Contraction and Convergence Policy Recommendations for Global Sustainable Supply of Strategic Natural Resources

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Contraction and convergence

- North – contract their resource consumption
- South – increase their resource consumption
- Meet at the same equitable consumption rate…
- CONVERGEproject – FP7

Climate change

Chemical pollution

Acidification of oceans

Atmospheric aerosol loading

Ozone in stratosphere

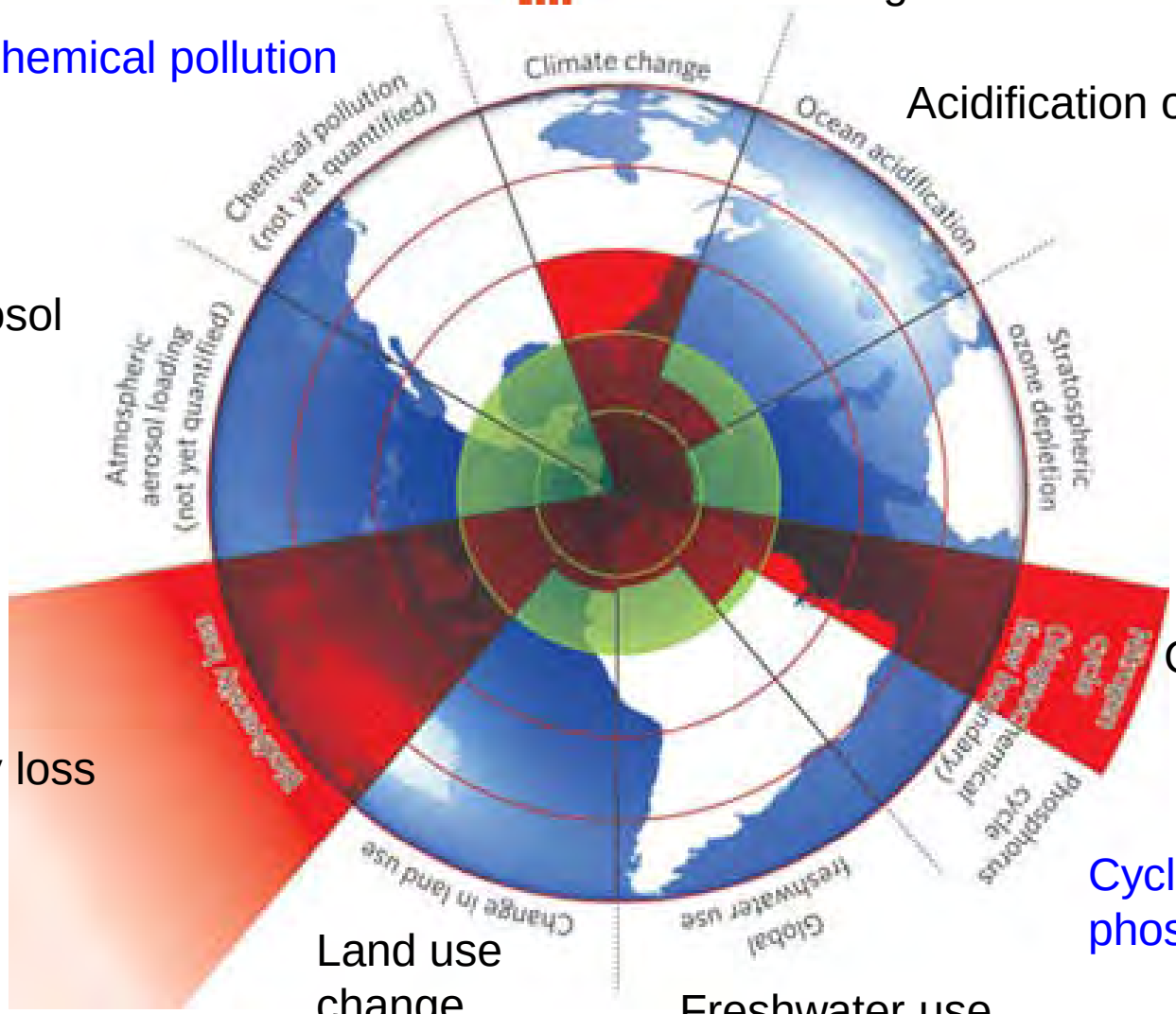
Cycling of nitrogen

Biodiversity loss

Cycling of phosphorous

Land use change

Freshwater use



Planetary boundaries

We have surpassed 3 of 9

Rockström et al. 2009

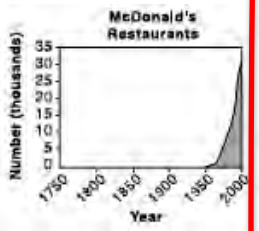
Resource depletion

- Man is a geologic force!!!
  - We move annually 10x more than nature
  - We now are in a biological extinction phase
    - 25% of mammals endangered
      - Thousands of species become extinct every year
      - Ecosystems on land and in oceans endangered
  - In 30 years
    - We have used up 1/3 of the Earth´s resources!
      - Destroyed 30% of forests, lost 25% of soil, 50% of oil, 50% of P…
      - Metals and other commodities are becoming scarce

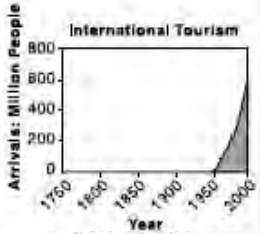
= Because of consumption

Exponential growth 1750-2000

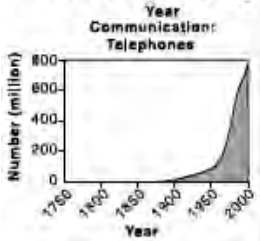
McDonalds



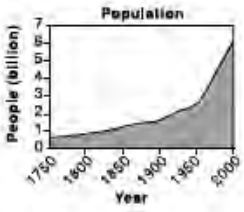
Tourism



Number of telephones

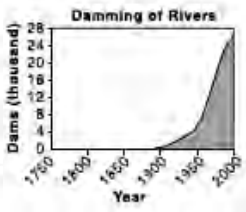


Polulation

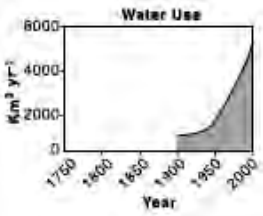


GDP

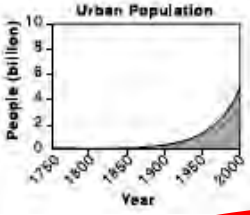
Dams on rivers



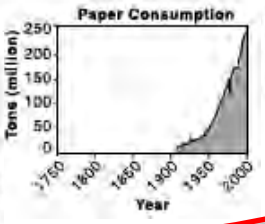
Water use

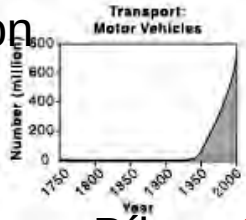


Urban population



Paper consumption

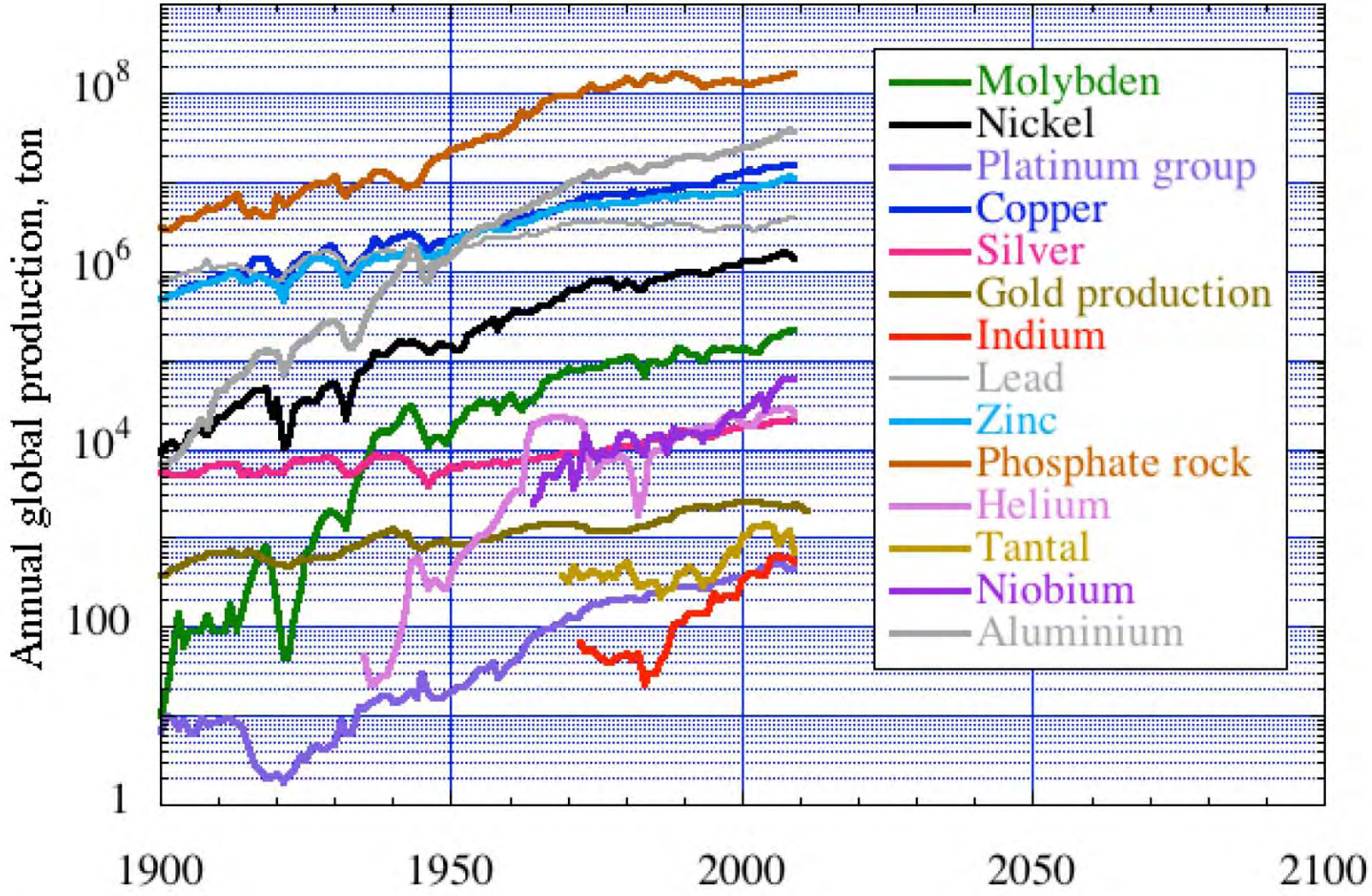




Bíla-samgöngur

HÁSKÓLI ÍSLANDS

Exponential growth forever?



Growth

"The greatest imperfection of mankind is that it does not understand the consequence of exponential growth"

Albert Allen Bartlett

"Anyone who believes that exponential growth can go on for ever in a finite world is either a madman or an economist"

Kenneth Boulding

Seven steps toward sustainability

- Think long term
- Understand systems
- Know limits
- Protect nature
- Change commerce
- Show equity
- Support entrepreneurship

(AtKisson 2008)

Sustainability Compass:

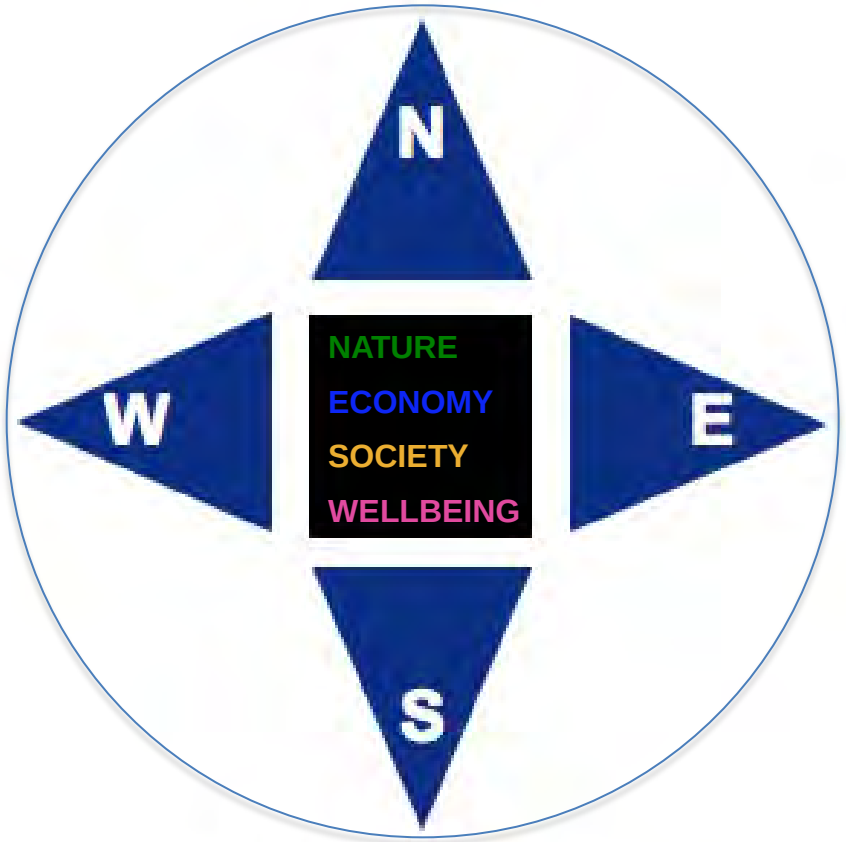
AtKisson 2008

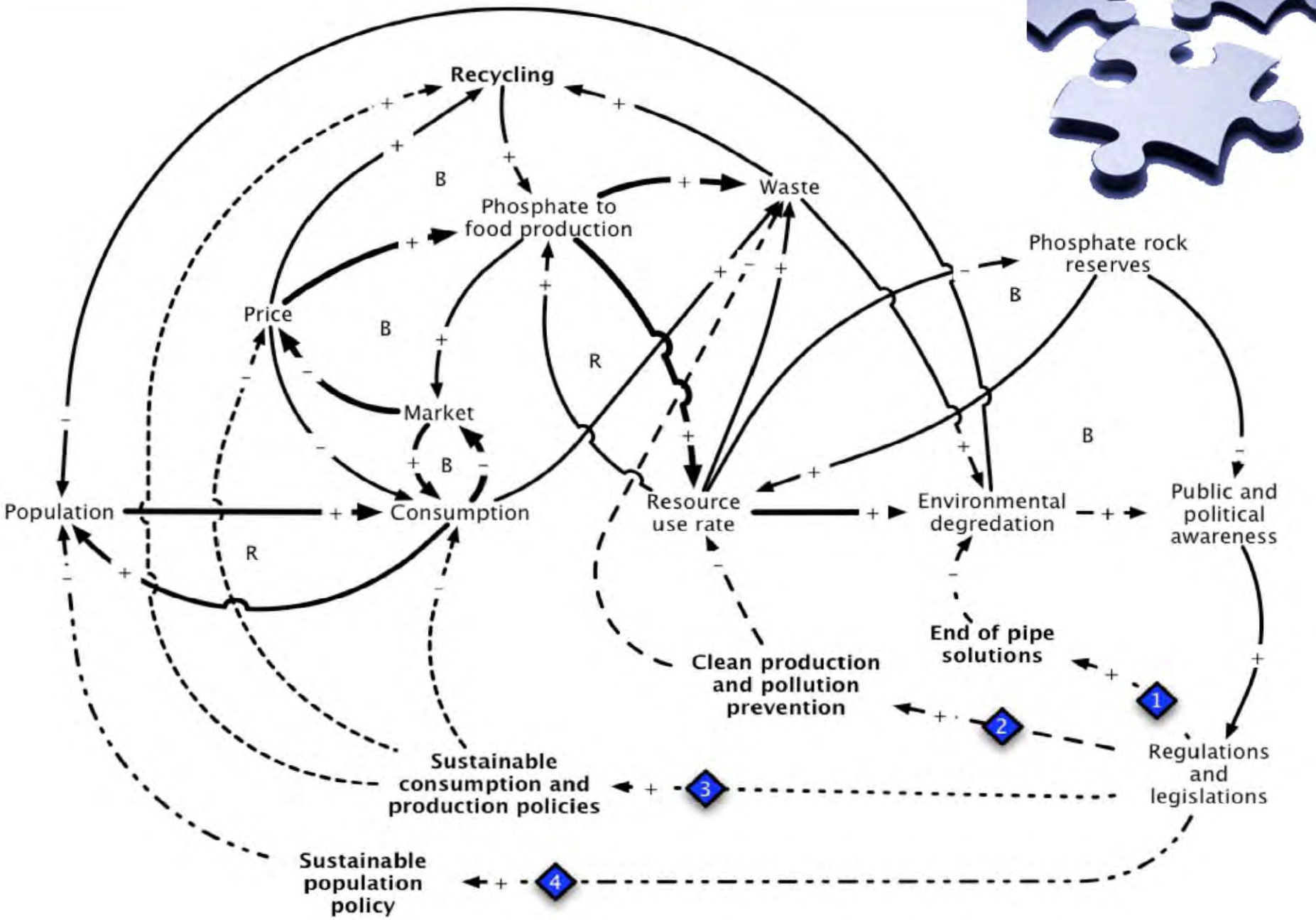
- ***N = Nature***
  Environment, resources, ecosystems, climate, resource use, land-use

- ***E = Economy***
  Production, consumption, employment, investment, infrastructure, labor, risk

- ***S = Society***
  Government, culture, institutions, collective concerns, education system

- ***W = Wellbeing***
  Individual health, families, education, quality of life, personal development, relationships



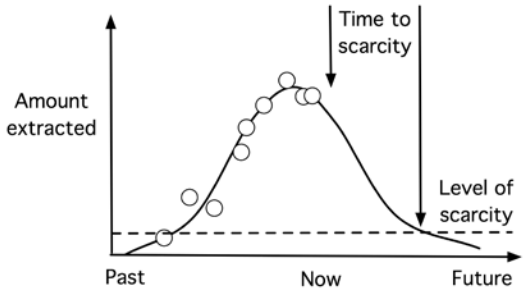

Recycling
Waste
Phosphate to food production
Phosphate rock reserves
Price
Market
Population
Consumption
Resource use rate
Environmental degredation
Public and political awareness
End of pipe solutions
Clean production and pollution prevention
Regulations and legislations
Sustainable consumption and production policies
Sustainable population policy
B
R
1
2
3
4

3 different methods used

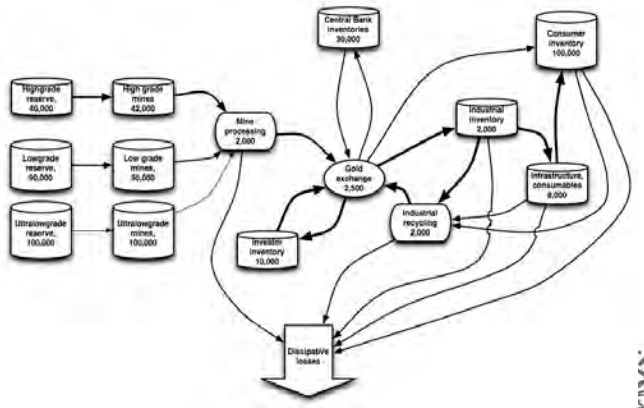
- Burn-off rates

$$\text{BURN-OFF TIME} = \frac{\text{ALL RESERVES}}{\text{EXTRACTION NOW}}$$

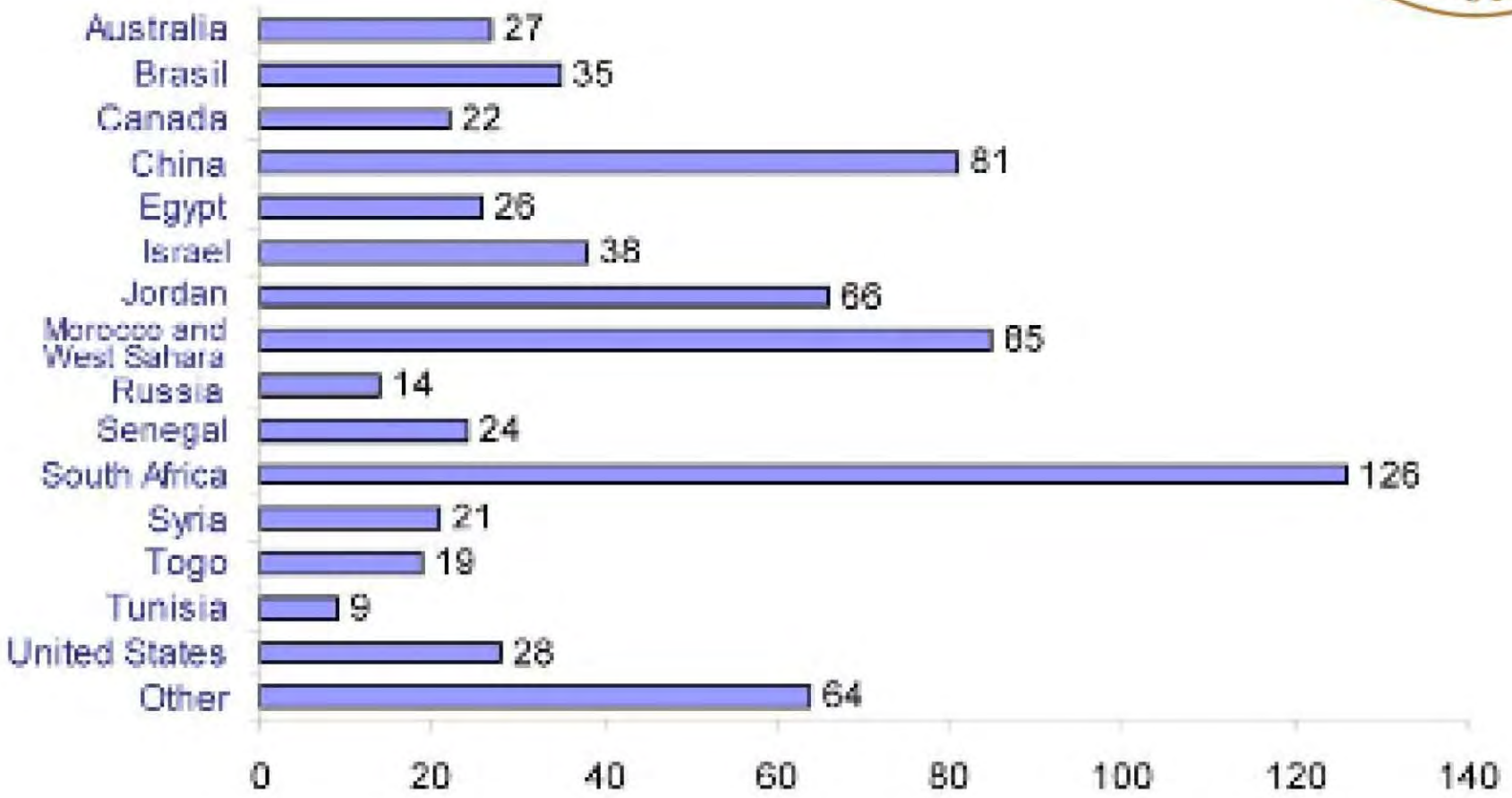
- Hubbert curve estimate



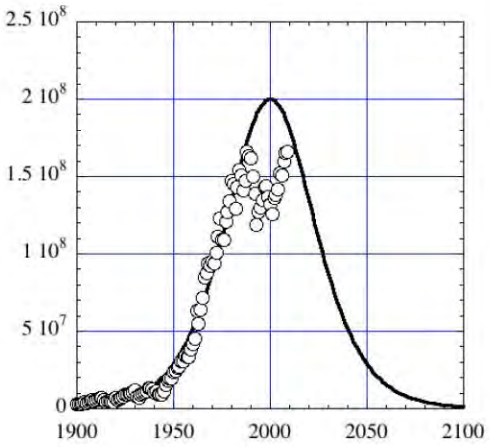
- Dynamic simulation models solving differential equations for metal stocks, use rates, market-price-mechanisms, mining rates

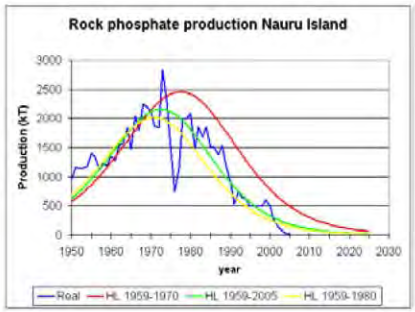


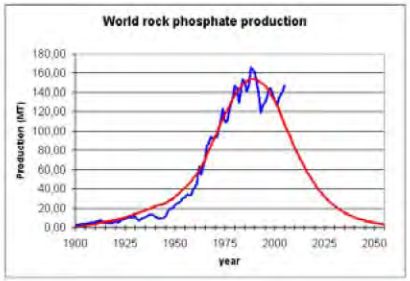
Phosphorus burn-off rates



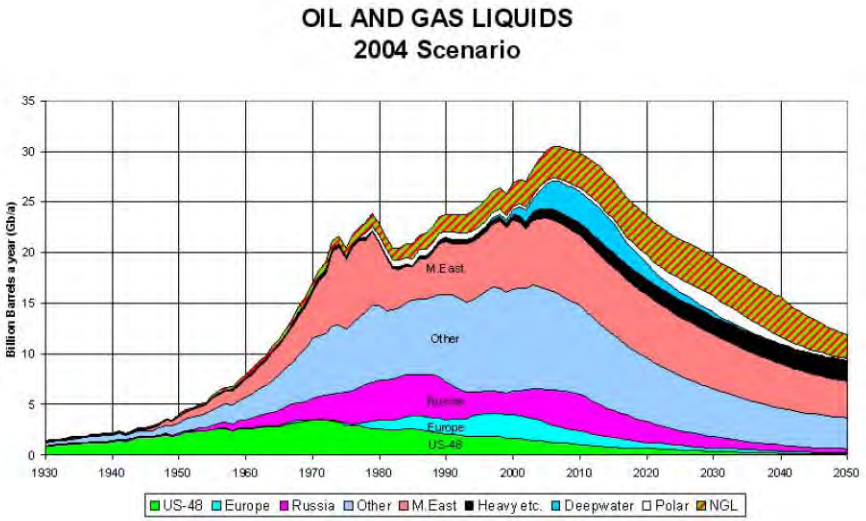
Phosphorus

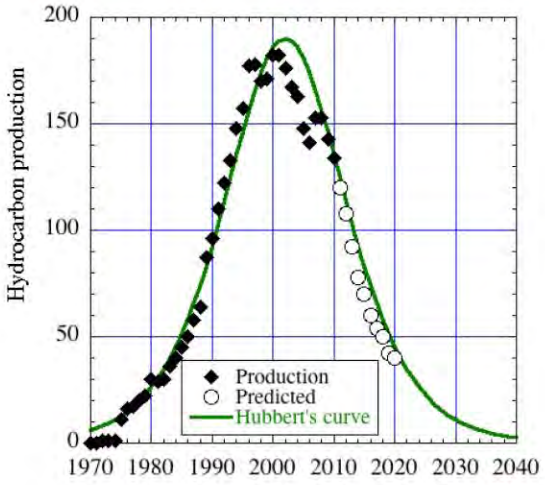




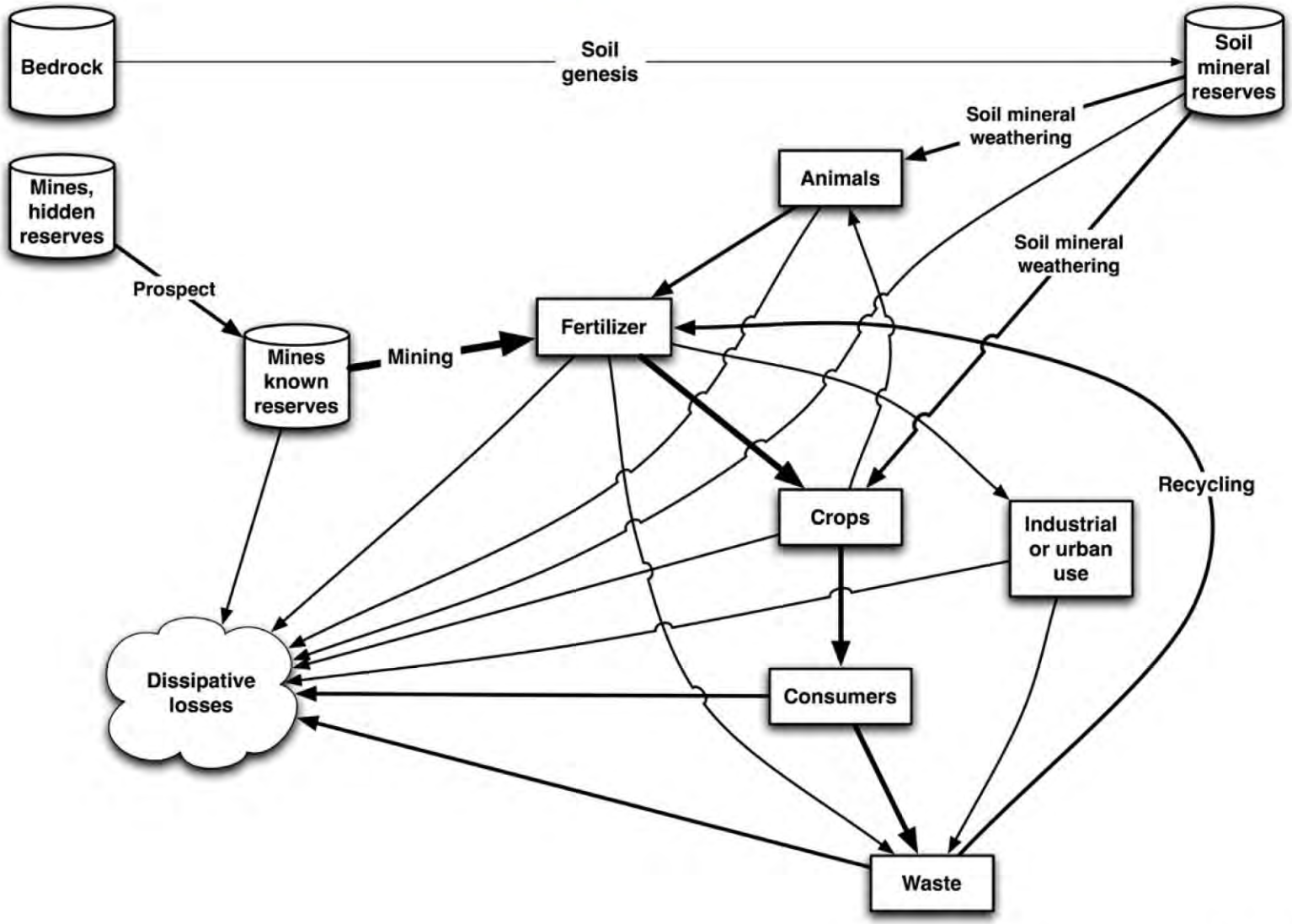


Oil

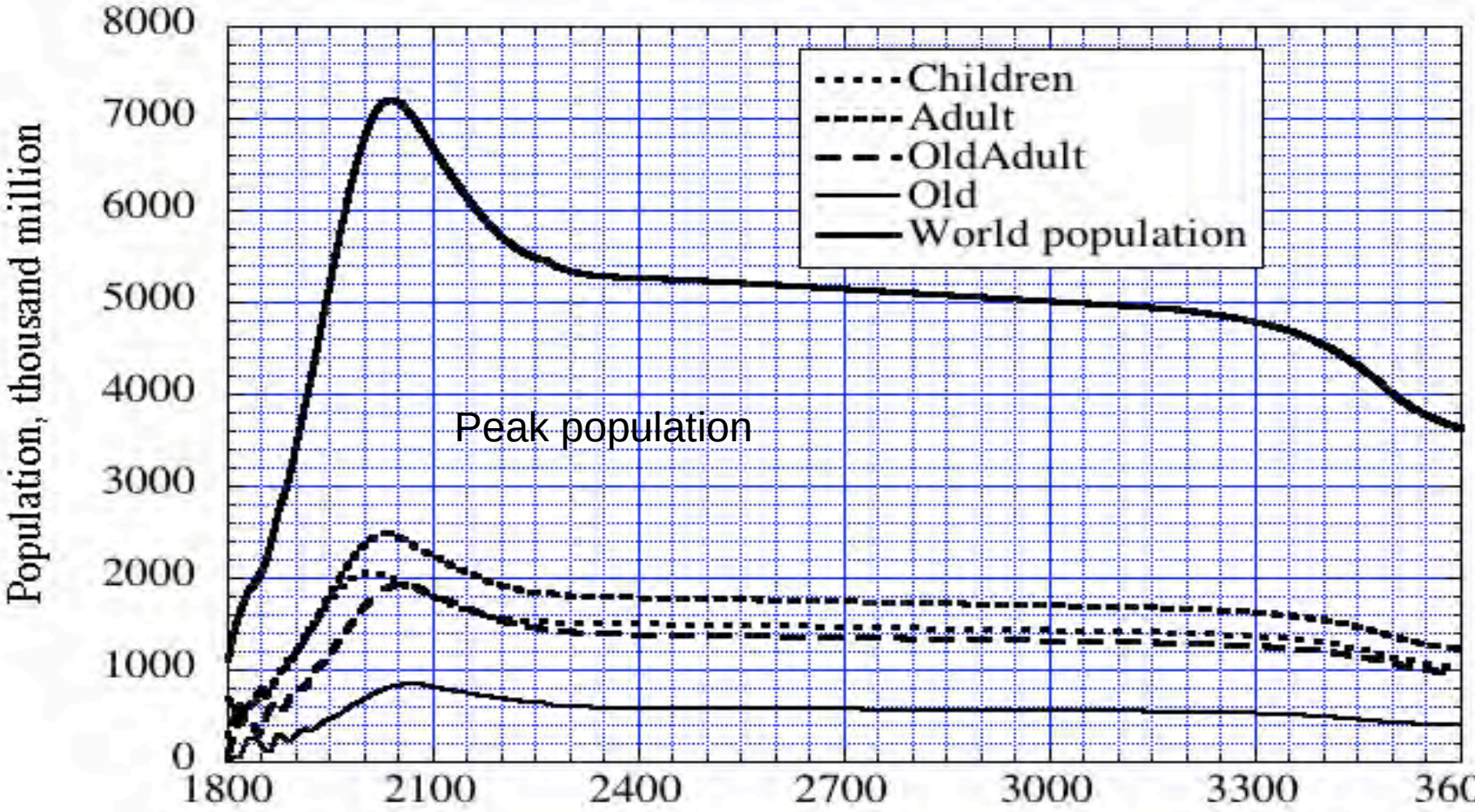




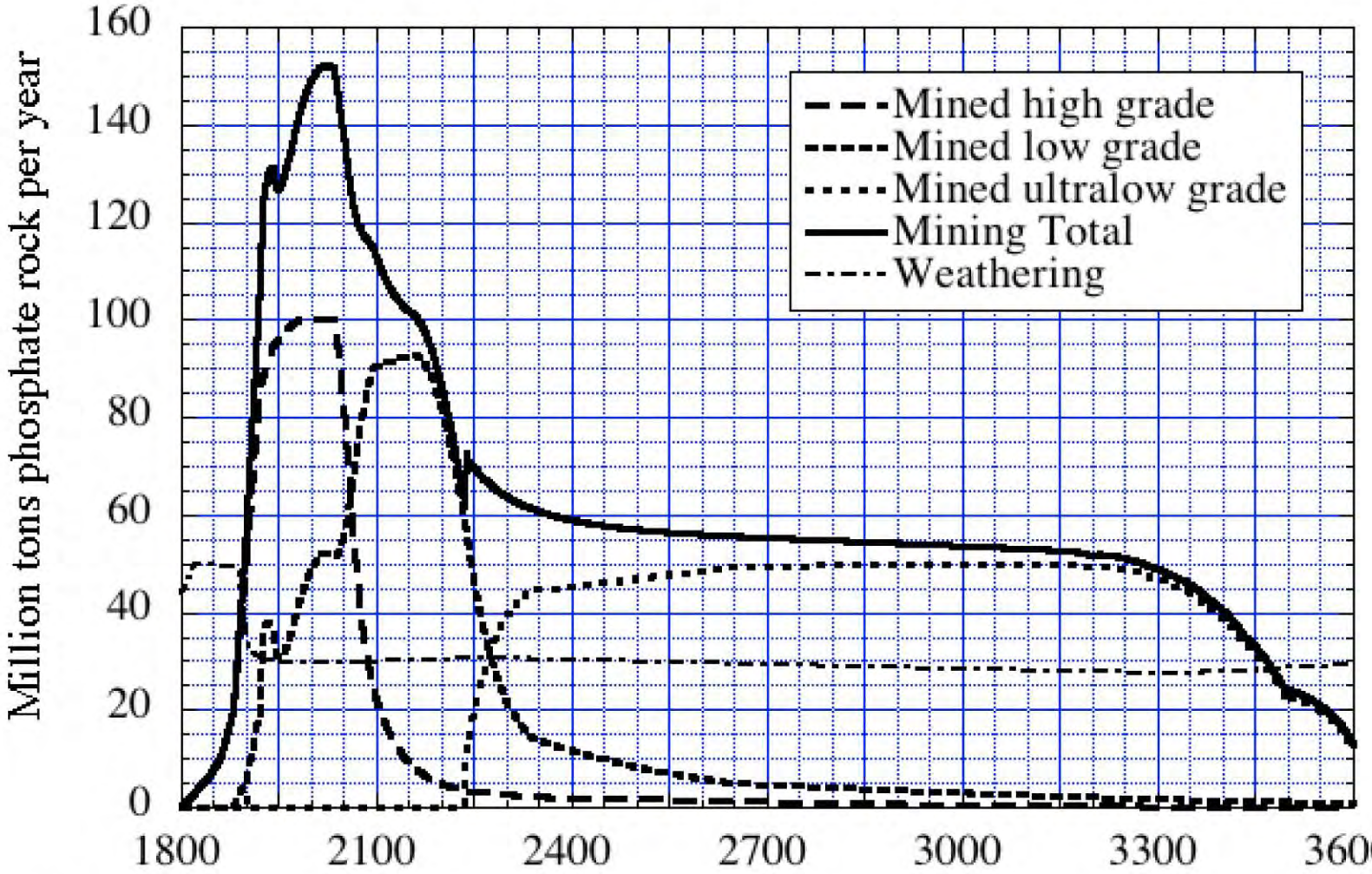
Mass flows


Bedrock
Soil genesis
Soil mineral reserves
Soil mineral weathering
Animals
Mines, hidden reserves
Prospect
Soil mineral weathering
Fertilizer
Mines known reserves
Mining
Recycling
Crops
Industrial or urban use
Dissipative losses
Consumers
Waste

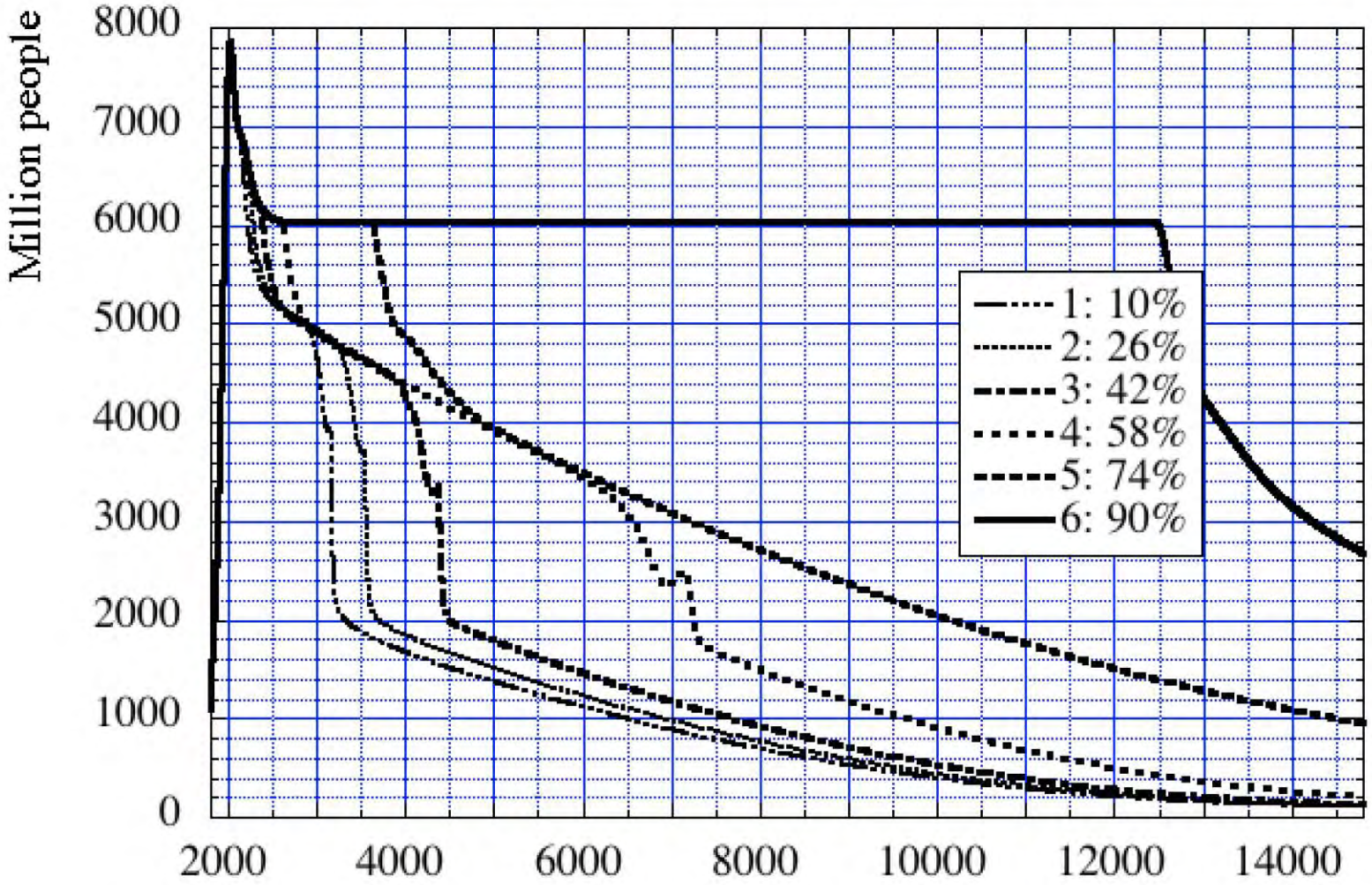
Business as usual, population trajectory, but with phosphorus limitation



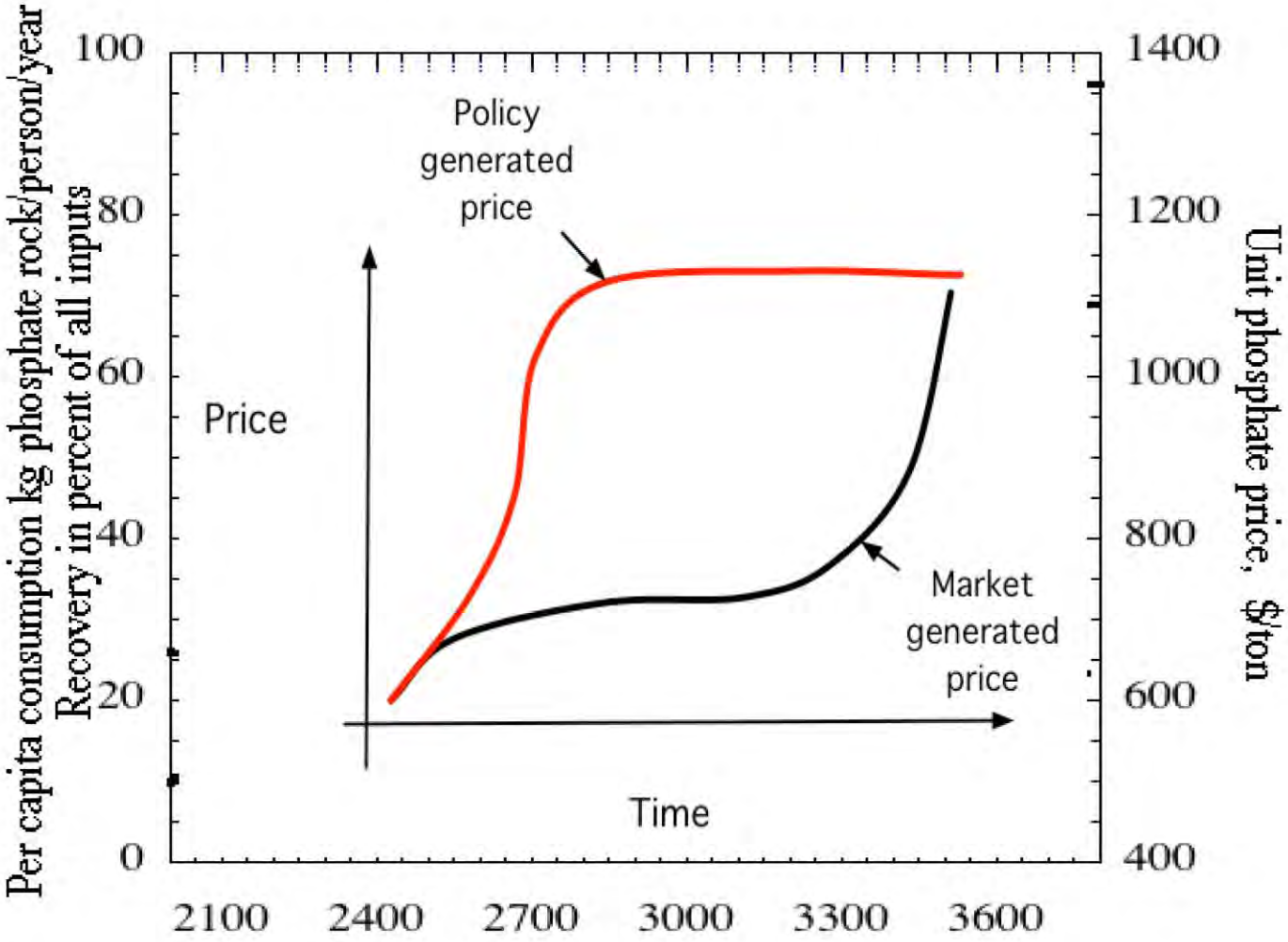
Mining and supply



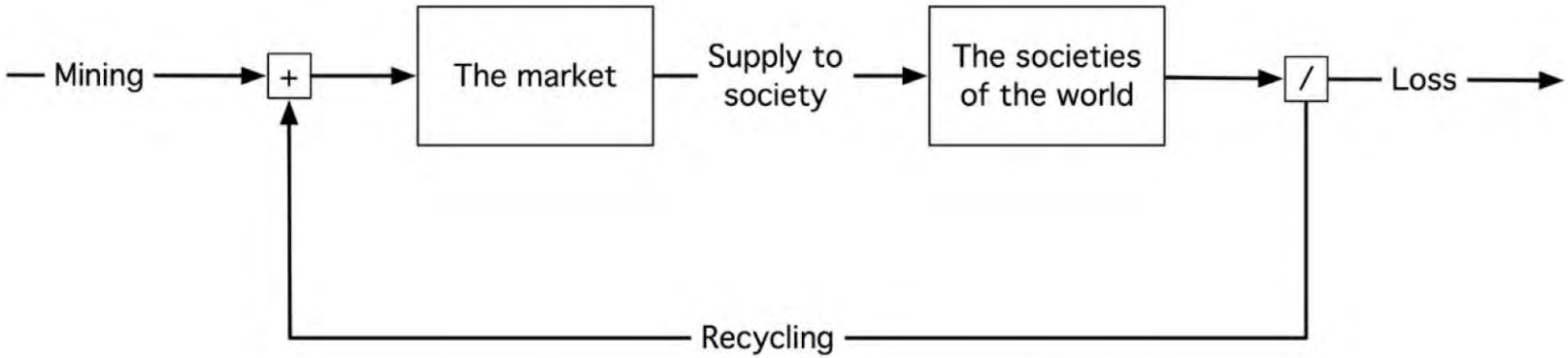
Recycling versus global population



The magic hand of the market is stupid



The recycling amplification effect



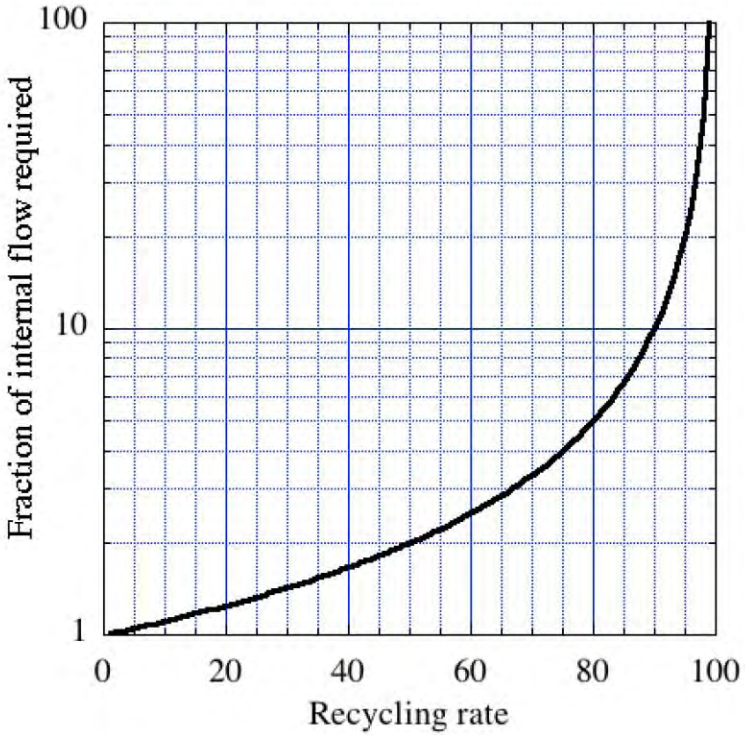


Table 4. Outputs on Hubbert-estimates for time to scarcity. (1) Business-as-usual, (2) 50% recycling (3) recycling to 90%, (4) recycling to 95%, (5) all recycling to 95%, population is reduced to 3 billion. (6) I recycling to 95%, assume one half of present per capita use, population is reduced to 3 billion.

Element	1	2	3	4	5	6
Bulk materials for societal infrastructures						
Iron	158	254	1,285	2,574	6,007	12,014
Aluminium	132	372	1,876	3,756	8,764	17,528
Nickel	82	82	424	851	1,986	3,972
Copper	61	61	317	638	1,488	2,975
Zinc	38	72	372	748	1,745	3,490
Manganese	35	58	306	616	1,437	2,874
Strategic materials for technology						
Indium (Zn-dependent)	35	74	385	771	1,798	3,597
Lithium	47	97	496	997	2,325	3,597
Rare earths	924	1,759	8,809	17,622	41,117	82,235
Yttrium (REE dependent)	120	616	1,235	2473	5,770	11,541
Hafnium (Zr-dependent)	12,649	12,649	25,303	50,609	118,087	236,174
Zirconium	133	214	1,085	2,173	5,071	10,142
Tin	38	58	304	611	1,425	2,850
Molybdenum	94	289	728	1,459	3,405	6,809
Rhenium	99	99	252	507	1,183	2,365
Lead	43	43	181	365	852	1,703
Wolfram	62	102	523	1,049	2,447	4,894
Cobalt	227	365	1,840	3,683	8,594	17,188
Tantalum	346	556	2,795	5,594	13,053	26,106
Niobium (Mo-dependent)	88	143	731	1,466	3,420	6,841
Helium	14	32	175	353	823	1,647
Chromium	175,000	262,000	1,310,000	2,600,000	6,100,000	12,200,000
Gallium	1,017	1,425	7,139	14,282	33,325	66,650
Arsenic	60	123	627	1,258	2,936	5,872
Germanium	201	282	1,425	2,854	6,659	13,317
Titanium	813	813	4,078	8,160	19,039	38,079
Tellurium	784	784	3,942	7,888	18,405	36,809
Antimony	48	68	354	711	1,658	3,317
Selenium	422	8,500	10,600	21,200	49,600	99,200
Precious metals						
Gold	94	94	142	725	1,693	3,385
Silver	26	26	84	434	1,012	2,024
Platinum	145	145	442	2,223	5,187	10,400
Palladium	121	121	369	1,860	4,340	8,679
Rhodium	86	86	266	1,343	3,135	6,269
Fossil energy resources						
Oil and gas	100	-	-	-	330	660
Coal	174	-	-	-	574	1,150
Uranium	121	240	1,215	12,184	28,400	56,900
Thorium	379	747	3,746	37,500	87,500	175,000
Planetary life support essential element						
Phosphorus	160	258	1,303	6,527	15,200	30,460
Colour legend						
TTS range, years	0-100	100-200	200-1,000	1,000-2,000	2,000-10,000	>10,000
Colour code						

The race on resources is on. This applies to many more strategic materials, phosphorus is only one of them.

Procrastination and denial is futile against mass balance and only lead to humiliation.

Exponential growth forever is a thermodynamic impossibility.

Adaptation of society is required.

Policy Recommendations

- Strict enforcement of all activities within sustainability boundaries.
- Define critical extraction rates. Enforce them.
- Make recycling of all natural resources compulsory – aim for over 90% within 5 years

Policy recommendations

- Place a large and substantial payable deposit on every ton of resource removed from the ground, returning the deposit to the entity carrying out the recycling.
- Arrange for production quotas from a long term basis for fossil materials that already are scarce. Stop in time when EROI goes negative.

Policy recommendation

- Vision a “happy” sustainable future.
- Promote the values of equity and ethical behaviour.
- Promote the culture of “enough.”

For a Sustainability Revolution

- In addition to
  - population reduction, more efficient use of resources, pollution control, technological advancement etc…
- We need
  - visioning, networking, truth telling, learning … and loving

Meadows et al. (2004)

Thank you!

Thanks to coworker

Harald Sverdrup

University of Lund, Sweden