The Criticality of Materials:

US and UN Activities

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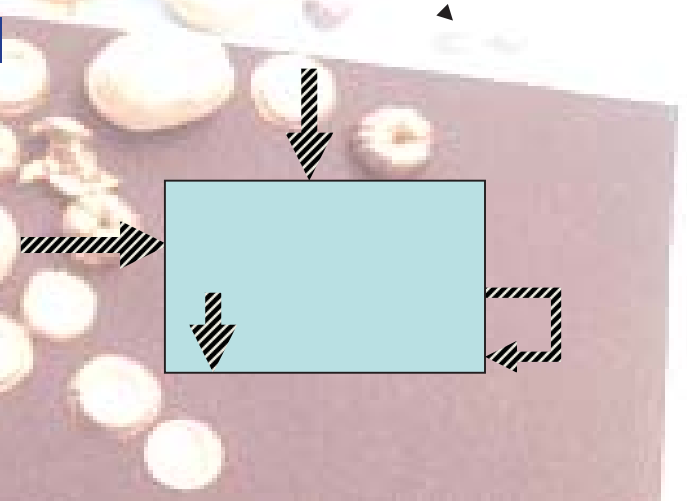
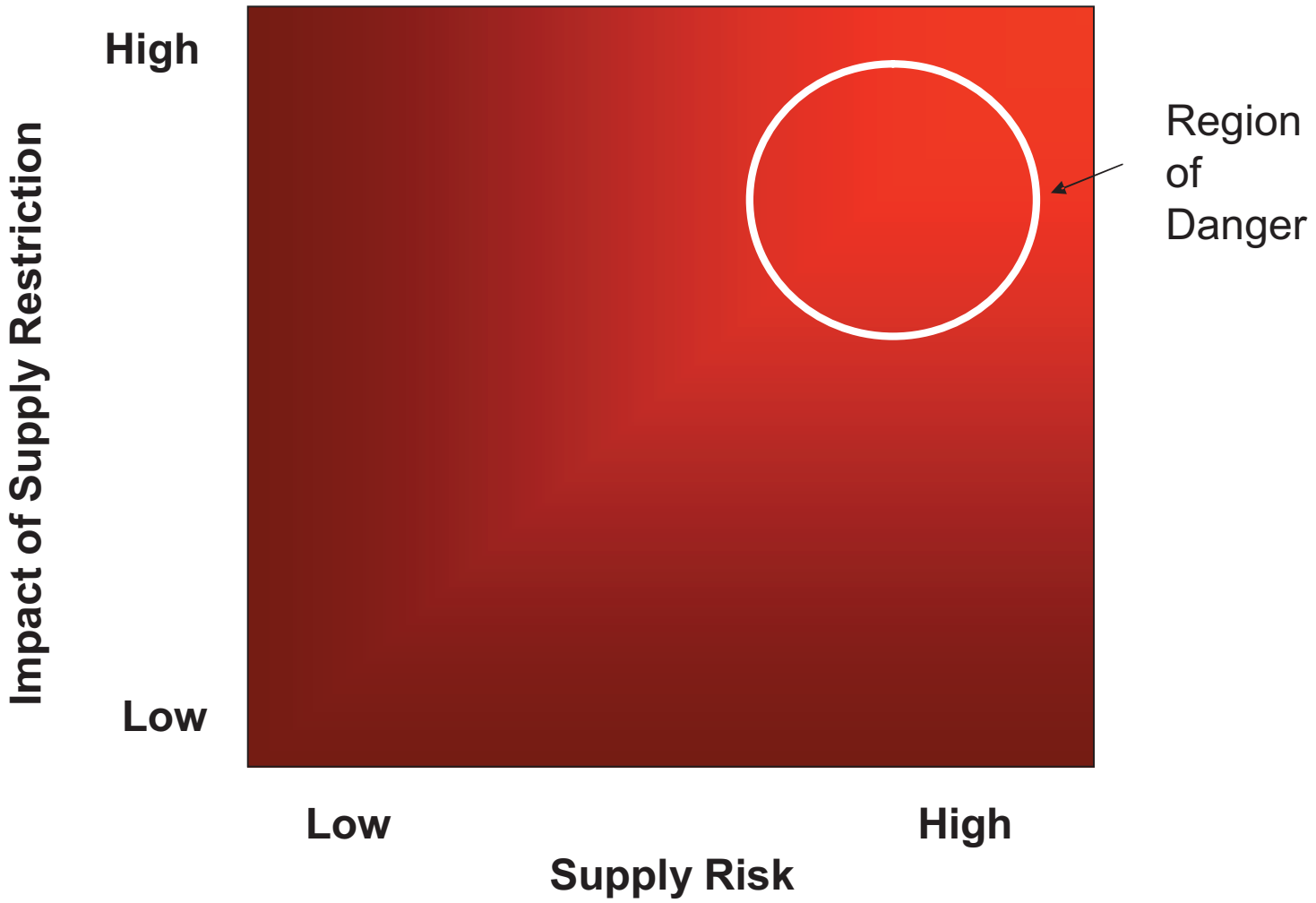
Yale University

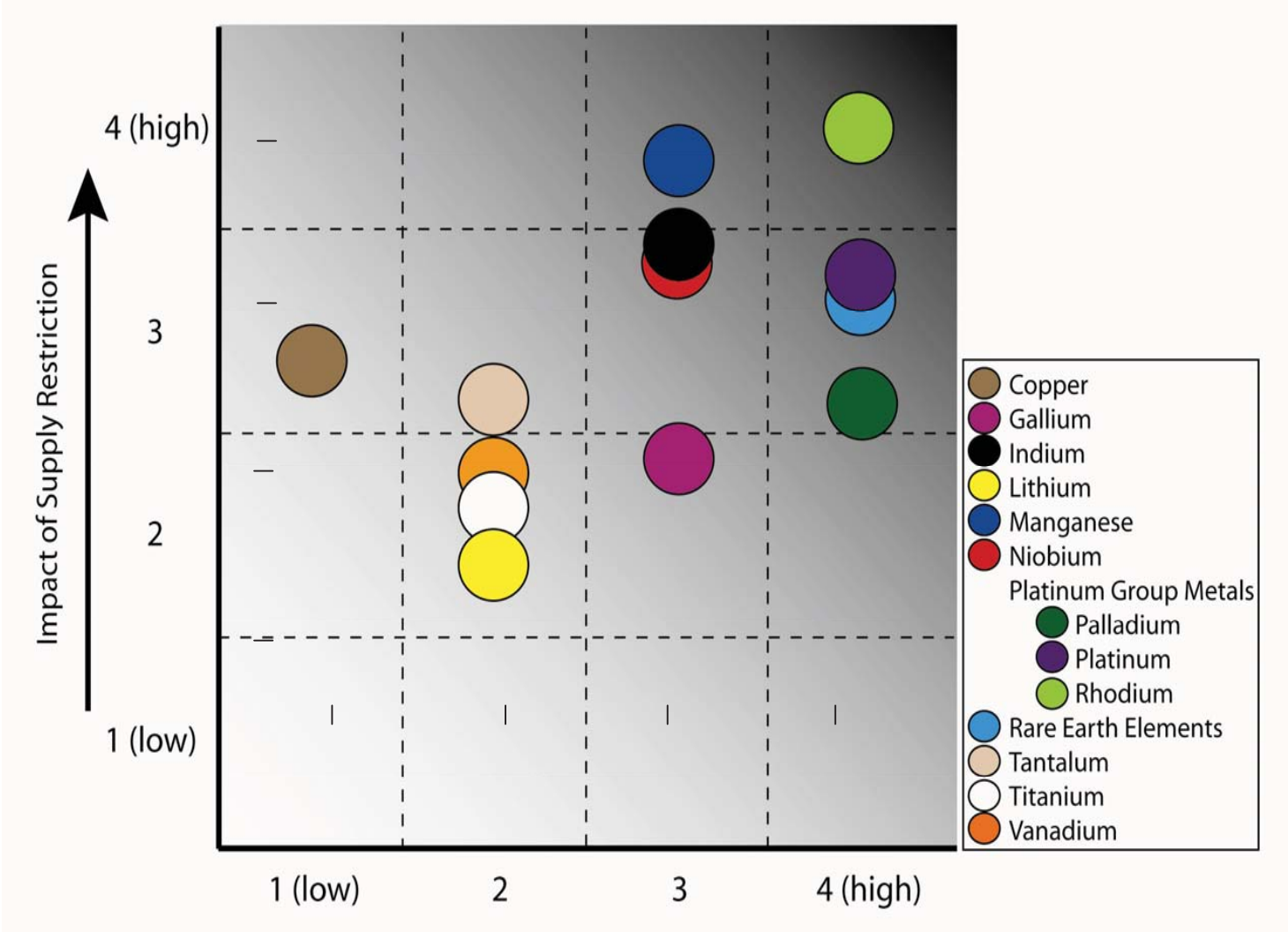


The U.S. National Academy of Sciences 2007 Study of Resource Sustainability

The Criticality Matrix, and the "Region of Danger"



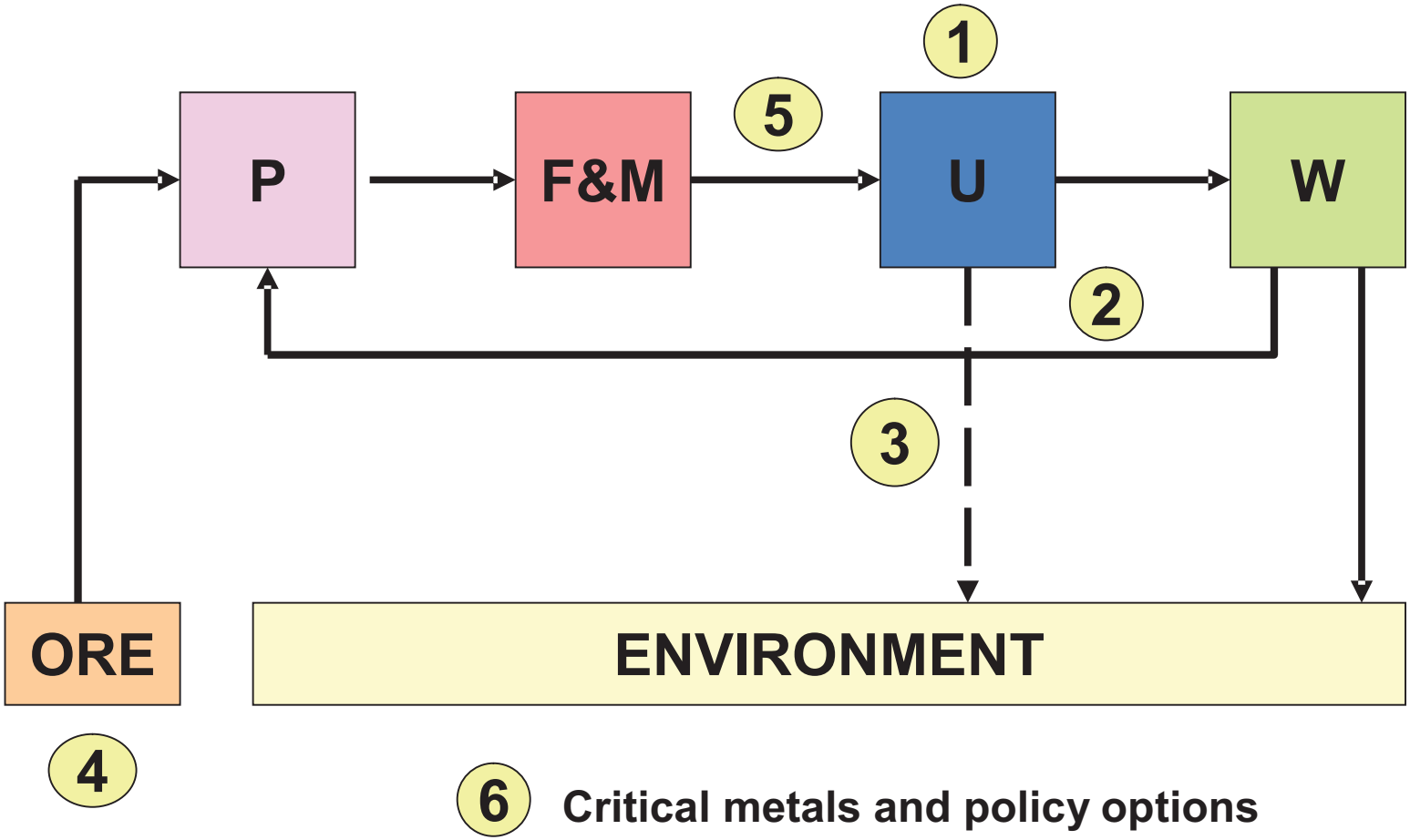
11 Minerals Evaluated



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

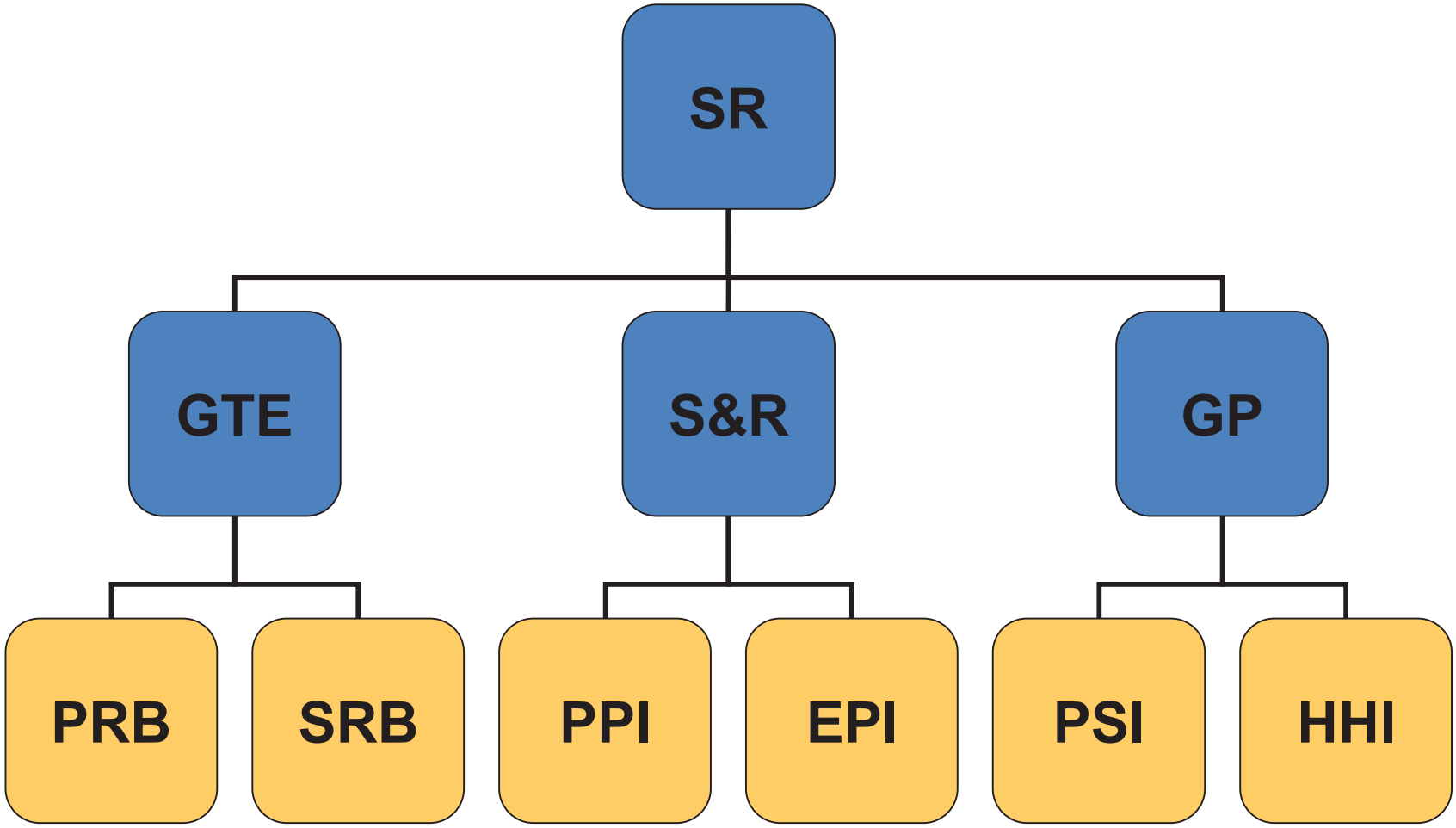
The Yale Criticality Project

- 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 defendable 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

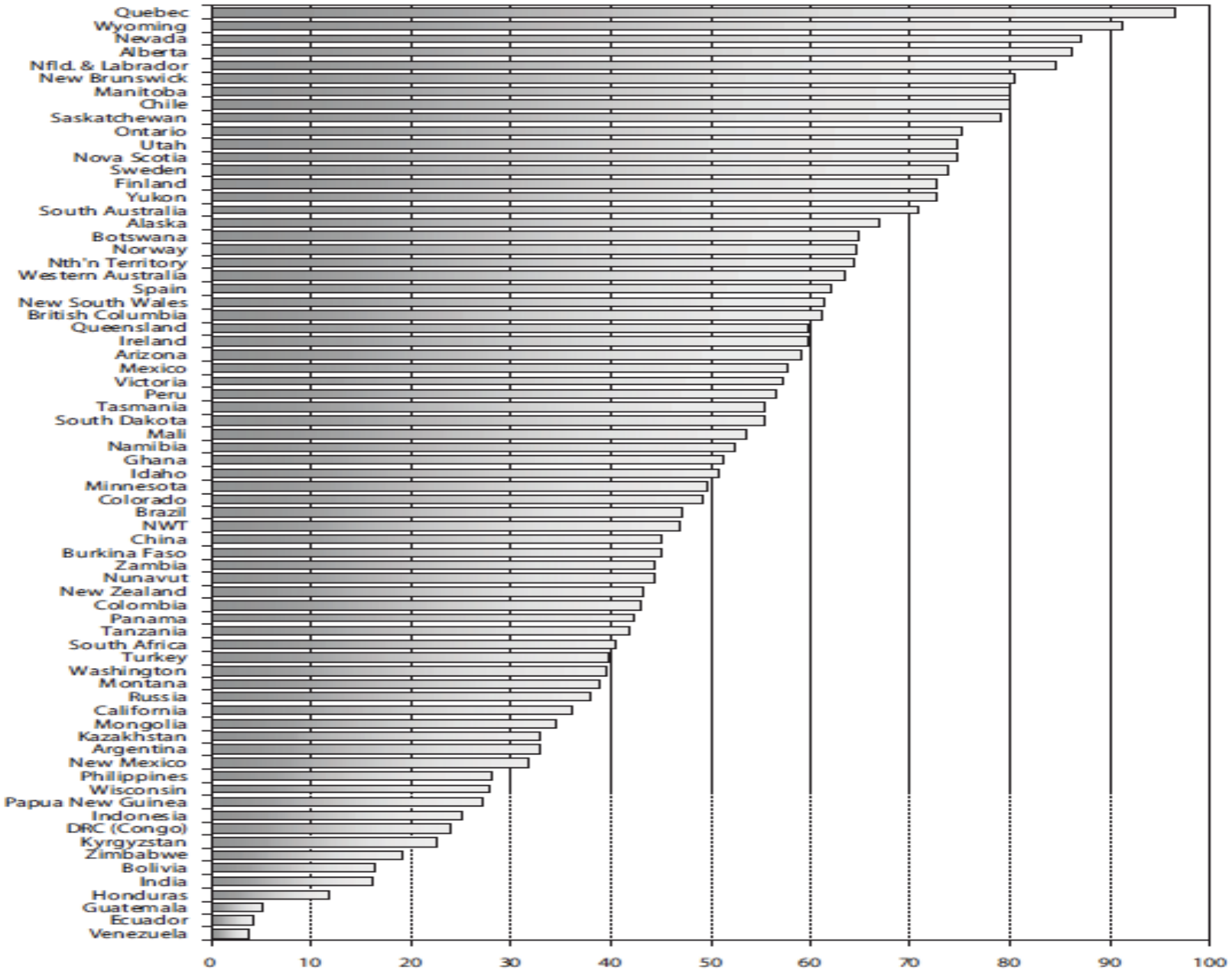
X Axis –Supply Risk



Fraser Institute Evaluation Methodology for the Policy Potential Index

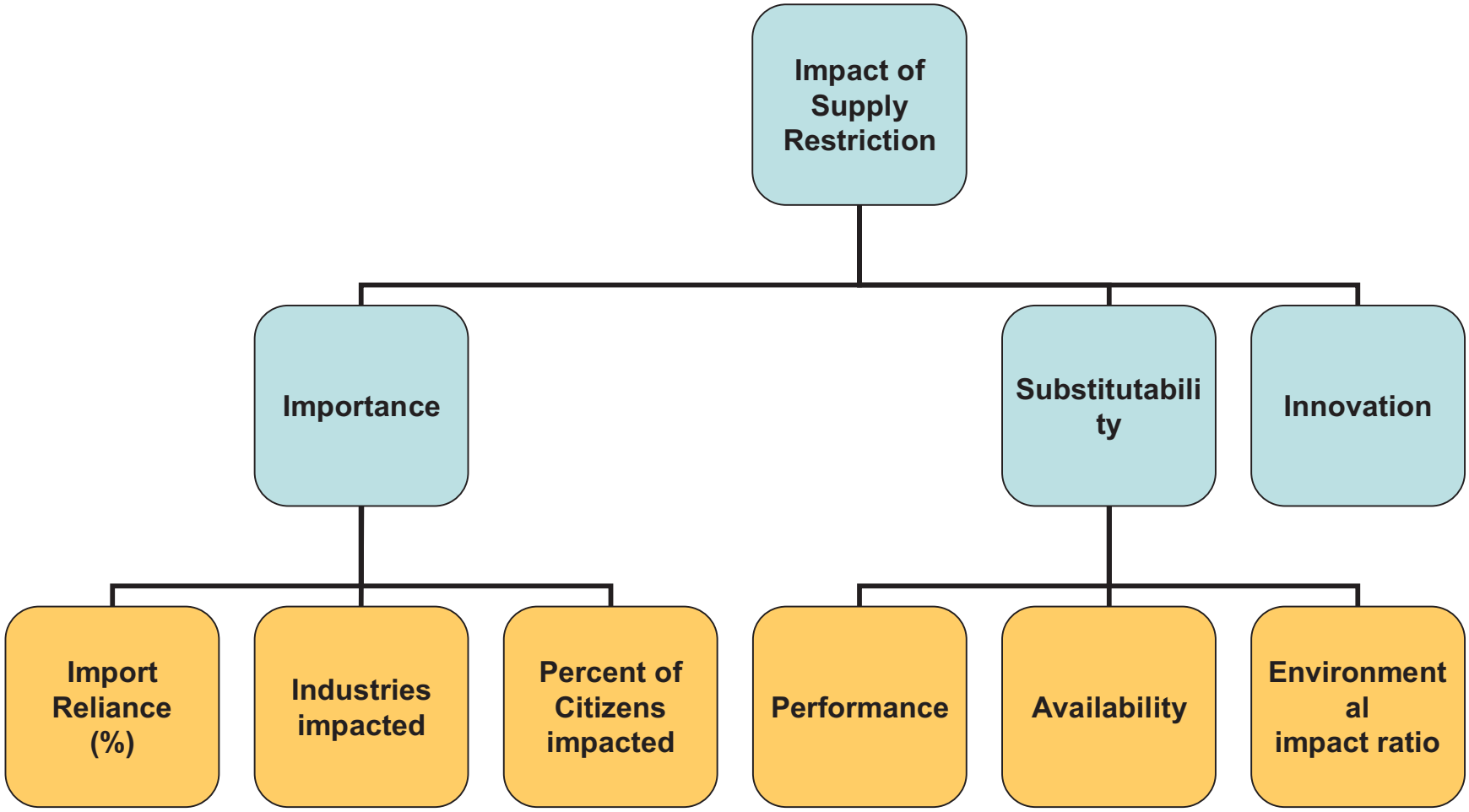
- Composite index of 13 factors (taxation, uncertainty concerning native land claims, security, environmental regulation, etc.)
- Scoring (1): For an individual factors, if *every* respondent evaluates a jurisdiction as “1”, it receives a score of 100, as so on down
- Scoring (2): The 13 factor scores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

The Policy Potential Index (2008/2009 rankings)

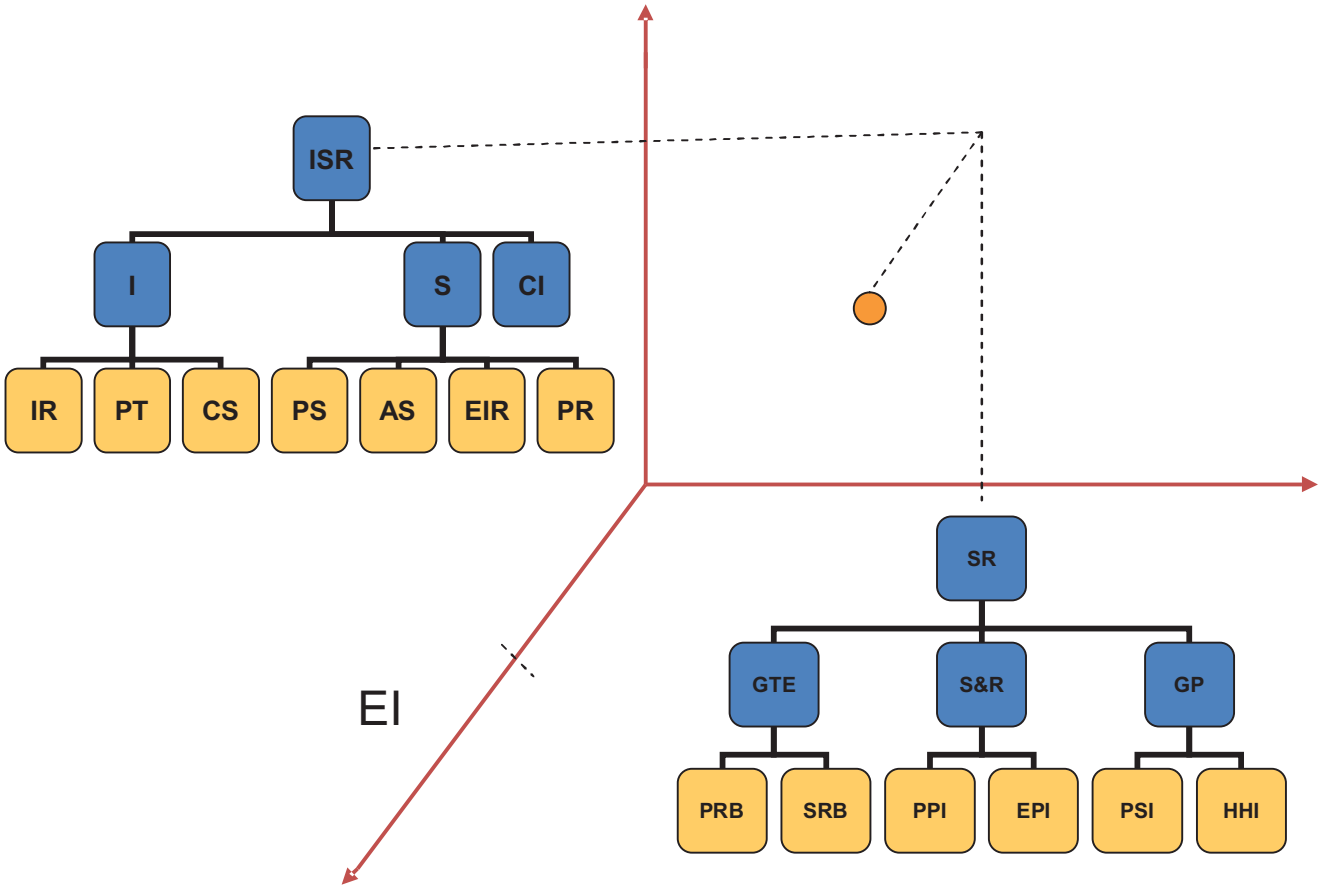


McMahon and Cervantes, 2009

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