European Commission

Assessing natural resources as area of protection in sustainability assessment

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1. Introduction

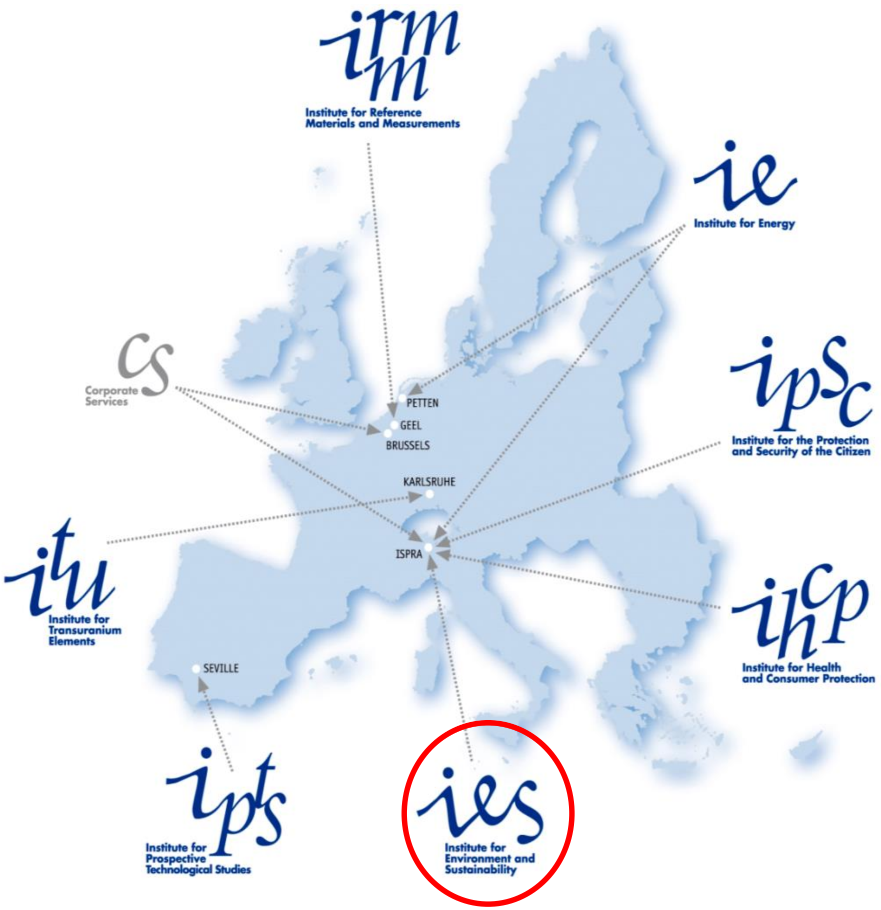
The JRC inside the European Commission

European Commission,

Joint Research Centre (JRC),

Institute for Environment and Sustainability (IES)

"The mission of the IES is to provide scientific-technical support to the European Union's policies for the protection and sustainable development of the European and global environment"



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The "Sustainability Assessment" Unit

The Sustainability Assessment Unit fosters sustainability principles in EU policies by developing an integrated assessment framework towards environmental quality and socio-economic viability in the decision making process.

Two existing integrative platforms are at the core of the development:

- The Land Use Modelling Integrated Sustainability Assessment Platform (LUMP/LUISA)
- The European Platform on Life Cycle Assessment (EPLCA).

Ghent University:

Research group ENVOC:
- Education at Ba and Ma:
  mainly in Bioscience Engineering curricula
- Research in:
  - Environmental chemistry of organic micropollutants
  - Removal of organic micropollutants in waste streams
  - Clean technology:
    - relying on principles of thermodynamics & life cycle assessment
    - method development
    - collaboration with biobased, chemical, pharma, waste & metal sector

2. Natural resources as Area of Protection

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Environmental LCA: three AoP:

- Human Health
- Ecosystem Quality
- Natural Resources

LCA in practice:

EC: Product Environmental Footprint:

- 14 impact categories
- Major emphasis on Human Health & Ecosystem Quality
- Explicitly linked to Natural Resources:
  - Resource Depletion – mineral, fossil
  - Resource Depletion – water
  - Land Transformation

Abiotic resource use category	Operational method	Water	Land	Flow energy resources [a]	Atmosph. resources	Metals and minerals	Fossil energy	Nuclear energy
Resource accounting methods (RAM)	CED / PED			X			X	X
	CE_xD	X		X	X	X	X	X
	ICEC / ECEC	X		X	X	X	X	X
	CEENE	X	X	X	X	X	X	X
	SED	X	X	X	X	X	X	X
	Ecological Footprint		X				X [b]	X [c]
	Water Footprint	X						
	Ecological Scarcity			X		Partial [d]	X	X
	Abiotic depletion potential (fossil fuels) [e]						X	
	Impact 2002+ ('non-renewable energy')						X	X
	Recipe Midpoint (fossil and water depletion)	X					X	
Resource depletion at midpoint level	EDIP 97/2003			Partial [g]		X	X	X
	Abiotic depletion potential					X		X
	Biotic Production Potential (BPP)		X					
	Ecological Scarcity (water)	X						
	Abiotic depletion potential (water)	X						
Resource depletion at endpoint level	EI99					X	X	
	Impact 2002+ ('mineral extraction')					X		
	Recipe Endpoint					X	X	X
	EPS2000					X	X	X
	Freshwater depletion	X						

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Source: PhD Pilar Swart, 2013

Natural resources:
much more than water, conventional fossils and minerals …

Impact category?
Characterization factors?

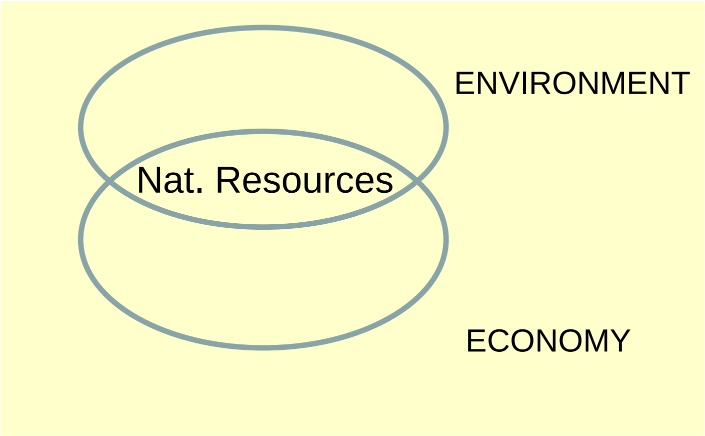
Natural resources in LCA:

- Anthropocentric perspective:
  - 'decreased availability'
  - 'Future effort'

  = provisioning for humans
- Natural resources:
  - also other 'ecosystems services'*:
    – regulation services:

      mediation,filtration, …
    - cultural services:

      aesthetic,heritage, …
  - even a role in an ecocentric perspective:
    - habitat
    - Inorganic/organic elements in biogeochemical cycles



*see CICES Classification:
Maes et al., Mapping and Assessment of Ecosystems and their services, JRC-EC, 2013

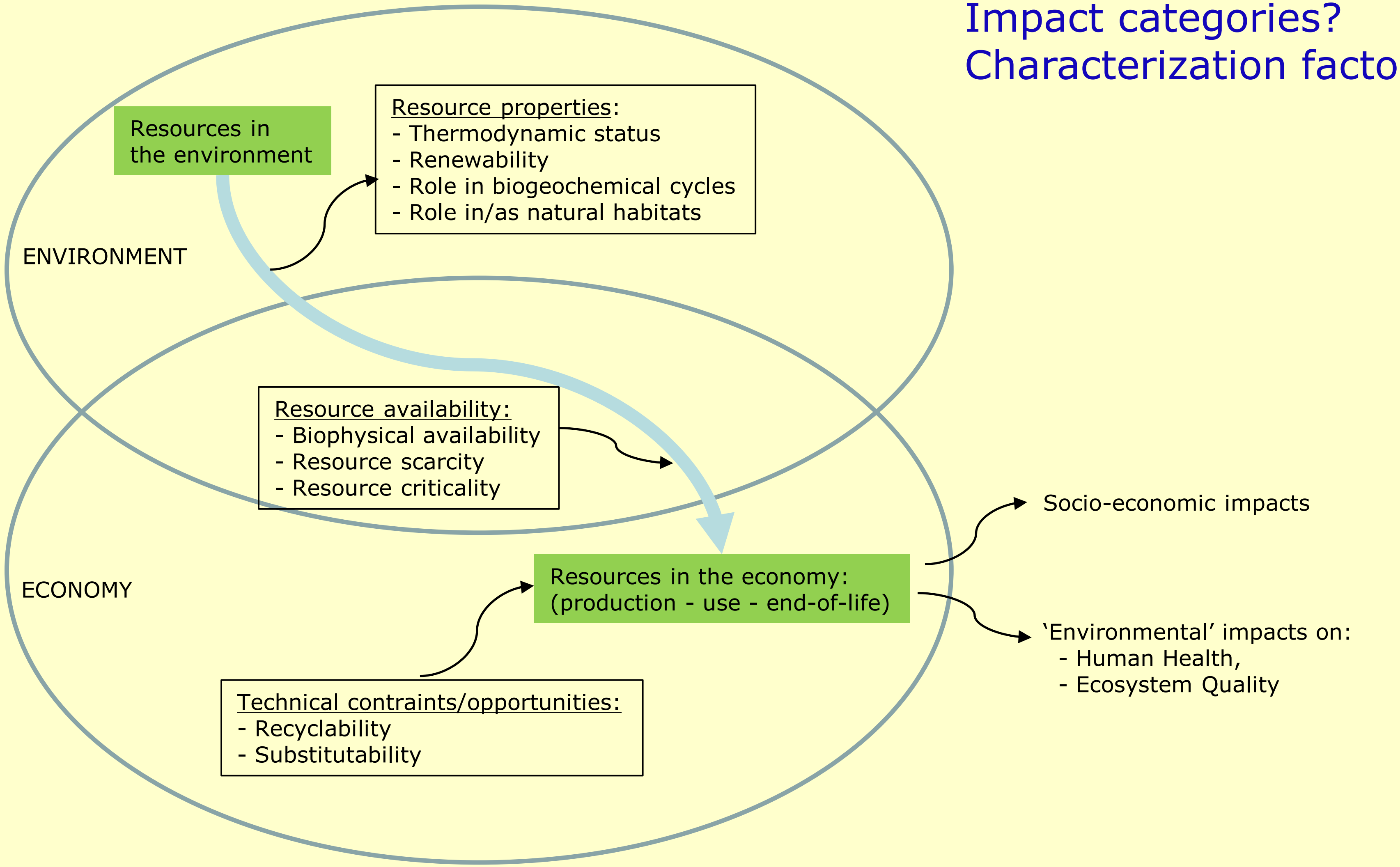
What do we like to "protect" with AoP "Natural resources":

- Natural resources in an ecocentric context?
  - natural resources in shaping natural habitats
  - natural resources in natural biogeochemical cycles

- Natural resources from their service point of view?
  - Provisioning services
  - Regulating services
  - Cultural services

- Natural resources from their role in society?
  - Economic sustainability?
  - Social sustainability?

Impact categories?
Characterization factors?



see also:
Mancini et al., Security of supply and scarcity of raw materials. JRC-EC, 2013

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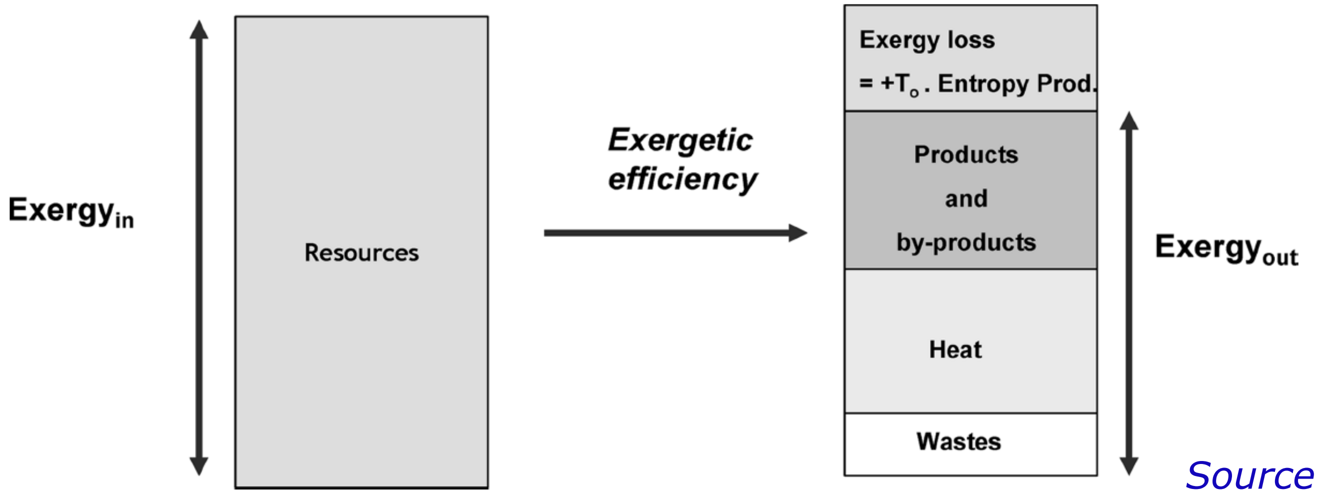
3. Natural resource accounting with exergy

Exergy:

Maximum amount of work we can obtain from a resource



Source: Dewulf et al., ES&T, 2008

Cumulative Exergy:

Maximum amount of work we have taken away in a life cycle perspective: at the 'cradle'

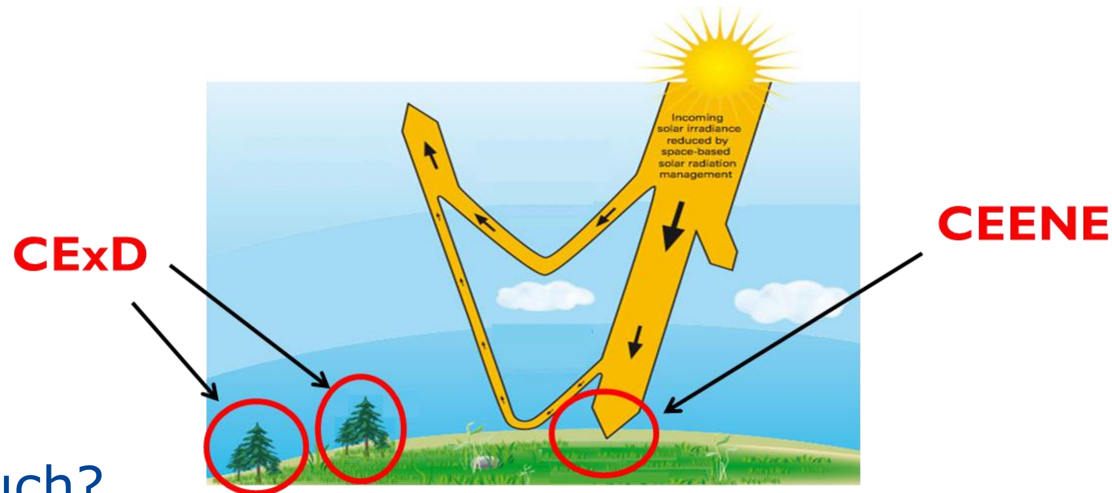
Methods/characterisation factor for natural resources:

- CExD: Bösch et al., ES&T, 2007
- CEENE: Dewulf et al., ES&T, 2007

Cumulative Exergy for natural resources:

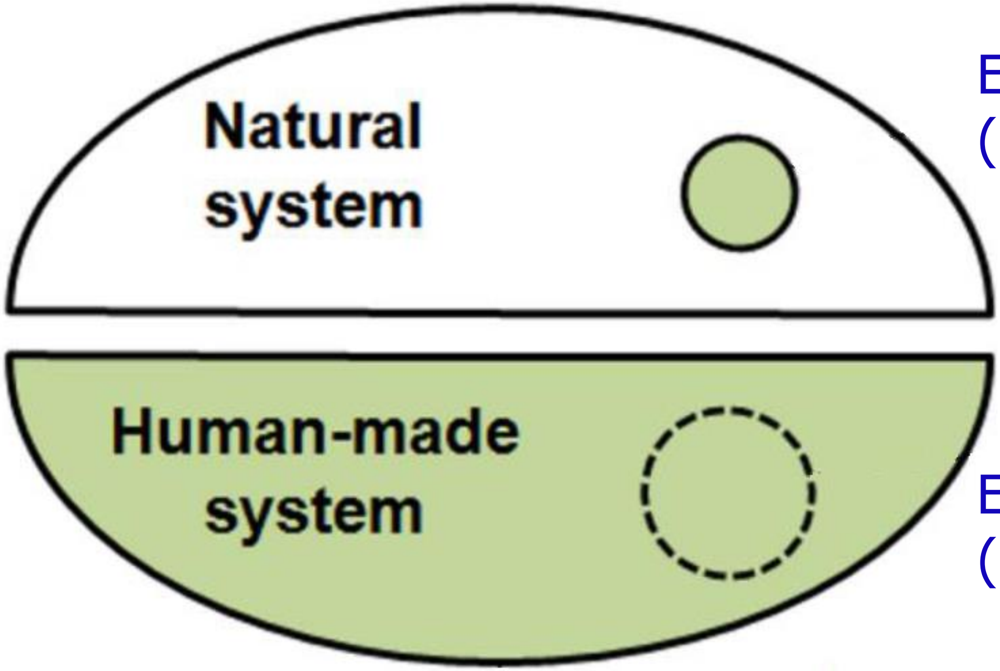
- Accounting thermodynamic value
- All kind of resources can be characterized
- Challenge: land occupation/biomass:

  how do we quantify what we have taken away by depriving land from the naturalenvironment?



- Biomass harvested?
- Solar radiation? How much?
- Ability to natural NPP?
- extensive/intensive land use?

Natural vs. Human-made systems:

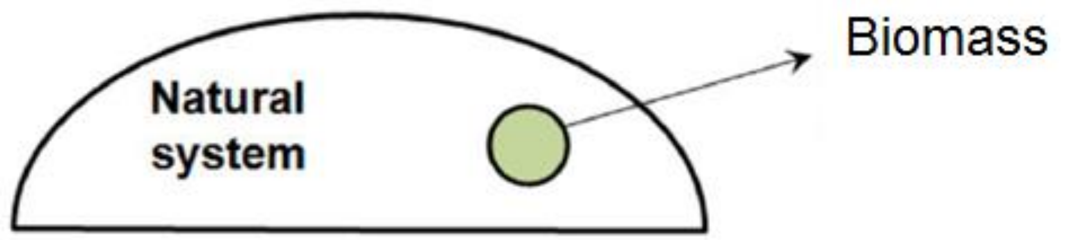


E.g. Wood from natural forest (South America)

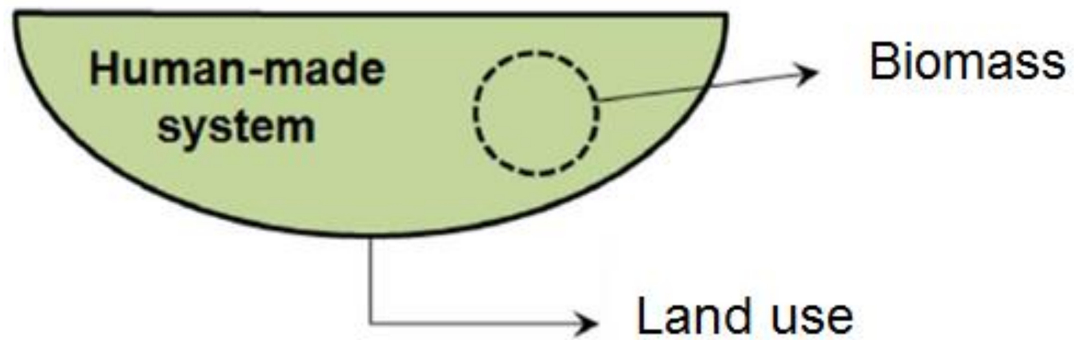
E.g. Wood from intensive forest (Scandinavia); Agriculture

Source: Alvarenga et al., IJLCA, 2013

- For natural systems → Biomass content (as CExD):



- For human-made system → Land (as CEENE), but using the natural potential NPP as proxy



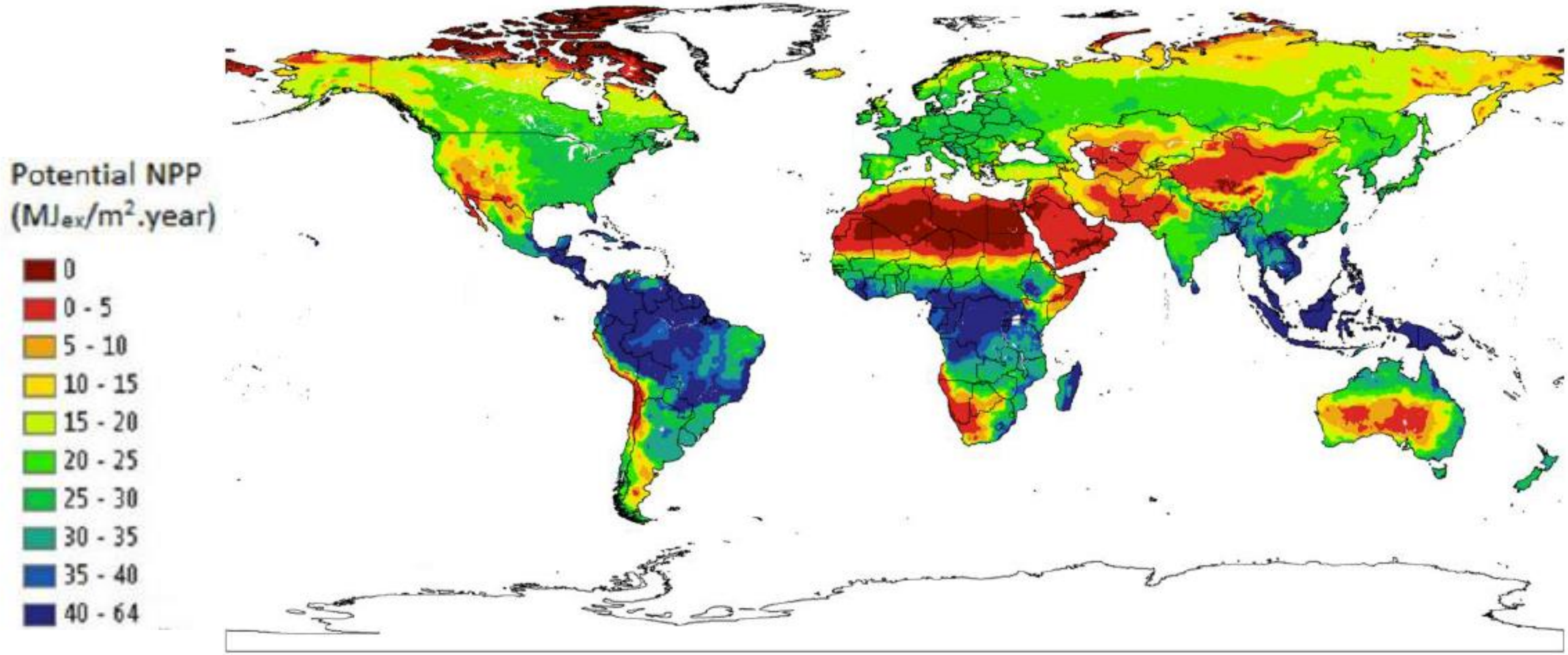
- NPP = Net primary production:

The amount of biomass produced in a certain land area, at a certain time

- Natural potential NPP:

the amount of natural biomass that **would be** produced in a certain land, if not occupied by humans

◦ Haberl et al. (2007) → Worldwide data



Source: Alvarenga et al., IJLCA, 2013

4. Ore grade change as indicator for metals

- Methods to determine impact on resource availability:
  - Ore grade based methods closest to mining reality

- Typical limitations:
  - Use of old data and simplifying assumptions
  - Co-mining not consistently considered
  - use of fixed costs per kg of ore
  - relation between ore grade, technology and effort

- To be verified with data from actual mining practice

Data source: Raw Materials Data

Contains data on individual mines located all over the world for the years (1998-2010):

- ore production
- ore grades
- metal production per metal
- mine type: underground, open pit

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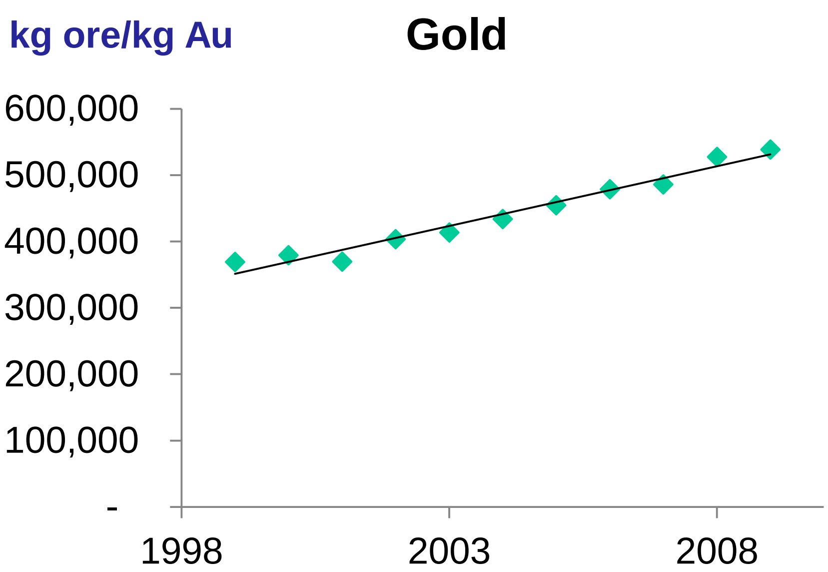
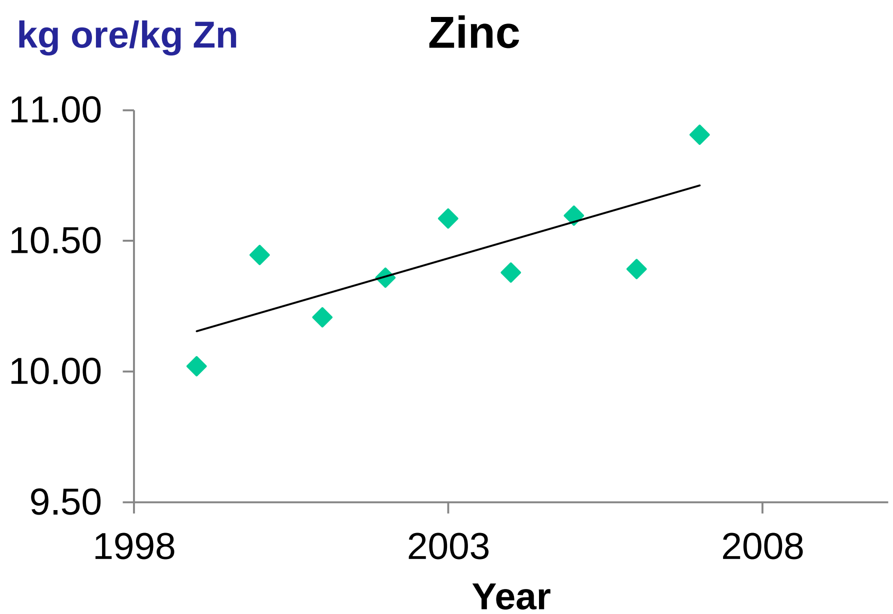
Typically more than one metal produced at a mine:
need to distribute ore quantity over the produced metals, based on economic value of the metals

$$\text{Average ore production for metal } i = \frac{\sum \text{ore production attributed to metal } i}{\sum \text{metal } i \text{ contained in ore}}$$

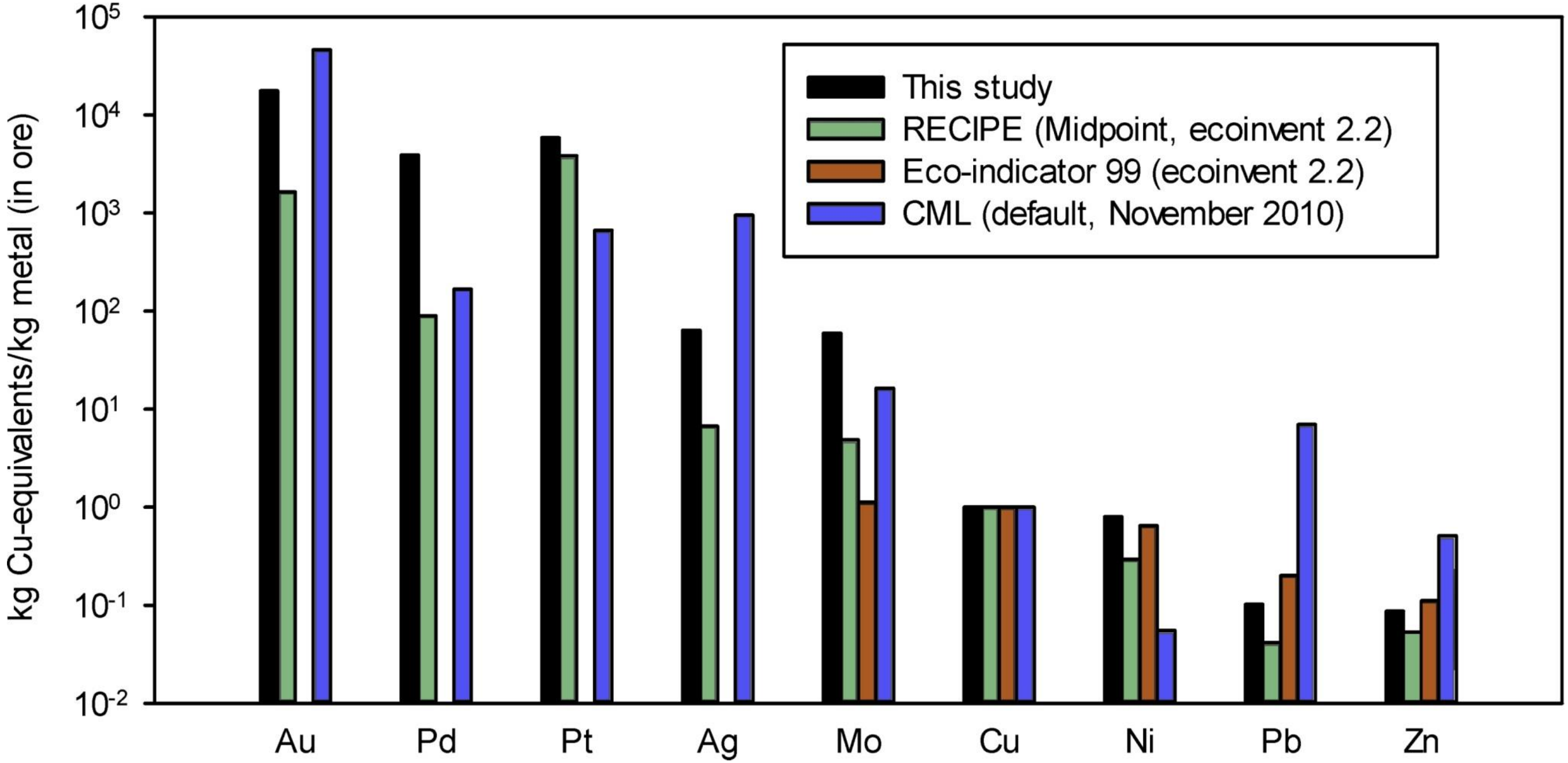
Results: Evolution of average ore demand



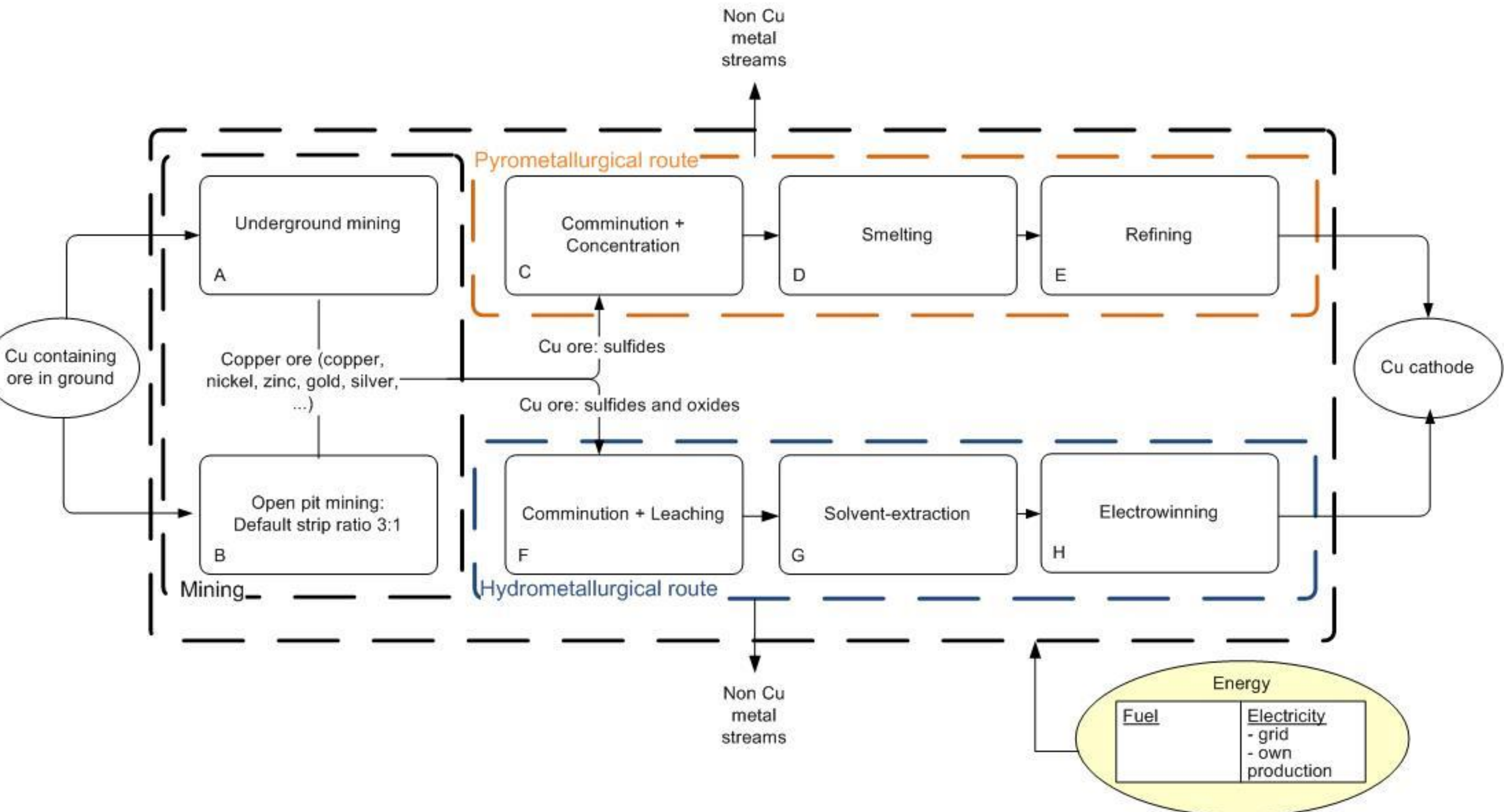


Source: Swart & Dewulf, RCR, 2013

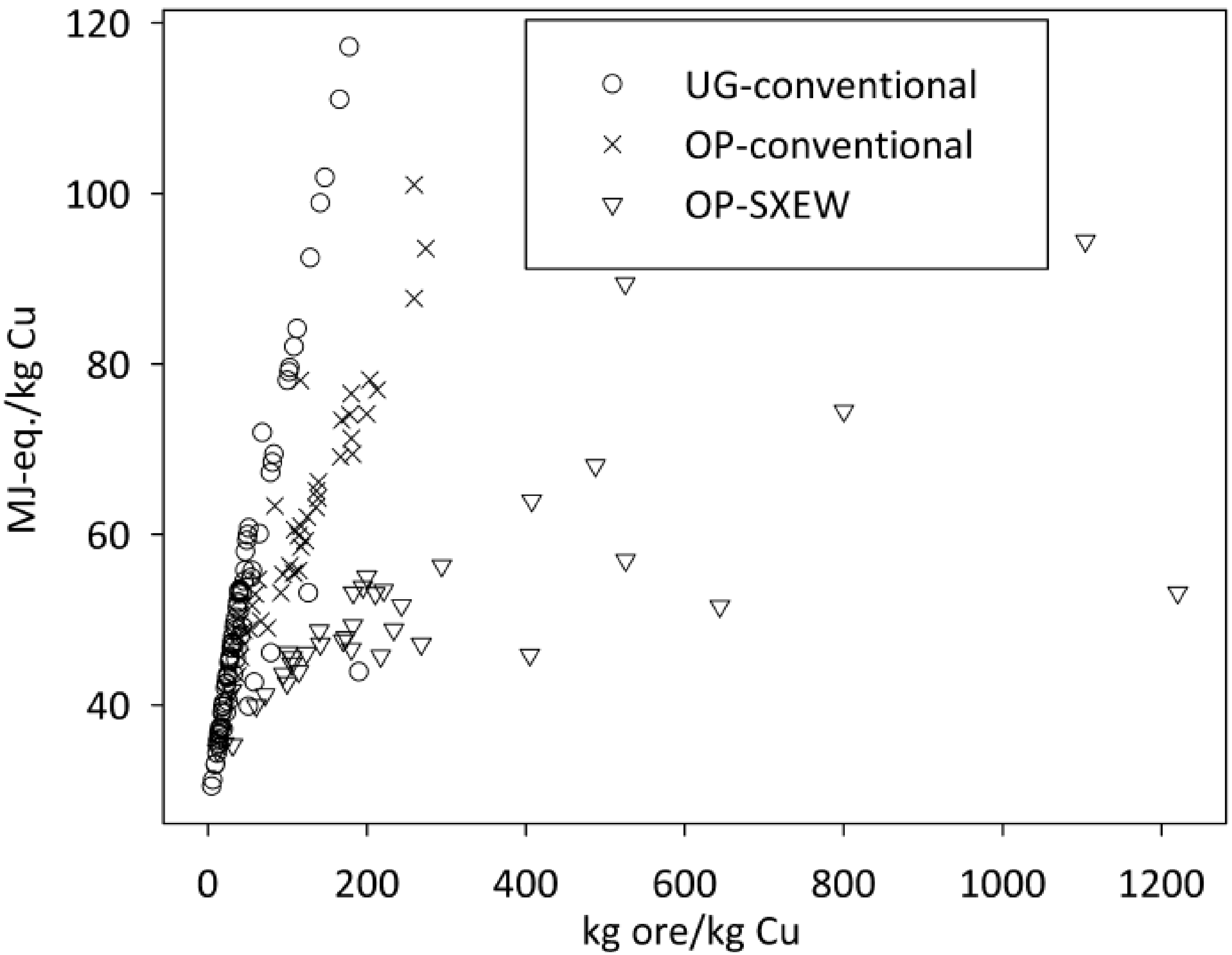
Results: Slope as indicator compared to existing methods for metal resource impacts (Cu=1)



Technology innovation:
overcoming ore grade quality decrease?



Efforts/Energy: not necessarily linear with ore grade



Source: Swart & Dewulf, ES&T, 2013

5. Criticality of resources

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Critical Raw Materials

Critical (in terms of economic criticality):

"Criticality of a resource means that it is scarce and at the same time essential for the present society."

Methods:

- US: Graedel et al., 2012
- EU: DG ENTR
→ Different methods result in different results …

Impact category?
Characterization factors?

see also:
Mancini et al., Security of supply and scarcity of raw materials. JRC-EC, 2013

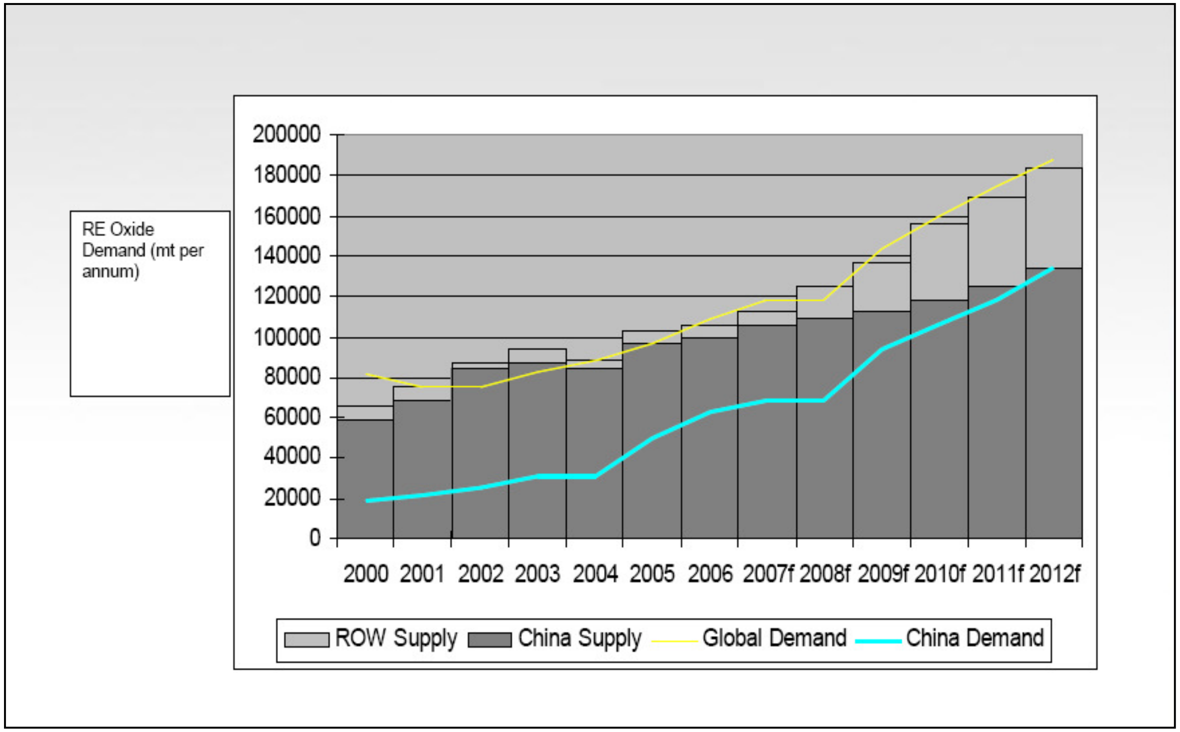
Criticality in the European context: factors:

- Economic importance: added value of the economic sector using a raw material
- Supply risk:
  - level of concentration of worldwide production of a raw material: Herfindahl-Hirschman Index (HHI)
  - political and economic stability of producing countries: Worldwide Governance Indicator, Worldbank (WGI)
  - potential of substitution of a raw material: Substitutability index (experts' judgement) (σ)
  - recycling rate: share of secondary materials in raw material in EU consumption (ρ)

$$SR_i = \sigma(1 - \rho_i)\, HHI_{WGI}$$

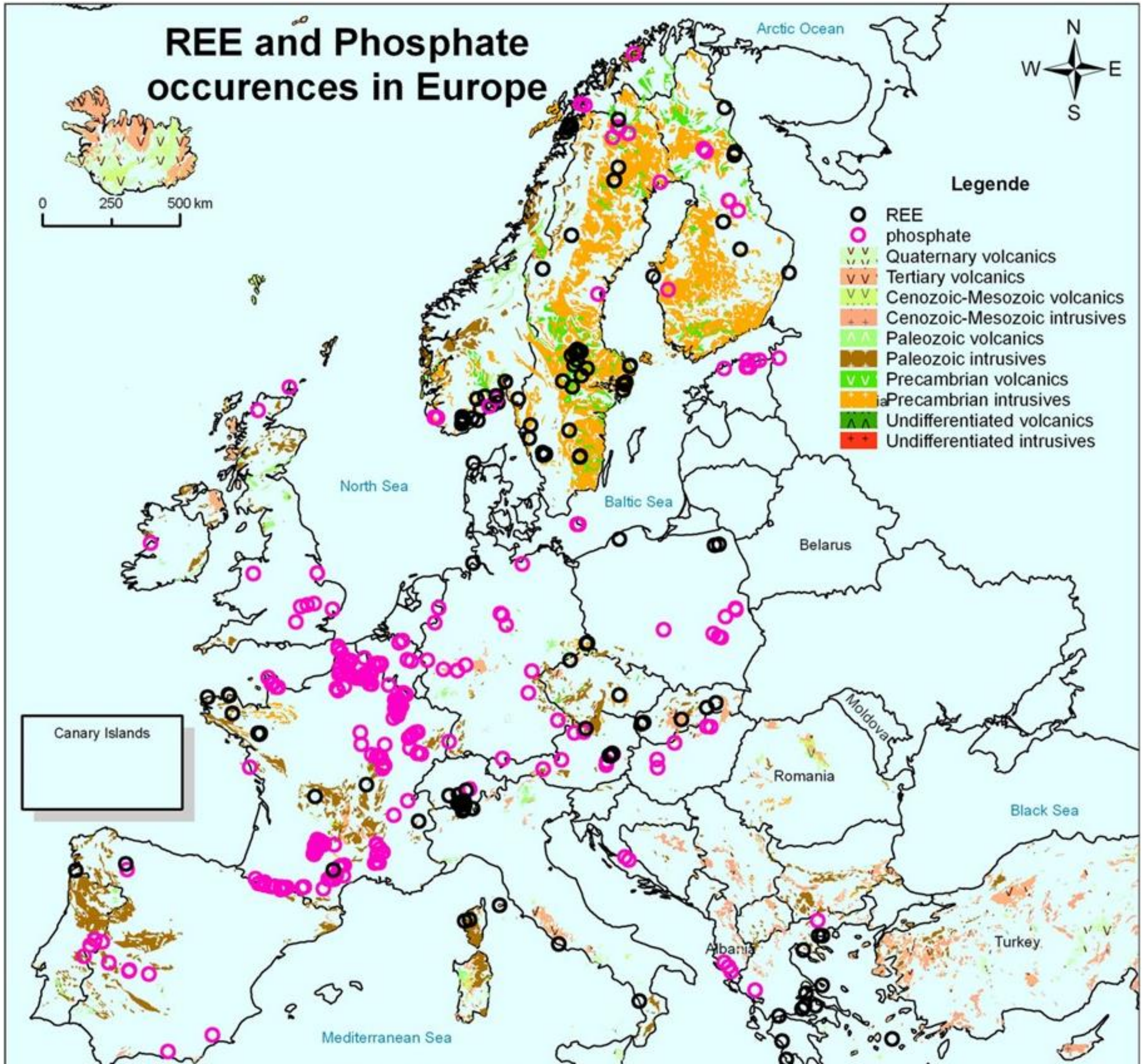
- Environmental country risk: EPI (Country level (!))

CRM: a changing framework …



-China’s own demand was expected to reach its production in 2012

- China restricted the REEs exports at 13% per year since 2004



Source:
Sadeghi et al.,
J. Geochem. Expl.,
2013

6. Conclusions

Available work on AoP Natural Resources:

- AoP Natural Resources in environmental LCA:
  - incomplete list of natural resources covered
  - anthropocentric point of view
- AoP Natural Resources:
  Need to see it beyond environmental LCA
- Natural resources as AoP in Sustainable development, relying on:
  - elements of classical environmental LCA
  - Ecosystem services?
  - Role in ecosystems as such?
  - Economic sustainability: criticality as a base?
    - primary supply risk
    - management in society (e.g. recycling rate)
  - Social LCA:
    - SHDB: negative impact
    - What about positive impact?

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http://sa.jrc.ec.europa.eu/ (Sustainability Assessment Unit website)