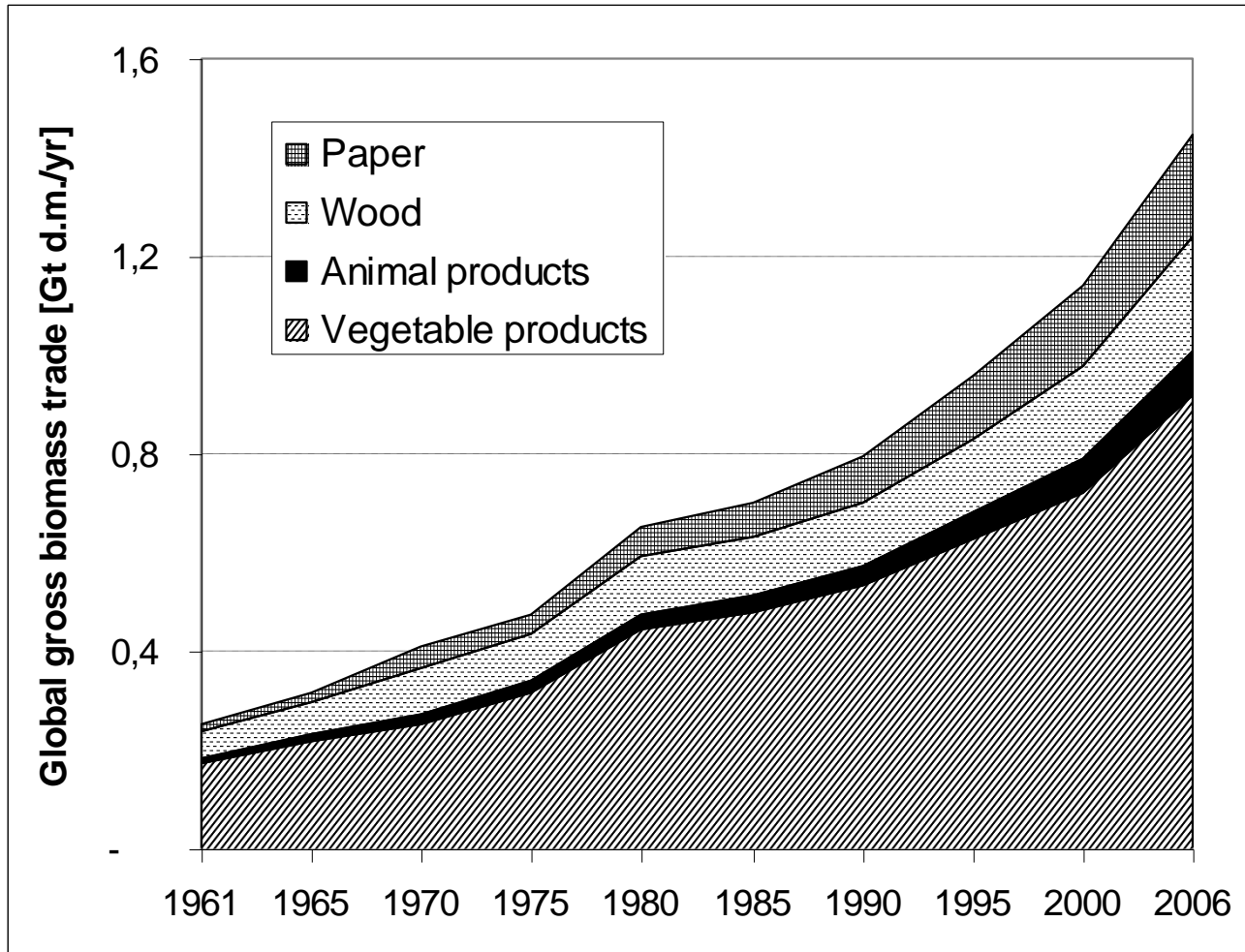
HANPP and international trade



- Only 7% of used biomass extraction is traded
- But embodied HANPP of traded biomass is large (>20% of global HANPP)

→ **Biomass and land use are globally connected systems**

Global biomass trade 1962-2006



New large driver: bioenergy

- Current global bio-energy production 48 EJ/yr (10)
- Energy crop potential in 2050, IEA (2008) 60-810 EJ/yr
- SRES-IPCC scenarios for 2050 100-200 EJ/yr
- Long-term potential estimates (various authors) <1 300 EJ/yr

For comparison:

- Current terrestrial aboveground NPP 1 240 EJ/yr
- Current global human fossil fuel use (GCV) 450 EJ/yr
- Total current human harvest of biomass (NPP_h) 350 EJ/yr
- Total current used biomass harvest, excl. by-flows 224 EJ/yr

Summary and outlook

- „Mainstreaming“ biodiversity into economic / social policies and trajectories (as part of resource policy, e.g. energy, agriculture is complementary to traditional conservation measures
- MEFA and HANPP help in understanding pressures on biodiversity and to identify their socioeconomic drivers
- Interlinkages between socioeconomic activities and resource use depend on trade, technology and many other factors
- MEFA accounts can support „dematerialization“ policies that would also re-orient socioeconomic trajectories into a more biodiversity-friendly direction
- Next steps: develop system models that link actors, socioeconomic trajectories, resource use, and biodiversity

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

The screenshot shows a Mozilla Firefox browser window displaying the website 'Alpen Adria Universität Klagenfurt - Data Download'. The browser's address bar shows the URL <http://www.uni-klu.ac.at/socec/inhalt/1088.htm>. The website has a blue header with the university name and navigation links like 'Datei', 'Bearbeiten', 'Ansicht', 'Chronik', 'Lesezeichen', 'Extras', and 'Hilfe'. Below the header is a search bar with the Google logo and various search options. The main content area is divided into several sections:

- Left Sidebar:** Contains the university logo and navigation links: 'die FORSCHUNG', 'die LEHRE', 'die ORGANISATION', and 'der CAMPUS'. Below this is a section for 'Soziale Ökologie' with links to 'Global Biomass Metabolism Data', 'Land Use Data', and 'Global HANPP Data'.
- Main Content Area:** Features a header for 'Institut für Soziale Ökologie | Data Download' and the 'social ecology vienna iff' logo. It lists three data download options:
 - Global biomass metabolism 2000:** Includes a small image of a field and a text description: 'Krausmann et al. 2007. Global patterns of socioeconomic biomass flows in the year 2000: A comprehensive assessment of supply, consumption and constraints. *Ecological Economics* in press (online first)'
 - Global HANPP 2000:** Includes a small world map and a text description: 'Haberl et al. 2007. Quantifying and mapping the global human appropriation of net primary production in Earth's terrestrial ecosystems. *Proc. Natl. Acad. Science*, 104: 12942-12947. (PNAS)'
 - Global land use 2000:** Includes a small world map and a text description: 'Erb et al. A comprehensive global 5min resolution land-use dataset for the year 2000 consistent with...'
- Right Sidebar:** Contains a 'Login' form with fields for 'Username' and 'Passwort', a 'Suche' (Search) bar, and a 'Webmail' link. Below these are several navigation links: 'ENGLISH', 'DATA DOWNLOAD', 'ARCHIV', 'Bibliothek', 'Studienvertretung', 'UNI News', and 'UNI Veranstaltungen'.

The browser's taskbar at the bottom shows the 'Start' button and several open applications, including 'Alpen Adria Univers...', 'Novell GroupWise - M...', 'Arbeitsplatz', 'D:\JH_IWorldData\Co...', and 'Microsoft PowerPoint ...'. The system clock in the bottom right corner shows '10:02'.