US EPA's Ecological Exposure Modeling Science:

Frameworks, Components and the Emerging Community of Practice for Reuse

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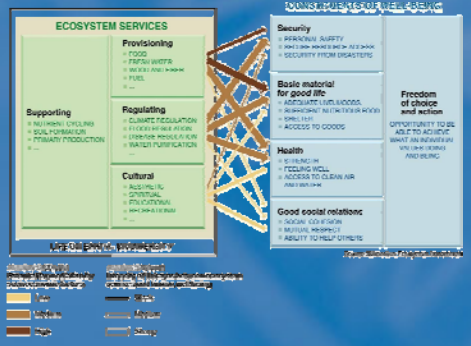
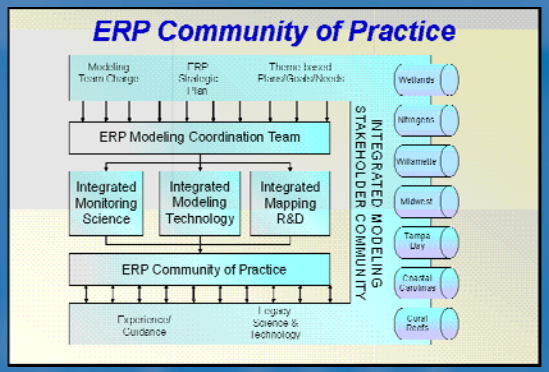
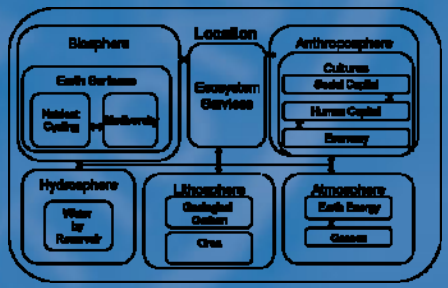
ISEM 2009, Quebec City October 6, 2009







Research and Development at EPA

- 1,950 employees
- $700 million budget
- $100 million extramural research grant program
- 13 lab or research facilities across the U.S.
- Credible, relevant and timely research results and technical support that inform EPA policy decisions

Making decisions with sound science requires..

- Relevant, high quality, cutting-edge research in human health, ecology, pollution control and prevention, economics and decision sciences
- Proper characterization of scientific findings
- Appropriate use of science in the decision process

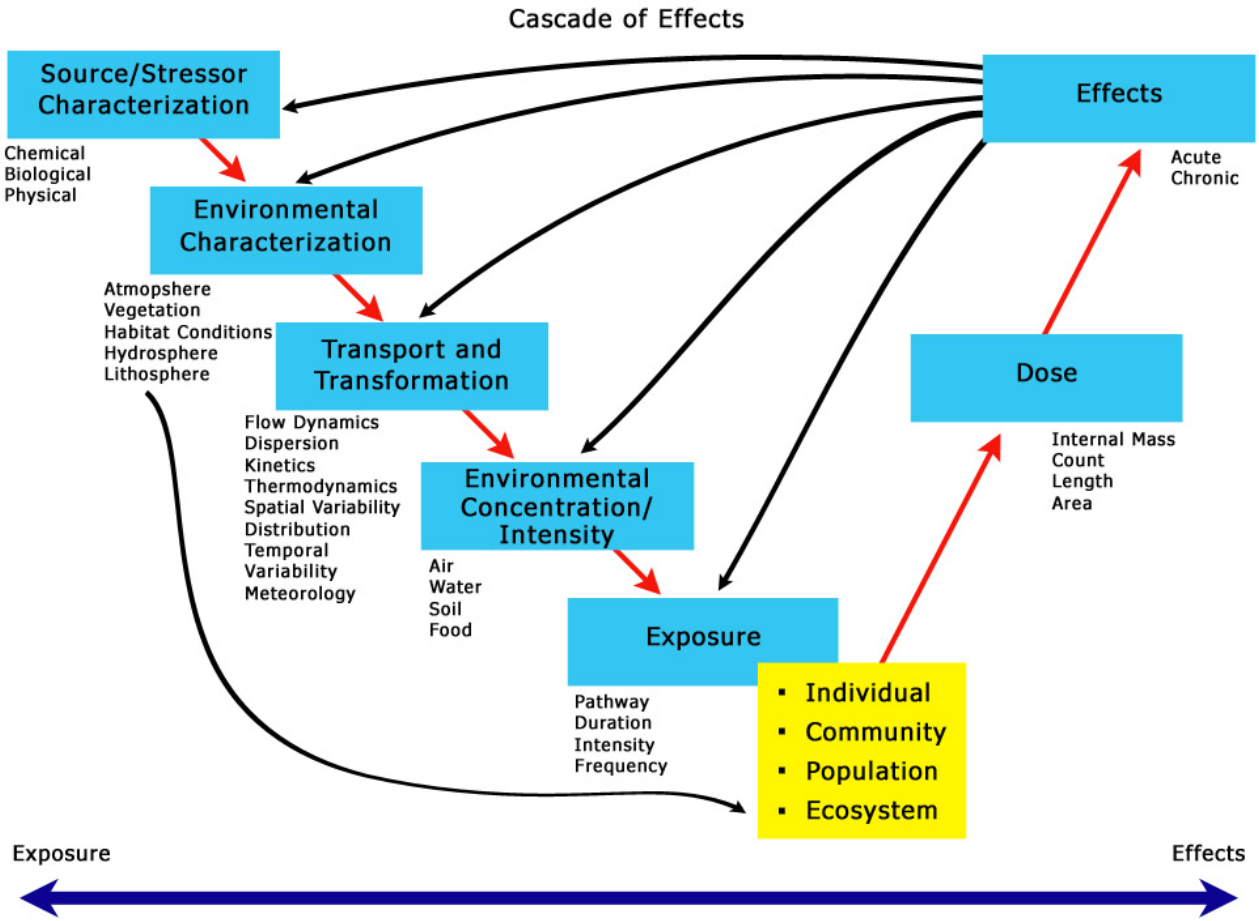
Research and development contribute uniquely to..

- Health and ecological research, as well as research in pollution prevention and new technology
- In-house research and an external grants program
- Problem-driven and core research

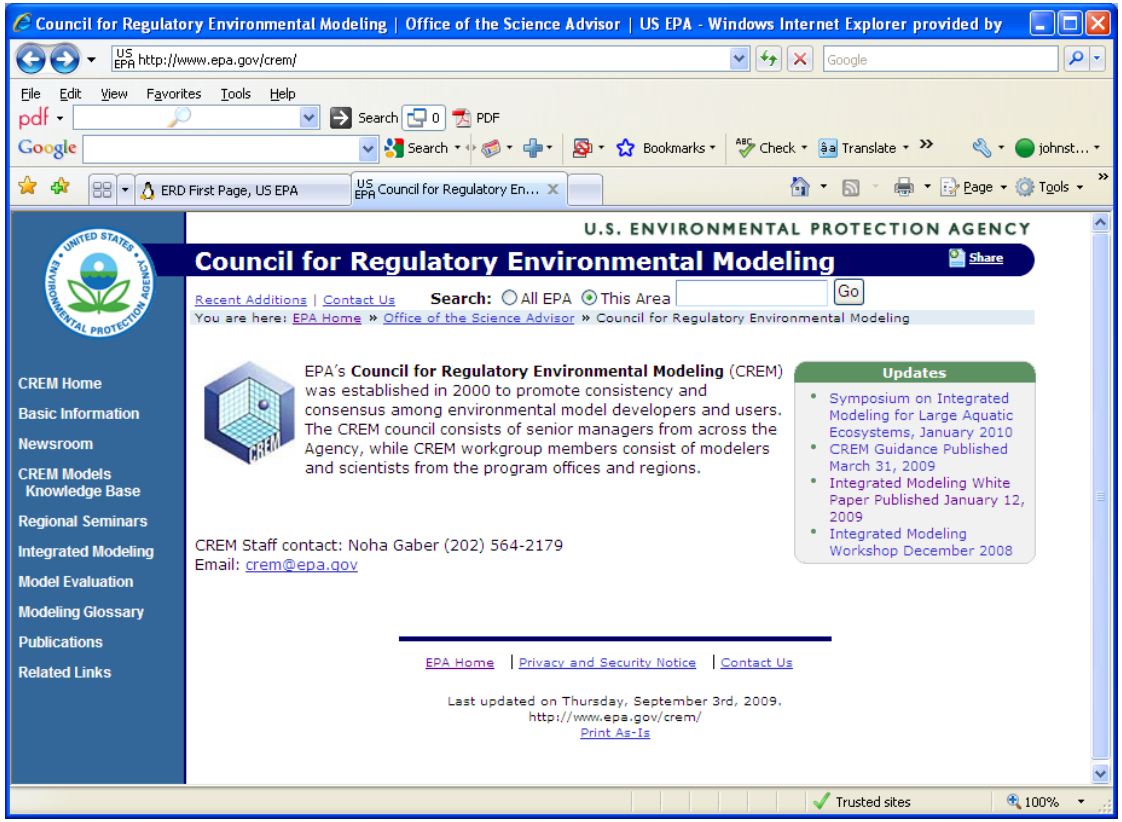
High Priority Research Areas

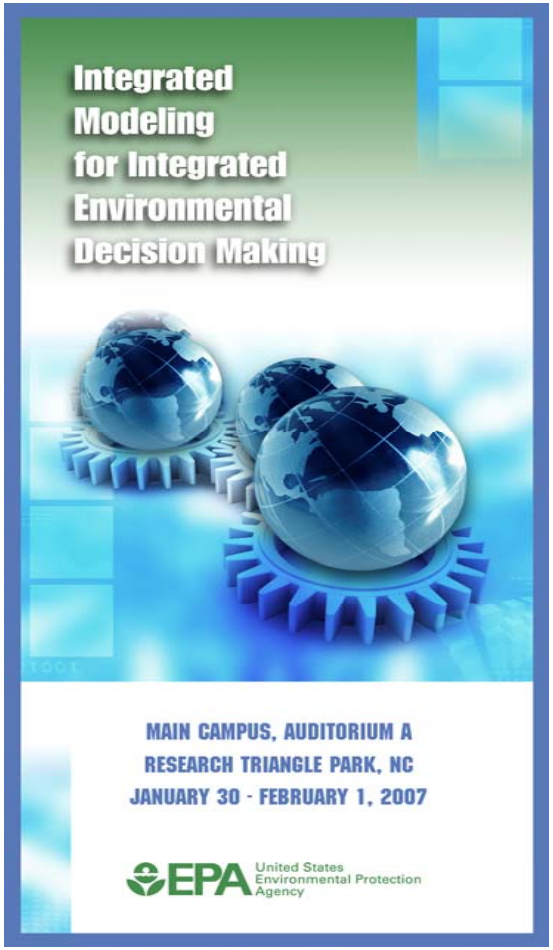
- Human Health
- Particulate Matter
- Drinking Water
- Clean Water
- Global Change
- Endocrine Disruptors
- Ecological Risk
- Pollution Prevention
- Homeland Security

National Exposure Research Laboratory



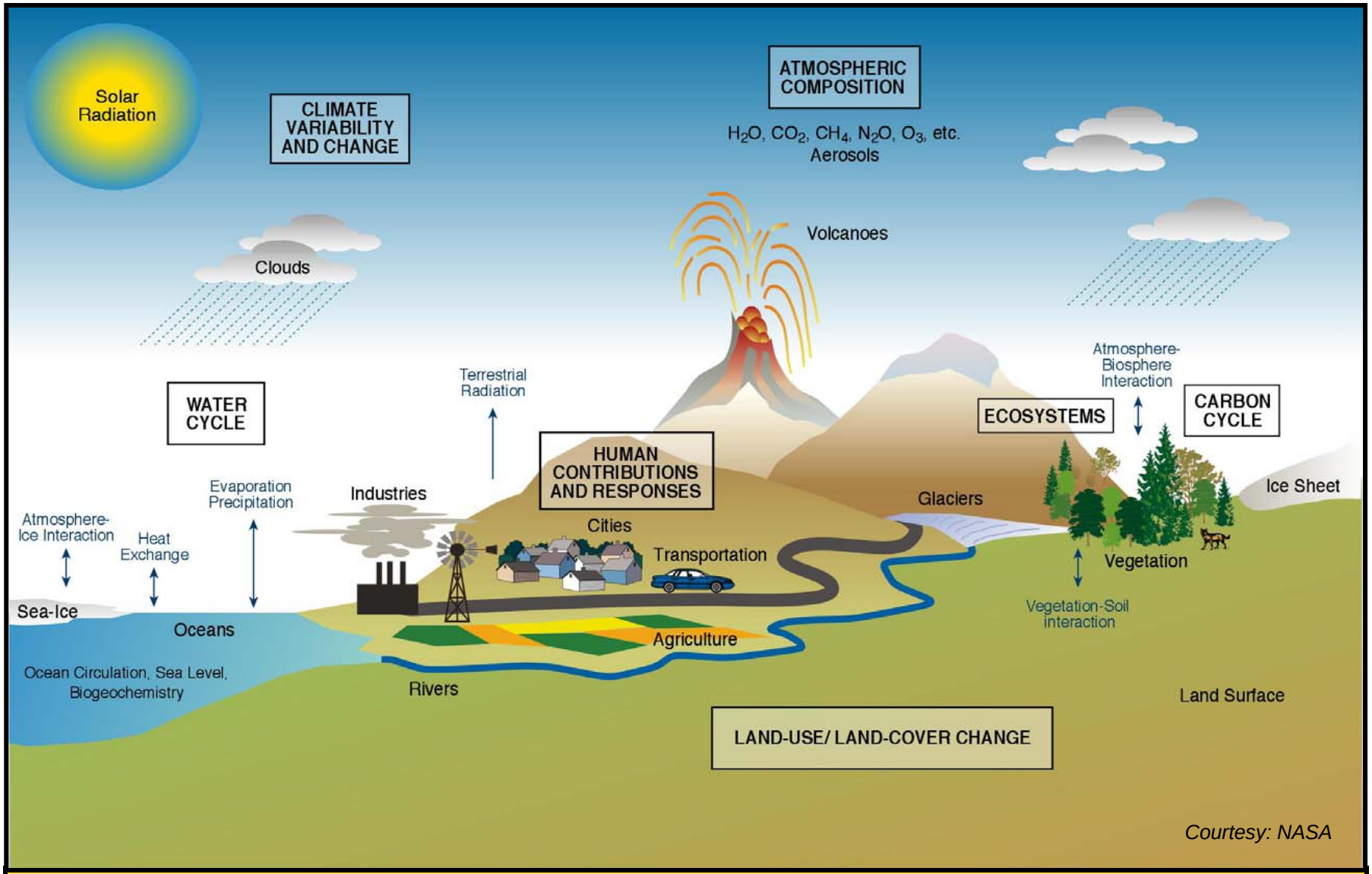
Council for Regulatory Environmental Modeling





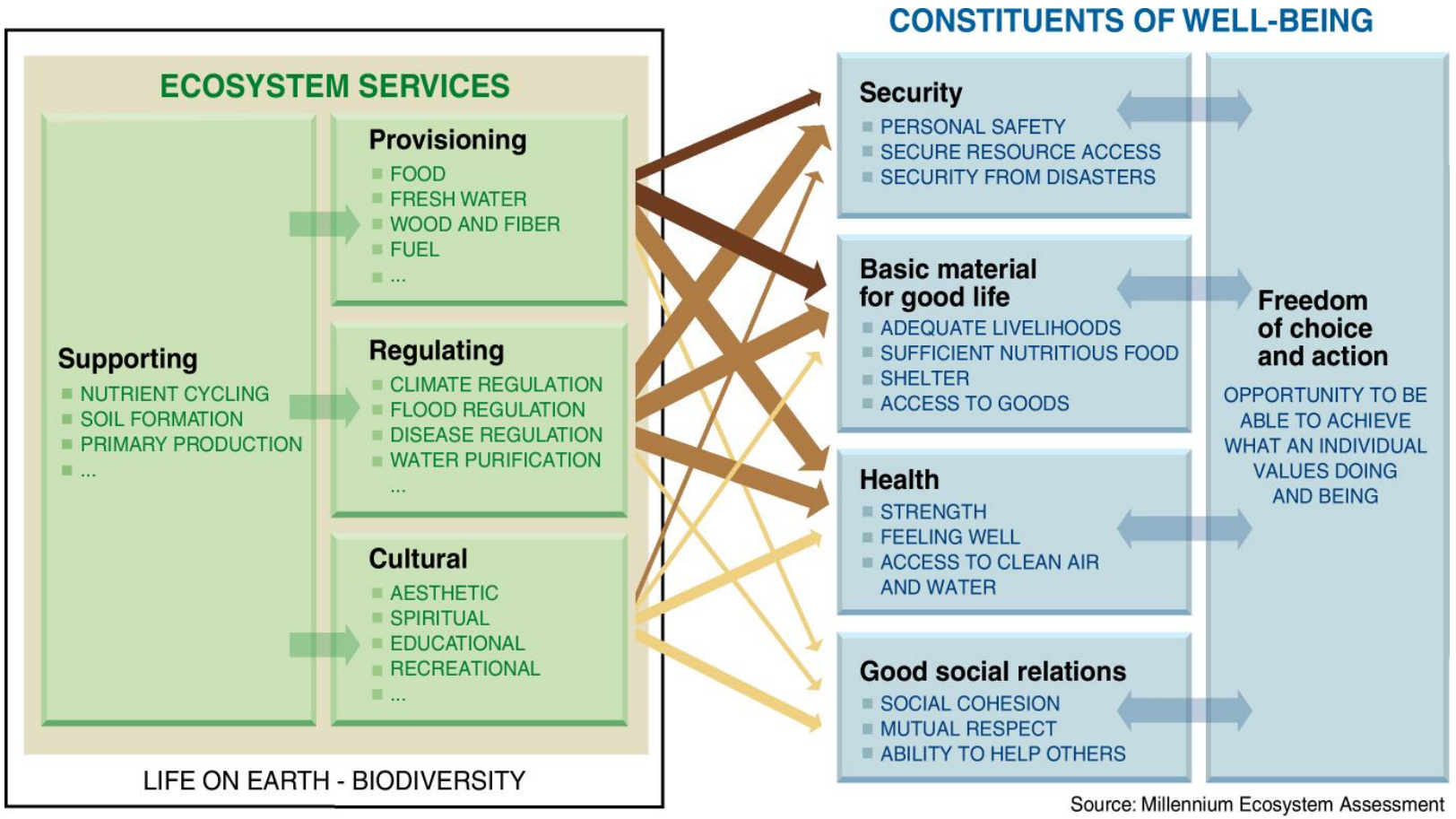
What does modeling provide?

- Modeling as synthesis and **integration**
- Modeling as pre-specification and structured approach to complex **problem solving**
- Modeling as necessary **science**
- Modeling as a **community of practice**



Environment is complex and its components are not separable

Ecosystem Services (MEA, 2005)



Source: Millennium Ecosystem Assessment

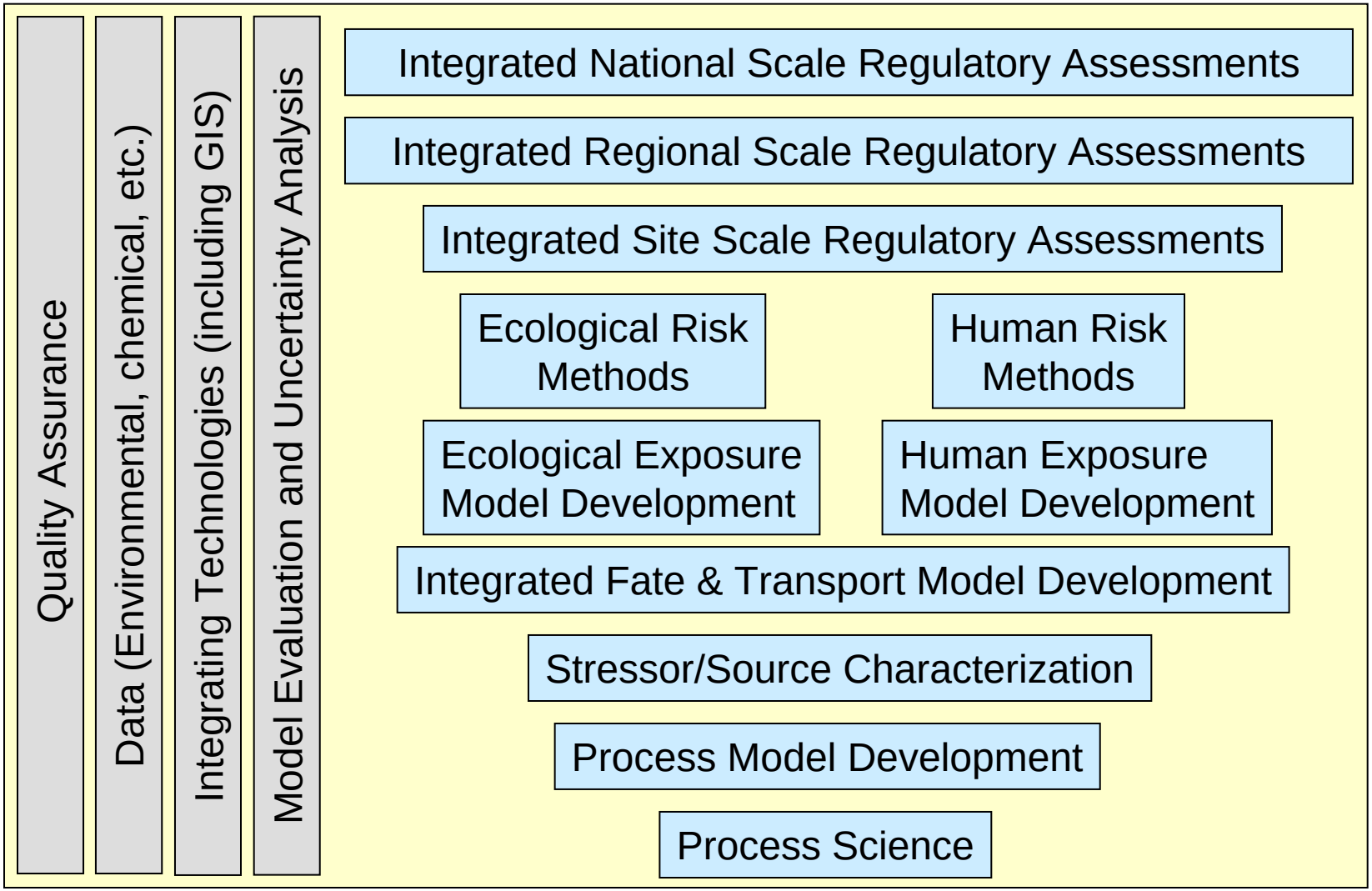
ARROW'S COLOR
Potential for mediation by socioeconomic factors

- Low
- Medium
- High

ARROW'S WIDTH
Intensity of linkages between ecosystem services and human well-being

- Weak
- Medium
- Strong

Agency Program-based Regulatory Problem Statement



Modeling Infrastructures (Frameworks)

Purpose and Benefits

- Facilitate the development and application of integrated systems
- Standards based
- Facilitates collaboration and additional levels of research
- Minimizes production of non-science software (more resources focused on science components)

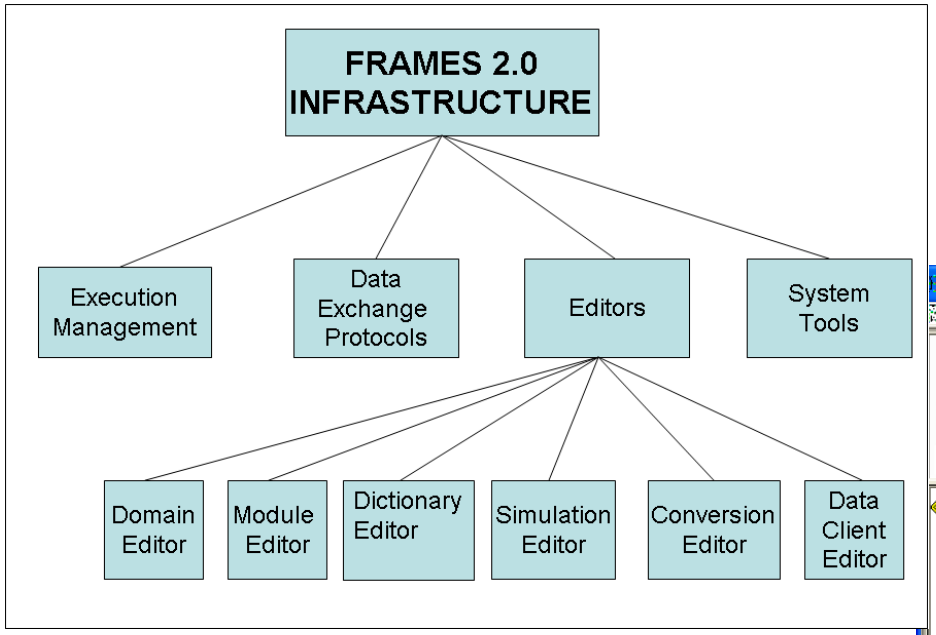
Elements and Functionality

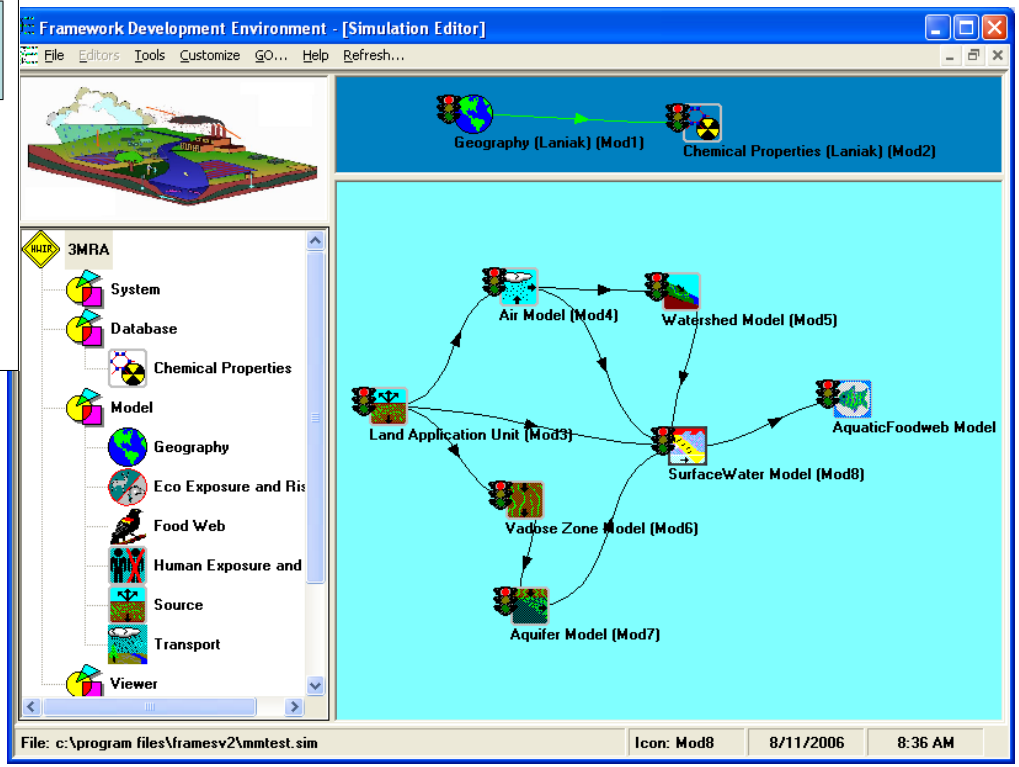
- Execution management
- Data flow management
- User interfaces (hierarchical – system levels down to components)
- Modeling support software (data access/retrieval/processing, visualization, quality assurance)

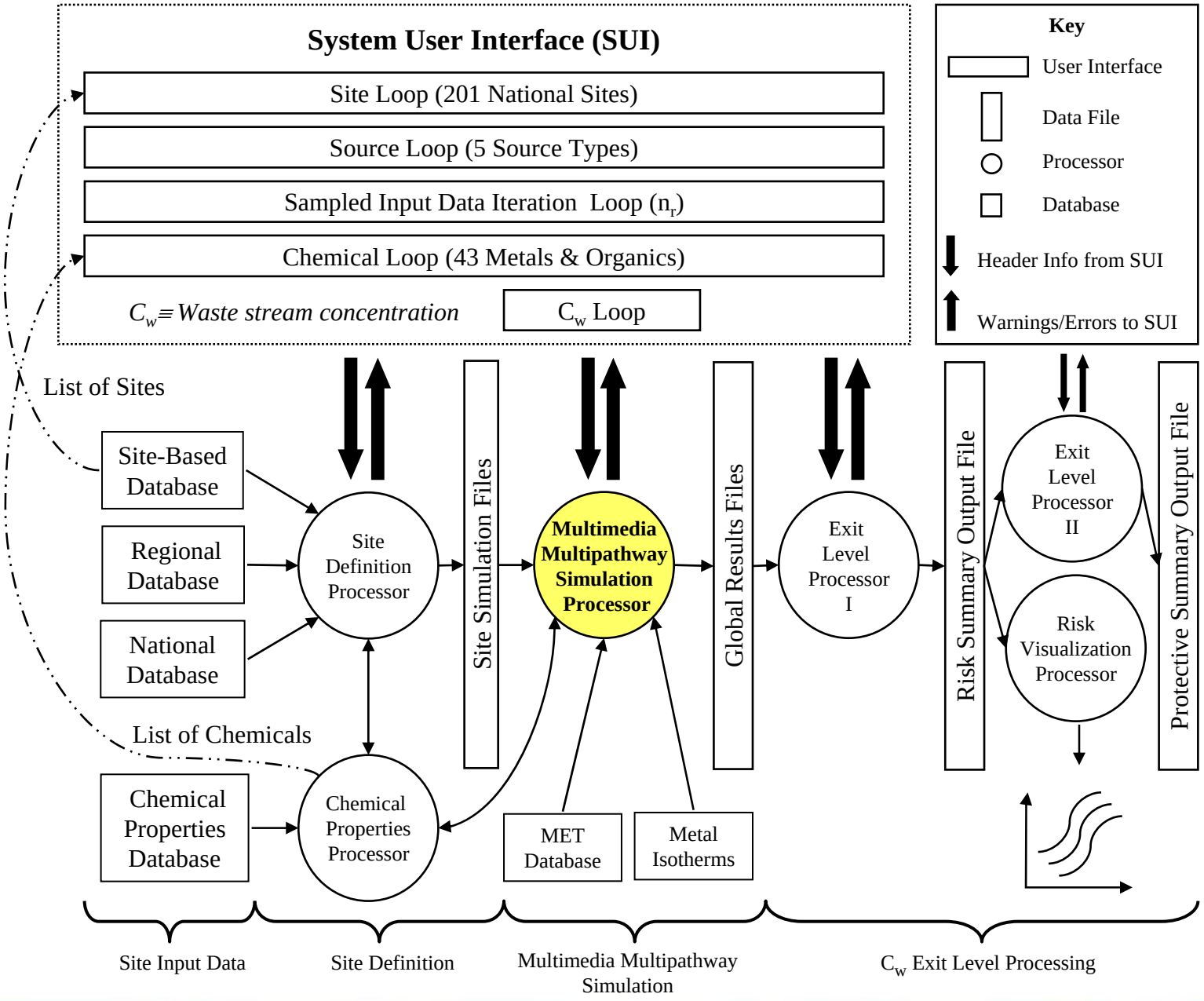
Limitations and Issues

- Standards (like opinions, everyone framework has one -- need community wide standards)
- Ongoing maintenance of large software systems is challenging
- Misperception that infrastructures solve science integration problems

Implementation into Framework






System User Interface (SUI)
Site Loop (201 National Sites)
Source Loop (5 Source Types)
Sampled Input Data Iteration Loop (n_r)
Chemical Loop (43 Metals & Organics)
C_w≡ Waste stream concentration
C_w Loop
Key
User Interface
Data File
Processor
Database
Header Info from SUI
Warnings/Errors to SUI
List of Sites
Site-Based Database
Regional Database
National Database
List of Chemicals
Chemical Properties Database
Site Definition Processor
Chemical Properties Processor
Site Simulation Files
Multimedia Multipathway Simulation Processor
MET Database
Metal Isotherms
Global Results Files
Exit Level Processor I
Risk Summary Output File
Exit Level Processor II
Risk Visualization Processor
Protective Summary Output File
Site Input Data
Site Definition
Multimedia Multipathway Simulation
C_w Exit Level Processing

National-Scale ABR Problem Statement

At what waste stream concentration (C_{wsafe}) will ABRs, when placed in non-hazardous landfills (e.g., industrial, municipal) over the unit's life, result in:

1. **(Human)** Greater than **A%** of the people living within **B** distance of the facility with a risk/hazard of **C** or less, and

2. **(Ecological)** Greater than **D%** of the habitats within **E** distance of the facility with an ecological hazard less than **F**,

3. **(National)** At **G%** of facilities nationwide,

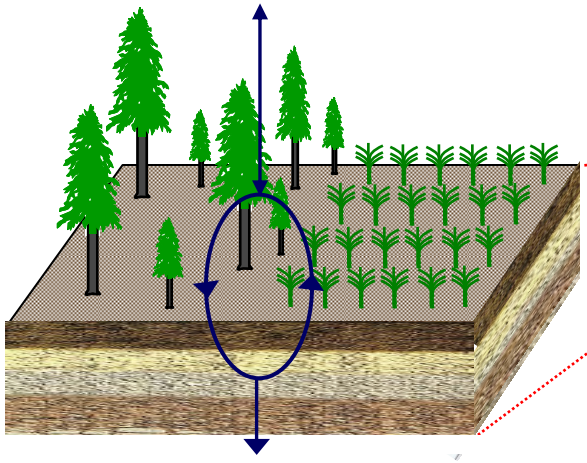
4. **(Uncertainty)** With confidence **H%** accounting for subjective input uncertainty (i.e., accuracy), and confidence **I%** accounting for output sampling error (i.e., precision).

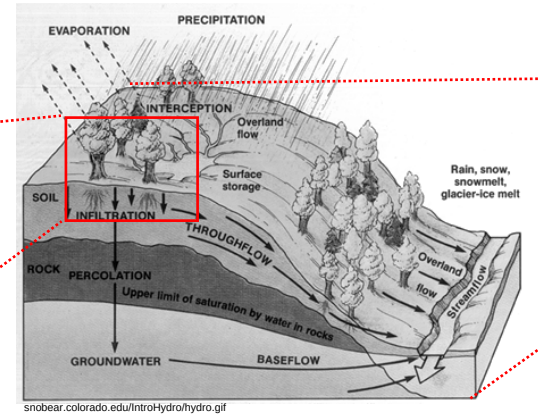
Example 3MRA Decision Variables in Red

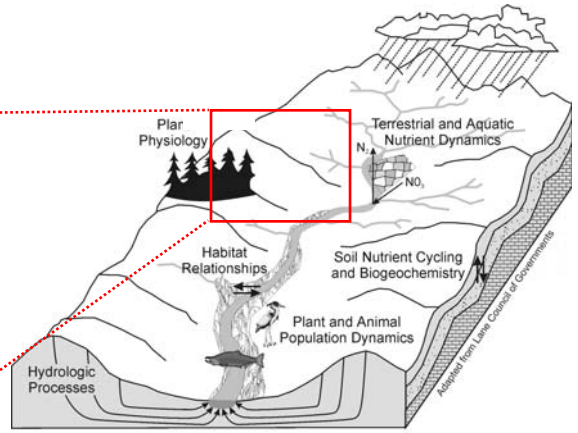
C_{wsafe} ≡ safe level

Science of Ecosystem Services

Scaling Up Ecosystem Services

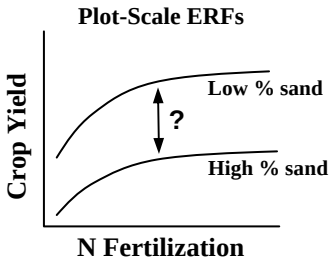


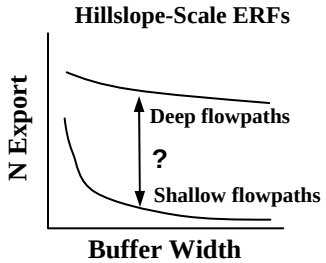


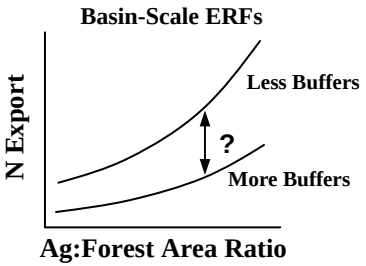


Plots, Stands | ***Hillslopes, Catchments*** | ***Basin, Region***

Using nitrogen addition & export as an example…



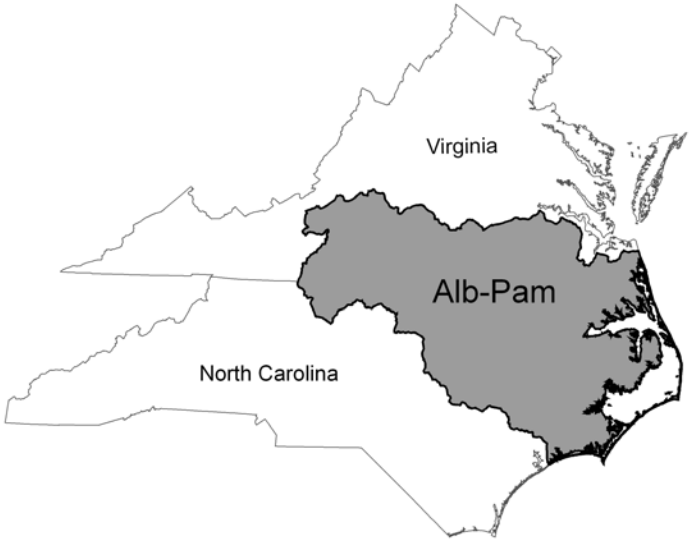


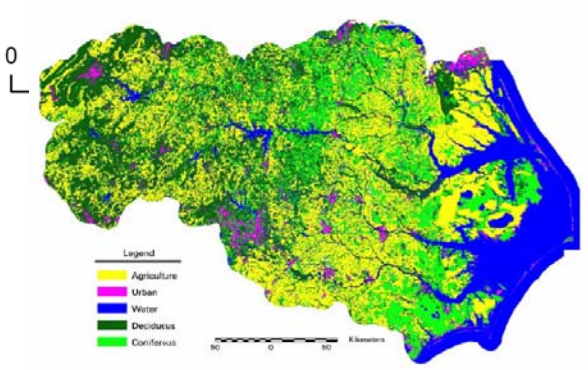


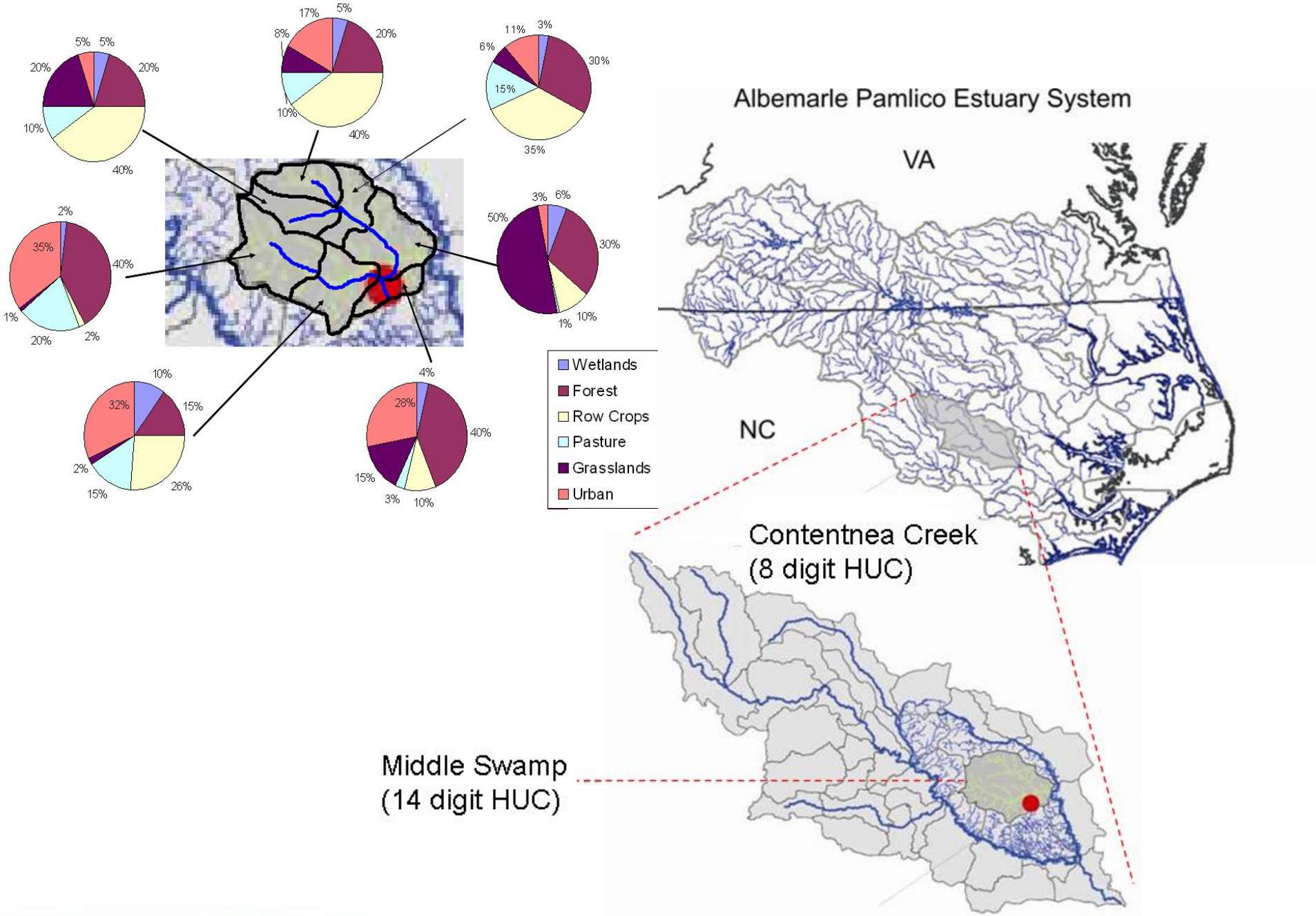
Models: Statistical and Process-Based

Synthesize & Scale Up Data → Plots to Region, Days to Centuries

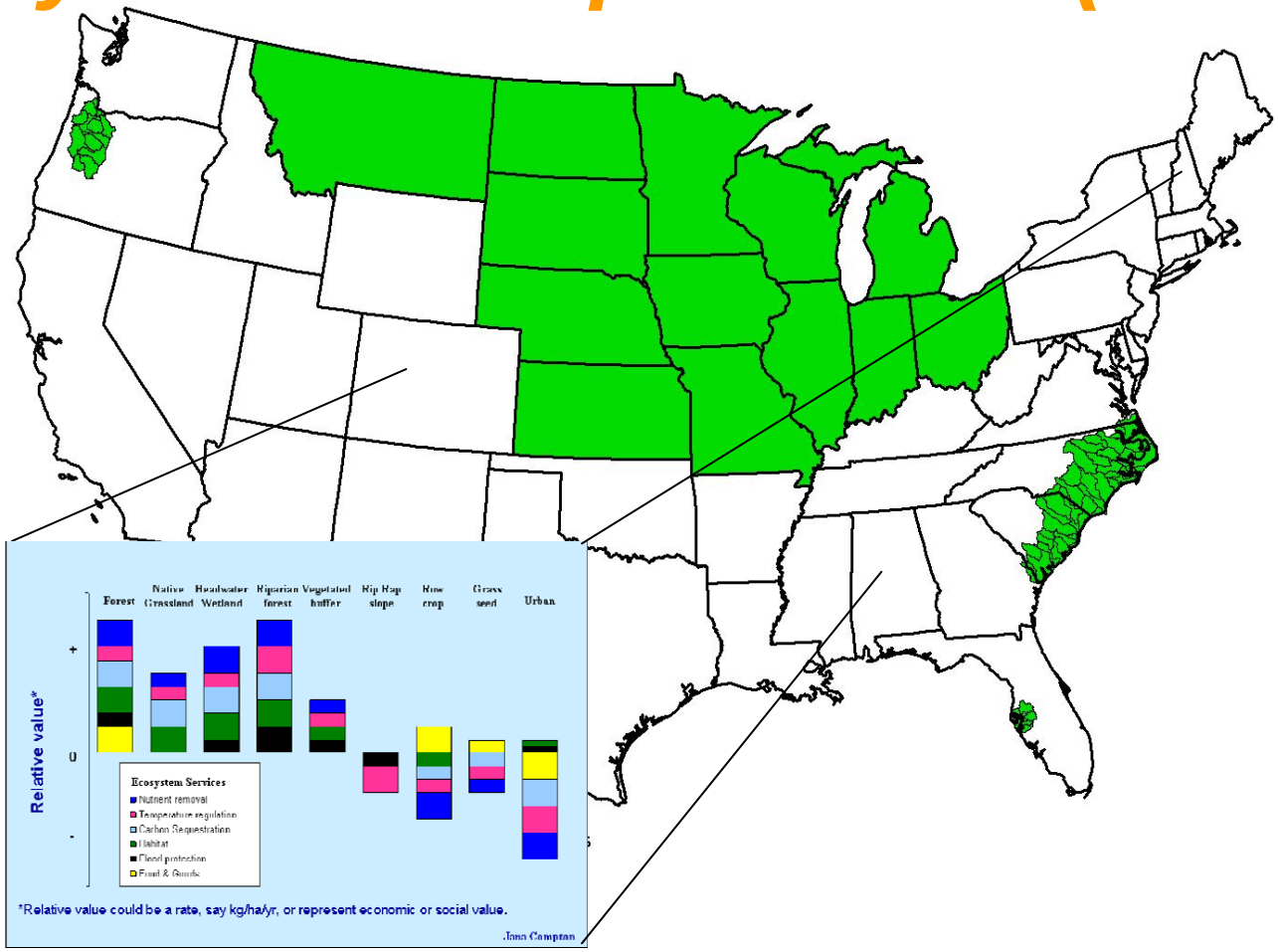
Albemarle Pamlico basins



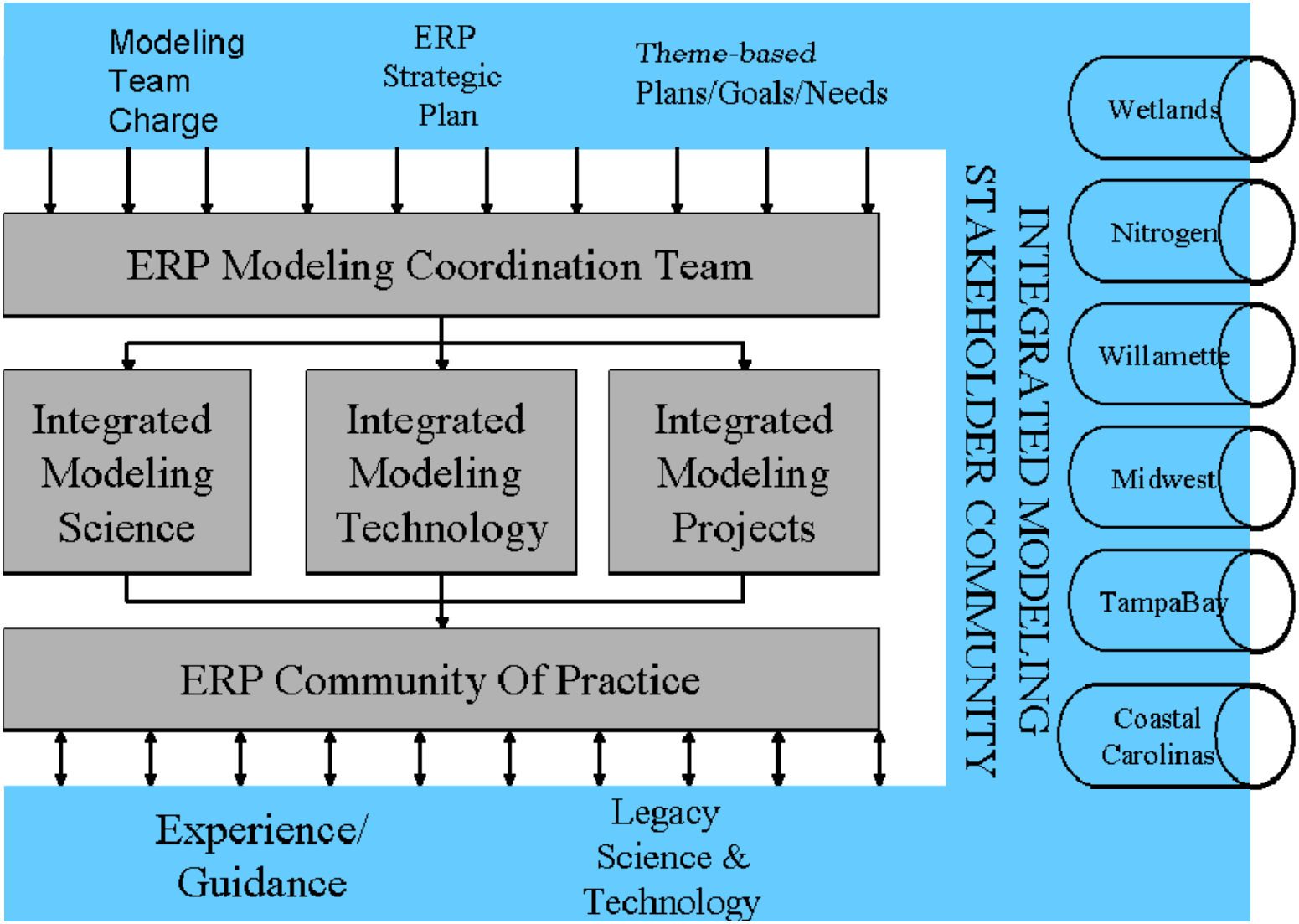



Albemarle Pamlico Estuary System
VA
NC
Contentnea Creek
(8 digit HUC)
Middle Swamp
(14 digit HUC)
Wetlands
Forest
Row Crops
Pasture
Grasslands
Urban
5% 5%
20%
20%
10%
40%
17%
5%
8%
20%
10%
40%
11%
3%
6%
30%
15%
35%
2%
35%
40%
1%
20%
2%
3%
6%
50%
30%
1%
10%
10%
32%
15%
2%
15%
26%
4%
28%
40%
15%
3%
10%

Nationwide dynamic modeling and mapping tools for ecosystem services analysis at multiple scales (2013)



Community of Practice

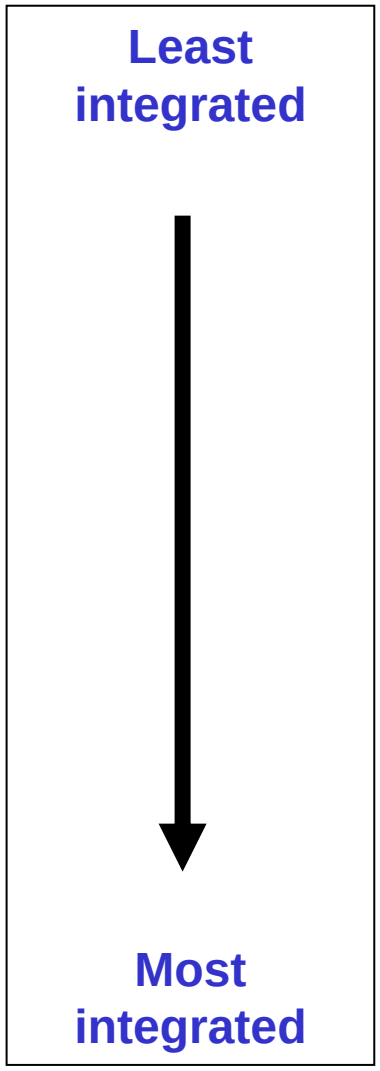


Facilitating technologies

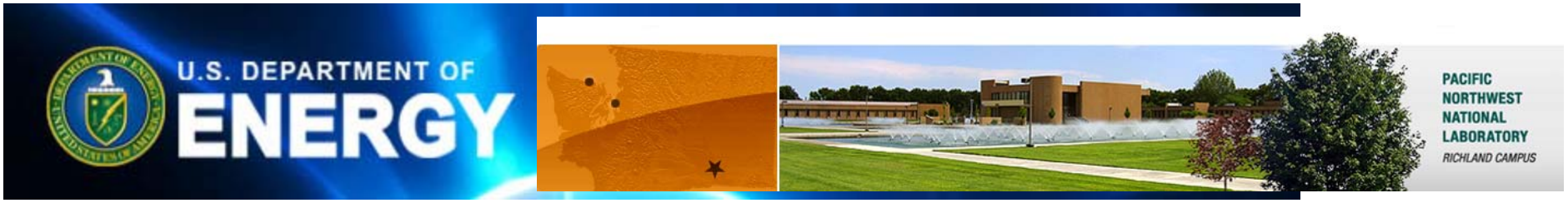
- Cmap Conceptual Modeling toolkit
  - http://cmap.ihmc.us/
  - http://cmc.ihmc.us/
  - http://www.hkkhpartnership.org/
- MapWindow GIS
  - http://www.mapwindow.org/
- Collaboratorium (MIT)
  - http://www.youtube.com/v/k2w2WBCn7ug
- Colab (USDA)
  - https://colab.sc.egov.usda.gov/
- Sourceforge
  - http://sourceforge.net

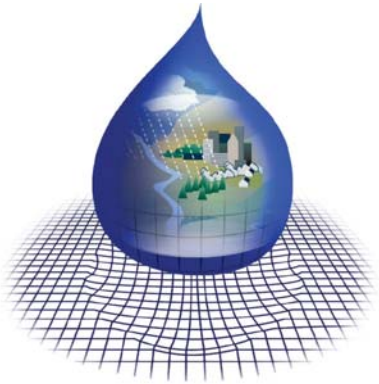
Integration options and tradeoffs

- Pursue modeling within each area essentially **independent** of each other (everyone builds their modeling team and pursues their theme interest)
- Pursue modeling within each area by **sharing ideas** with each other (occasional workshops to discuss issues and brainstorm solutions)
- Form a **modeling community** and formulate **area specific approaches** that reflect the principles of integrated modeling (approaches may be different across themes but all theme approaches follow the principles in a consistent manner)
- Form a **modeling community** and formulate **consensus approaches** to common modeling needs and format solutions for reuse and interoperability
- Form a **modeling committee** and select a **specific set of models** and supporting infrastructure/framework that all areas must utilize and/or co-develop

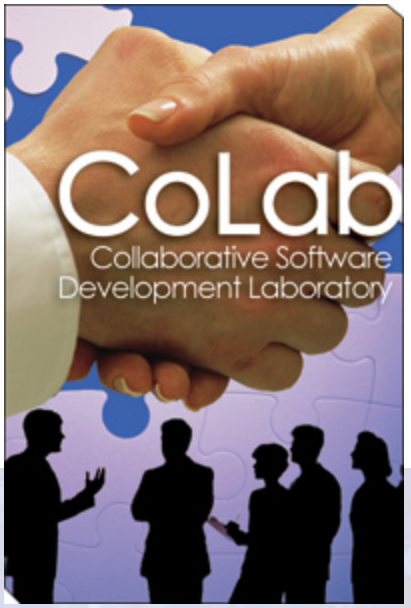


Invitation to Collaboration





MapWindow™ GIS



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Questions?