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Roundtable on Science and Technology for Sustainability
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Considerations for Developing
Sustainable and Resilient Energy Systems

Role of Natural Capital in Sustainability & Resilience

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Note: The content of this presentation reflects the views of the author and does not represent the policies or position of the U.S. EPA.

Urgent Questions

- Can we trust our predictive capabilities in a tightly-coupled, complex, and turbulent world?
- How can the current "risk-based" paradigm be extended to address "inherent" resilience?
- When does pursuit of resilience support or conflict with sustainability goals?
- How can the public and private sectors adopt a more "adaptive" approach to decision making?
- Can we develop a new generation of analytic tools based on "systems thinking" that are suitable for the "new normal"?

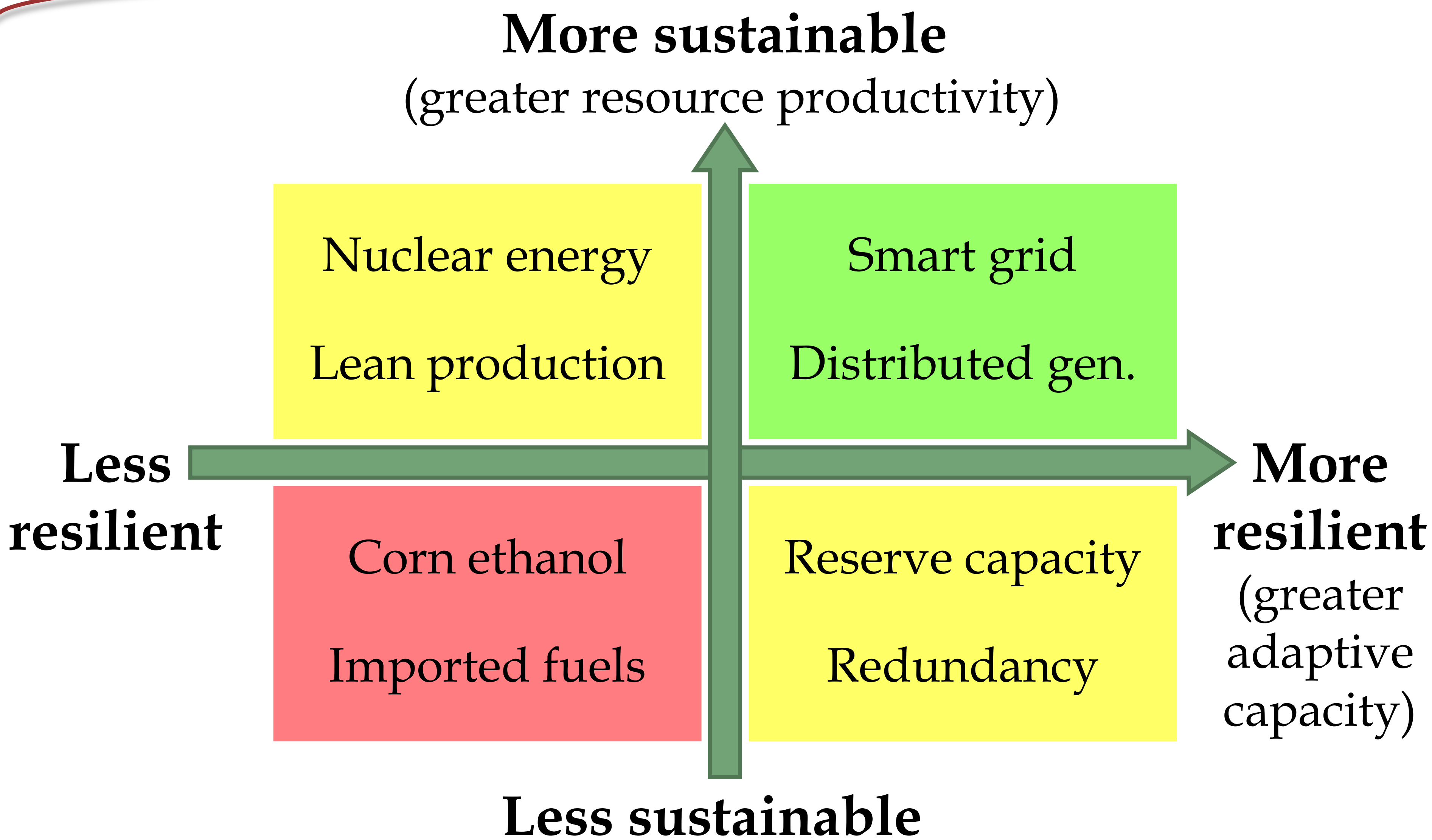
Sustainability and Resilience

- **Sustainability** is the capacity for long-term realization of human health and well being, economic prosperity, & environmental protection
  - However, **unforeseen** conditions can lead to unintended and/or undesired consequences
- **Resilience** is the capacity to survive, adapt, and flourish in the face of changing conditions and potential disruptions (assuring continuity)
  - Dispersion, diversity, foresight, agility, redundancy, flexibility, simplicity, buffering, adaptability, etc.
- In a complex and turbulent world, resilience is a **prerequisite** for realization of sustainability goals

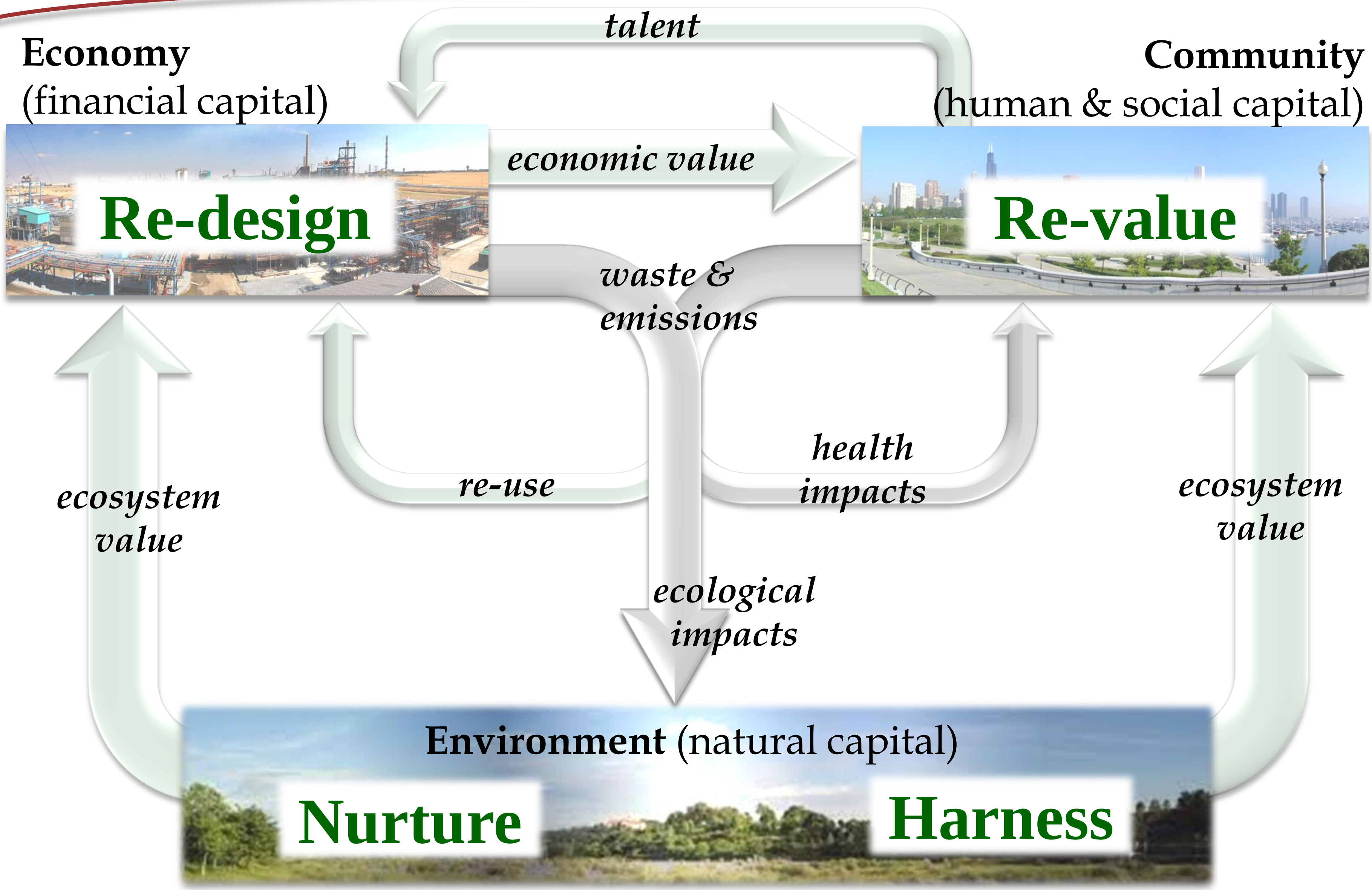
Principles of System Resilience

1. Resilience, i.e., adaptive capacity, is an intrinsic characteristic of all self-organizing systems.
2. Resilience is manifested in a system's response to gradual changes or sudden disruptions.
3. The resilience of a system is influenced by its components or subsystems and its environment.
4. The resilience of a system is influenced by cycles of change at different temporal and spatial scales.
5. Indicators of relative resilience can be defined for a specific category of systems.
6. The resilience of a system can be enhanced even without foresight about potential disruptions.
7. Resilience is necessary, but not sufficient, for long-term sustainability of a system.

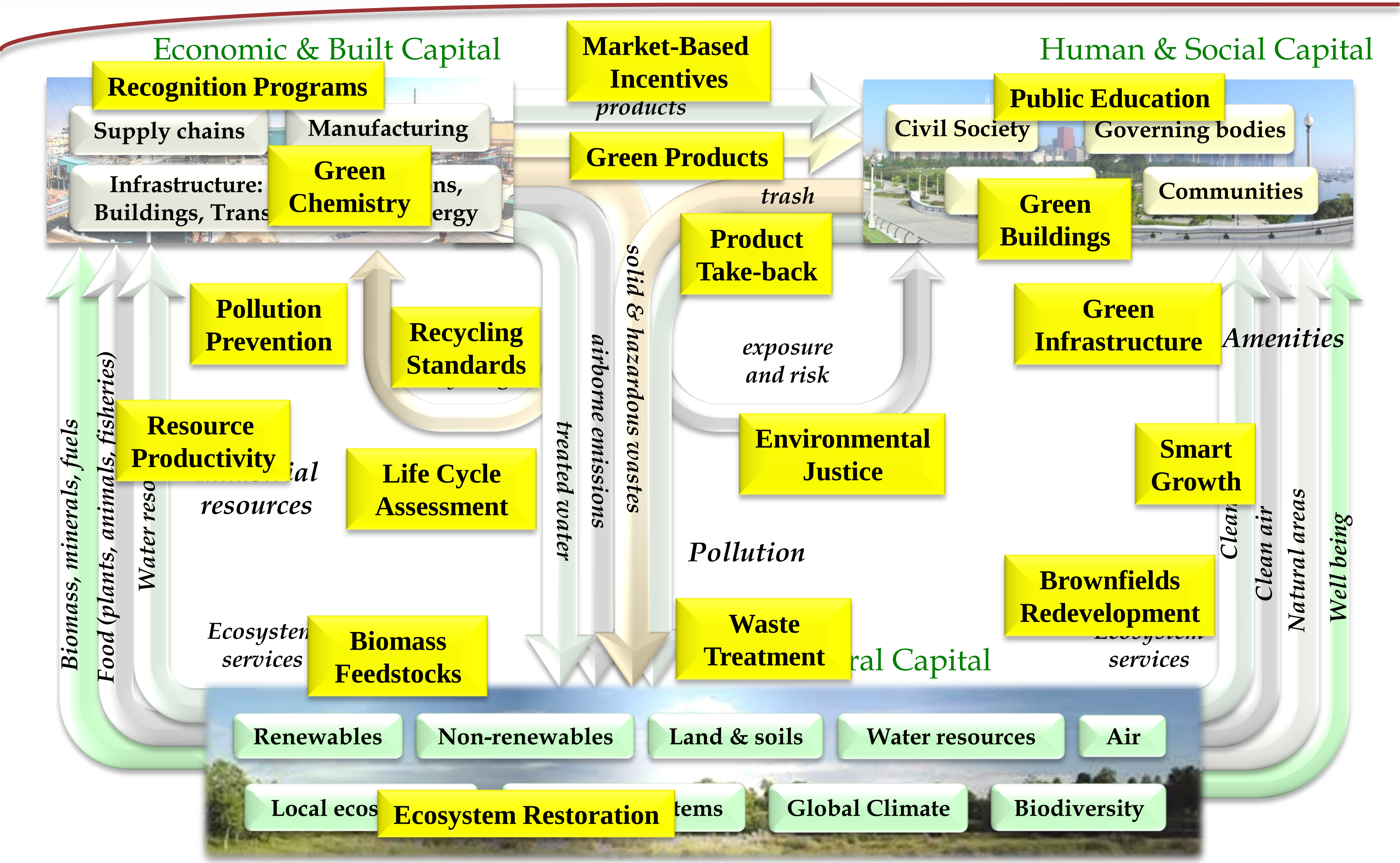
Resilience vs. Sustainability: Examples of Synergies and Trade-offs



Systems View: Triple Value Model

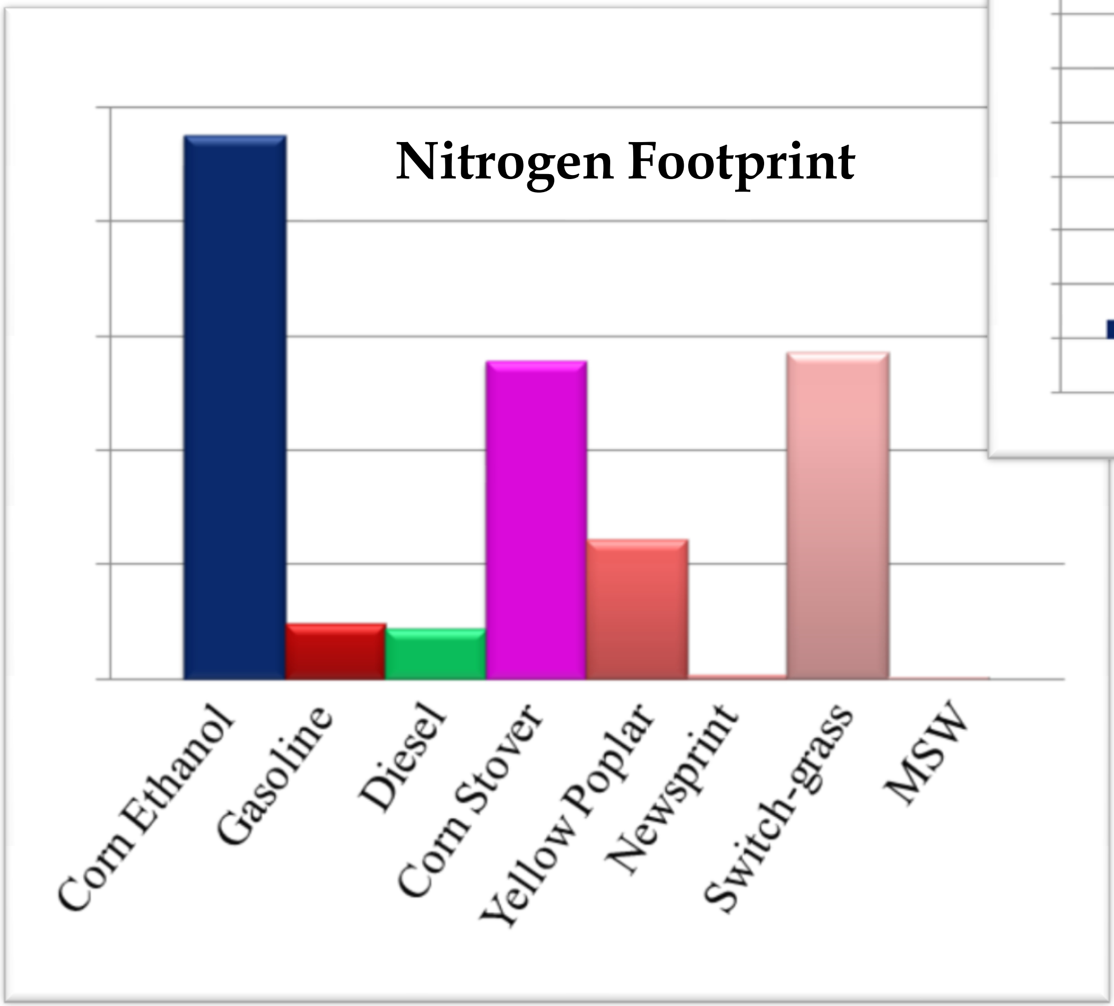


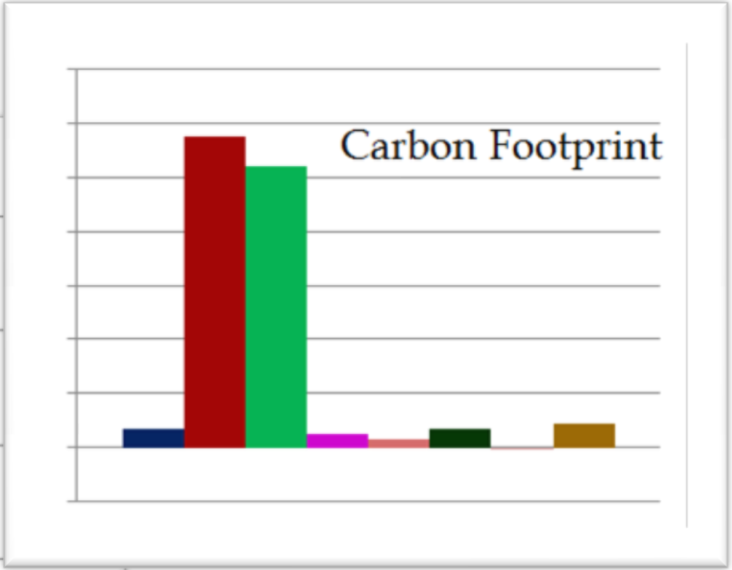
Principal Stocks and Flows and Beneficial Policy Interventions



J. Fiksel, "A Systems View of Sustainability: The Triple Value Model," *Environmental Development*, June 2012.

Example: The Carbon-Nitrogen Nexus



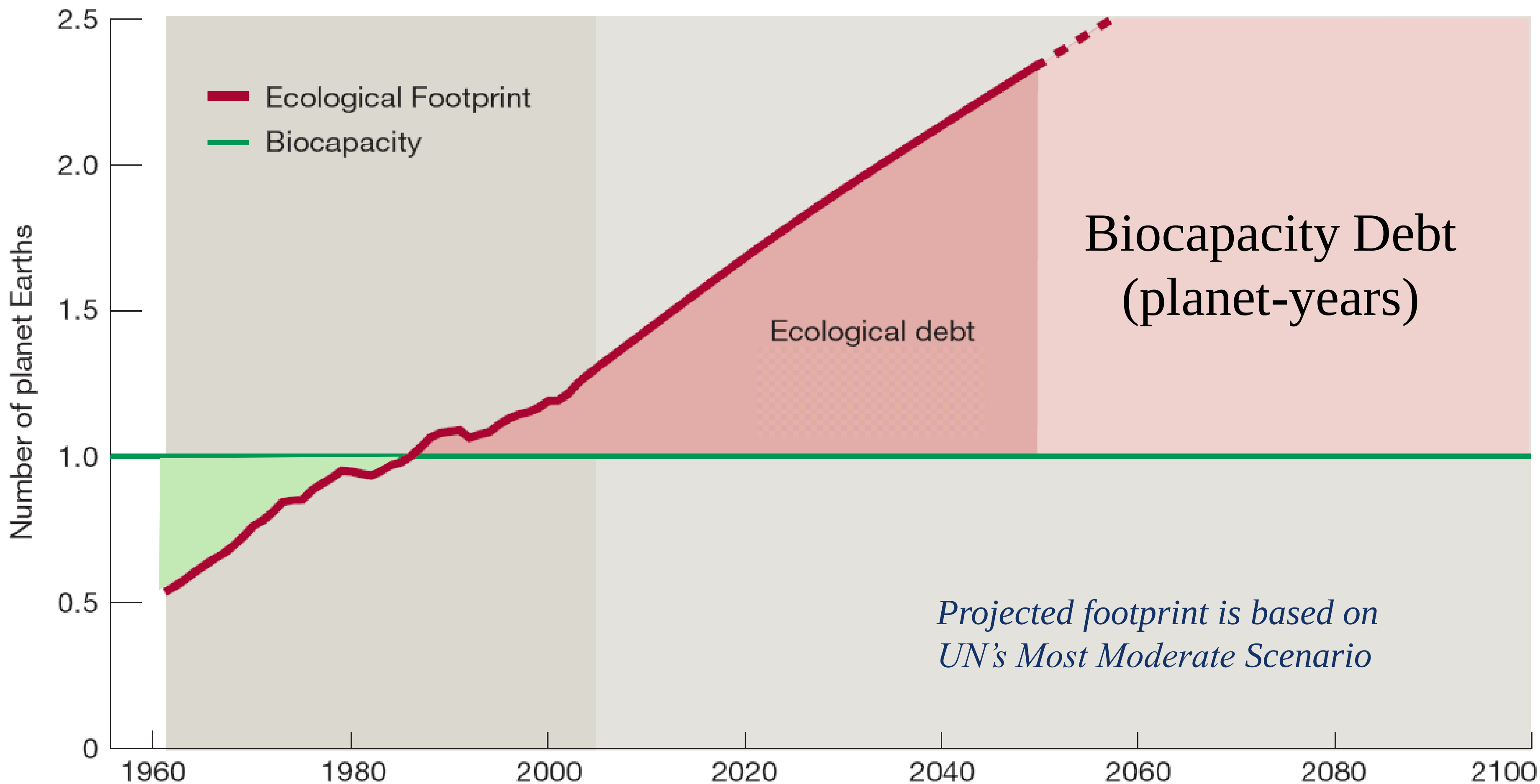


Life-cycle footprints of emissions for selected biofuels (kg/km)

Source: B. Bakshi, OSU

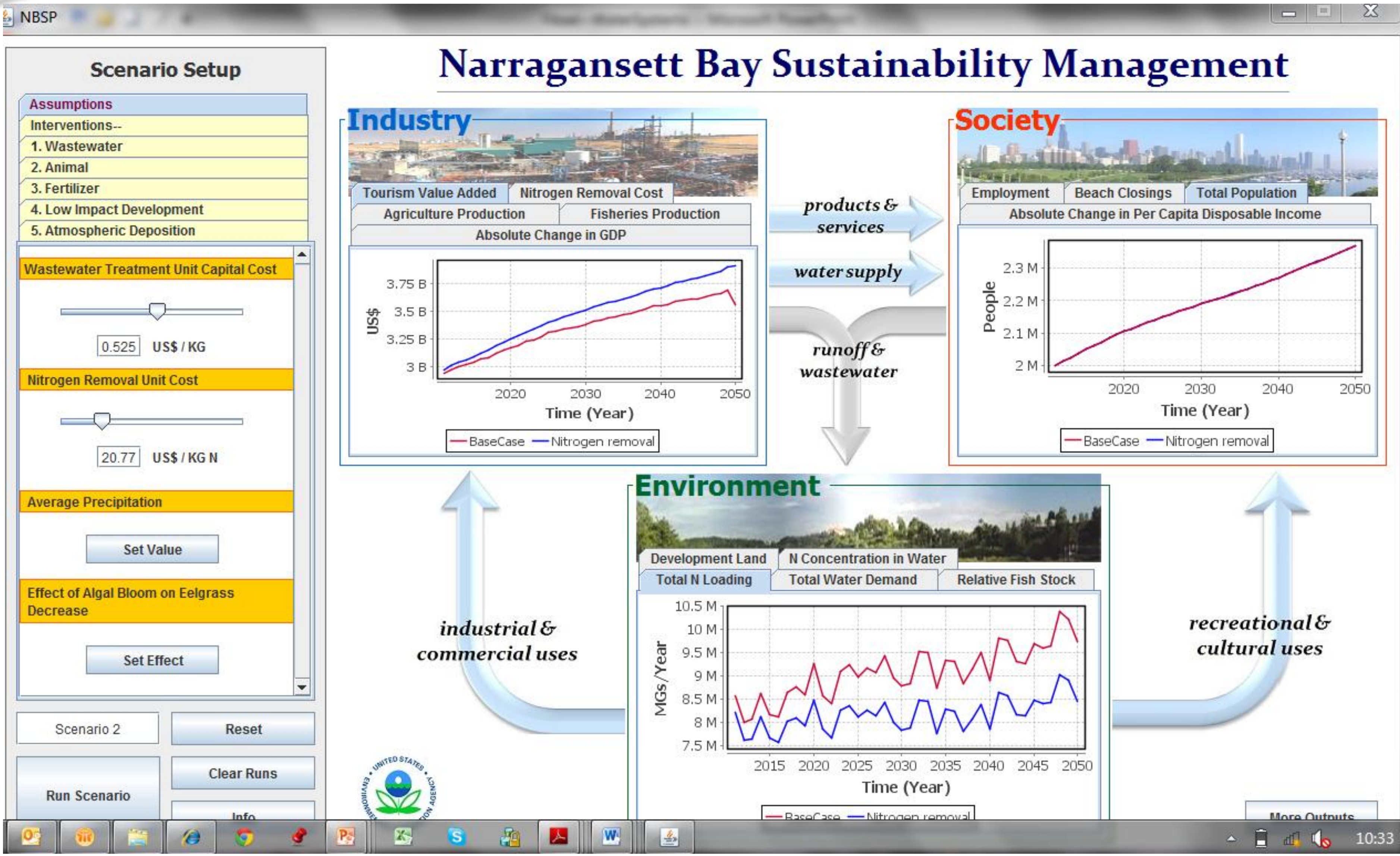
The Ecological Footprint

Projected Natural Capital Deficit

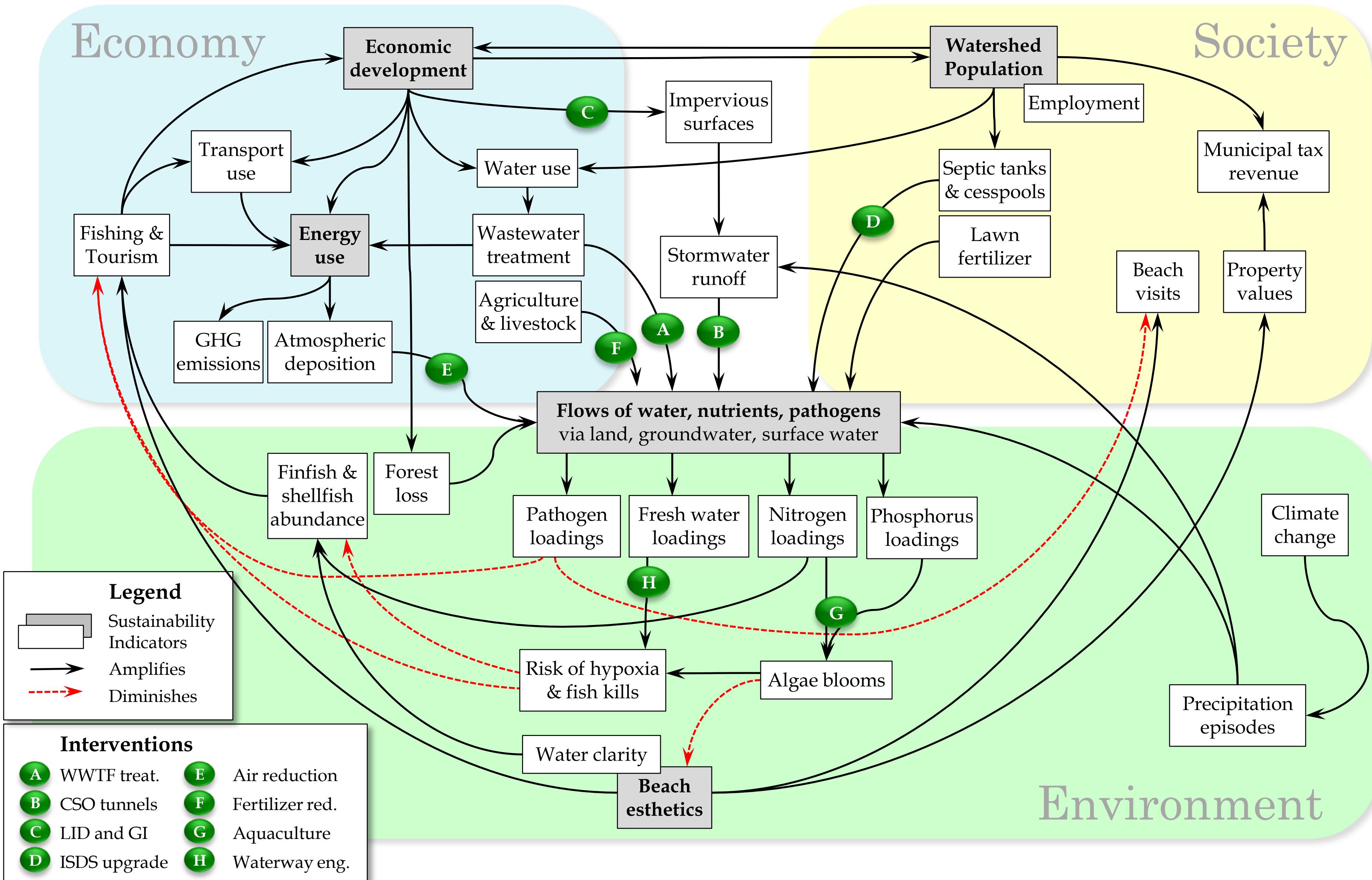


Global Footprint Network
Advancing the Science of Sustainability

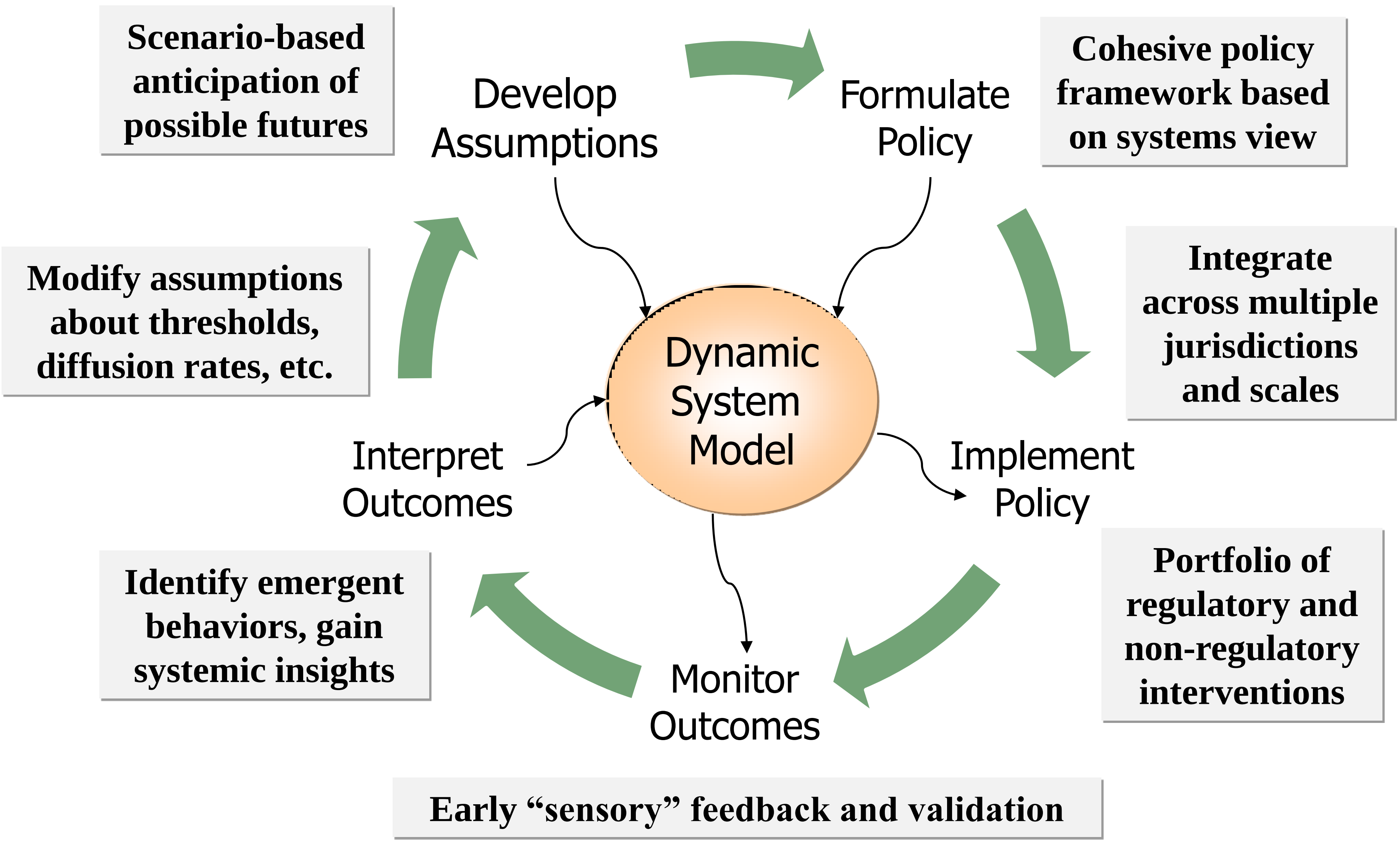
Example: EPA's Integrated Model for Nutrient Mitigation in New England



System Dynamics Model: Narragansett-3VS



Adaptive Approach to Public Policy

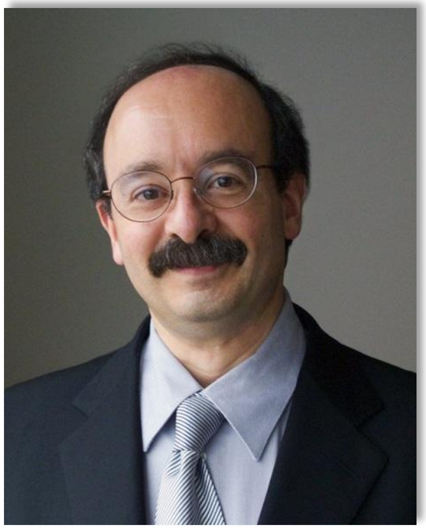


Waves of Innovation

Challenge	Response
Unintended environmental, health, or safety impacts over the product life cycle	Design for Environment (1990's)
Threat of resource scarcity and diminished opportunity for future generations	Design for Sustainability (2000's)
Complexity and turbulent change in global economic, social, & ecological systems	Design for Resilience

“…the widespread use of inherently resilient technologies for supplying energy, in conjunction with highly efficient energy use, can profoundly improve national security.”

Amory B. Lovins
and L. Hunter Lovins
Brittle Power, 1982



Thank You!

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