Industrial Ecology, Resource Decoupling, and the "Master Equation"

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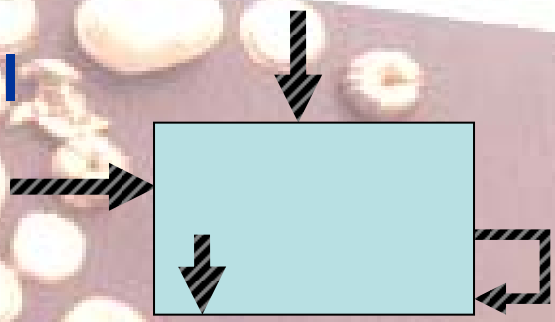
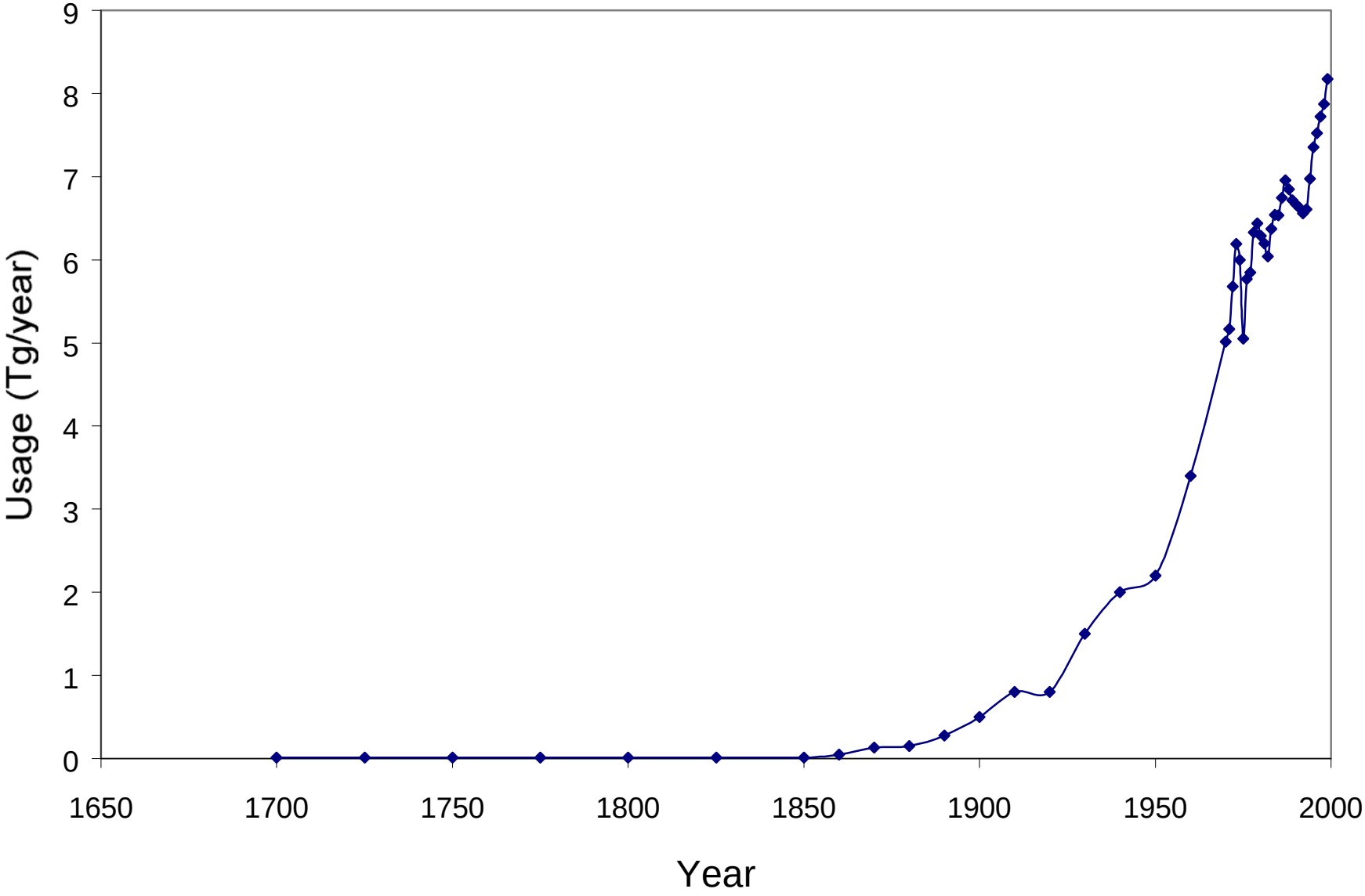
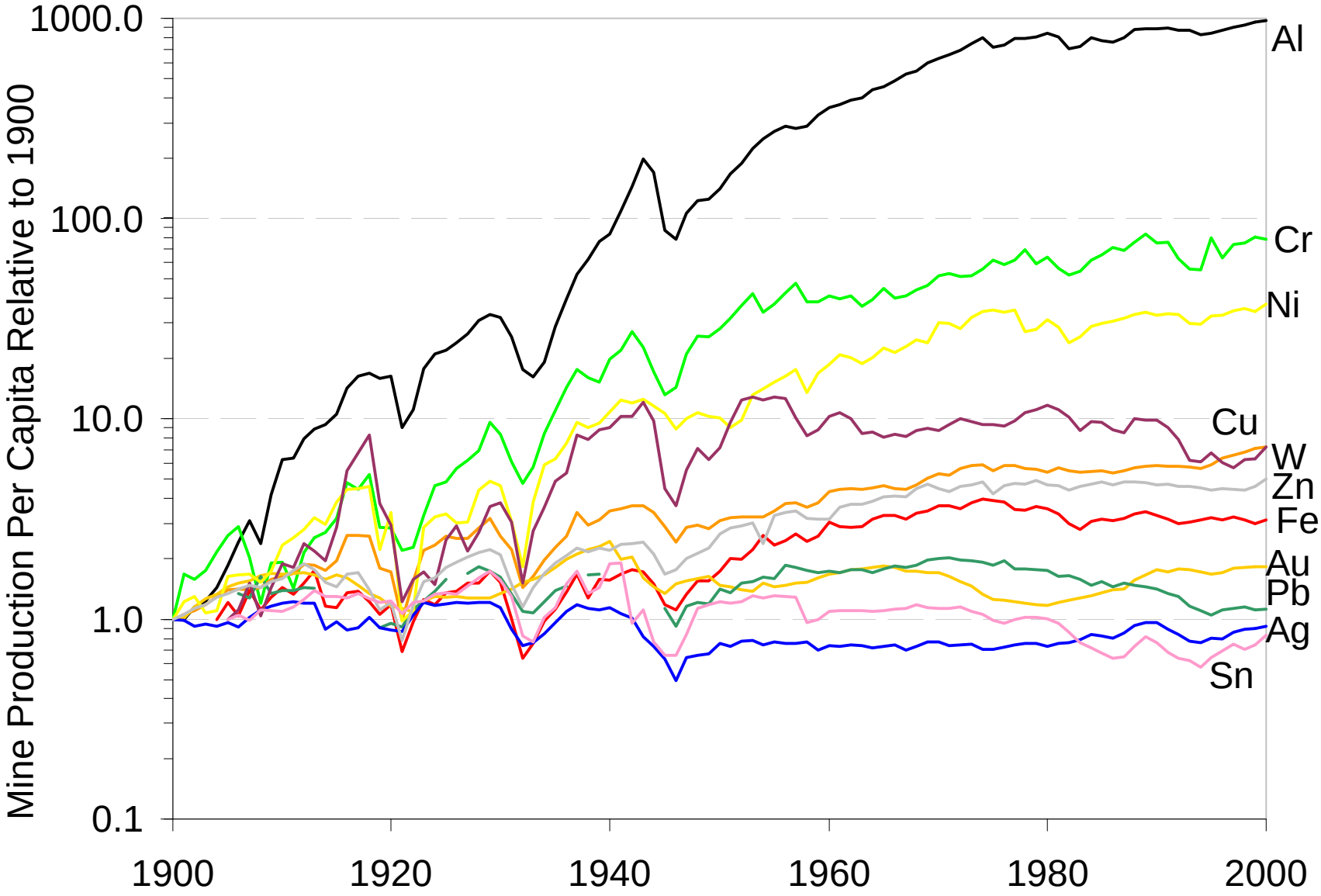


Global Zinc Use, 1700-2000

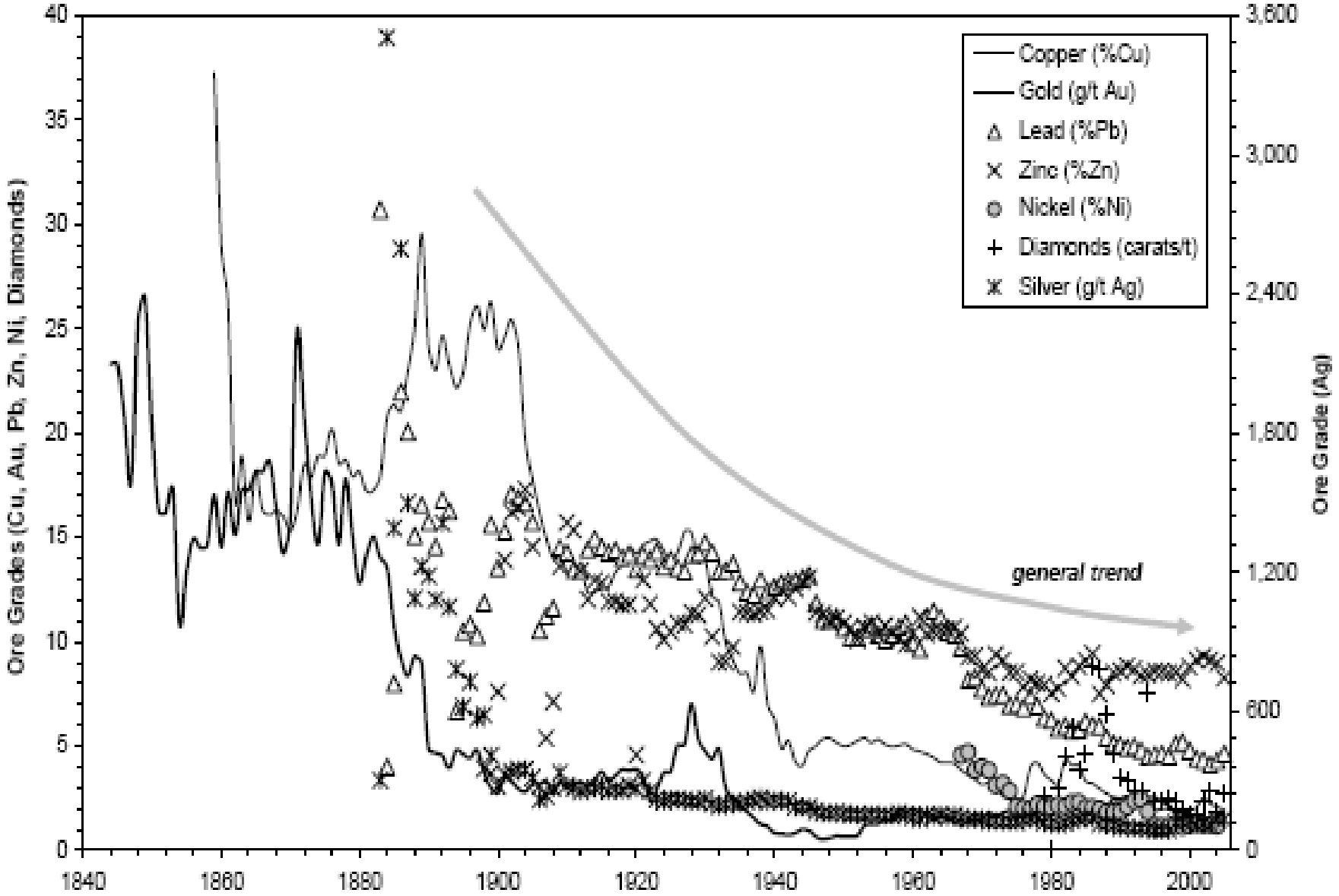


Global per Capita Metals Use in the 20th Century



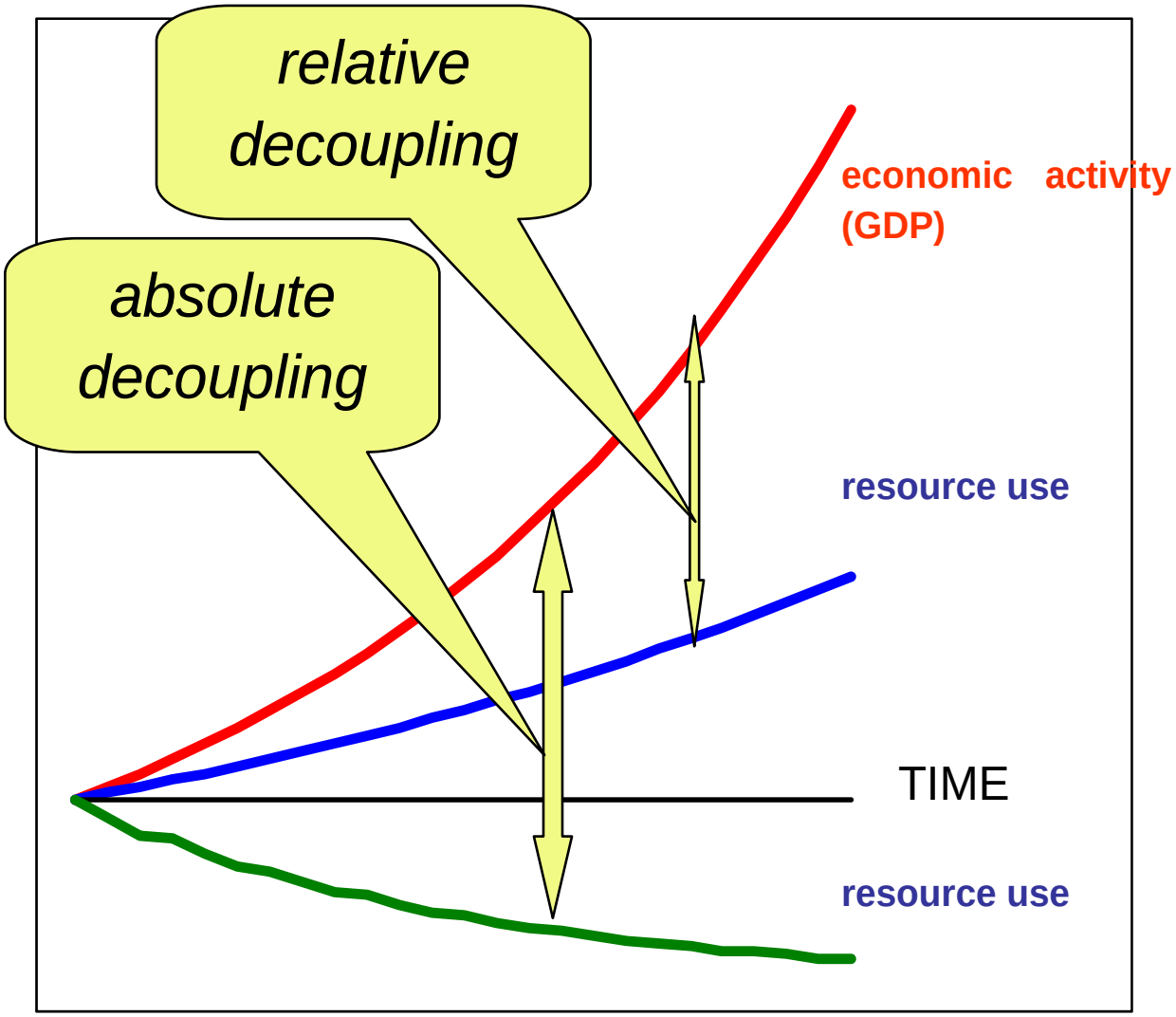
Histories of Australian Ore Grades, 1845-2007

Source: G.M. Mudd, Sustainability of Mining in Australia, Research Report No. RR5, Monash Univ., 2007.

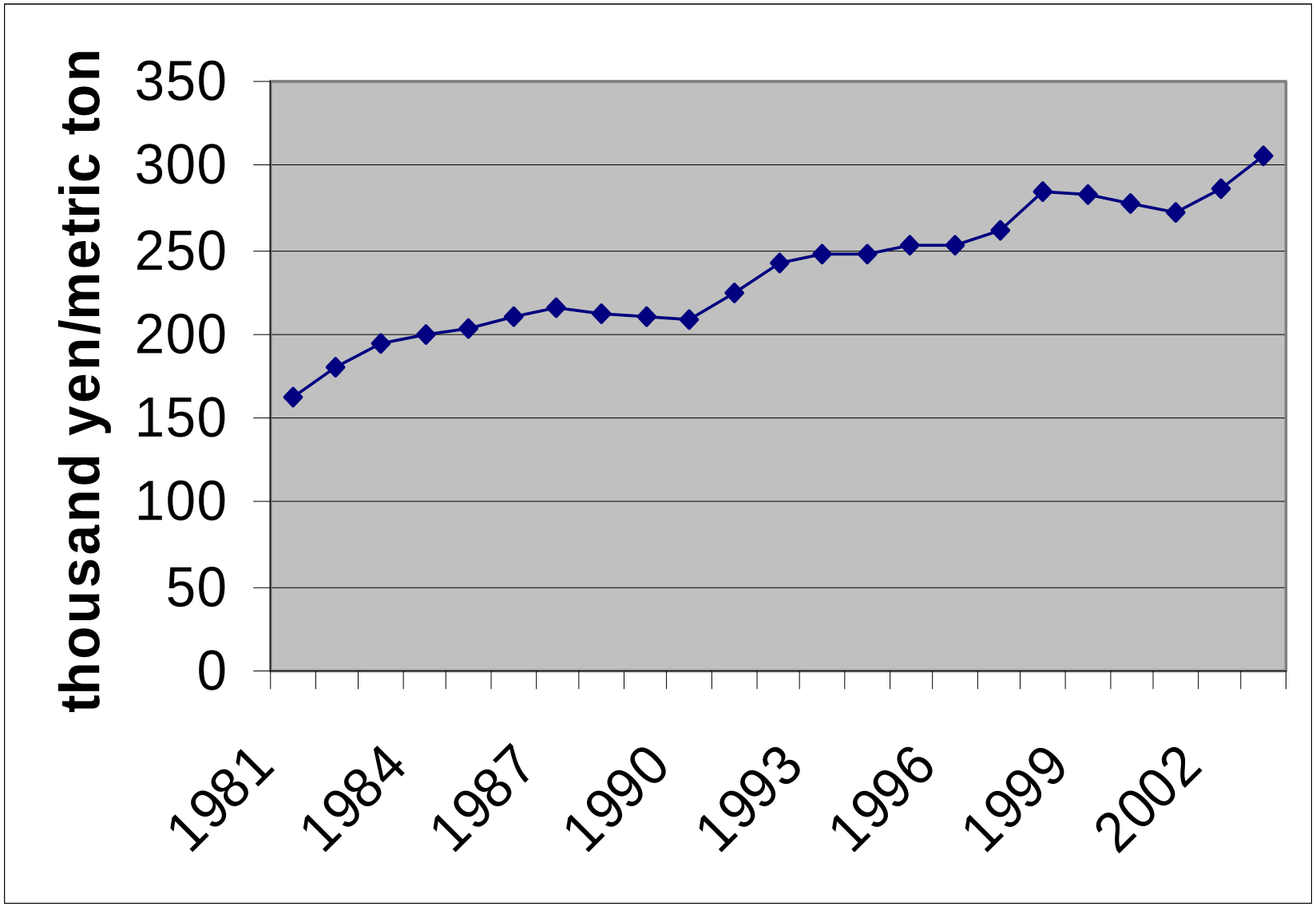


Is this a recipe for trouble?

Defining Decoupling



Japanese Resource Decoupling



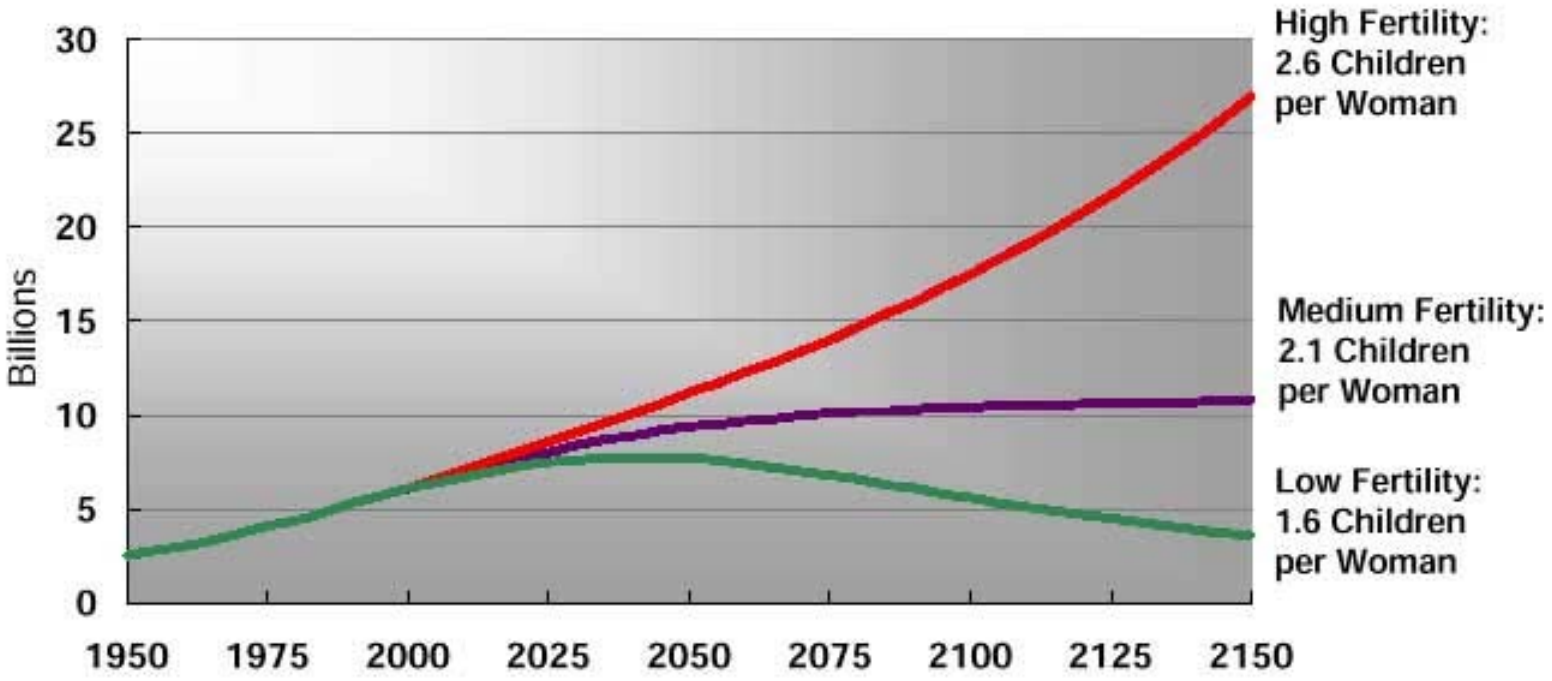
The “Master Equation”

Overall Environmental/Sustainability Impact =

$$\text{Pop.} \times \frac{\text{GDP}}{\text{person}} \times \frac{\text{resource use}}{\text{GDP}} \times \frac{\text{envt./sust. impact}}{\text{unit of resource use}}$$

Projected World Population to 2150

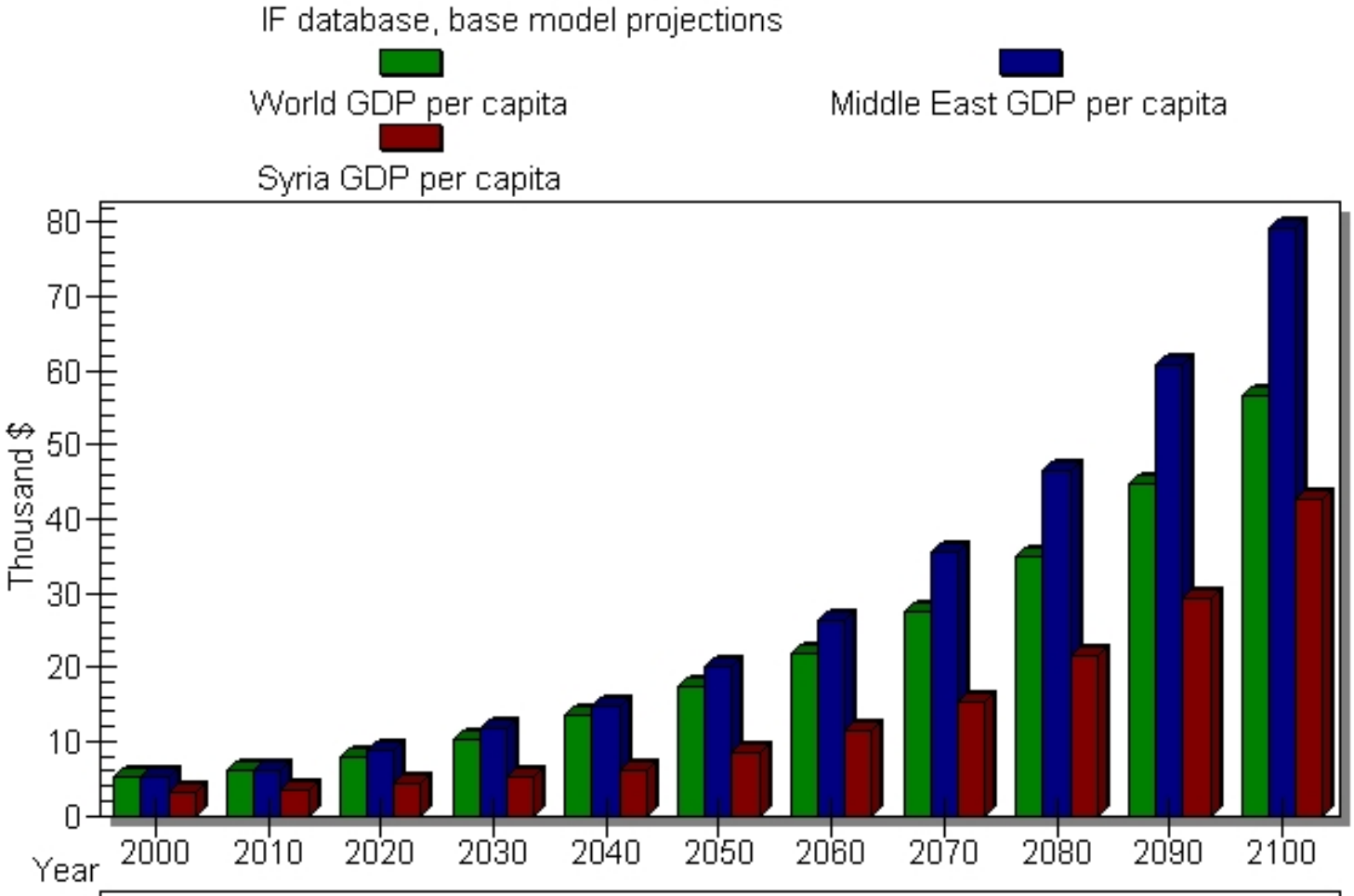
Three scenarios



Source: UN, *World Population Projections to 2150*, 1998.

PRB

GPD per capita: World, Middle East & Syria



	2000	2010	2020	2030	2040	2050	2060	2070	2080	2090	2100
World GDP per capita	5.183	6.127	7.859	10.283	13.491	17.323	21.745	27.404	34.939	44.592	56.588
Middle East GDP per capita	5.126	6.202	8.782	11.730	14.834	19.959	26.315	35.414	46.628	60.789	79.116
Syria GDP per capita	3.231	3.474	4.230	5.087	6.064	8.507	11.560	15.354	21.622	29.232	42.580

Source: www.faculty.fairfield.edu/.../Oct16/Part4.html

Copper Stock per capita

137 kg Cu

New Haven

35 kg Cu

Beijing

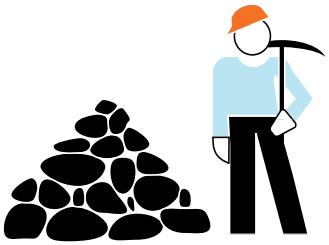
Copper Stock and Copper Need

137 kg Cu

New Haven

137 kg Cu

Beijing



1.3 Pg Cu

Global need in 2040

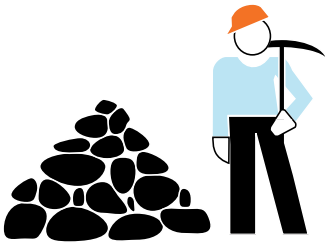
Limits to Materials:
Copper Stock and Copper Supply

137 kg Cu

New Haven

137 kg Cu

Beijing



1.3 Pg Cu

Global need in 2040

1.6 Pg Cu

Global resource

Ad in *Newsweek*

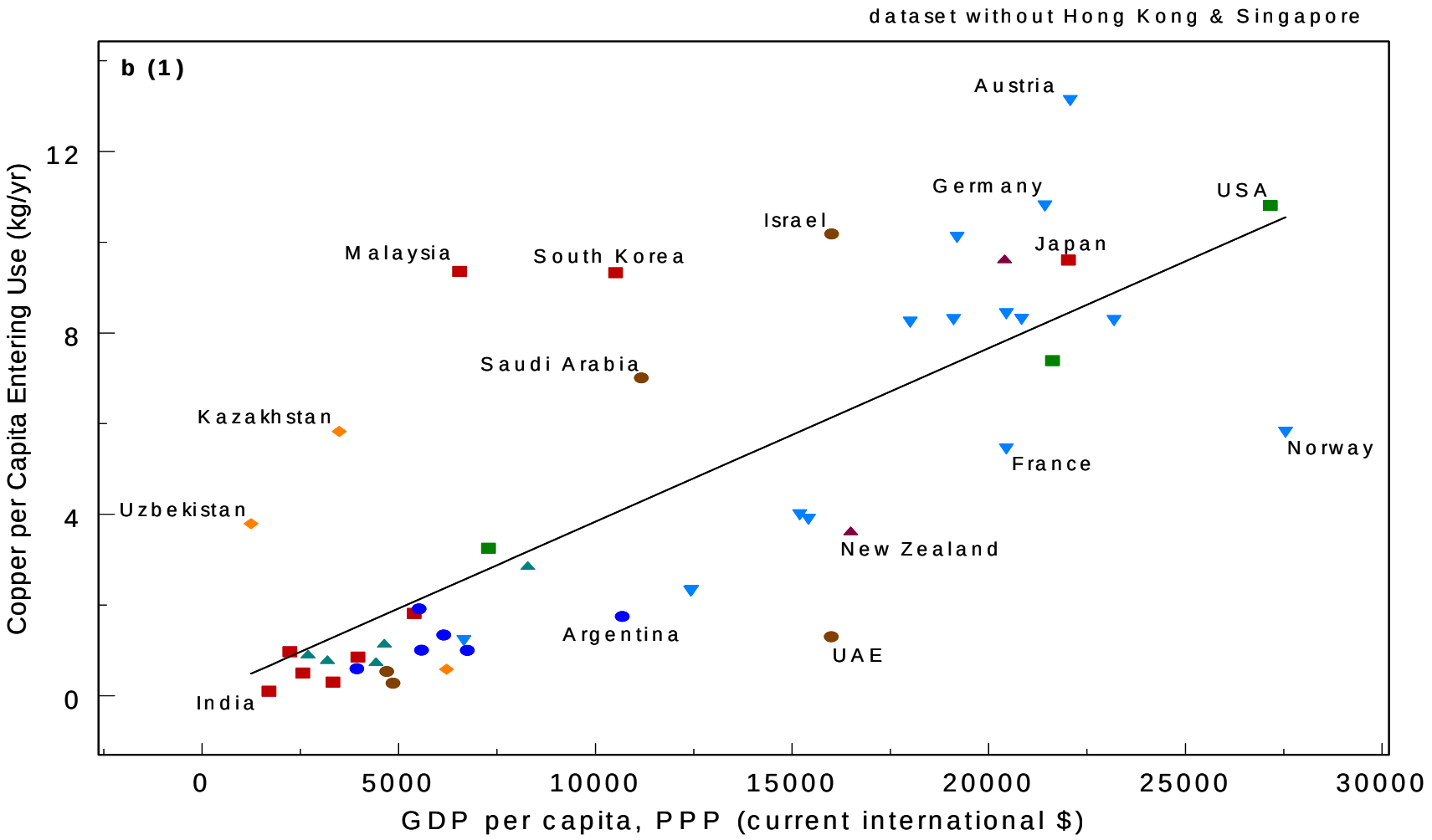
August 20, 2001

http://www.allaboardwashington.org/cms/images/uploads/Trains_Crop2.jpg

A Typical Water Treatment System

http://images.google.com/imgres?imgurl=http://civil.engr.siu.edu/Ray_H2ODsn/images/WTPAerial1.jpg&imgrefurl=http://civil.engr.siu.edu/Ray_H2ODsn/Default.asp&usg=__WrYw0oEkKBTB3yzEETk4P87ga3w=&h=438&w=500&sz=97&hl=en&start=5&tbnid=fsIDd54infh_bM:&tbnh=114&tbnw=130&prev=/images%3Fq%3Dwater%2Btreatment%2Bplant%26hl%3Den%26sa%3DX

Copper Use as a Function of Wealth



The Master Equation

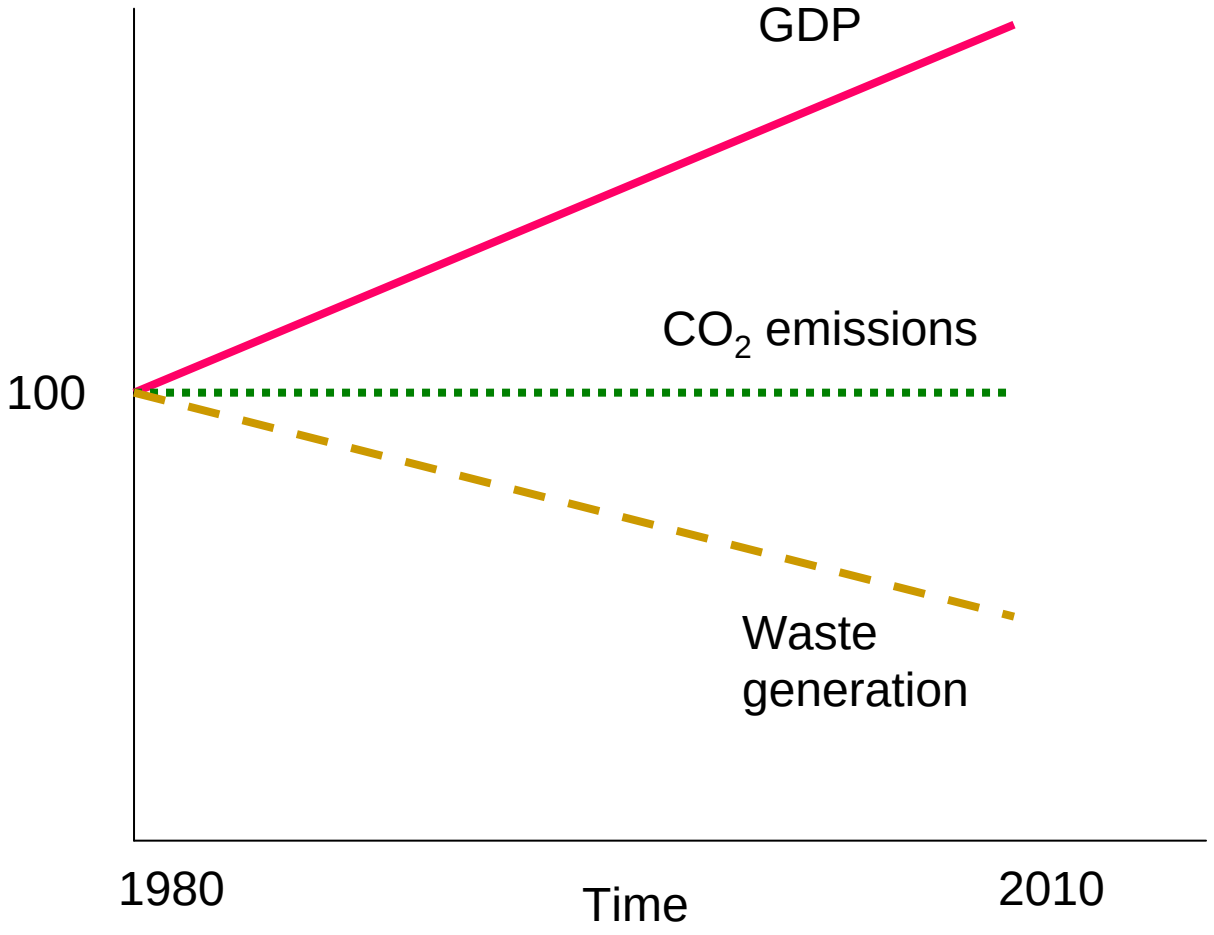
Overall Environmental Impact =

$$\text{Population} \times \frac{\text{GDP}}{\text{person}} \times \frac{\text{resource use}}{\text{GDP}} \times \frac{\text{environmental impact}}{\text{unit of resource use}}$$

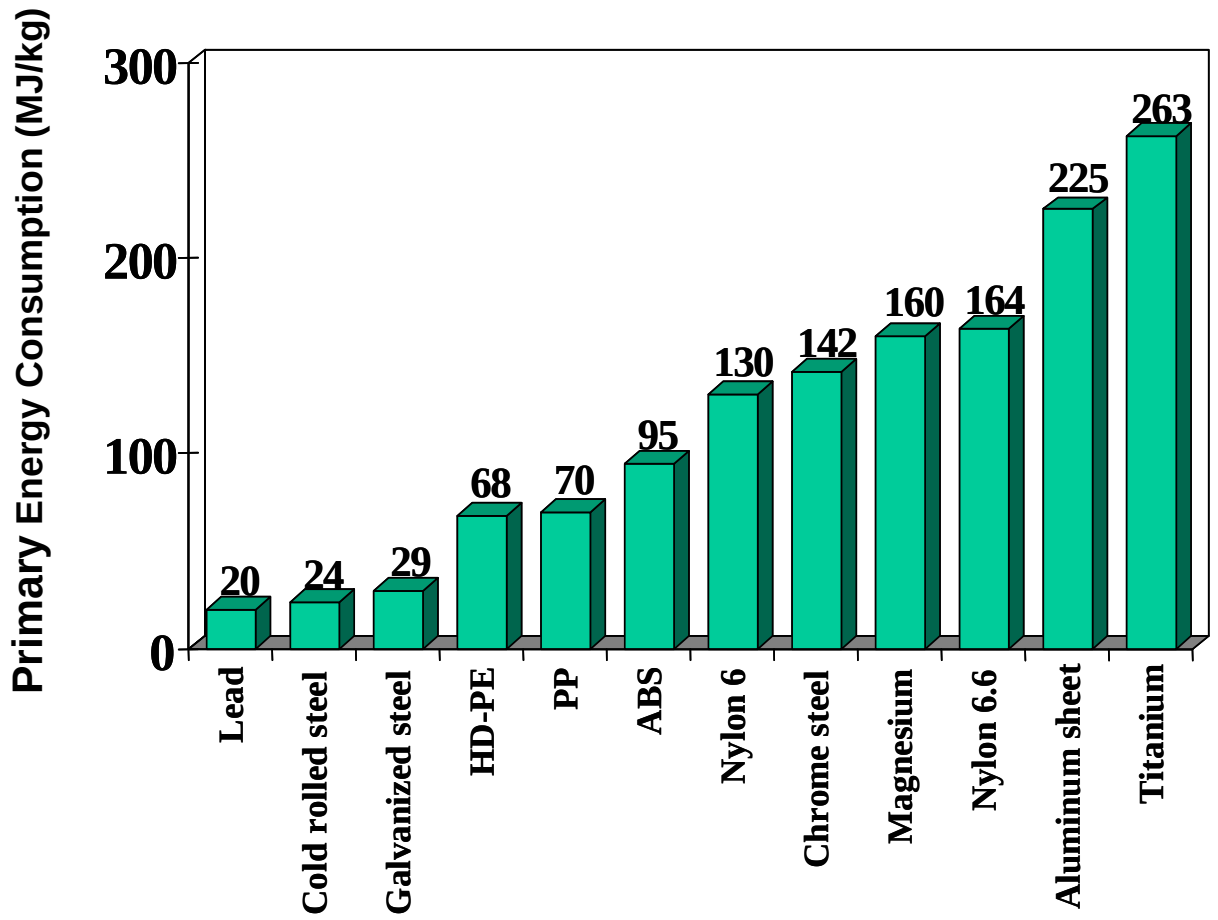
2050/2010

1.5 ↑ 3 ↑ 2 ↑ ?? ↓

Environmental Improvement in The Netherlands



Embedded Energy for Different Industrial Materials



Source: M. Schukert et al., *3rd Intl. Conf. Ecomaterials.,* Tokyo, 1997

Highland Valley Canada Copper Mine Empoundment

Source: switttersb.wordpress.com/2008/08/

Implications for Policy of Resource Supply and Use

- Virgin resources are being used at increasing rates
- We demand resources without a good idea of the ultimate quantities available for extraction
- The master equation demonstrates that absolute decoupling will be a product of addressing the technical and societal relationships that link personal wealth, development, and consumption
- New recycling technology and design for recycling will help, but major cultural changes to “dematerialize” wants and needs are probably the most effective way to insure long term sustainability

The Challenge of Decoupling Needs and Wants from Their Realization