Decision Analysis Research at the U.S.EPA

Brian Dyson
National Risk Management Research Laboratory
U.S. Environmental Protection Agency
Cincinnati, OH

28th Annual Meeting of the Ohio Valley Chapter of SETAC
Cleveland State University,Cleveland,OH
September 15-16, 2011

Call for Decision Research at EPA

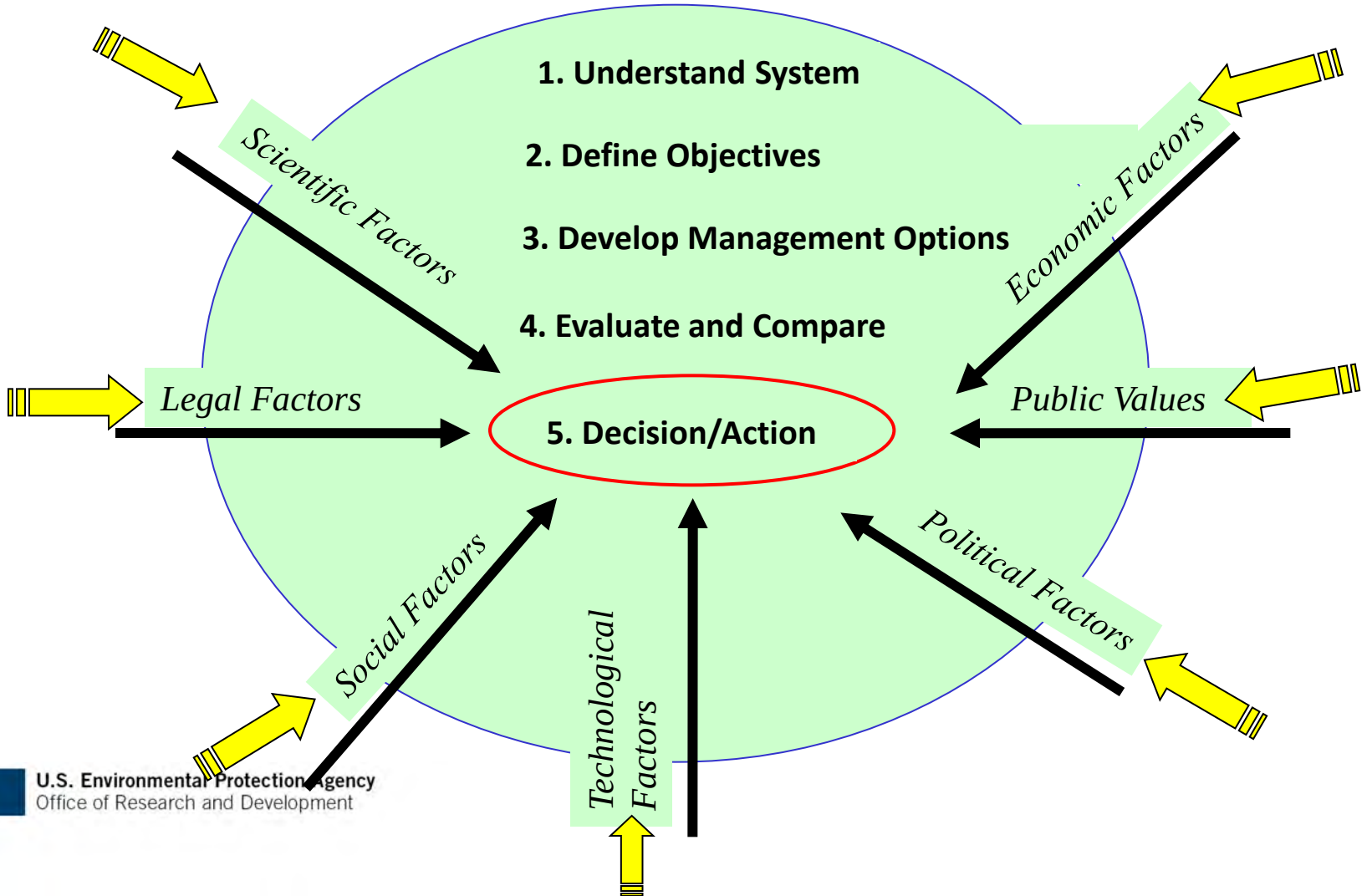
"Improve dramatically the **integration** of **economics** and the **decision** and **behavioral social sciences** into **research and policy development** across the Agency. ... [The Agency's] capability in the behavioral social sciences, and decision sciences, is so limited that it typically is not even in a position to ask the right questions."

SAB (2008). SAB Advisory Report "EPA's Strategic Research Directions 2008." November 26, 2008, EPA-SAB-09-006

In Response

- **The goal of the Decision Support Framework (DSF) Team is to help provide this assistance through development, demonstration and dissemination of effective, user-friendly methods that:**
  - **Improve the Agency's ability to incorporate scientific (e.g., environmental) knowledge with economic, legal, political and societal knowledge to better inform decisions**

Framework for Integrated Decision Analysis Process



Framework Characteristics

- Focused on sustainable systems solutions
- Engages stakeholders
- Amenable to decision-maker needs
- Probabilistic/incorporates uncertainty
- Iterative and adaptive
- Employs decision analysis ideas

Decision Analysis

Basic Concepts & Definitions

- Decision - a choice made from alternatives intended to achieve a desired yet uncertain outcome
- Decisions are a function of available information
- Decisions and outcomes are not the same
  - A good decision can yield a bad outcome

How do we use available information in decision-making to increase the chance of getting desired outcome

Decision Analysis

- Merging of systems analysis and decision theory
  - Need to use a systems perspective
    - Systems modeling/framing
  - Understand how people make decisions
    - Behavioral decision theory
  - Incorporates mathematics, economics, behavioral psychology, and computer science

Decision Analysis Definition

"Decision analysis is a logical procedure [that]…incorporates uncertainties, values, and preferences..."

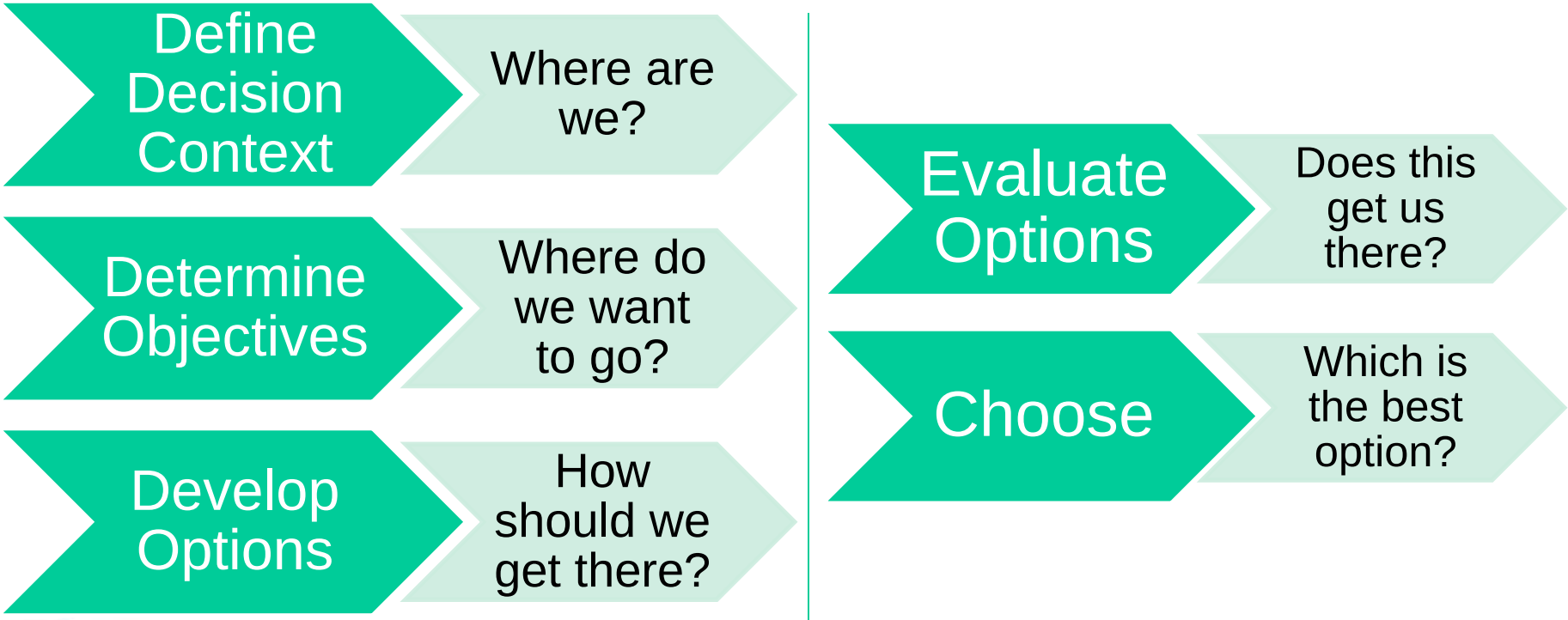
"The essence of the procedure is the construction of a structural model of the decision…suitable to computation and manipulation…"

Howard, 1966, Decision Analysis: Applied Decision Theory

Decision Model Structure

Stakeholder Engagement

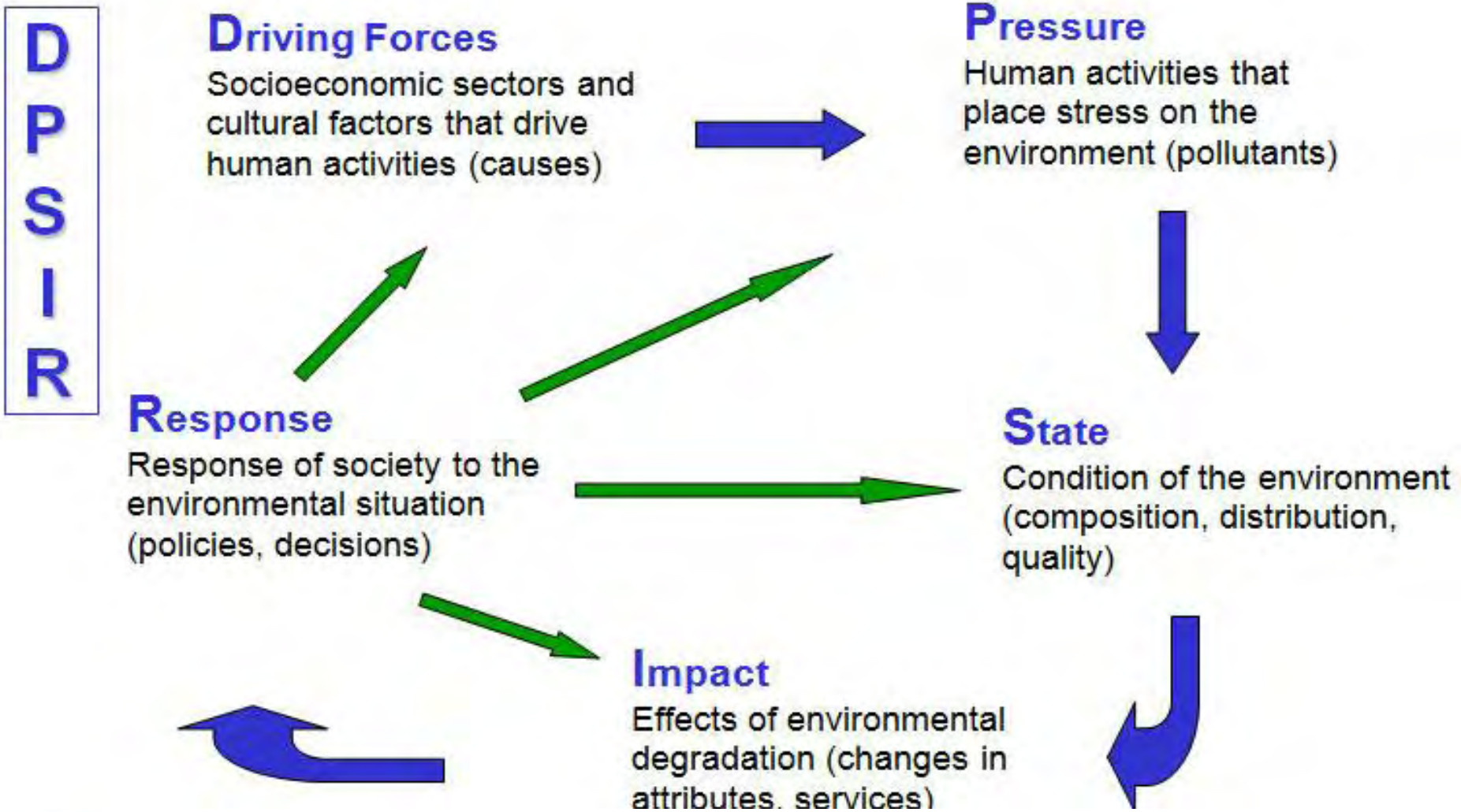
Decision-maker Support



Descriptive/Qualitative

Analytical/Quantitative

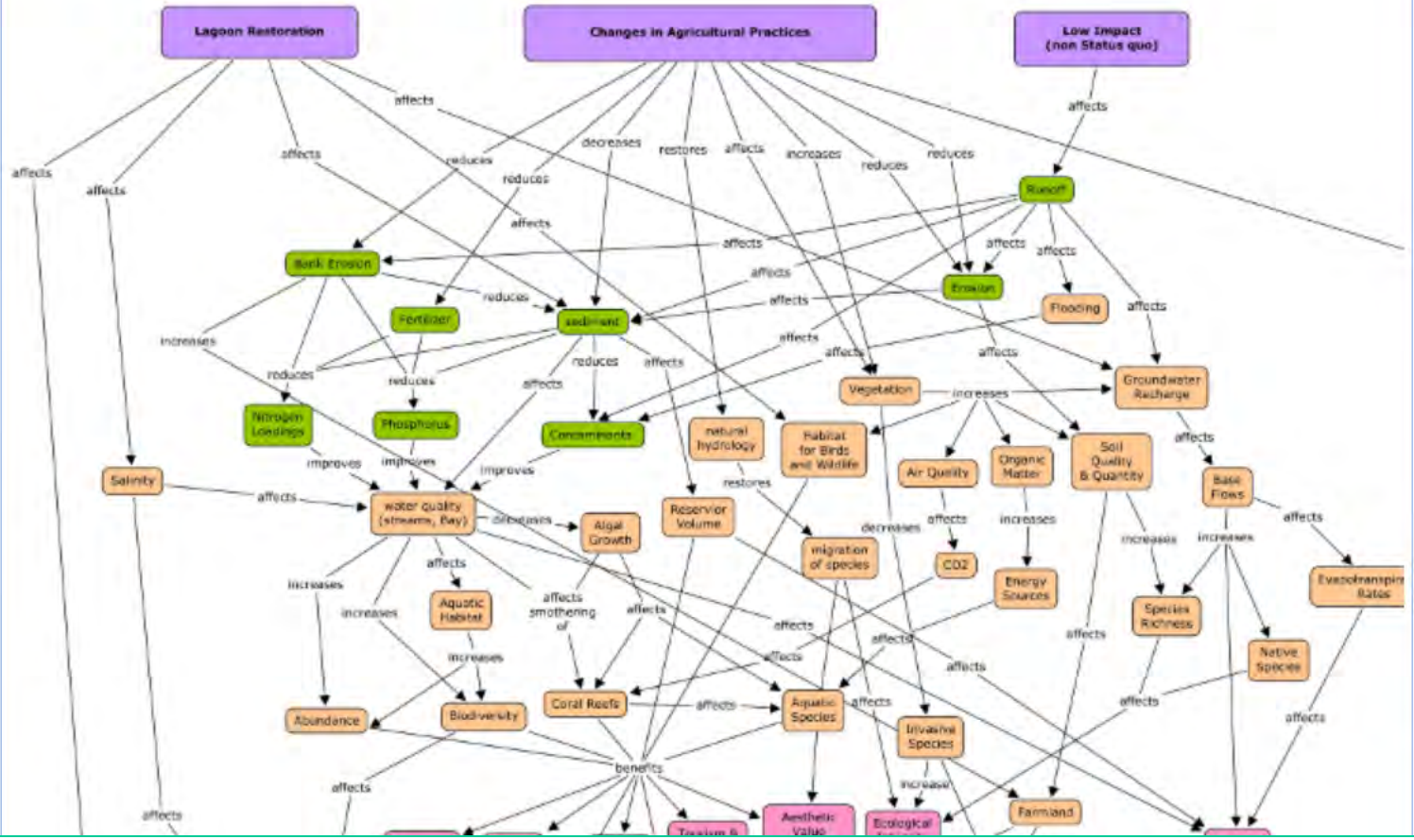
Step 1. Decision Context



Step 1: Understand Context | Step 2: Define Objectives | Step 3: Develop Options | Step 4: Evaluate Options | Step 5: Take Action

Decision Landscape | **DPSIR** | Social Network Analysis

Drivers, Pressures, States, Impacts, Response (DPSIR) is a causal framework for building a conceptual model (CM) of the interactions between society and the environment. Development of a DSPIR can guide **Objectives** development in **Step 2**, **Management Options** development in **Step 3** and provides the foundation for State & Impact modeling in **Step 4**.



Step 1: Understand Context | Step 2: Define Objectives | Step 3: Develop Options | Step 4: Evaluate Options | Step 5: Take Action

Decision Landscape | DPSIR | **Social Network Analysis**

Social Network Analysis (SNA) maps the relationships and interactions among people in order to identity knowledge flows. SNA can help to identify stakeholders and decision-makers from which **Objectives** can be elicited in **Step 2**. SNA can also identify knowledge and information sources to **Evaluate Options** in **Step 2**

Build a Social Network

Network Diagram

Respondents (select a person to see their contacts)

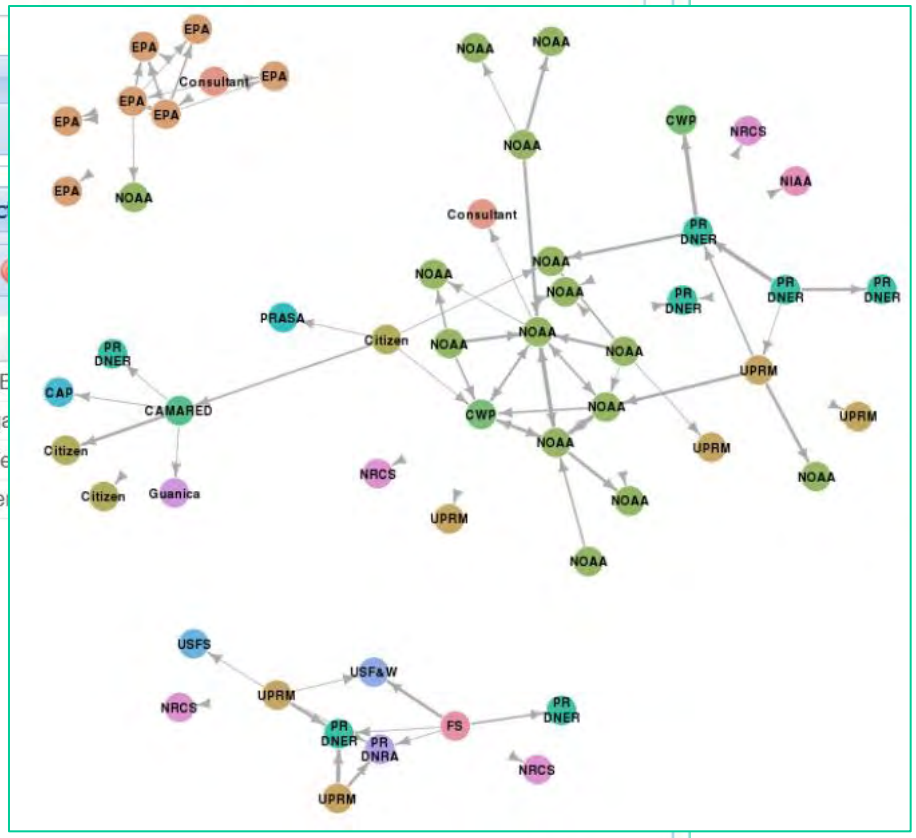
Add

Name	Organization	Position
Tom Stockton	Consultant	Decision Scier
Bill Fisher	EPA	Research Biol
Richard Appel	UPRM	Professor and
John Czapiga	Citizen	Citizen Editor
Lisamarie Car	NOAA	Natural Resou
Chris Caldow	NOAA	Senior Scienti
Magaly Figuer	FS	no anwser
Tom Moore	NOAA	Coral Reef Re
Dave Whitall	NOAA	Senior Scienti
Paul Sturm	CWP	Biologist
Skip Van Bloe	UPRM	Professor
Lia Brune	NOAA	Intern

Contac

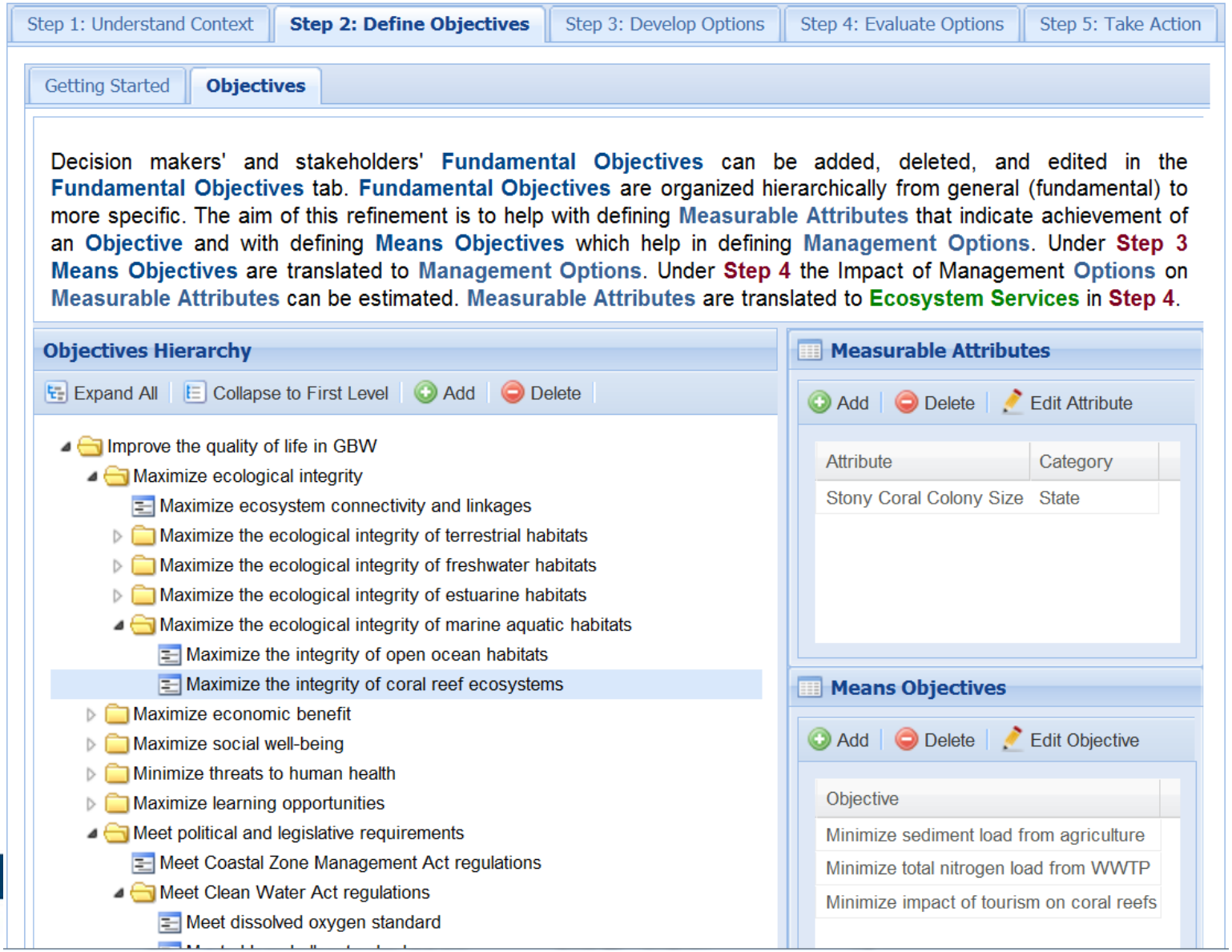
Add

Contact
Patricia E
Ann Vega
Susan Ye
Bill Fishe



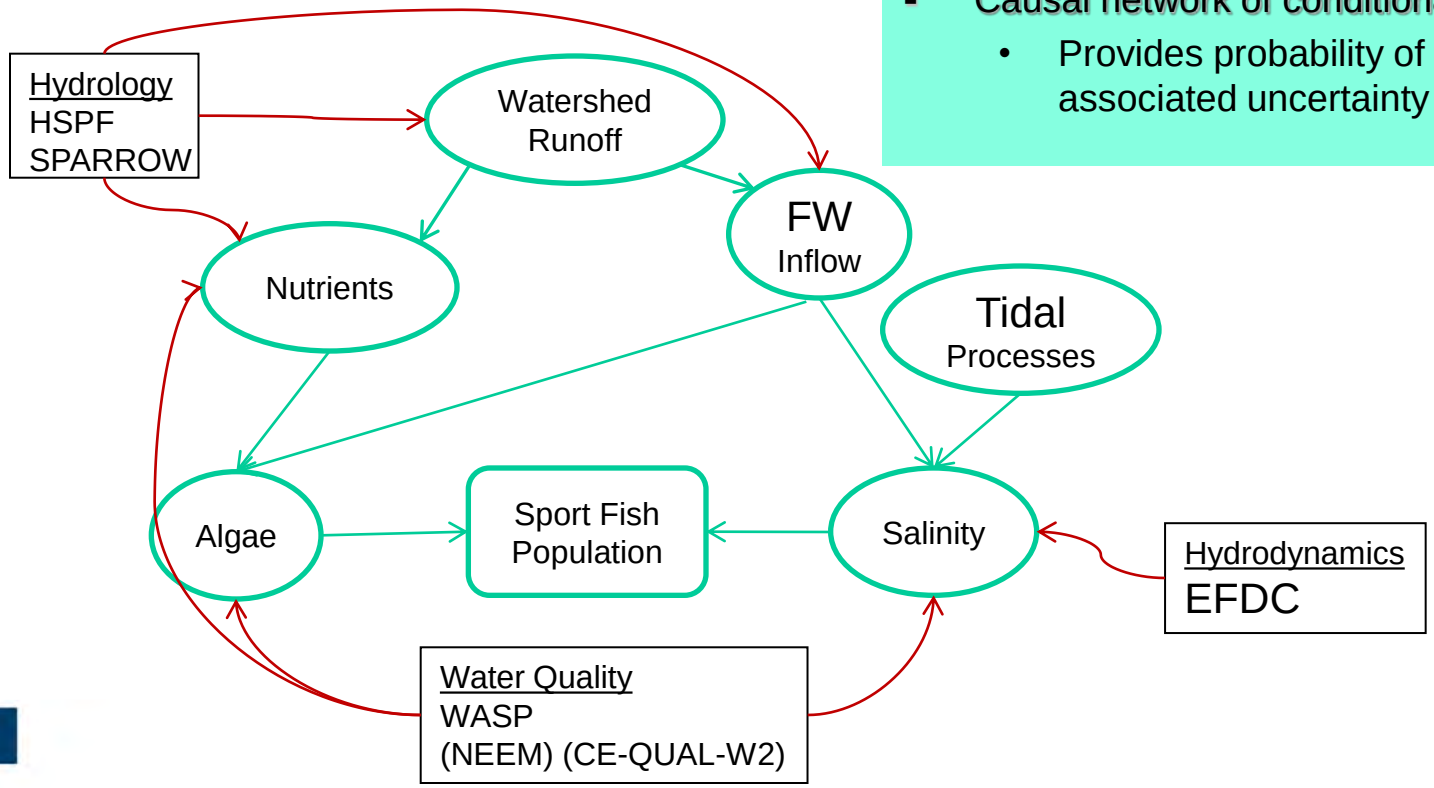
Step 2. Define Objectives

- **Vision – Values vs. Alternatives focused thinking** What do the decision makers and stakeholders want/need?
- **Identify Objectives –** What are specific objectives for achieving these outcomes?
- **Structure Objectives –** Which are the *fundamental* objectives and which are the *means* objectives?
- **Identify Measures –** What are the measures we can associate with each means objective
- **Prioritize Measures –** What measures/objectives are of most value to the stakeholders and decision makers?


Step 1: Understand Context
Step 2: Define Objectives
Step 3: Develop Options
Step 4: Evaluate Options
Step 5: Take Action
Getting Started
Objectives
Decision makers' and stakeholders' Fundamental Objectives can be added, deleted, and edited in the Fundamental Objectives tab. Fundamental Objectives are organized hierarchically from general (fundamental) to more specific. The aim of this refinement is to help with defining Measurable Attributes that indicate achievement of an Objective and with defining Means Objectives which help in defining Management Options. Under Step 3 Means Objectives are translated to Management Options. Under Step 4 the Impact of Management Options on Measurable Attributes can be estimated. Measurable Attributes are translated to Ecosystem Services in Step 4.
Objectives Hierarchy
Expand All
Collapse to First Level
Add
Delete
Improve the quality of life in GBW
Maximize ecological integrity
Maximize ecosystem connectivity and linkages
Maximize the ecological integrity of terrestrial habitats
Maximize the ecological integrity of freshwater habitats
Maximize the ecological integrity of estuarine habitats
Maximize the ecological integrity of marine aquatic habitats
Maximize the integrity of open ocean habitats
Maximize the integrity of coral reef ecosystems
Maximize economic benefit
Maximize social well-being
Minimize threats to human health
Maximize learning opportunities
Meet political and legislative requirements
Meet Coastal Zone Management Act regulations
Meet Clean Water Act regulations
Meet dissolved oxygen standard
Measurable Attributes
Add
Delete
Edit Attribute
Attribute
Category
Stony Coral Colony Size
State
Means Objectives
Add
Delete
Edit Objective
Objective
Minimize sediment load from agriculture
Minimize total nitrogen load from WWTP
Minimize impact of tourism on coral reefs

Bayesian Belief Net –evalauting options

- Normative framework - Relates spatial and temporal differences
- Causal network of conditional probabilities
  - Provides probability of outcome and associated uncertainty



Step 5. Choose

- Decision Theory
  - Choice depends on:
    - Scientific uncertainty (characterized in Step 4)
    - Stakeholder attitude toward that uncertainty (risk)
- Quantified with Subjective Expected Utility
  - Integrates uncertainty of outcome and stakeholder values

Subjective Expected Utility

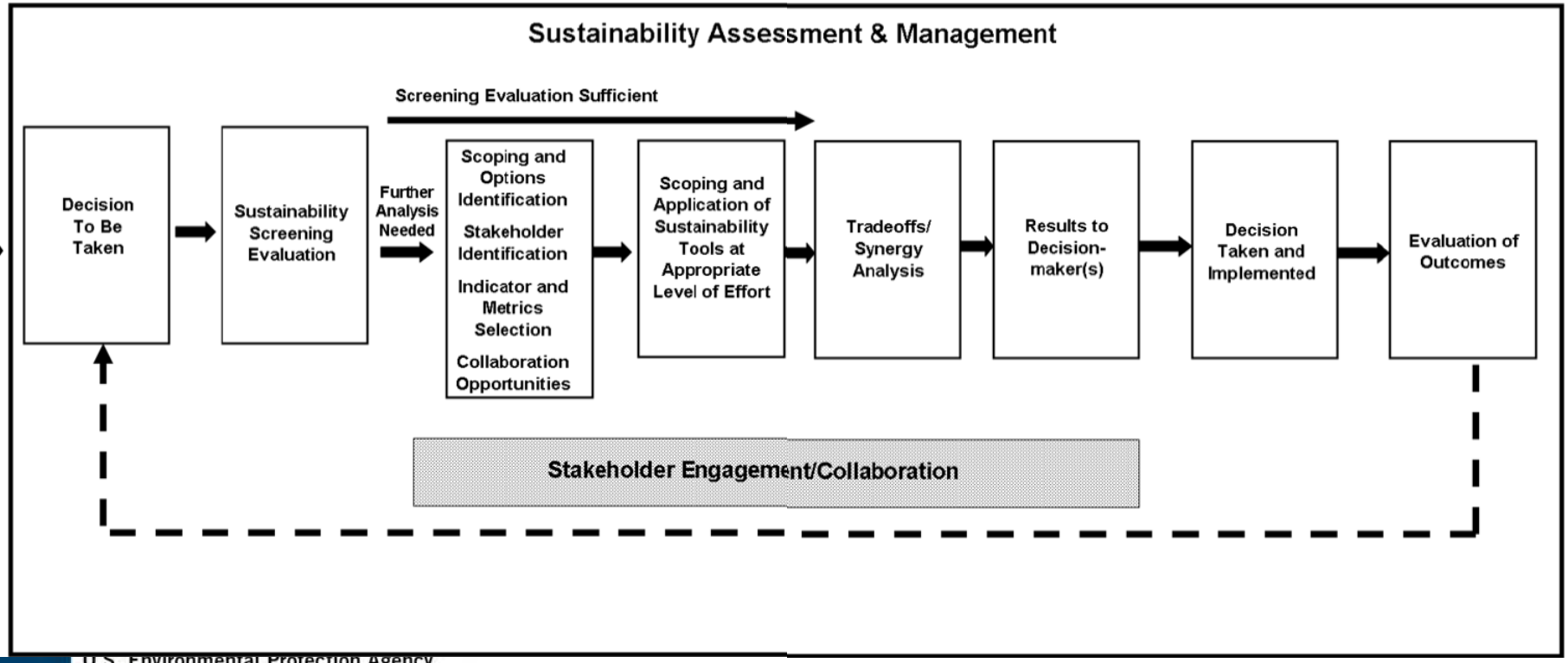
$$\sum u(x)_i \, P(x)_i$$

Where:

$u(x_i)$ = preference for an outcome measure

$P(x_i)$ = probability of outcome measure occurring

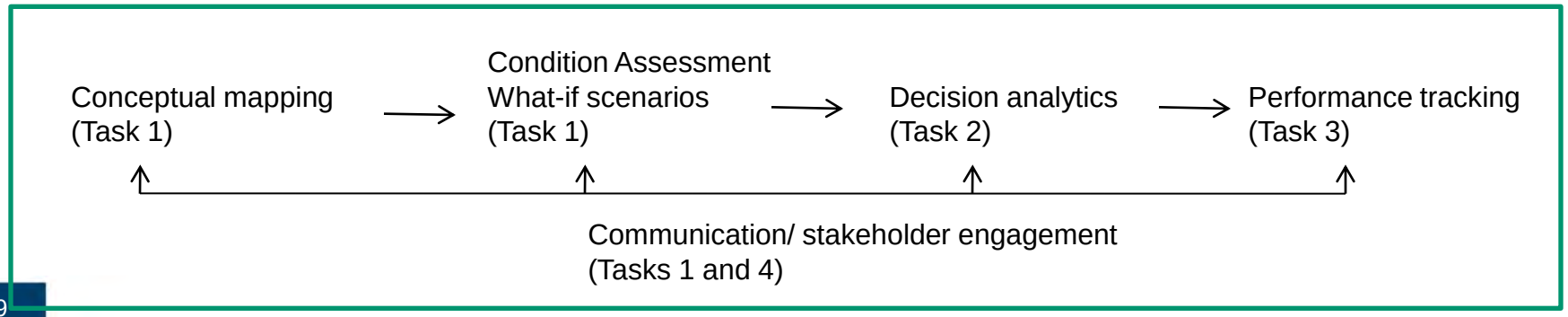
Sustainability and the U.S. EPA: Committee on Incorporating Sustainability in the U.S. Environmental Protection Agency; National Research Council



Sustainable and Healthy Communities Research Program

Administrator Jackson:
"incorporate sustainability into the way the Agency approaches environmental protection."

"The SHCRP intends to improve access to information, tools, and decision frameworks that allow community decision-makers to understand how specific actions affect community well-being, weigh the full consequences of alternative management actions, track progress towards goals, and allow the creation of innovative solutions to community problems."



IT modernization, interoperable tools (Task 4)