RENEWABLE RESOURCE ECONOMICS

HARVESTING RENEWABLE RESOURCES x

$$\frac{dx}{dt} = F(x) - h$$

GROWTH $F(x) = rx\left(1 - \frac{x}{c}\right)$

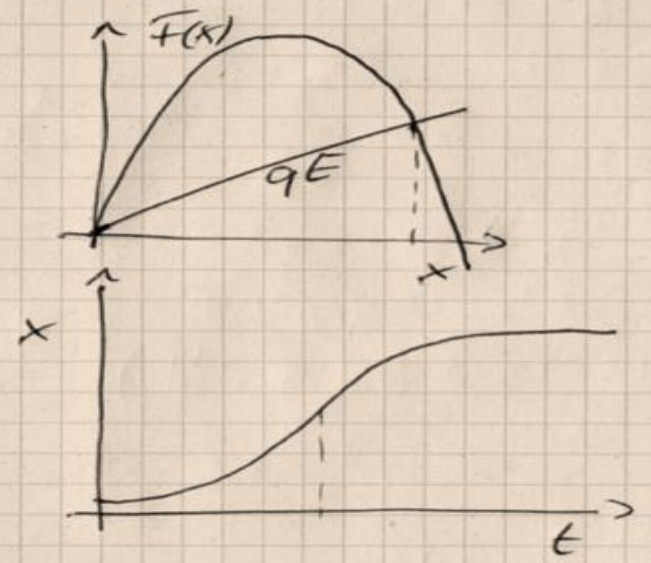
growth rate r

capacity c

HARVEST $h = qEx$

catchability q

Effort E



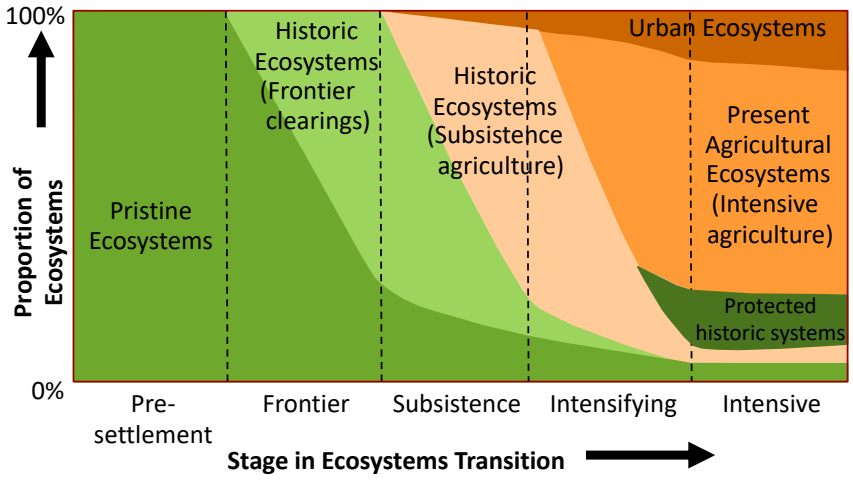
Peak rate years of global resource use: Implication to land use, biodiversity and major agricultural production trends

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

Ralf Seppelt

Harvesting a Cultivated Planet

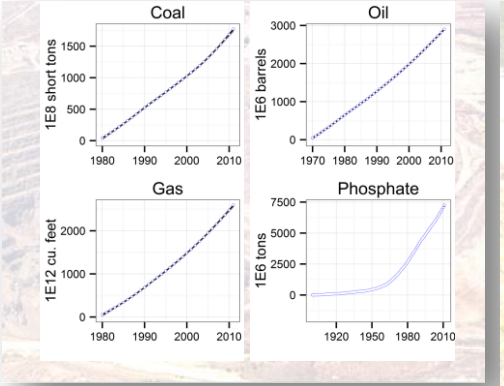
- Increase of 106% of overall food crop yield per unit area
- 12% increase in cropland
- 10% rise in permanent pasture
- 97% rise in irrigated land
- 638%, 203%, and 854% increase, in the use of fertilizers, pesticides, herbicides
- Reduction of 42% pesticides possible

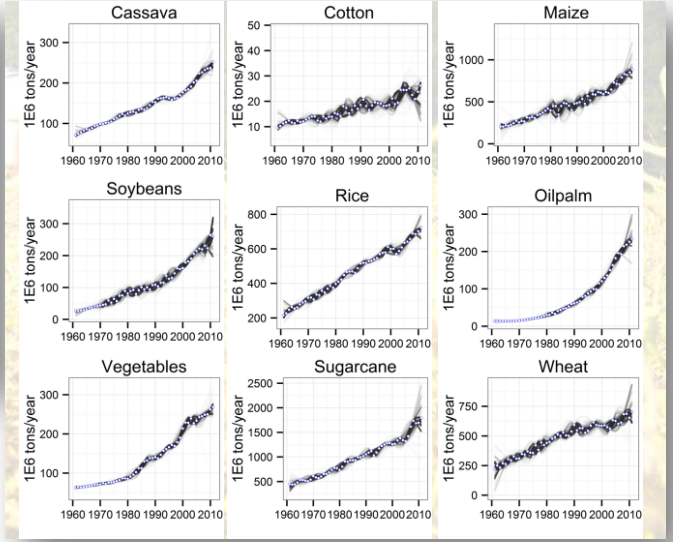


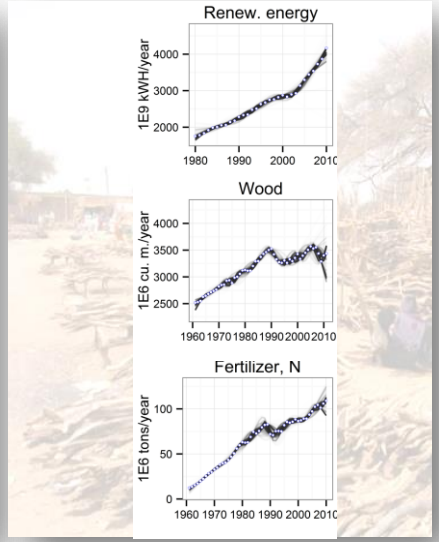
Adapted from Foley et al. (2005)

Foley et al. (2005) Nature, Green (2005) Science, Haberl et al. (2007) PNAS, Lechenet et al. 2017) NatPlants

Seppelt et al., 2014

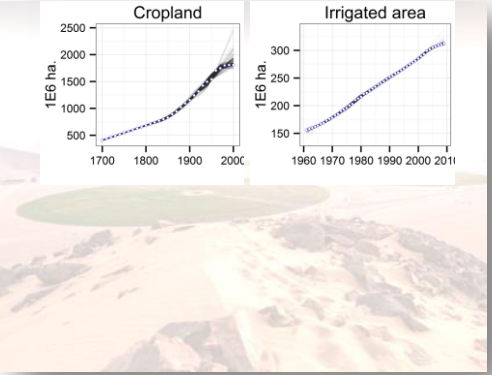


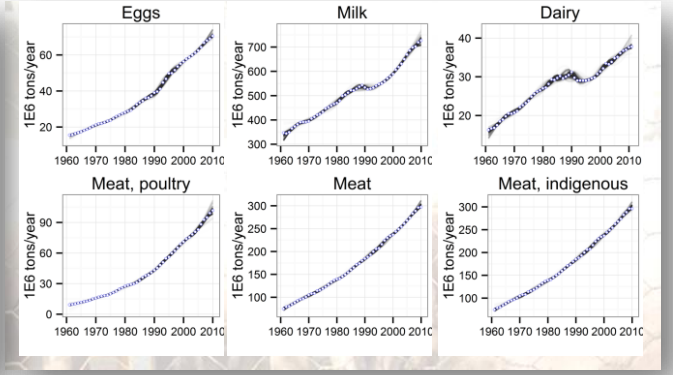


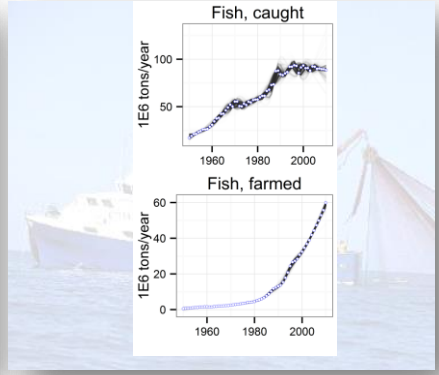


Peak year

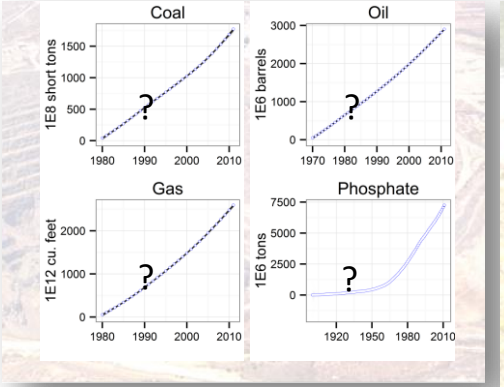
= Year of maximum production increase

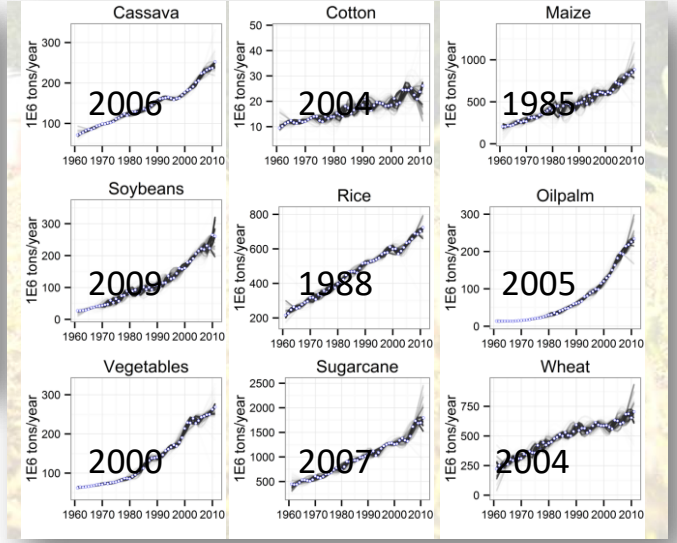


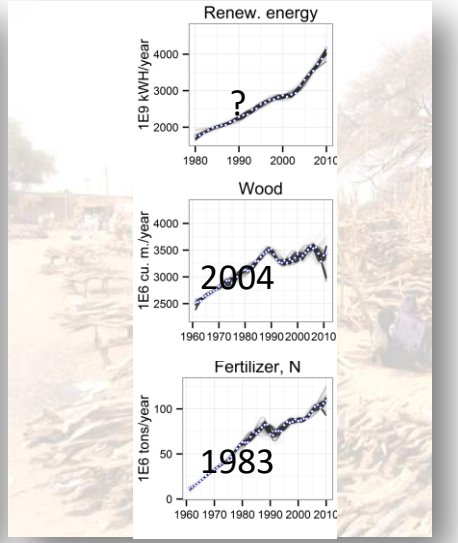




Seppelt et al., 2014







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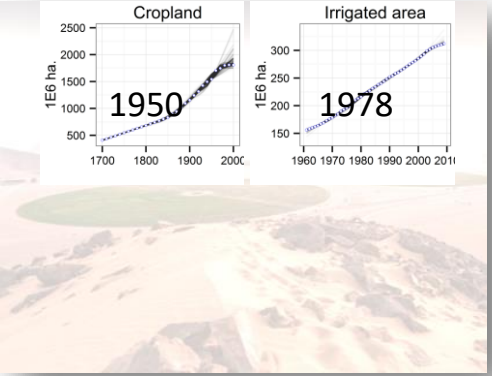
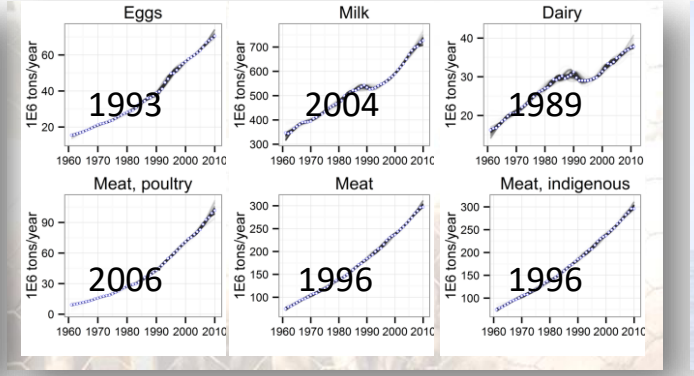
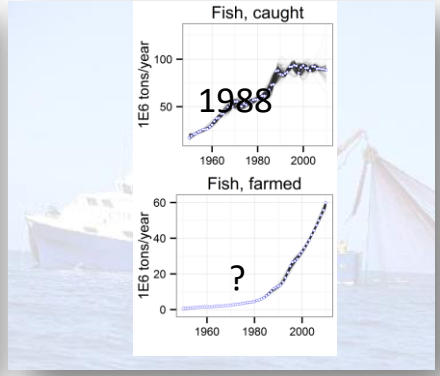






Seppelt et al., 2014

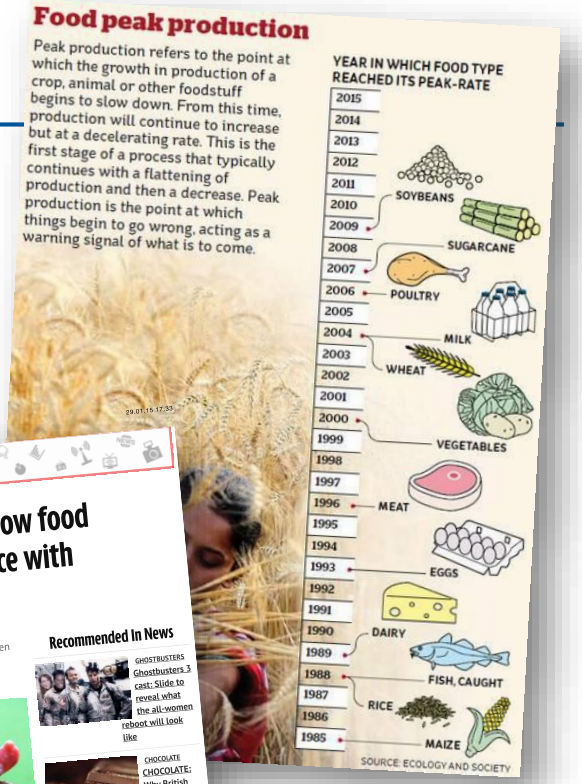
The Independent, 28.1.2015

Synchrony

Peak rate years are clustered around 2006 (1989-2008): **Synchrony**, but why**?**

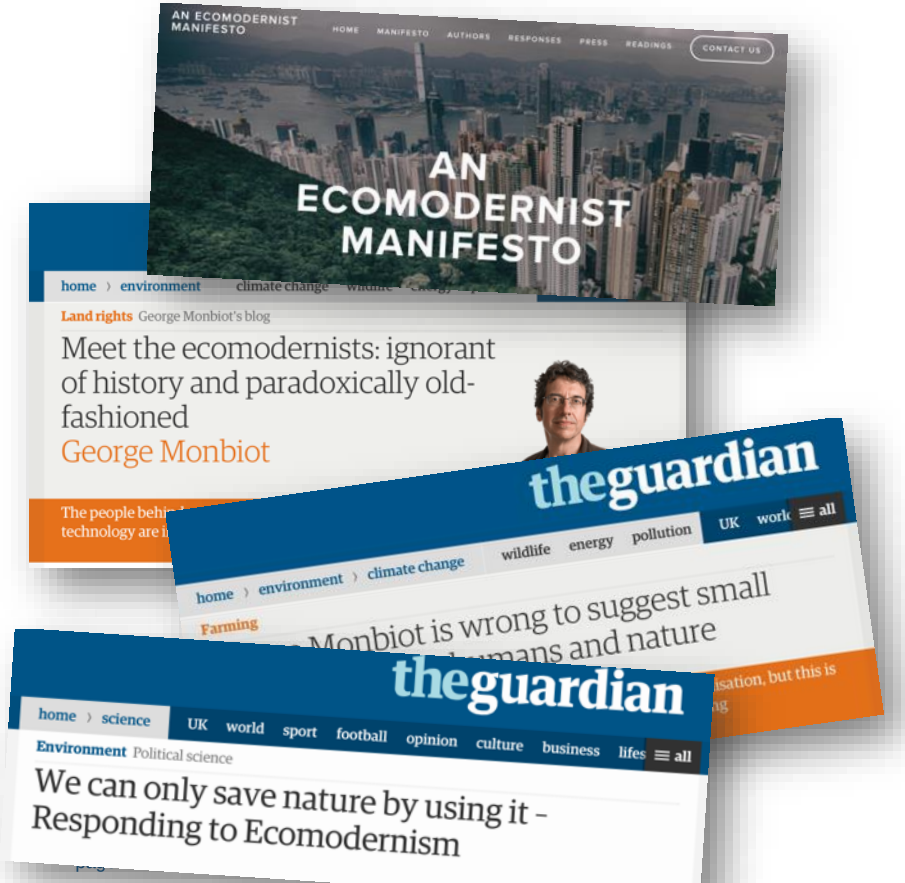
- Multiple resources are consumed at the same time meeting human needs
- Producing a resource requires the use of others
- Less demand? No
- Availability of substitutes? No

We approach an “over-harvested planet”



The Daily Mirror

The Optimistic View: Trust in Innovations?



Peak in innovation? Cost per invention are increasing
(Huebner 2005, Fenichel & Zhao 2014)

Further increase in photosynthetic efficiency is expected to be hard to achieve
(Zhu et al. 2010)

A basic constrain on breeding is biological diversity: Peak rate years of species domesticating: 2600 B.C. (3600-1500 B.C.)

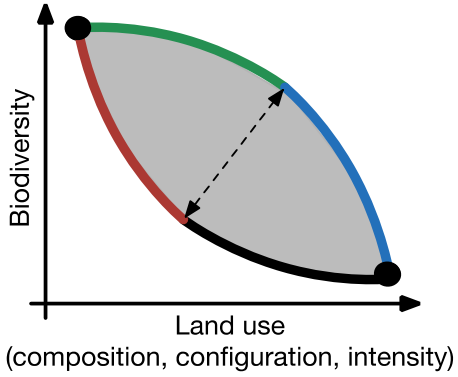
UFZ

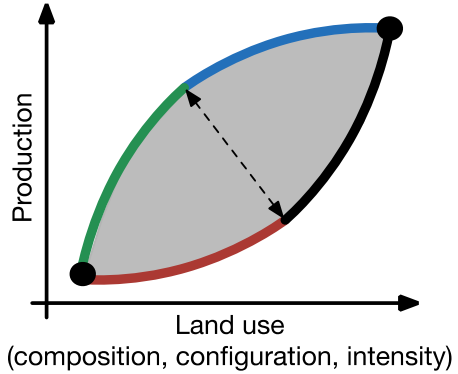
Conclusions

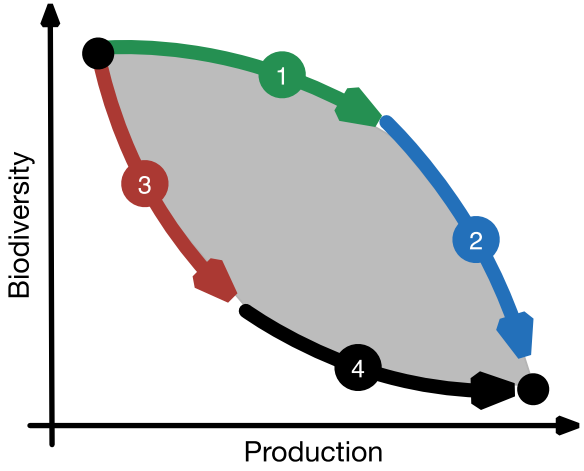
- A peak year in renewables is more frequent that for non renewables
- The synchronization of peak rate years of global resource appropriation can be far more disruptive than a peak rate year for one resource
- There is potential for further increase in yields, but it will come with high efforts, unlikely in high productive regions

Wirtschafts Woche

Harmonizing Biodiversity and Ecosystem Services



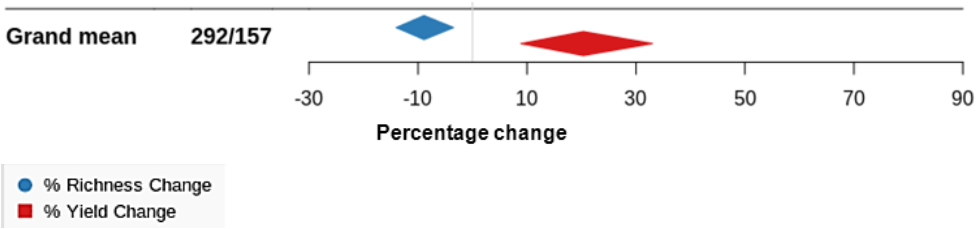




Seppelt et al. (2016) Bioscience

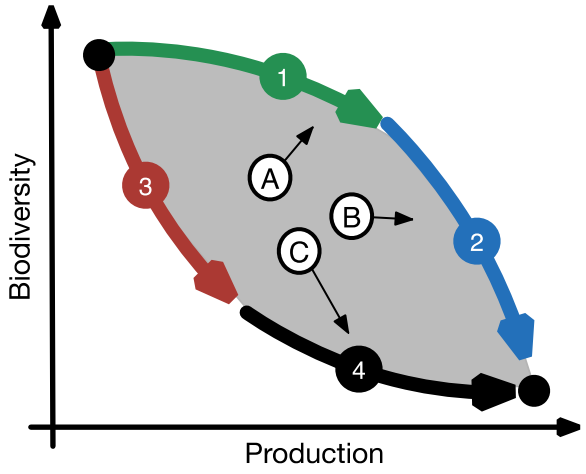
Quantifying the Biodiversity – Production Trade-offs

- The higher the increase in yield, the greater the loss of biodiversity: **No “win-win” situation**
- **Largest effect in medium-medium systems**: suitable for “closing the yield gap” strategies, *but* with highest risk for biodiversity
- Biodiversity loss **even in high-intensity systems**



Beckmann et al. (under review, GCB)

Summary & Outlook



Renewable resource limitations require "Solutions for a cultivated planet" that consider landscape context in land management

Paradigm shift needed to overcoming frequent "protection" vs. "use" dichotomy

- Biodiversity is lost through intensification even in systems under high intense use
- Forget abou “land sharing/sparing”

Develop quantitative understanding of changing feedbacks along a land-use intensification gradient