Interlinkages between Societies and Ecosystems - Examples from Europe

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Long-term Industrial Ecosystem Model – Hawai'i Island
Conference 22 May 2009
Kohala Center, Yale University

Global LAND Project

FWF Der Wissenschaftsfonds.

social ecology vienna iff
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Overview

- The fallacy of simple answers: Why we need integrated long-term studies of the interaction between societies and ecosystems (LTSER).
- Changes in energy and land-use systems in Austria 1830-2000
- Scale interactions between local and national levels and changes in the spatial organization of socioecological systems
- Case study: The fossil-fuel powered carbon sink
- Integrated socioecological modelling: A participative approach
- Conclusions

Austria's northern alpine fringe: 1584

1900

2001

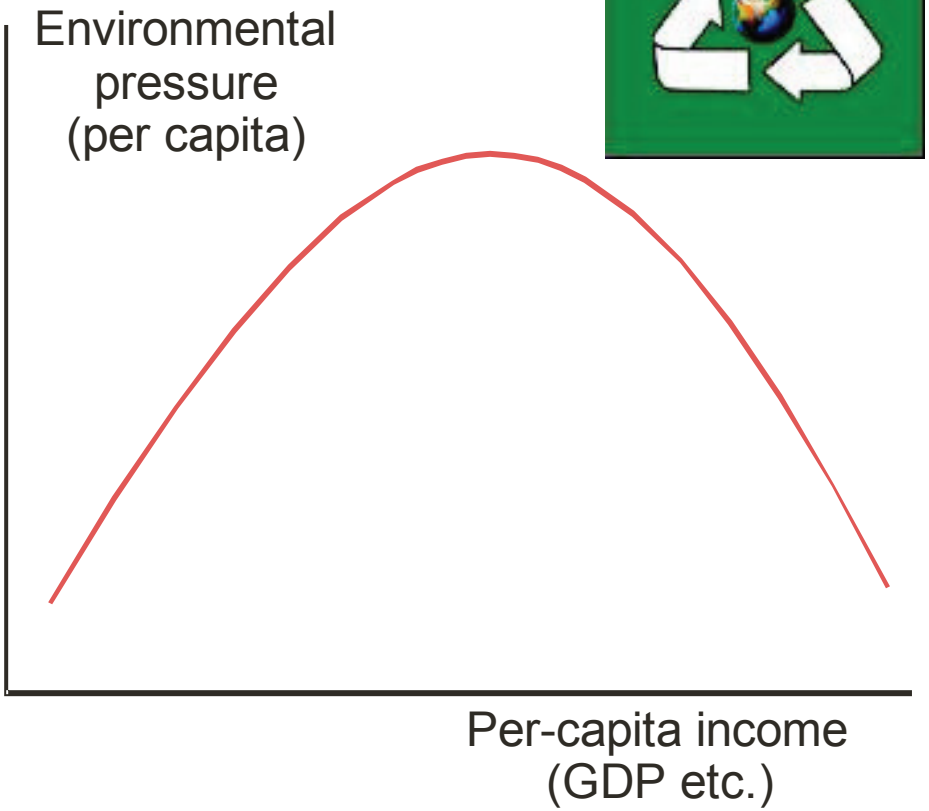
The Kuznets Curve: Is economic growth good for the environment?

For example: Austria 1830 → 2000

- GDP (constant €) +2700%
- GDP/cap/yr +1100%
- Forest area +22%

BUT

- What was the price?
- Is more forest always „good“?



The picture is more complex: Socio-ecological changes in Austria 1830-1995

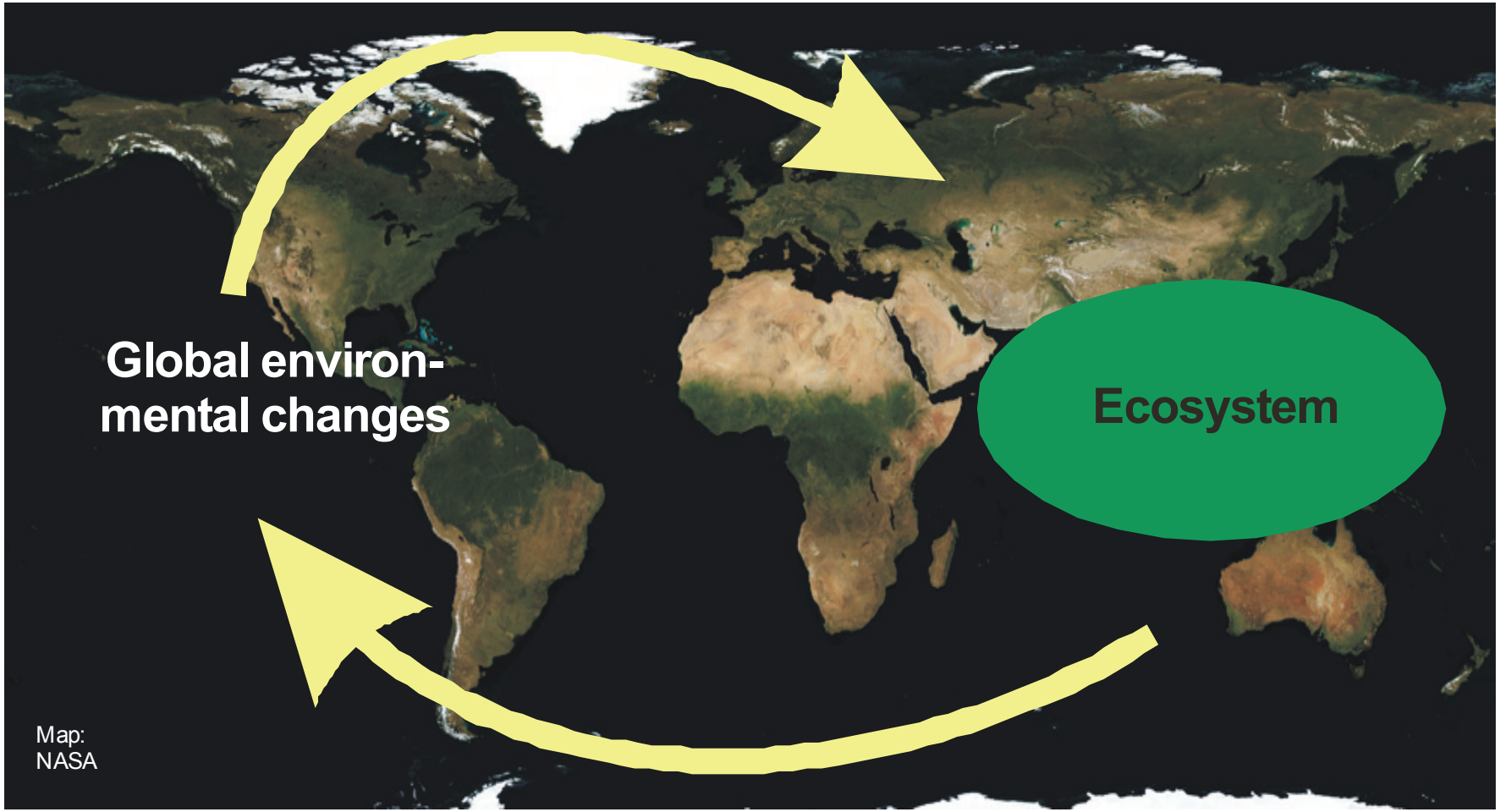
Indicator	1830/1880* - 1995 Multiplied by…
Population number	1.9
GDP (constant value)	20.6
Per-capita GDP (constant value)	10.6
Net C emissions (land use + fossil fuels)	34.8
Fossil energy use (Joules)	119.6
Total energy use, incl. food&feed (Joules)	5.1
Biomass harvest (t dry matter)	1.7
HANPP (t dry matter)	0.9
Farmland (area of cropland+grassland)	0.7
Forest area	1.2

* geometric mean of the value in 1830 and in 1880

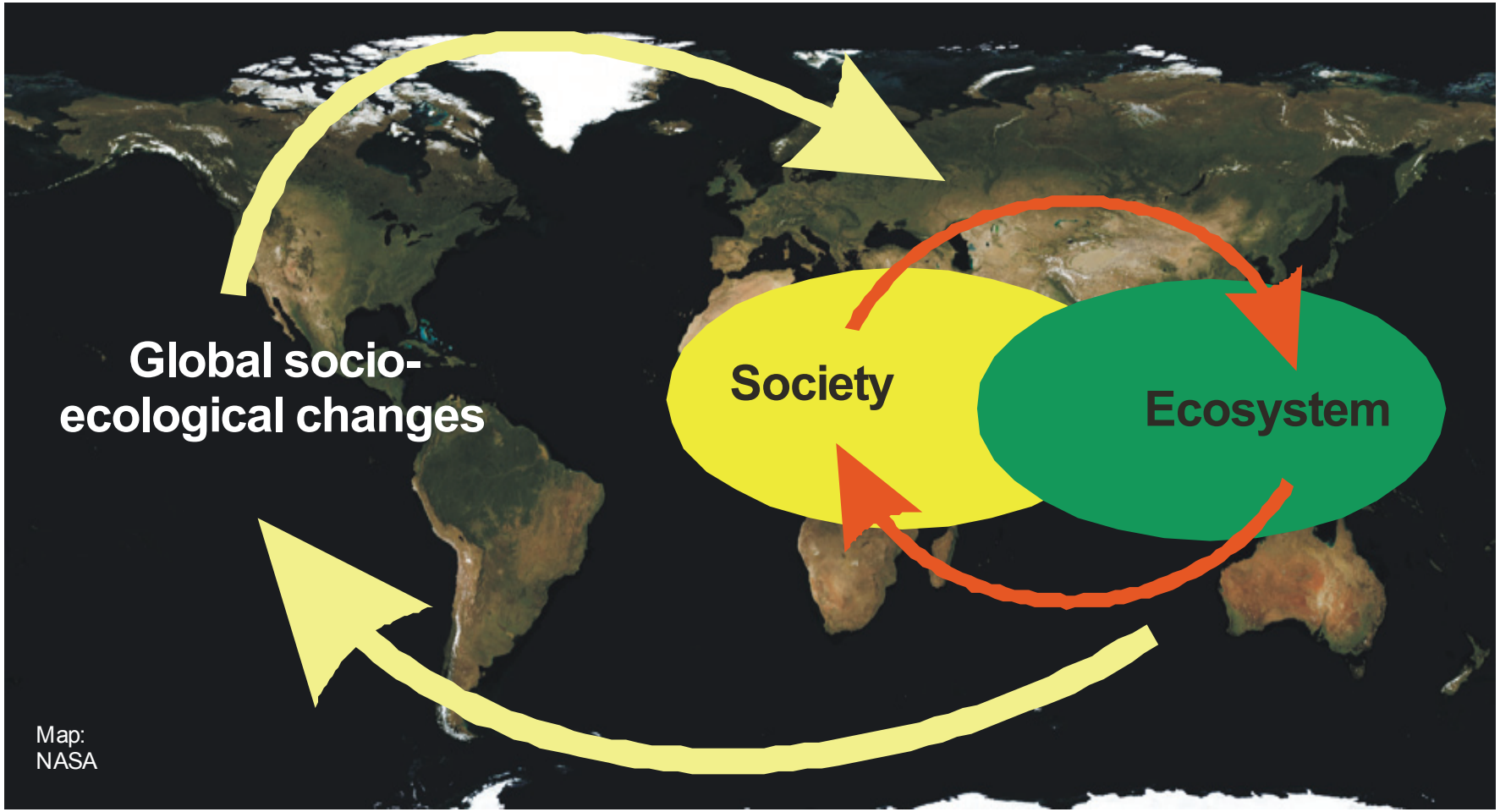
Haberl/Krausmann, 2001. *Popul. Environ.* **23**, 49-70

Erb et al., 2008. *J. Ind. Ecol.* **12**, 686-703

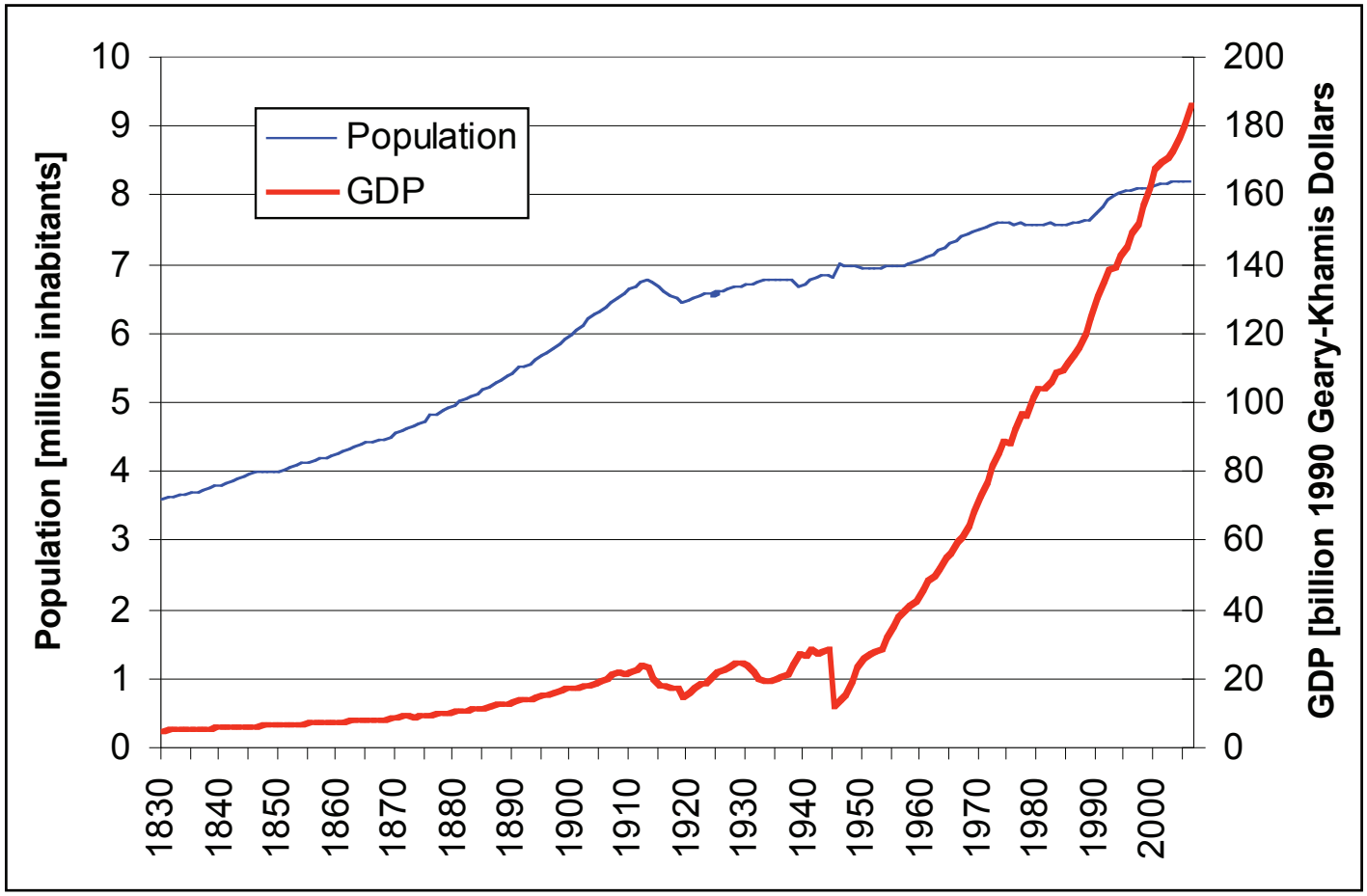
Long-term ecological research (LTER): Understanding impacts of Global Change



Long-term socioecological research (LTSER): A basis for sustainability

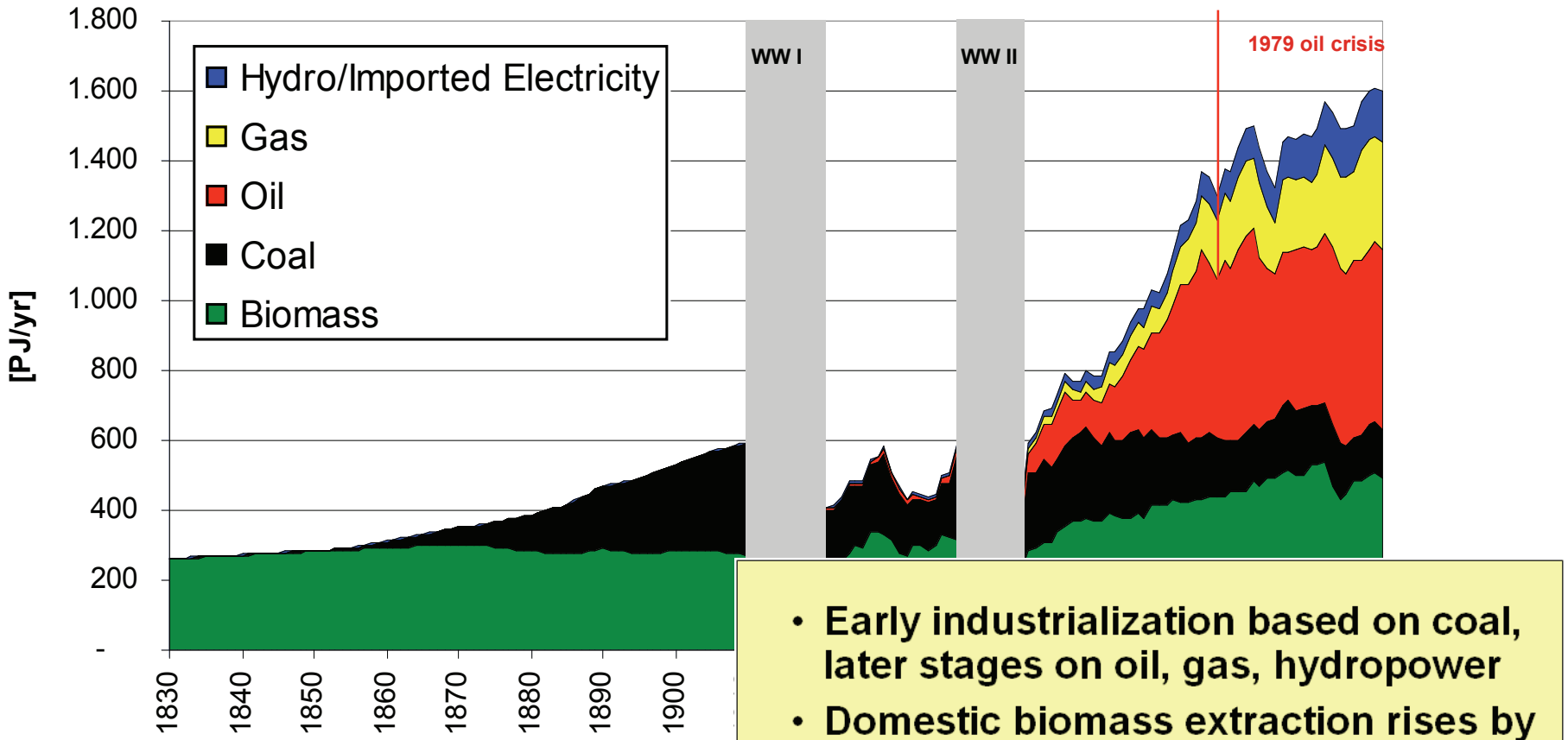


Growth of population and GDP Austria 1830-2006



Maddison, 2008
http://www.ggdc.net/maddison/

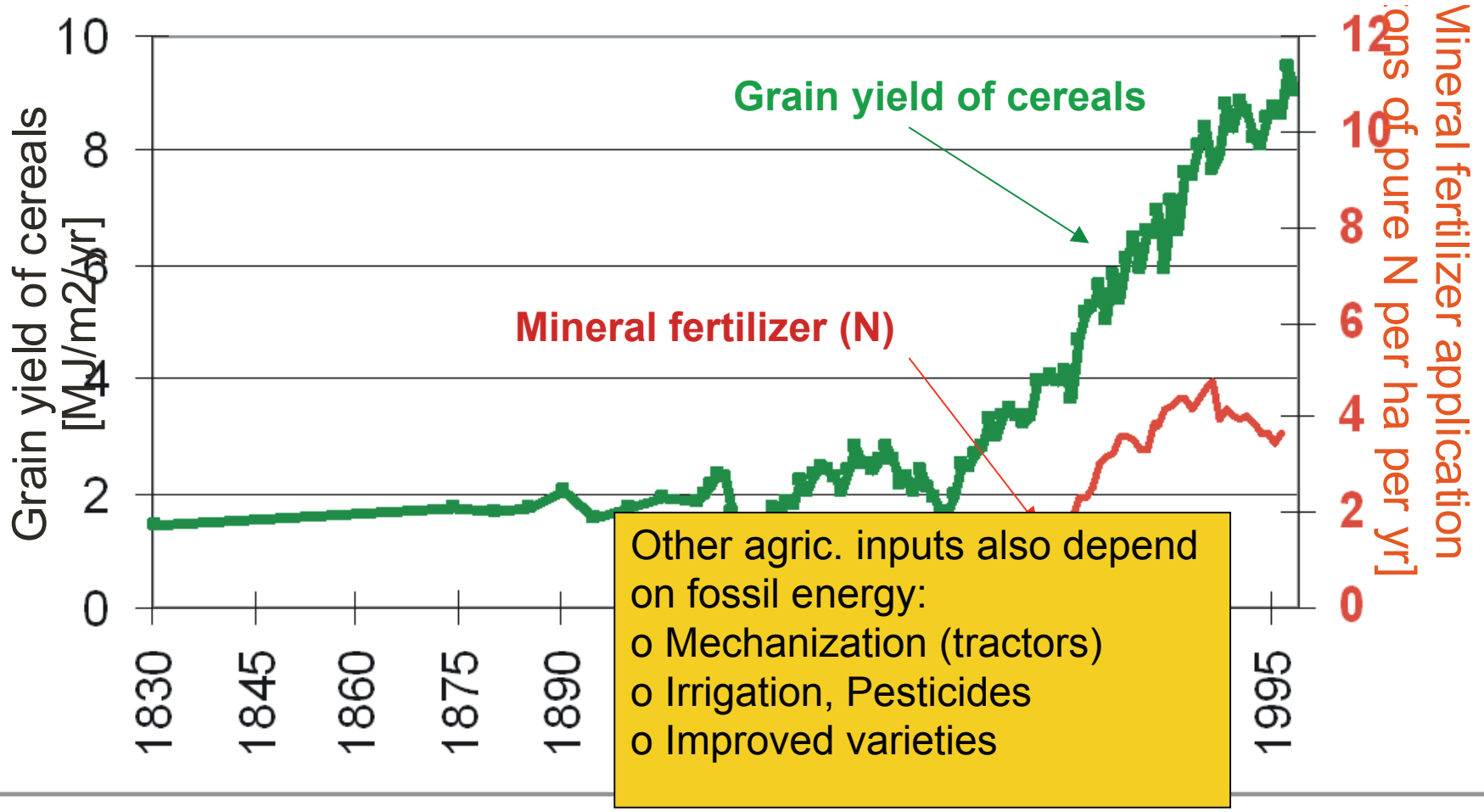
Austria's energy transition 1830-2000



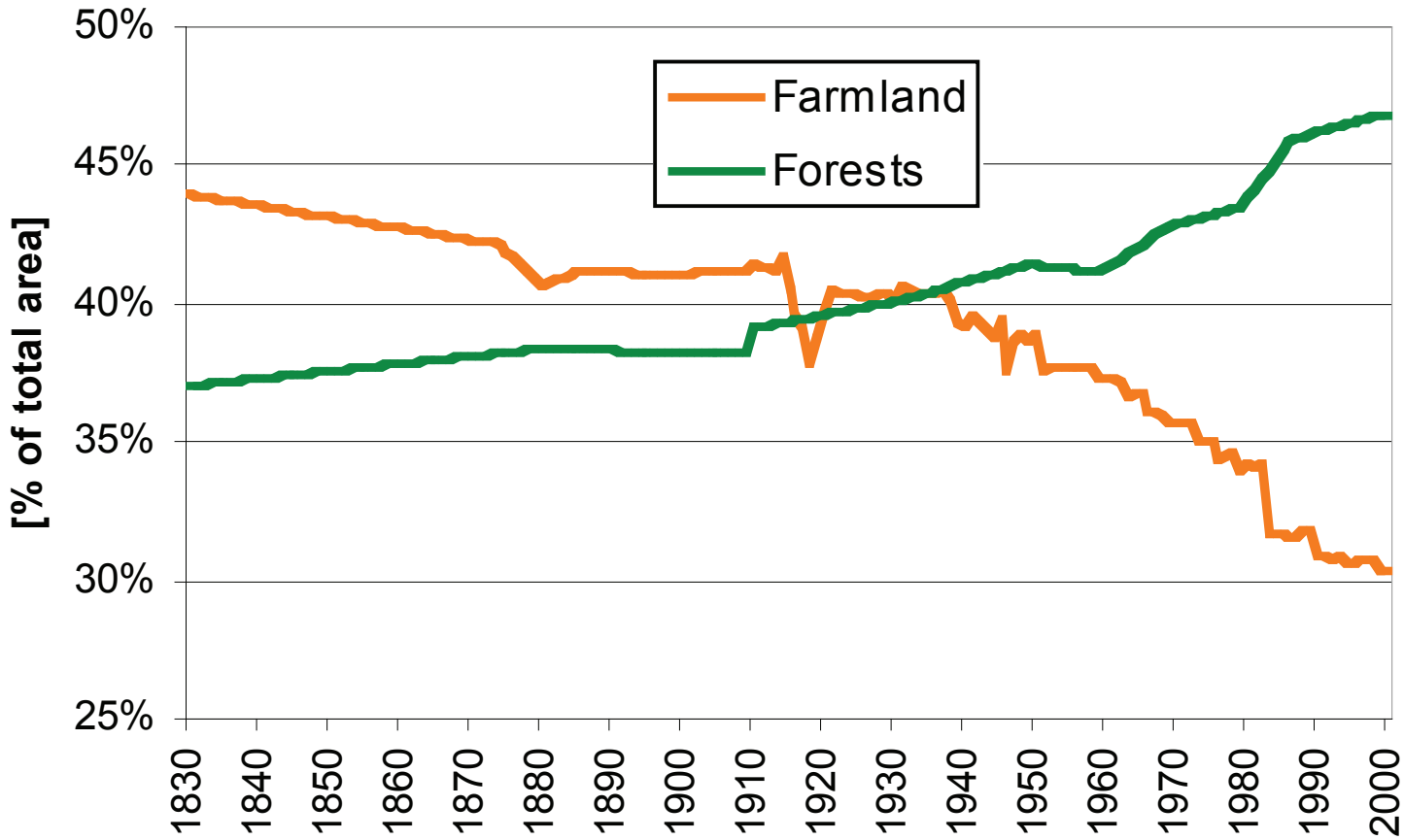
- **Early industrialization based on coal, later stages on oil, gas, hydropower**
- **Domestic biomass extraction rises by 70%**

Krausmann, Haberl, 2002
Ecol. Econ. **41**, 177-201

Agricultural intensification Austria 1830-2000

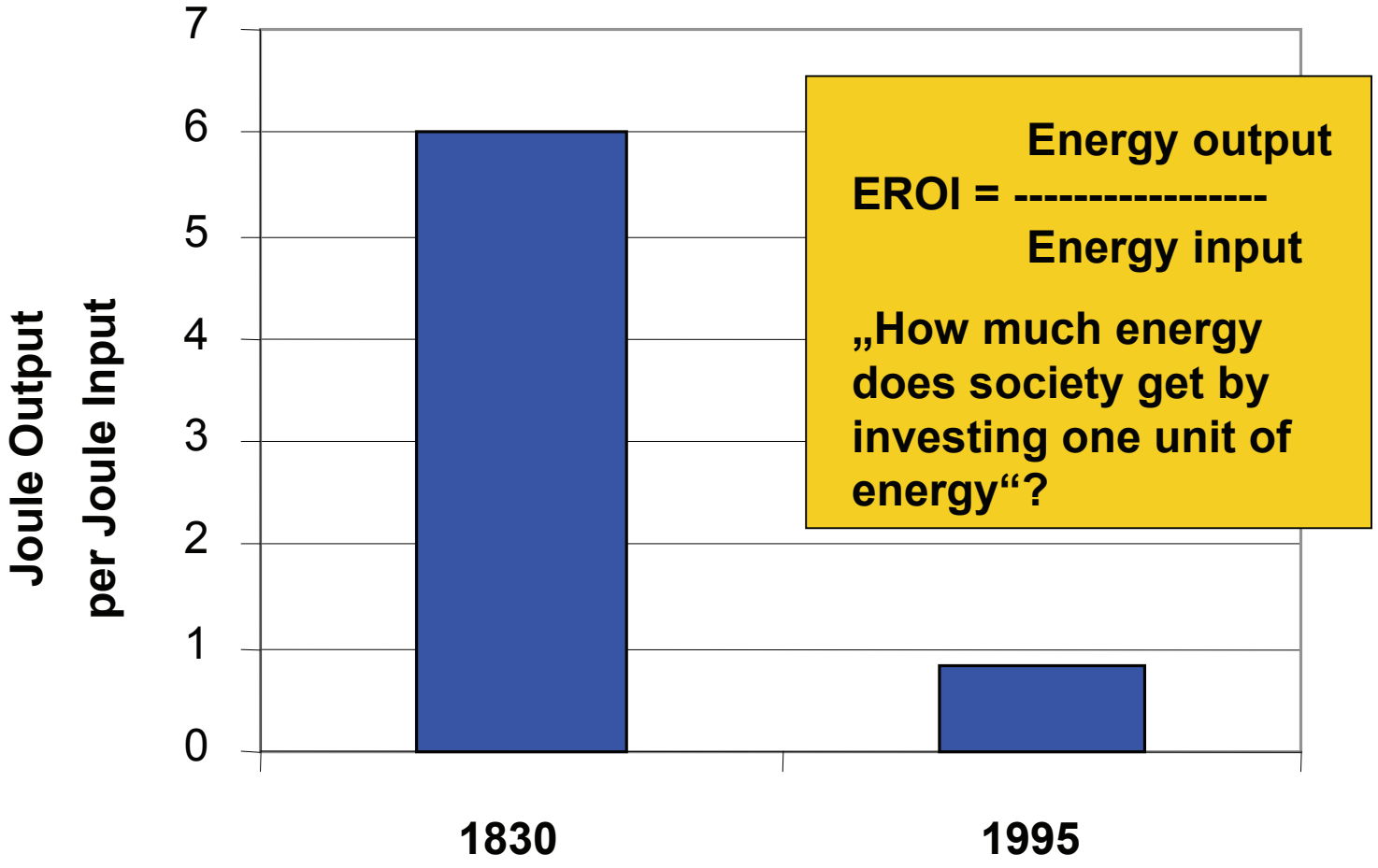


The land-use transition („forest transition“) in Austria 1830-2000



Krausmann, 2001.
Land Use Pol. **18**, 17-26

Energy return on investment (EROI)
Austrian agricultural sector 1830 and 1995

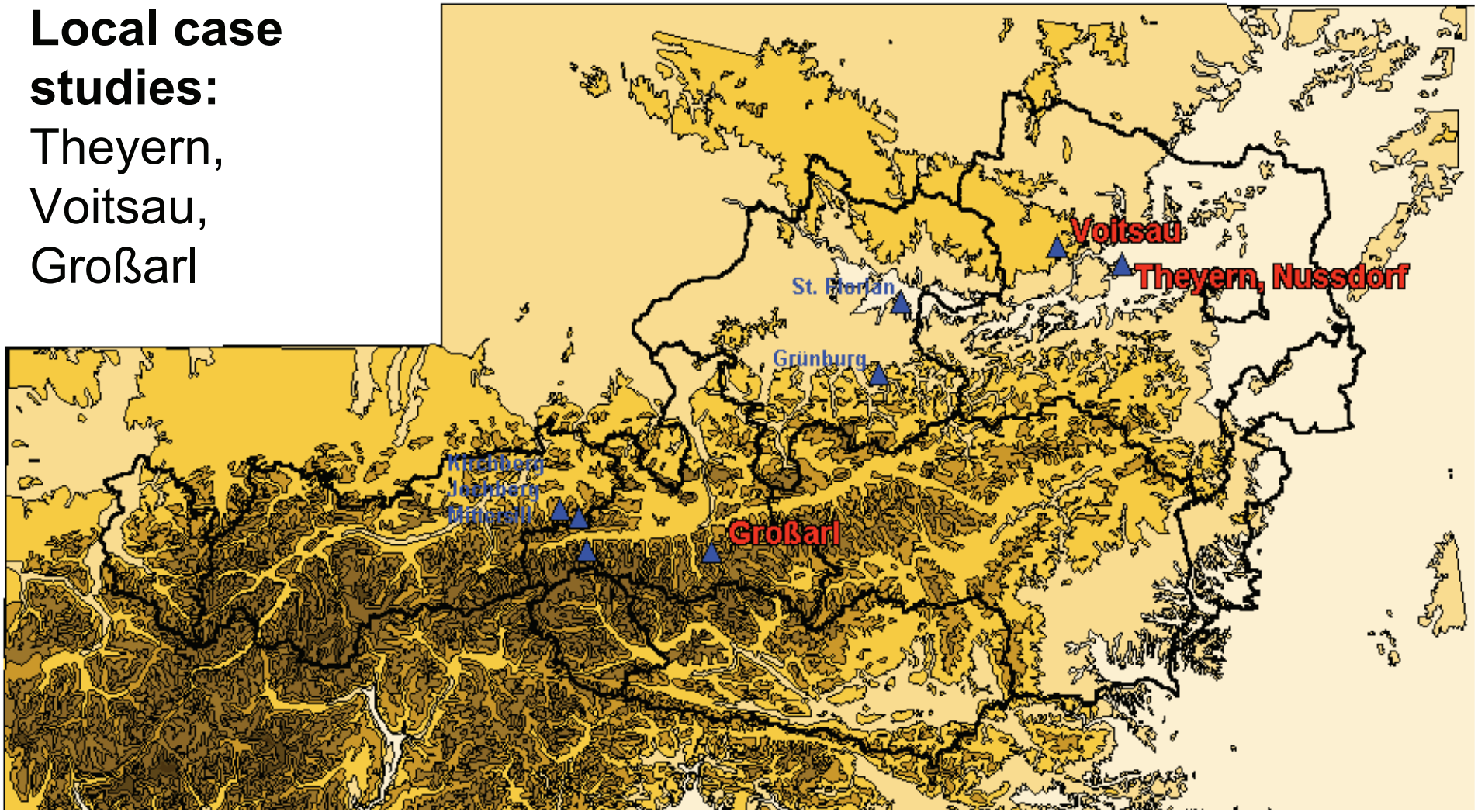


Energy and land-use system changes during the agrarian-industrial transition

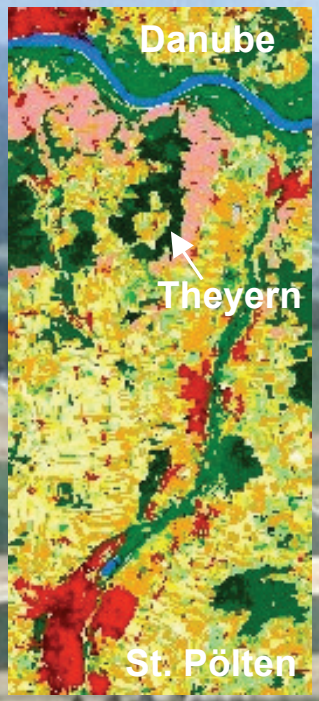
- In **agrarian society** (e.g., Austria 1830) society's energy supply depends almost exclusively on photosynthesis, i.e. the energy system is **area-dependent**. Agriculture has a high EROI (about 1 : 6) but low area-efficiency and labour efficiency.
- **Industrial society** runs on **area-independent energy**, above all fossil fuels. Abundant energy allows phenomenal increases in yields (i.e. area-efficiency) by factors 5-10 and of labour efficiency (factor >30).
- As a result, biomass harvest can be increased while farmland area (and therefore HANPP) declines. Forests grow in terms of area and stocking density.

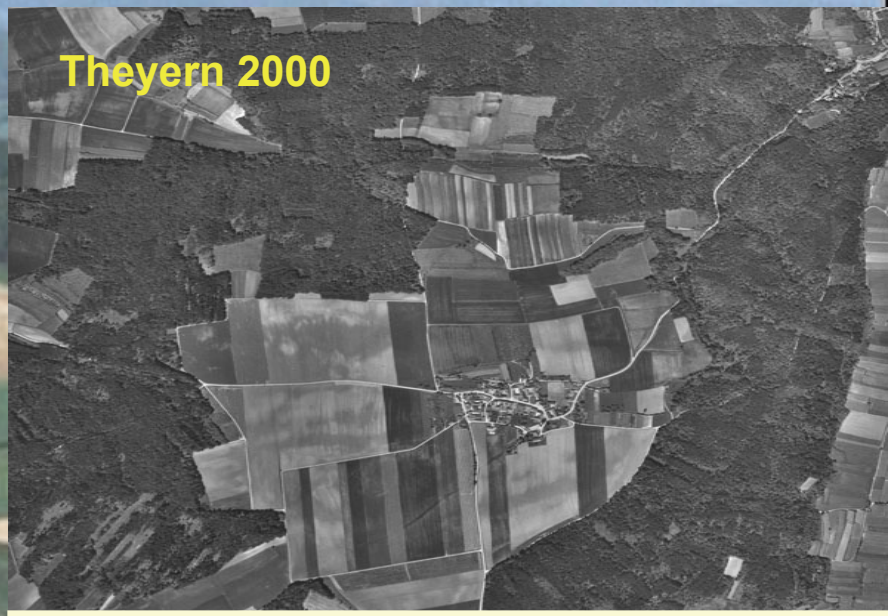
Comparing local systems 1830 and today

Local case studies:
Theyern,
Voitsau,
Großarl

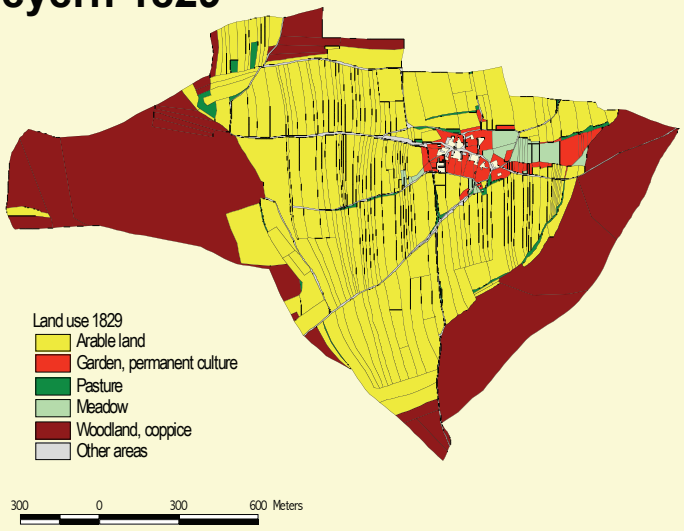


Theyern 1829 and 2000





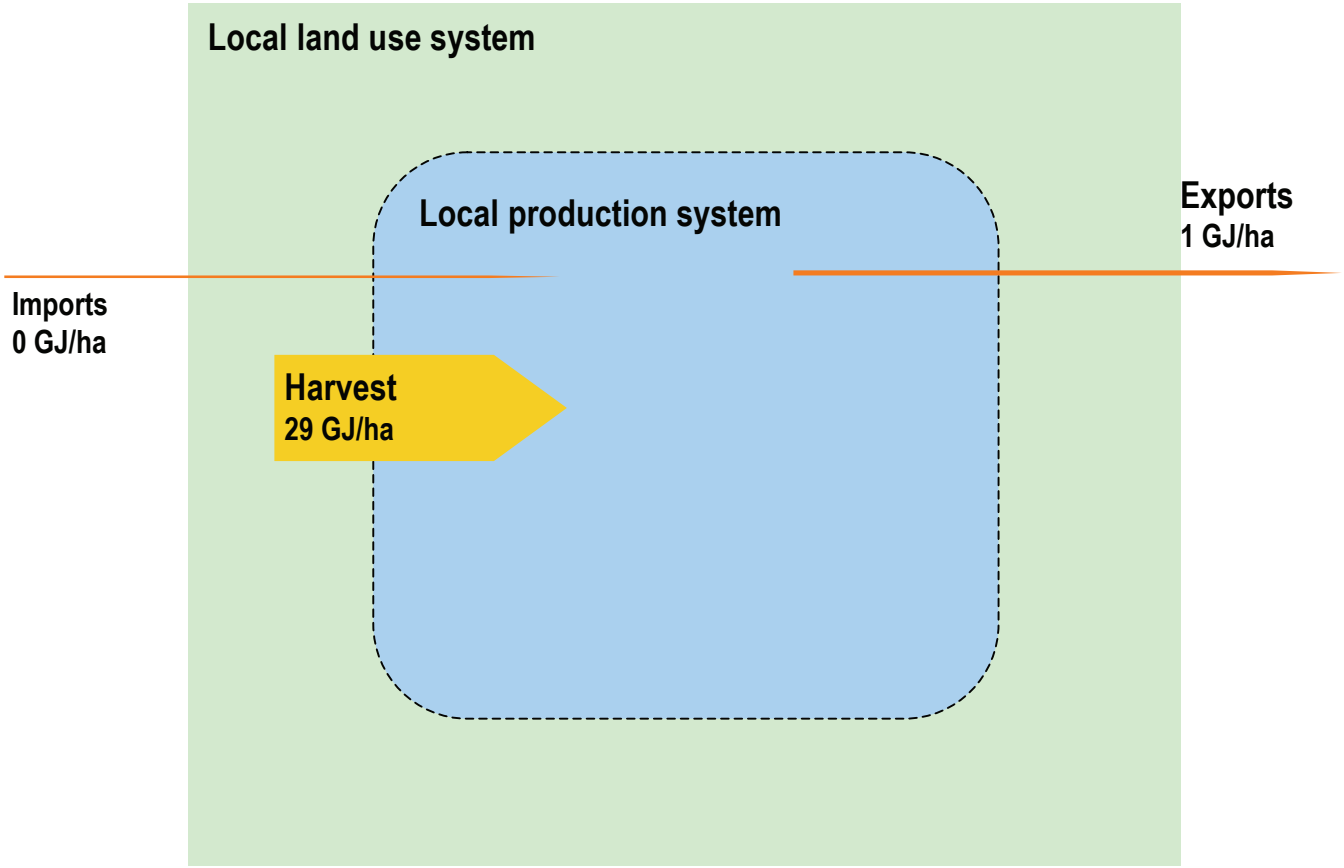
Theyern 1829



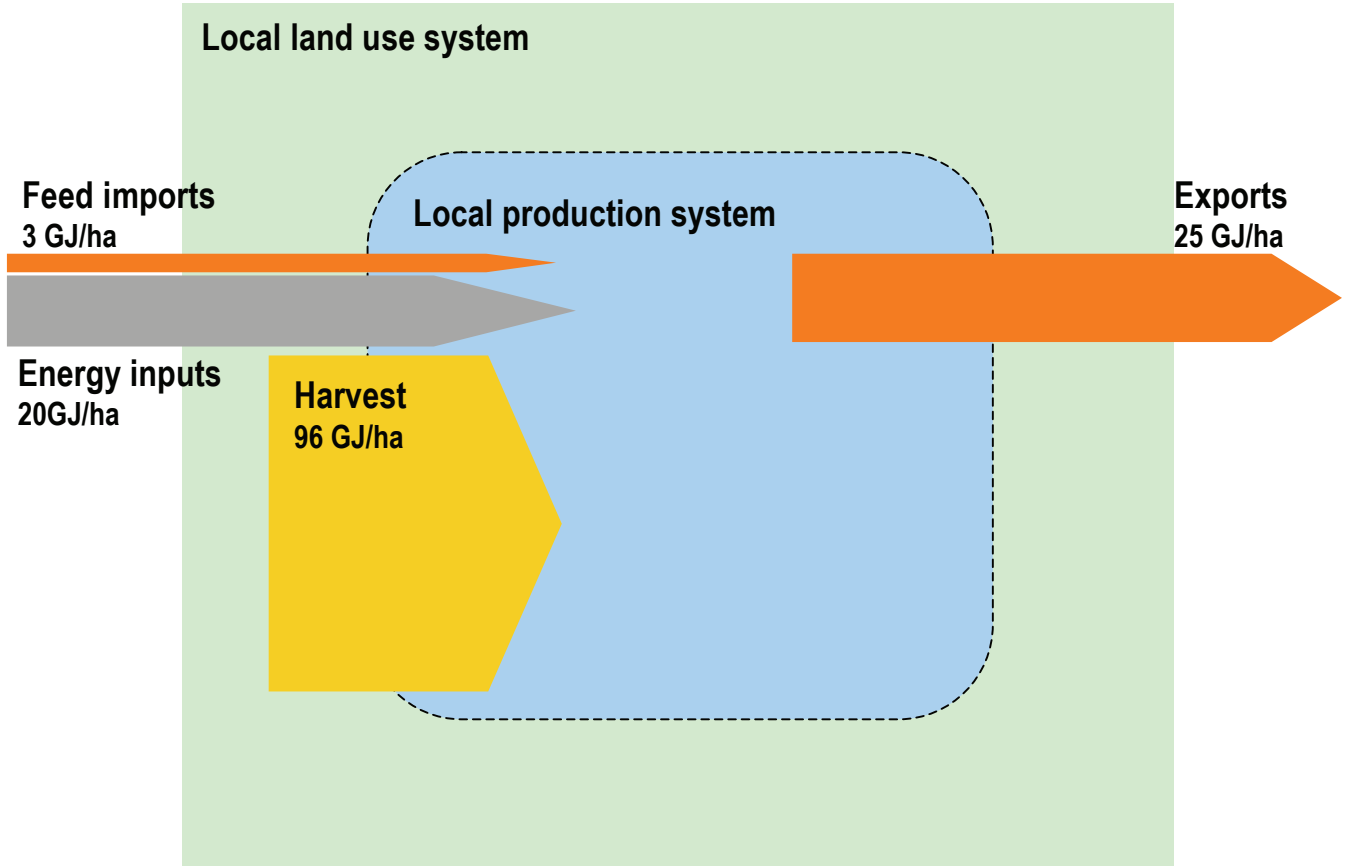
Theyern's socio-economic system
1829 and the 1990s

	1829	1990s
Population below 25 / above 60	64% / 8%	33% / 28%
General description of the economy	More or less closed subsistence economy, tithes and taxes about 10-20% of output	Dependent on income from outside the system, agriculture mostly cash crops (heavily subsidized)
Dominant economic activities	Agriculture	People living off pensions, agriculture (often part-time), employment outside Theyern
Main agricultural production systems	Cropland, cattle	Little livestock and grain farming, mostly specialized cultures (e.g. orchards)
Agricultural population	100%	10-20%
Gross grain yield	0.8 t/ha/yr	5 t/ha/yr
Available power	0.26 kW/ha	9.6 kW/ha

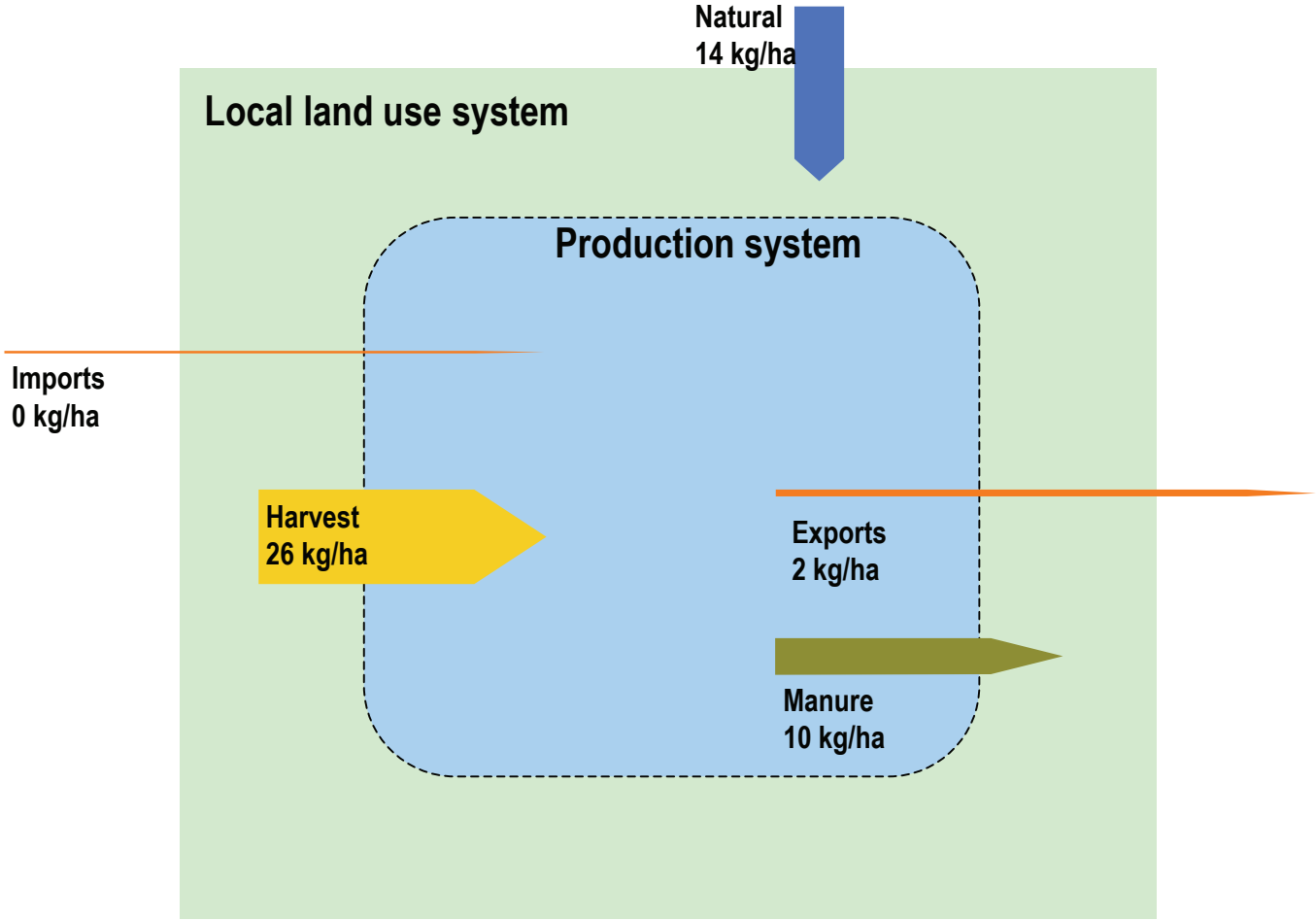
Selected local energy flows 1830



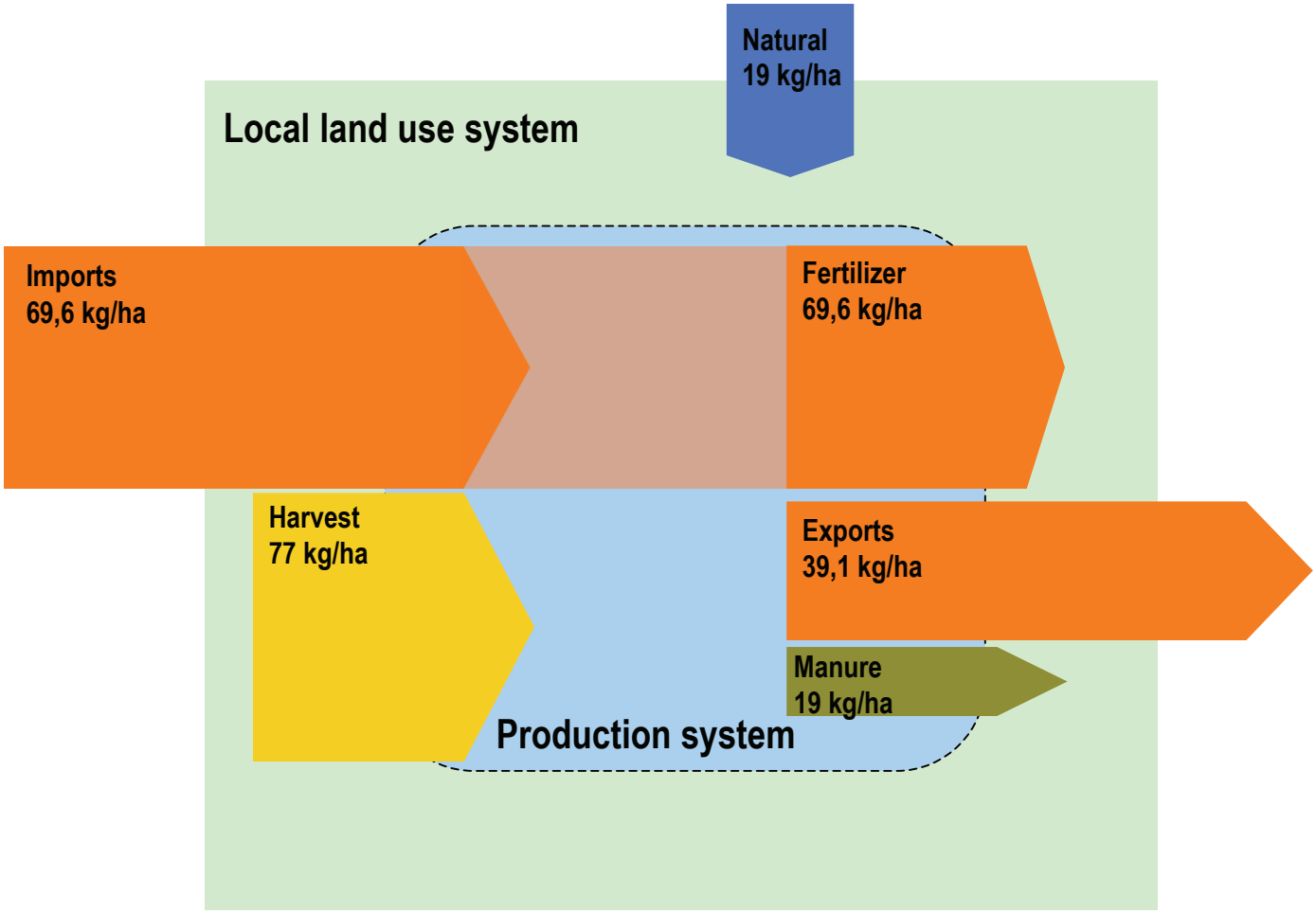
Selected local energy flows 1995



Nitrogen flows 1830

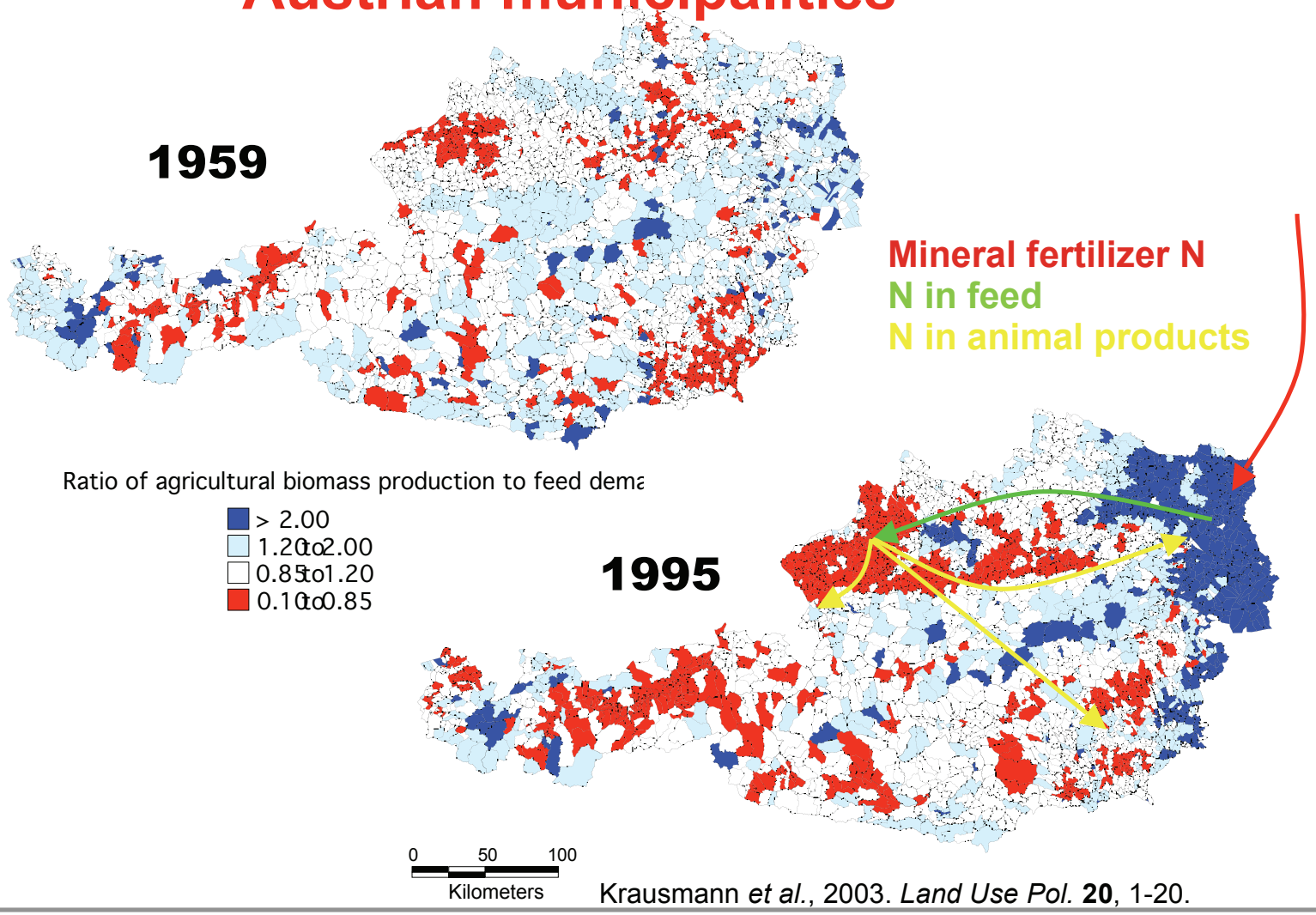


Nitrogen flows 1995



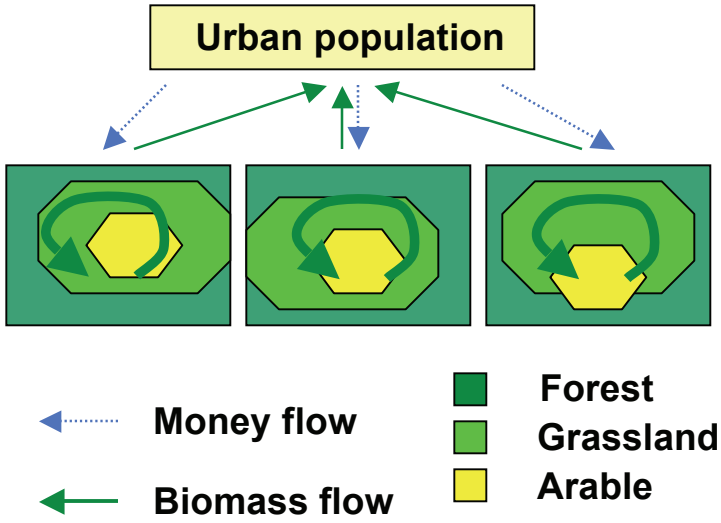
Scale Interactions: Feed supply/demand

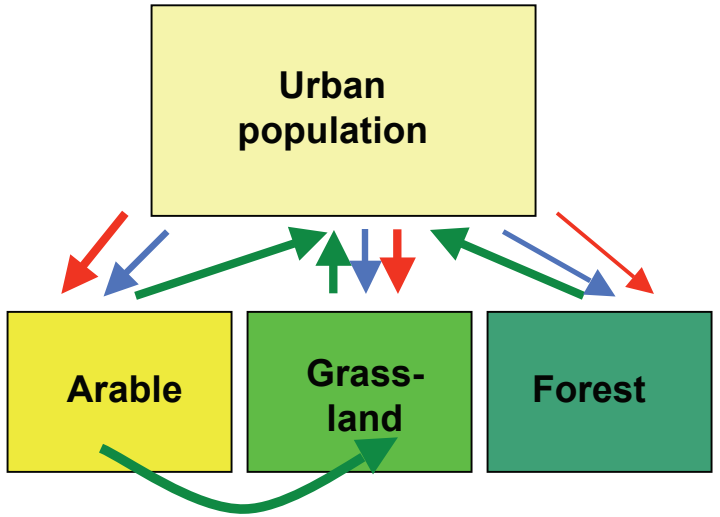
Austrian municipalities



Krausmann *et al.*, 2003. *Land Use Pol.* **20**, 1-20.

Pre-industrial versus modern agriculture





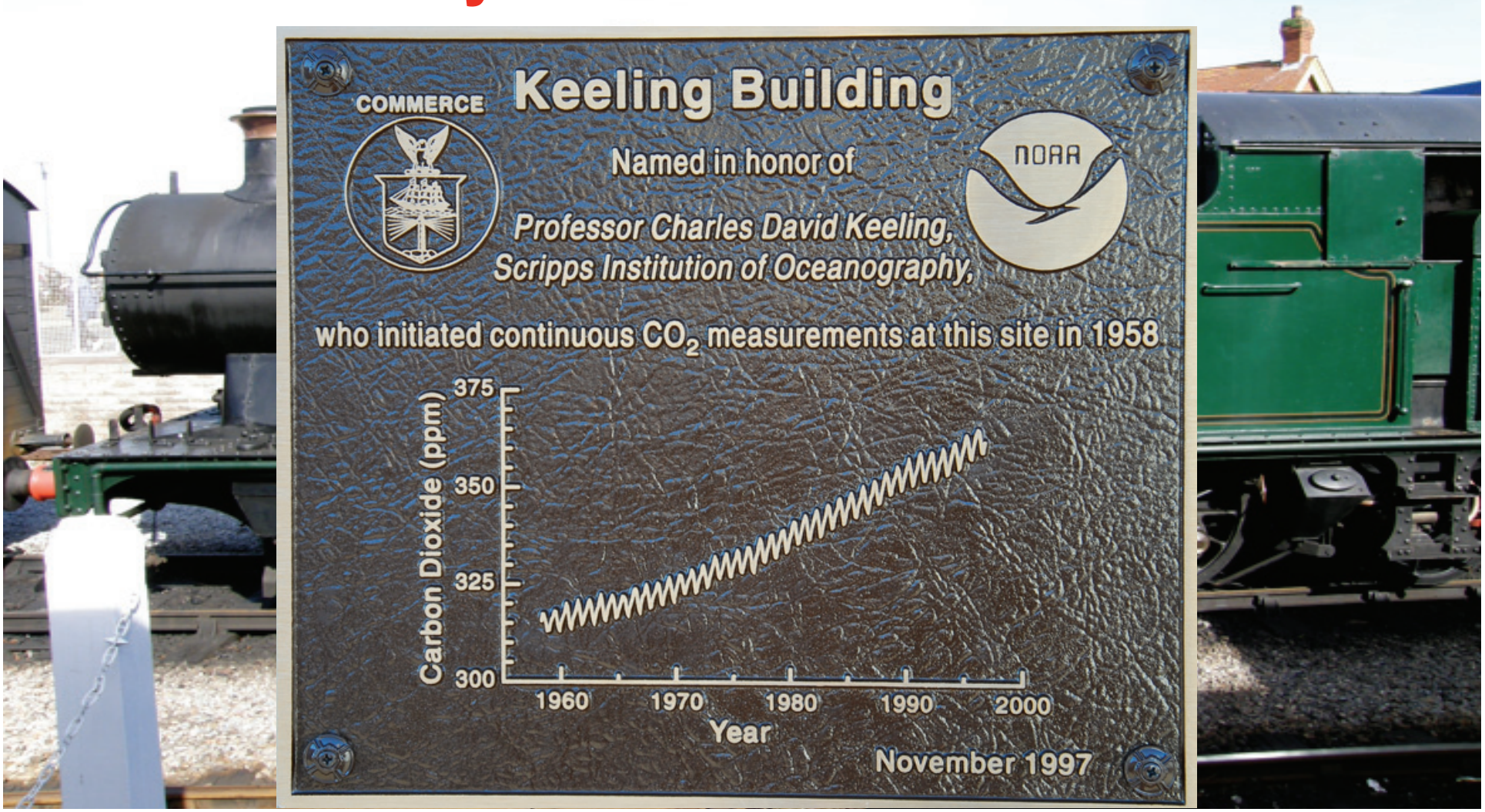
- Self-sufficient, integrated local systems ⇨ homogenous throughput systems
- Low input-low output ⇨ high input-high output
- Energy-efficient ⇨area- and labor efficient
- Surging transport intensity.
- Globalization of environmental pressures.

Biomass flow

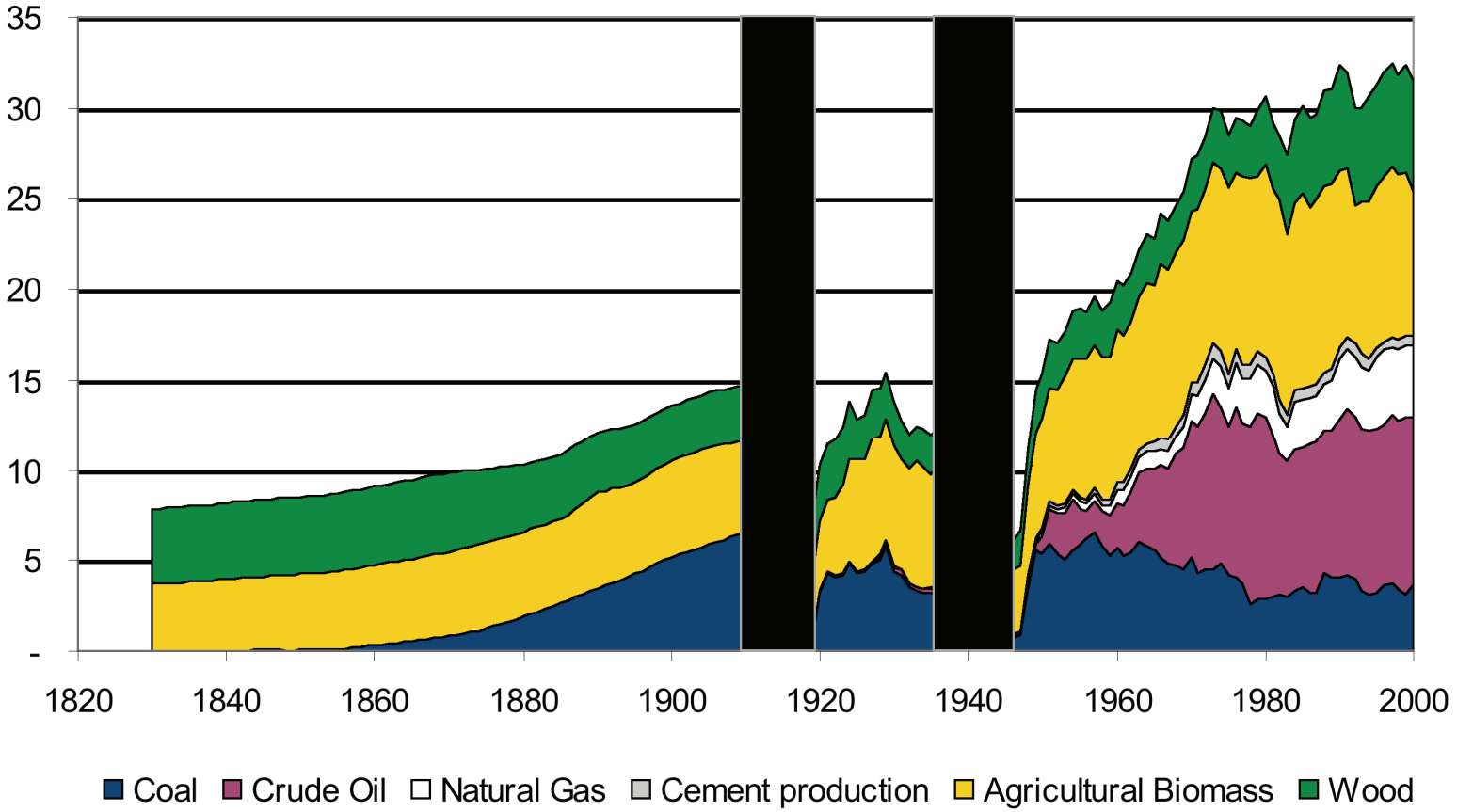
Money flow

Flow of fossil fuels

Case study carbon: Austria 1830-2000

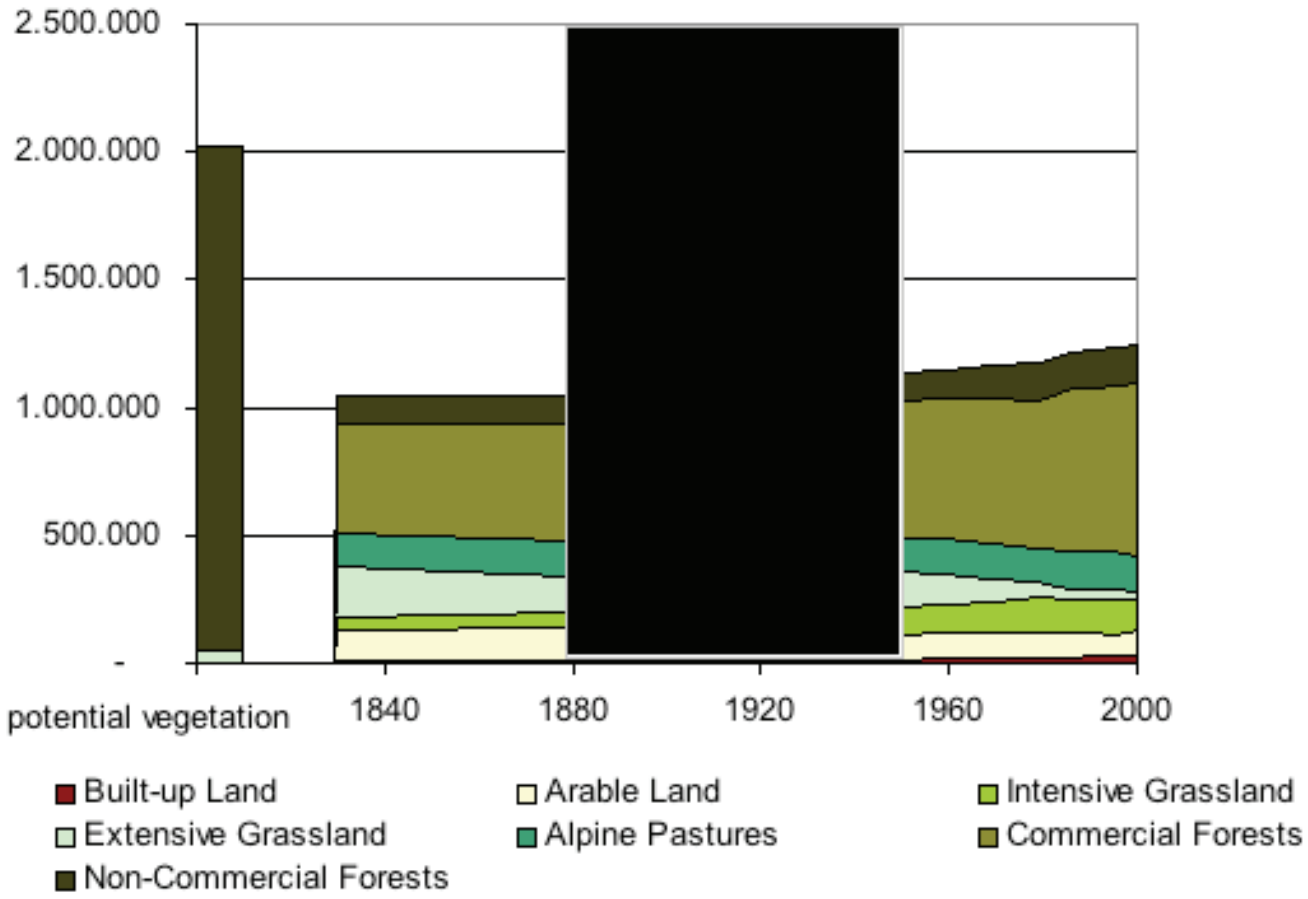


Socioeconomic carbon flows
Austria 1830-2000



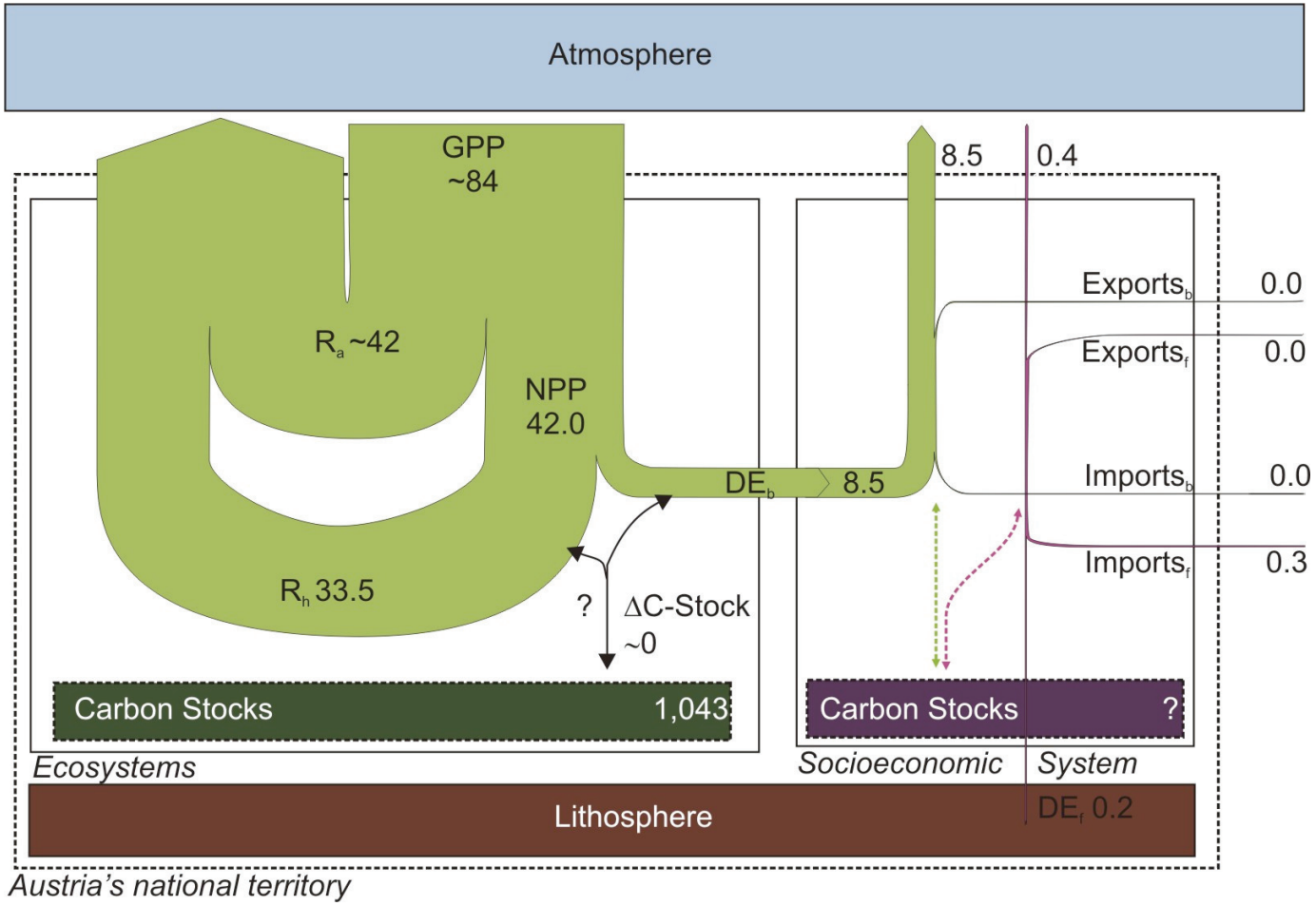
Erb et al., 2008
J. Ind.Ecol. **12**:686-703.

Carbon stocks in Austria‘s biota and soils 1830-2000



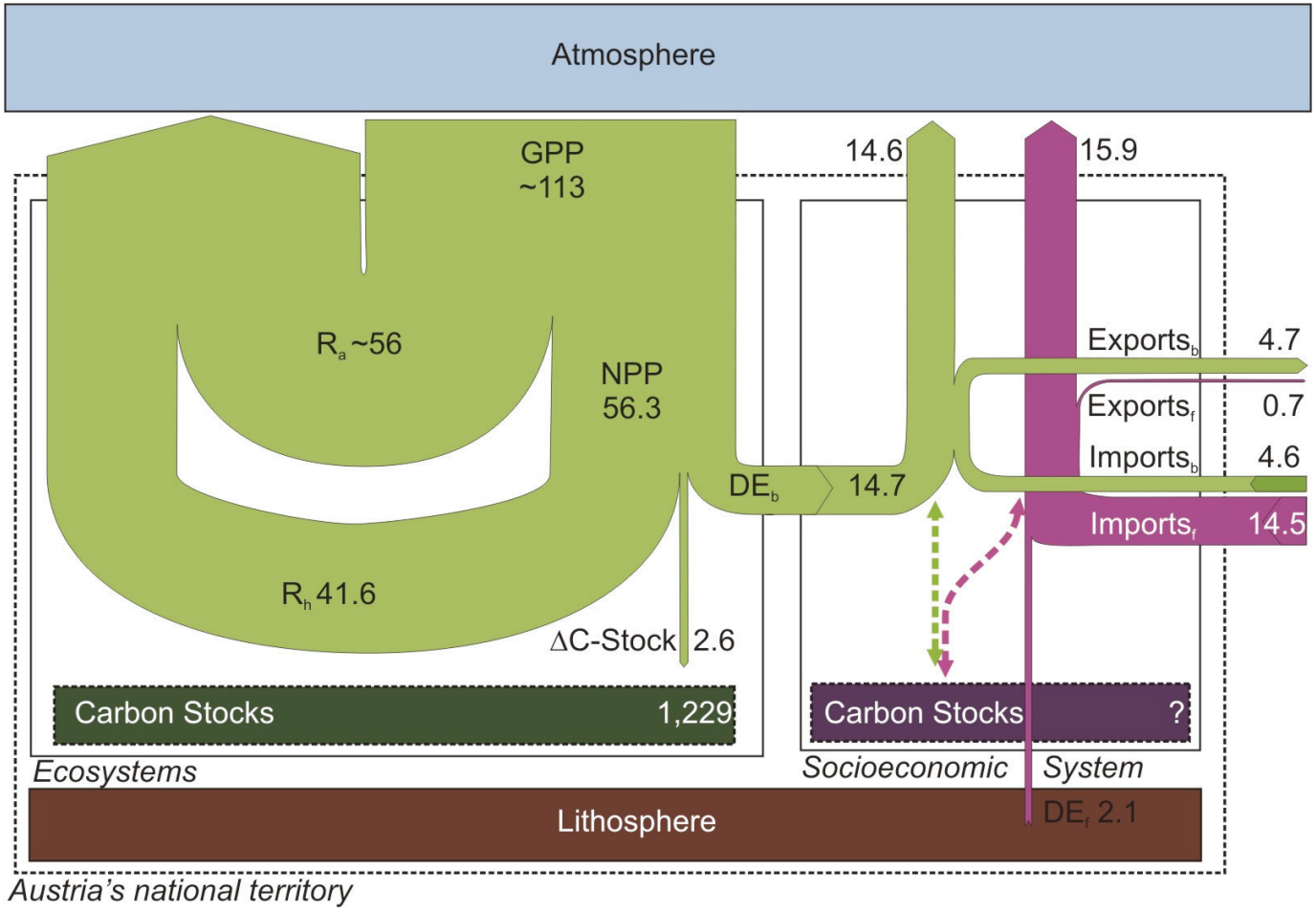
Gingrich et al. 2007. *Region. Environ. Change* **7**:37-47.

The fossil-fuel powered carbon sink
Austria 1830/1880



Erb et al., 2008
J. Ind.Ecol. **12**:686-703.

The fossil-fuel powered carbon sink
Austria 1986/2000



Erb et al., 2008
J. Ind.Ecol. **12**:686-703.

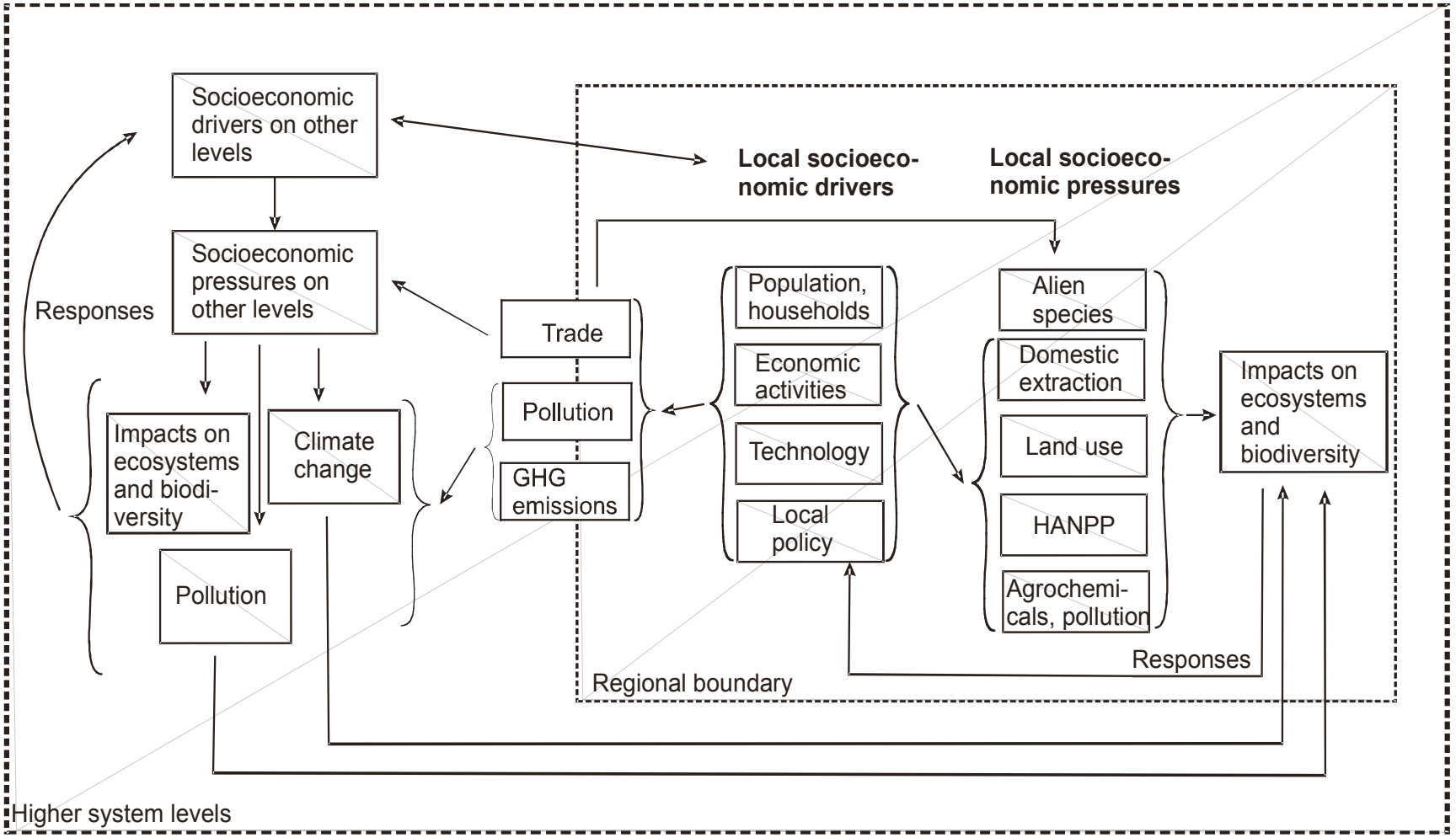
Agrarian-industrial transitions and sustainability

Sustainability challenges change fundamentally during agrarian-industrial transitions:

- **Agrarian society:** Maintaining a viable balance between population, (agrarian) technology, organization of labour processes and the productivity of agro-ecosystems. Failure leads to local collapse.
- **Industrial society:** Limitations of agrarian society are overcome by area-independent energy and transport/trade. Local sustainability problems are solved at the expense of global ones → globalization of the sustainability challenge (e.g., climate change). Failure might lead to global collapse.

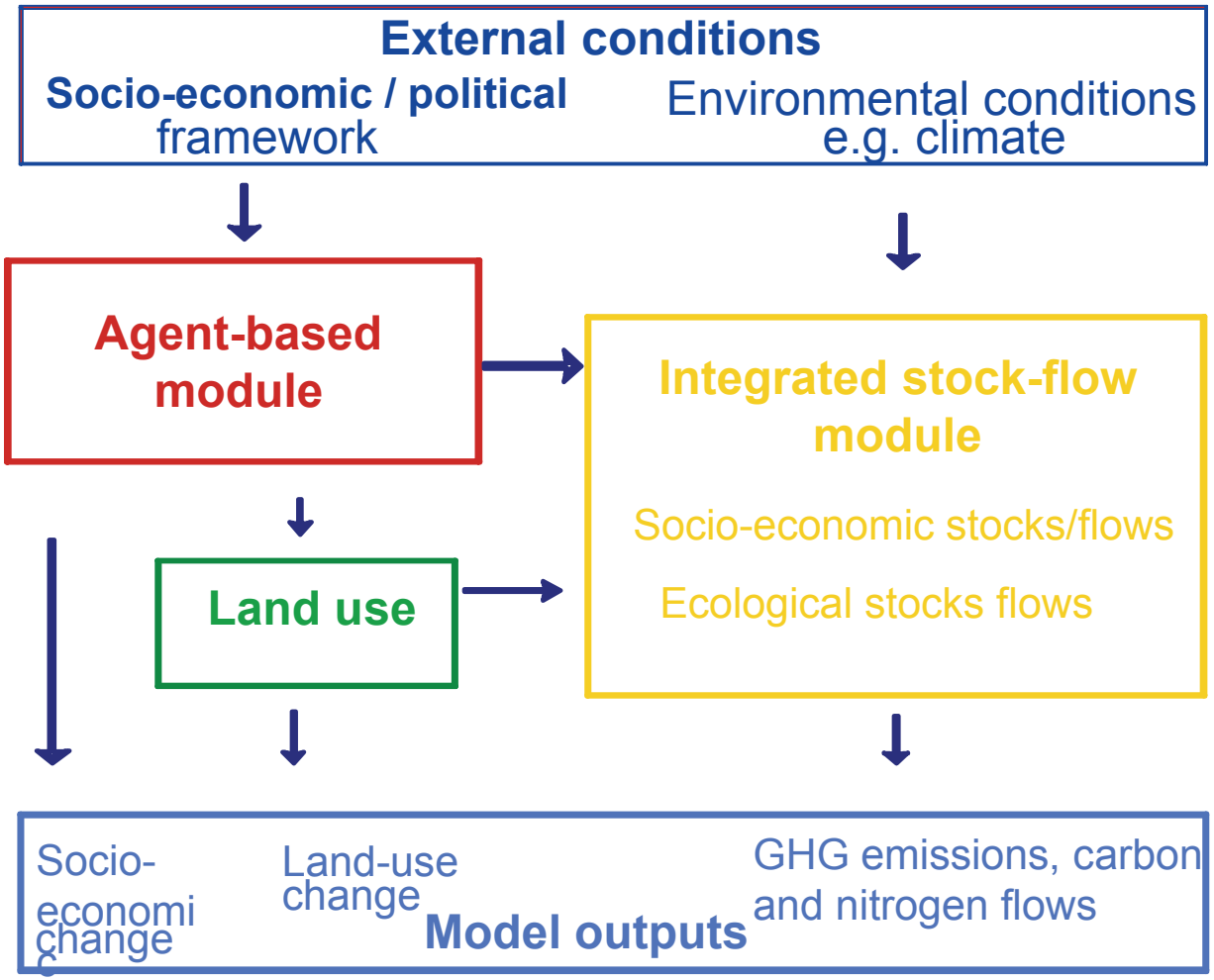
> Two thirds of the world population are in the midst of this transition right now.
> A globalization of our industrial metabolism is not sustainable (peak oil, climate change, biodiversity loss, etc.).

The vision: a multi-scale integrated socioecological modelling framework



Haberl et al., 2009. E*col. Econ.* **68**: 1797-1812

Currently feasible: integrated model
(municipal level)



Gaube et al., 2009
Landscape Ecology, in press.

Participatory model development

System model
(integrates agents with stocks and flows)

Modelling

Formalization

Scenarios
Results

Interpretation

Conclusions

Stakeholders in a participatory process

Modified after Berger *et al.*, 2006. *Agric. Syst.* **88**:28-43

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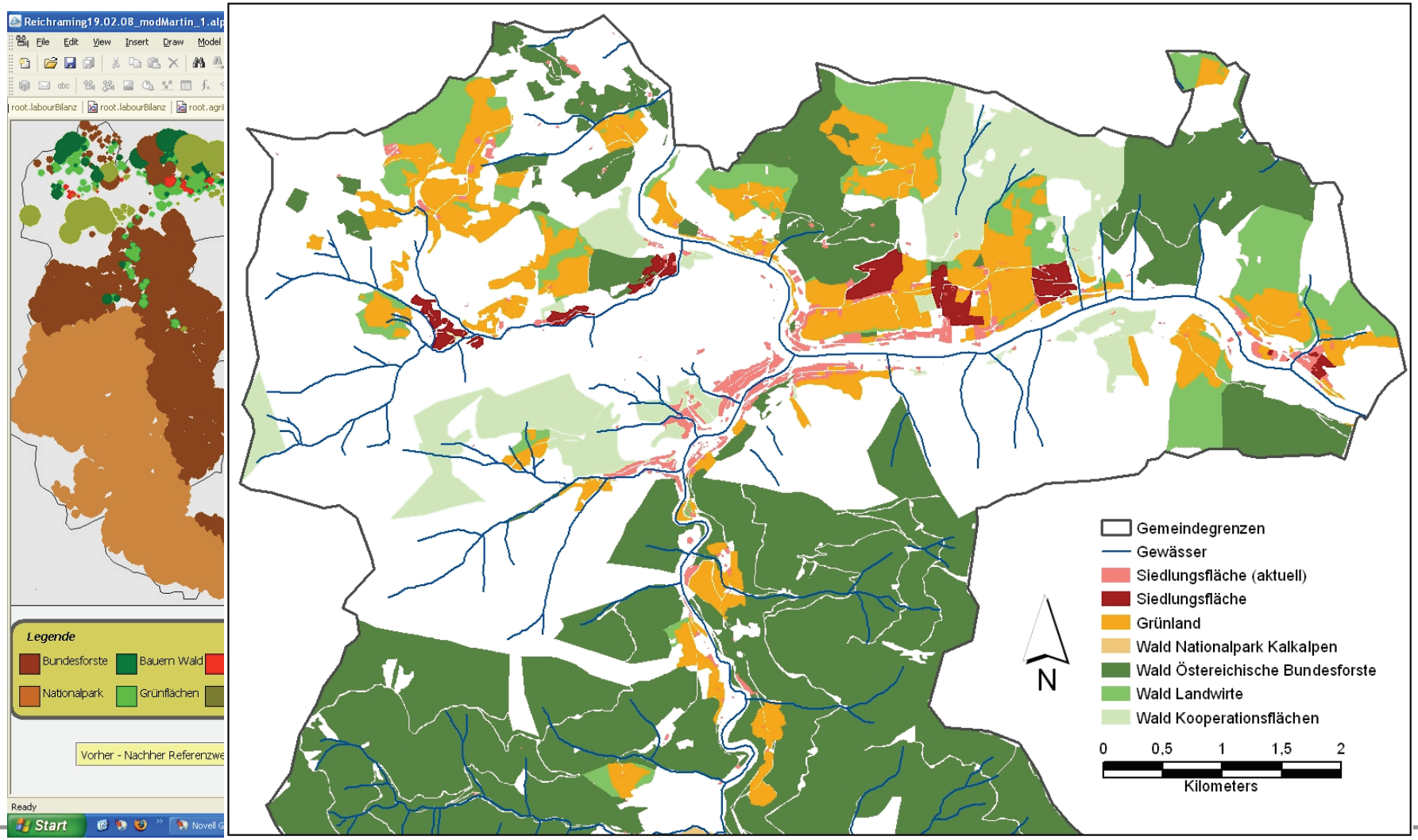
Example of a model run



Outlook and conclusions

- Longterm approaches are needed to get a sufficiently complex understanding of transitions in socioecological systems that result in fundamental changes in sustainability challenges.
- LTER, while useful, is not sufficient to provide a knowledge basis for sustainability. We need truly integrated approaches, that is long-term socioecological research (LTSER).
- A suite of methods based on statistics, cadastres, surveys, fieldwork etc. needs to be combined in interdisciplinary research to provide empirical data required to understand long-term trajectories in socioecological systems.
- Integrated modelling is a useful strategy to foster understanding between disciplines and involve/empower stakeholders. It helps in analyzing feedbacks between societies and ecosystems, as well as feedbacks between scales.

Data download area: http://www.uni-klu.ac.at/socec/inhalt/1088.htm