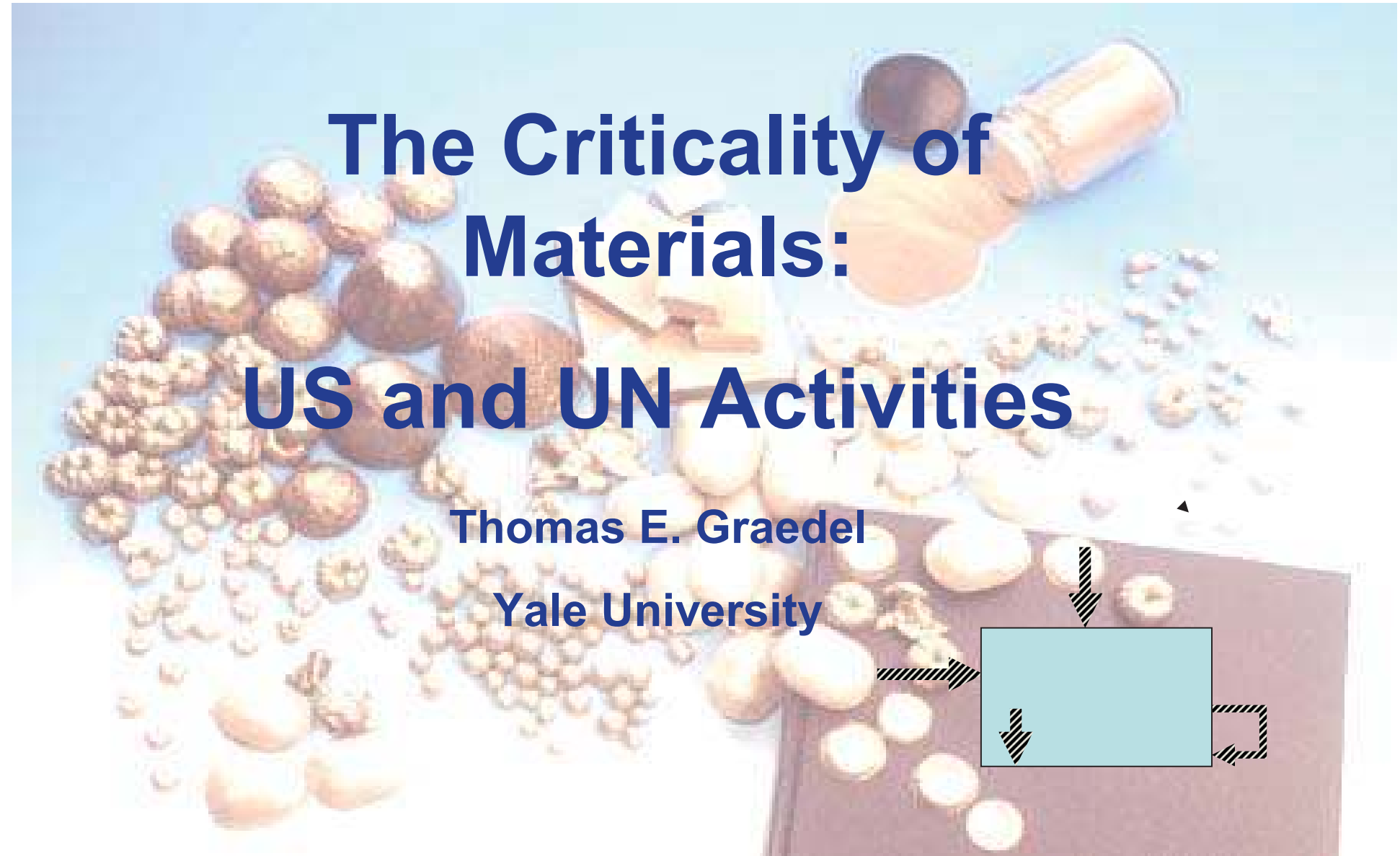




# The Criticality of Materials: US and UN Activities

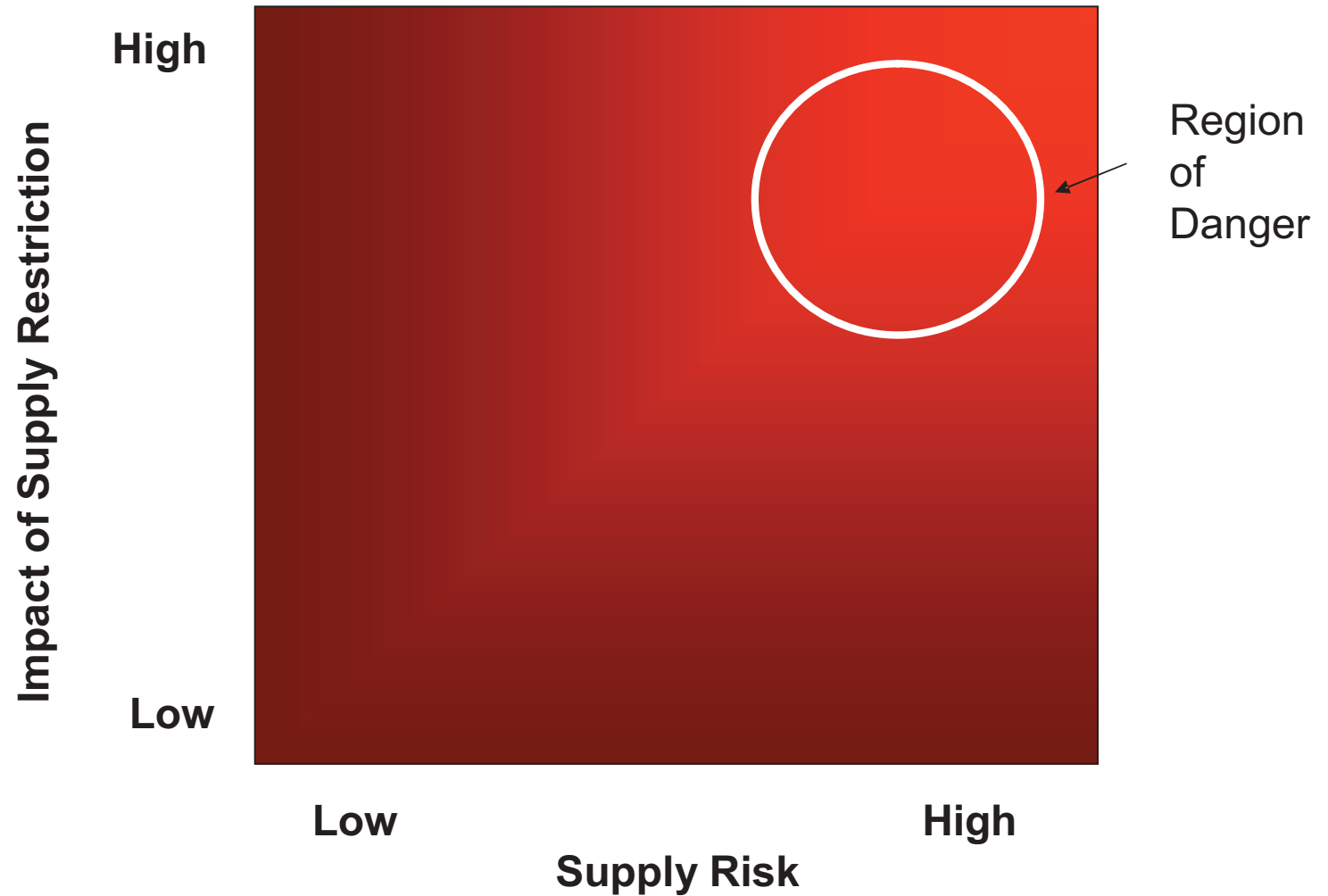
Thomas E. Graedel

Yale University

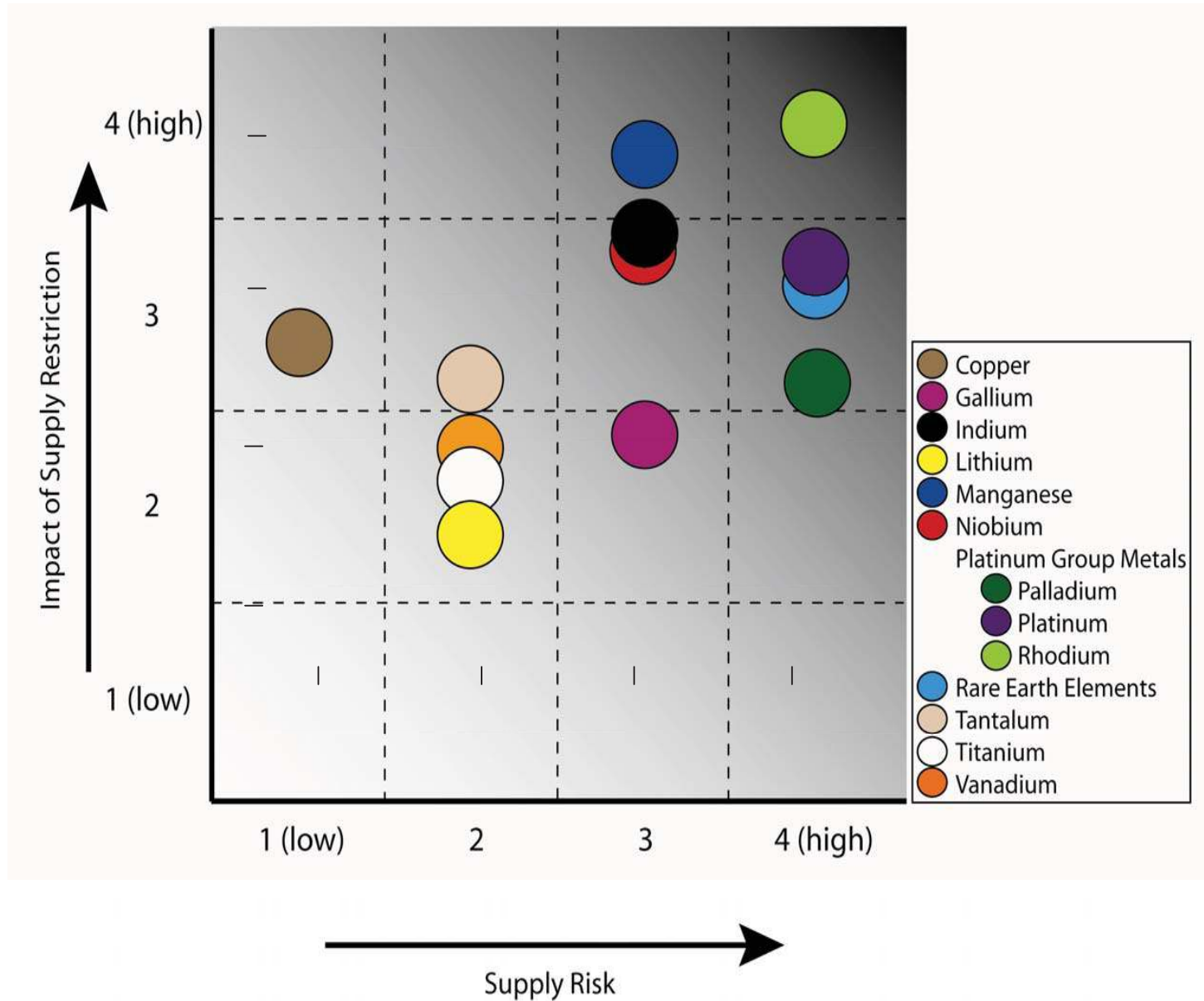


The U.S. National Academy of Sciences  
2007 Study of Resource Sustainability

## The Criticality Matrix, and the “Region of Danger”



# 11 Minerals Evaluated

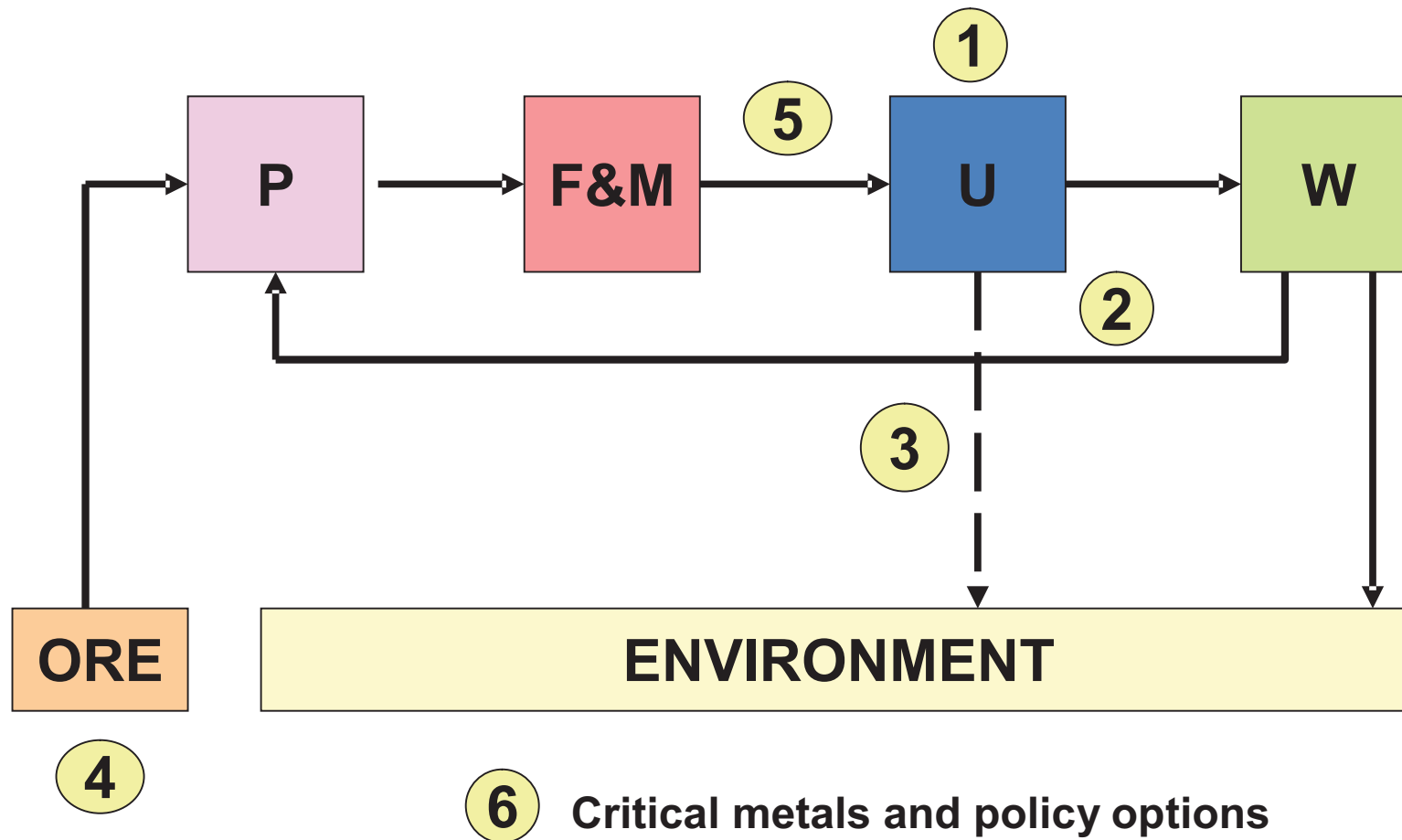


# The U.N. International Panel on Sustainable Resource Management



**International Panel  
for Sustainable  
Resource Management**

# Reports of the Global Metal Flows Working Group



# Recycling rates of metals

- Investigation of 60 different metals: ferrous (iron-rich), non-ferrous, precious, specialty
- The vital number is the end-of-life recycling rate
- Only a few metals, such as iron and platinum, currently have end-of-life recycling rates above 50%

# Non-Ferrous Metals: Copper Example



Courtesy of International Copper Association



# Recycling Rate for Copper

- Common uses: power distribution, electrical wiring, plumbing
- Usually used in pure form and in rather large pieces, which makes recycling more probable
- Estimated 2009 end-of-life recycling rate: >50% (varies among countries and copper-containing products)

# Specialty Metals: Indium Example



Courtesy of Umicore Precious Metals Refining

# Recycling Rate for Indium

- Strategic metal used for flat panel display glass, lead-free solders, semiconductors, photovoltaics
- Strong growth in gross demand is predicted for indium: from ca. 1,200 tons (2010) to ca. 2,600 tons (2020)
- The current end-of-life recycling rate of indium is below 1%, as is the case for most other specialty metals

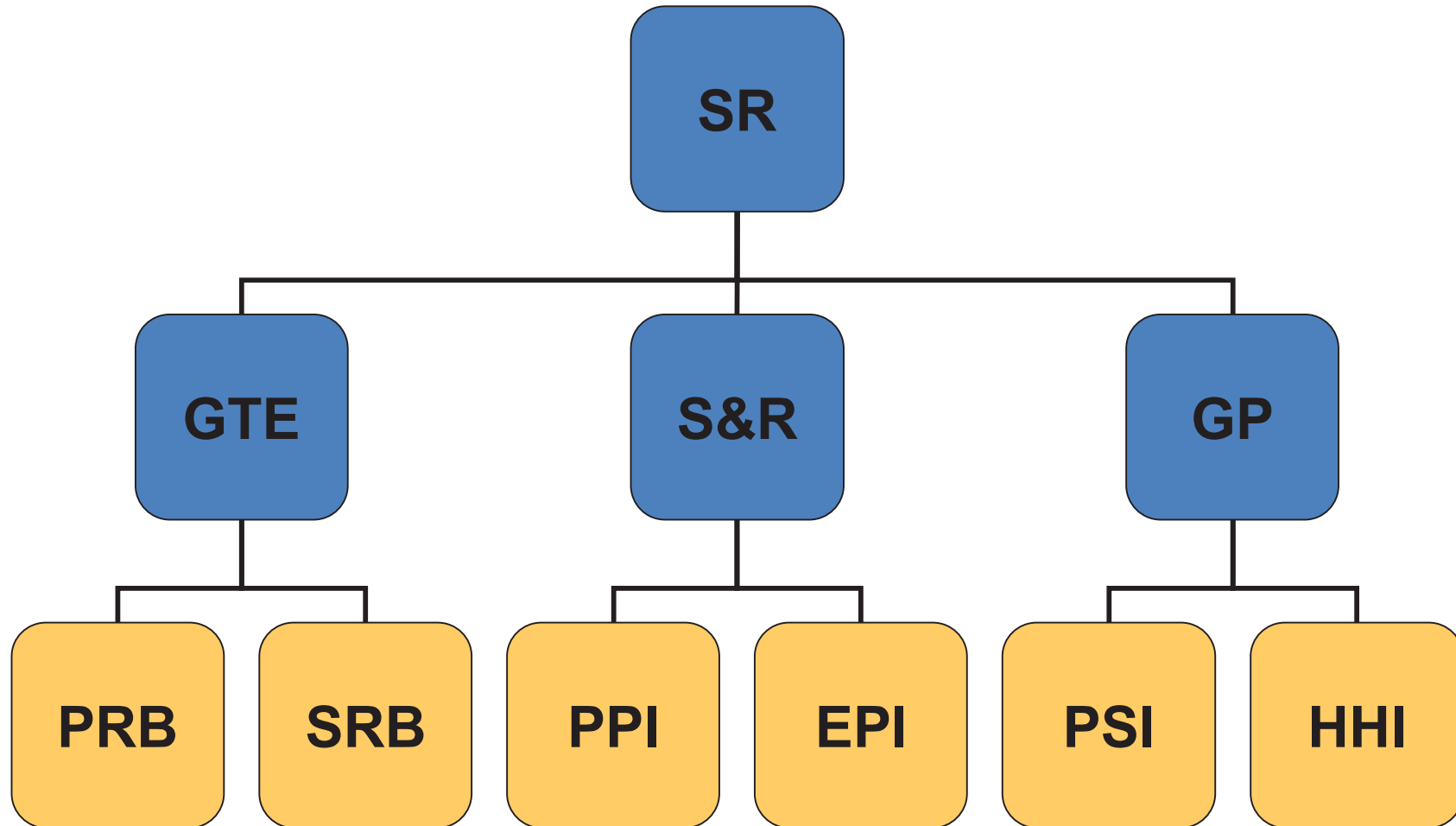
# The Yale Criticality Project

- NSF funded, 2009-2012
- Several undergraduates, several master's students
- 5-10 hours per week each

# Goals of the Yale Criticality Project

- Year 1: Developing a defensible and workable methodology for evaluating the degree to which a metal is “critical”
- Year 2: Using the methodology, evaluate the criticality of a number of different metals
- Year 3: Create a family of scenarios to study the possible evolution of metal criticality

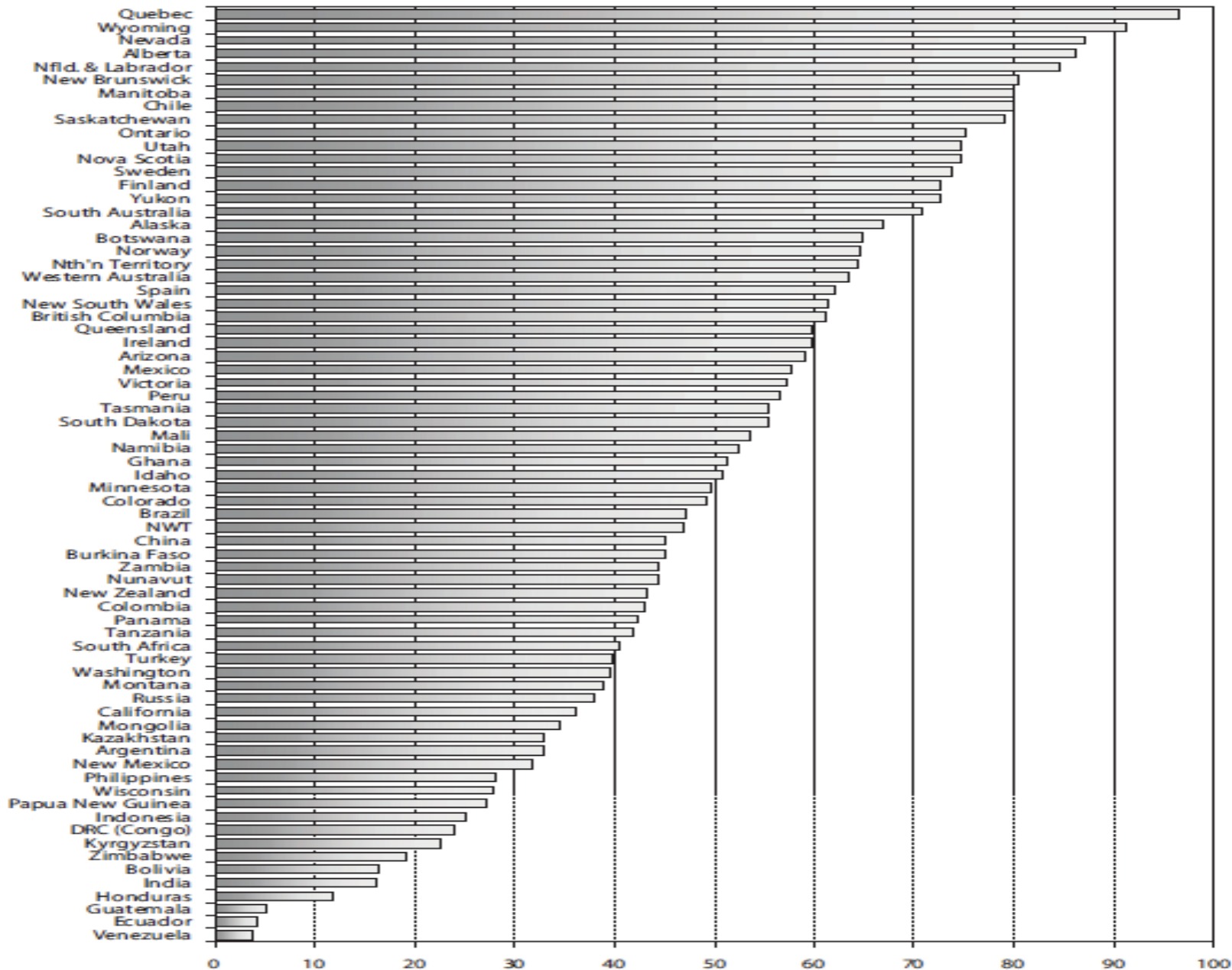
# X Axis –Supply Risk



# Fraser Institute Evaluation Methodology for the Policy Potential Index

- Composite index of 13 factors (taxation, uncertainty concerning native land claims, security, environmental regulation, etc.)
- Scoring (1): For an individual factors, if *every* respondent evaluates a jurisdiction as “1”, it receives a score of 100, as so on down
- Scoring (2): The 13 factor scores for a jurisdiction are added, and a perfect score again normalized to 100

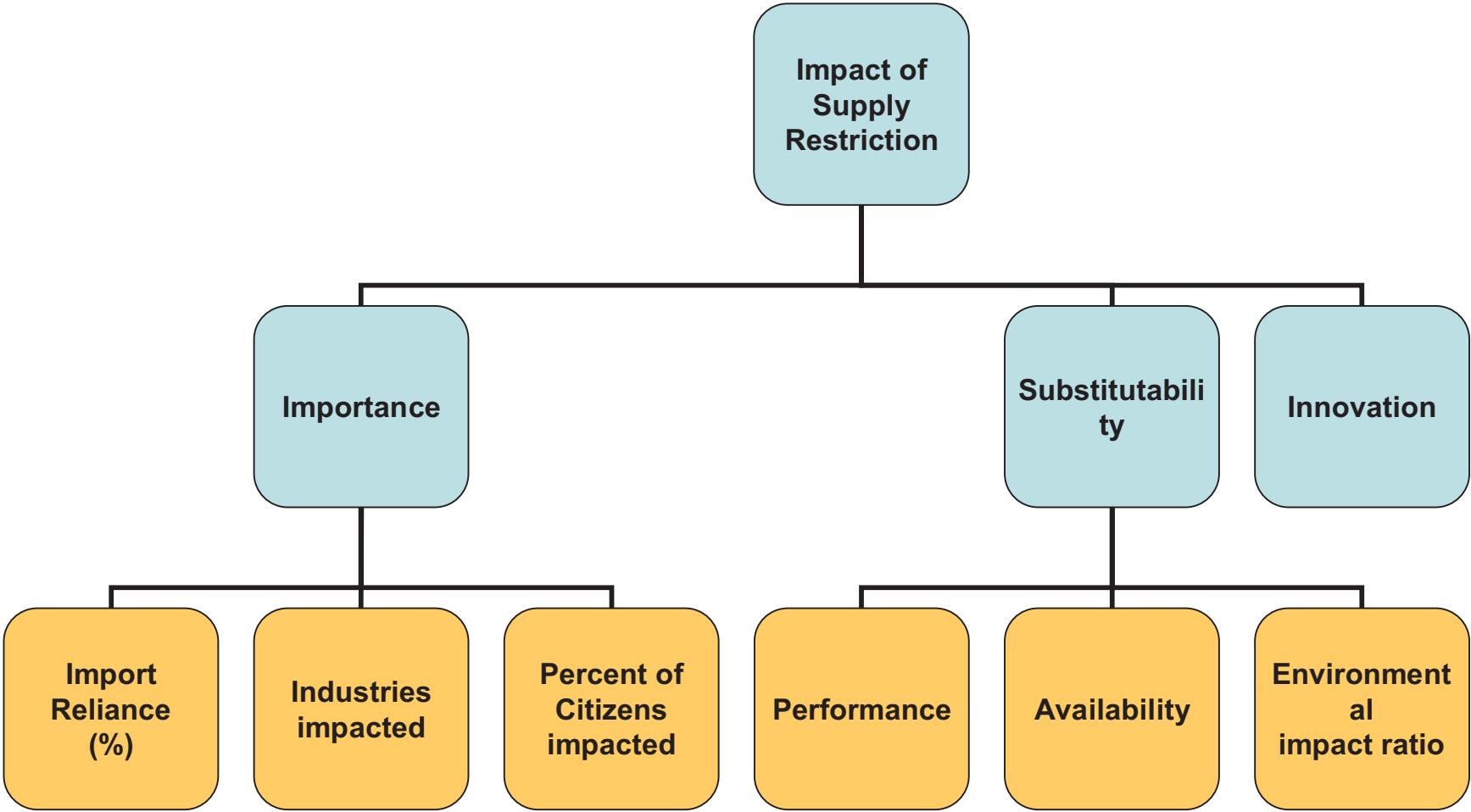
# The Policy Potential Index (2008/2009 rankings)



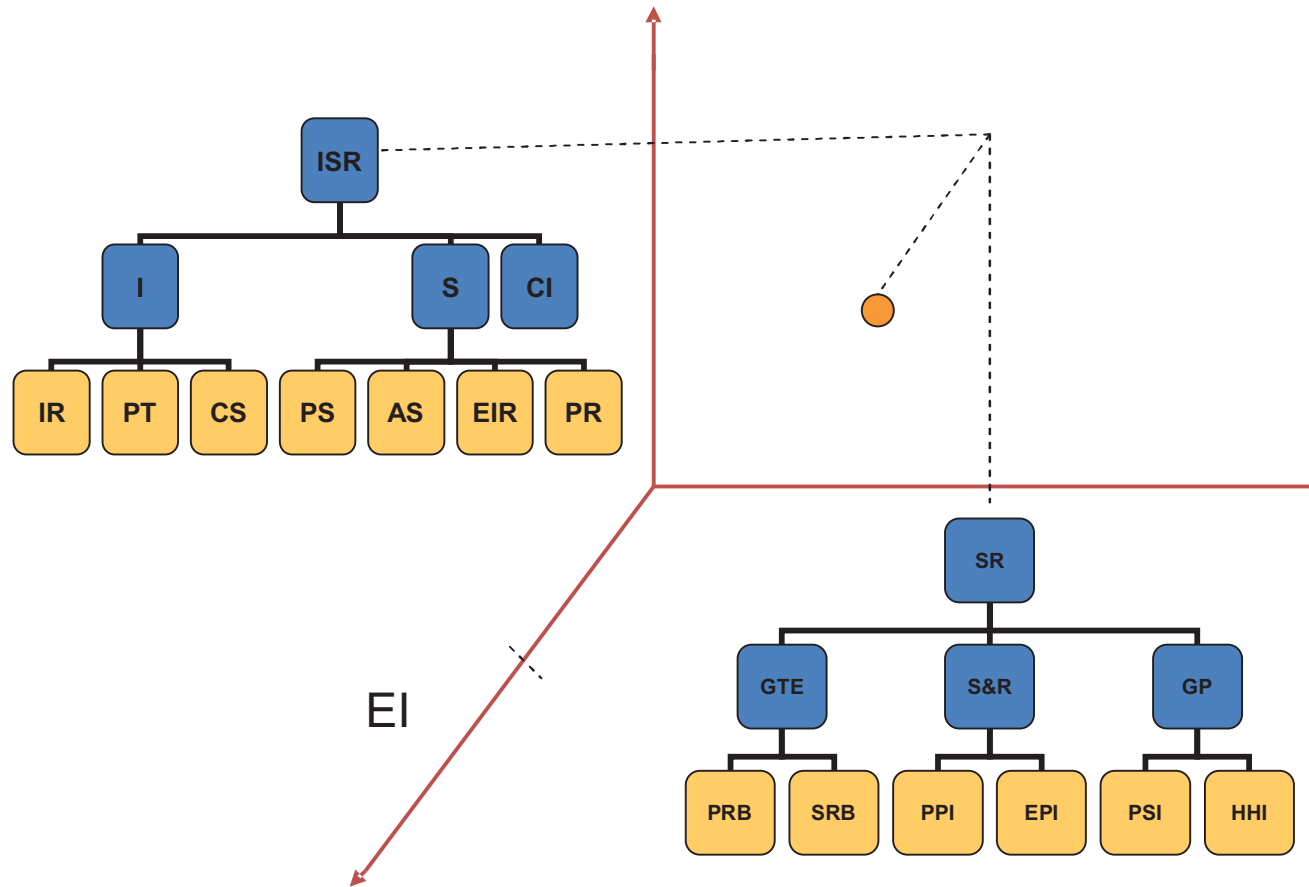
McMahon and Cervantes, 2009



# Y Axis – Impact of Supply Restriction - National



# The Three-Axis Criticality Evaluation Concept



# Summary

- **Many countries and groups of countries have become interested in criticality in the last few years**
- **Methods for evaluation of and choice of metal criticality are thus far diverse, as are the results**
- **Research is now underway in the US to make robust and comprehensive assessments and scenarios of criticality for the entire suite of metals**

# The No-Build” Periodic Table

