Multi-Criteria Decision Analysis

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Overview

- What is Multi-Criteria Decision Analysis (MCDA)?
- Why is it Useful?
- What are MCDA Methods?
- What are MCDA Tools?
- Feedback from RECOVER on Decision-Support Tools
- Integration with Spatial Decision Support Systems
- Potential Integration with Adaptive Management

Multi-Criteria Decision Analysis (MCDA) Tools

- Multiple Indicators: Integrate multiple performance indicators related to multiple restoration objectives and/or constraints
- Identity Competing Objectives: Alternatives that improve some performance indicators can impact others
- Incorporate Values (Preferences): Stakeholders and partner agencies may value performance towards multiple objectives differently

*Inform decision makers and stakeholders, but don't make the decisions!

Multiple Indicators

Table 1. List of System-wide Indicators (SCG Indicators Report)

- Fish and Macroinvertebrates
- Wading Birds (Wood Stork and White Ibis)
- Wading Birds (Roseate Spoonbill)
- Florida Bay Submerged Aquatic Vegetation
- Florida Bay Algal Blooms
- Crocodilians (Alligators and Crocodiles)
- Oysters
- Periphyton-Epiphyton (communities of microscopic algae and bacteria)
- Juvenile Pink Shrimp
- Lake Okeechobee Littoral Zone
- Invasive Exotic Plants

Table 2. Additional RECOVER System-wide/Regional Performance Measures

- High and Low Water Levels
- Sheet Flow
- Wet Prairie
- Duration of Dry Events
- Inundation duration
- Coastal Salinity Gradients
- Ridge and Slough Patterns
- Tidal Creek Patterns
- Lake Okeechobee Stage
- Lake Okeechobee WQ
- Lake Okeechobee Vegetation, Fish Population, Macroinvertabrates

Table 3. Constraints

- TP - TN concentrations, loading
- TP in soils
- Endangered Species Critical Habitat
- Flood Damage Reduction Protection

Table 4. Additional Metrics and Values

- Cost/Benefits
- Recreational Benefits
- Socio-Economic
- Historic Preservation

Potential Competing Objectives

(National Research Council 2010 Report on Everglades Restoration Progress)

- Short-term and Long-term tradeoffs between water quality and quantity (NRC 2010)
- Band 1 Report (RECOVER 2010):
  - LO high stages vs. estuary discharges
  - Dry-season releases to ENP vs. North WCA 3A Dryouts and potential highwater WCA 3B
- Everglades Restoration Transition Plan (USACE 2010):
  - WCA-3A discharge to ENP vs. Sparrow Critical Habitat

Example of Different Values (Weights) by Agency

Table 5. Criteria weights (%) for different scenarios in the New York/New Jersey (USA) case study (Kiker et al. 2005)

Criterion/scenario	USEPA experts[a]	USACE experts[b]	SRA Workshop participants[c]
Impacted area/capacity	7.37	12.46	10.77
Magnitude of ecological hazard quotient	20.29	14.72	16.58
Ecological pathways	15.36	12.40	15.87
Human pathways	12.81	14.79	12.63
Magnitude of cancer risk	18.86	14.13	18.48
Ratio of fish contaminant of concern/risk level	15.33	11.82	13.00
Cost	9.97	19.66	12.67

MCDA Methods

(Linkov, et al., 2006. Environment International 32: 1072-1093):

- **Multi-Attribute Utility Theory** – aggregate multiple criteria scores into single expression (assumption is the higher Utility the better). Weighting can be used based on preferences of each criteria's importance.
- **Analytic Hierarchy Process** – uses pair-wise comparisons of decision criteria rather than utility or weighting functions (assumption is that humans are more capable of relative judgments rather than absolute)
- **Outranking** – Compare alternatives to each other using multiple criteria to identify the one that is dominantly better. Dominance of an alternatives occurs when one performs better than another on at least one criteria and no worse on others.

Decision Support Tools and MCDA

Wikipedia: http://en.wikipedia.org/wiki/Decision_making_software

- USACE IWR Planning Suite – MCDA Extension (http://www.pmcl.com/iwrplan/MCDAUsersGuideSep10.pdf)
- MCDA integrated with ELM (Fitz, et al., 2010)

Software	Supported MCDA Method (s)	Pairwise comparison	Time Analysis	Sensitivity analysis	Group evaluation	Risk management	Web-based version	Software licence
1000Minds	PAPRIKA	Yes	No	Yes	Yes	No	Yes	21 days trial
Analytica		No	Yes	Yes	No	Yes	Yes	30 days trial
Criterium DecisionPlus	AHP	No	No	Yes	No	No	No	
D-Sight	PROMETHEE, MAUT	Yes	No	Yes	Yes	Yes	No	30 days trial, academic, corporate
Decision Lab		Yes	No	Yes	No	Yes	No	
Decision Lens	AHP ANP	Yes		Yes	Yes		Yes	
Decision Manager		No	No	Yes	No	Yes	No	
DPL Syncopation		No	No	Yes	No	Yes	No	
ERGO		Yes	No	Yes	No	No	Yes	
Expert Choice	AHP	Yes	No	Yes	Yes	Yes	Yes	
Hiview3		No	No	Yes	Yes	No	No	
Logical Decisions		No	No	Yes	No	No	No	
MakeItRational	AHP	Yes	No	Yes	Yes	No	Yes	Free, Standard, Team, Server
MindDecider		Yes	Yes	Yes	Yes	Yes	No	Demo, Standard, Pro, Team
RPM-Decisions		No	No	Yes	No	No	Yes	
SelectPro	AHP	Yes	No	Yes	Yes	No	Yes	Demo, Machine, Corporate, Floating
TreeAge Pro		No	No	Yes	No	Yes	No	
Vanguard Studio		No	No	Yes	Yes	Yes	Yes	
Kessera Random Decisions		No	No	No	No	No	Yes	Free
Criteria Decision								

Feedback from RECOVER and Agencies

Based on:

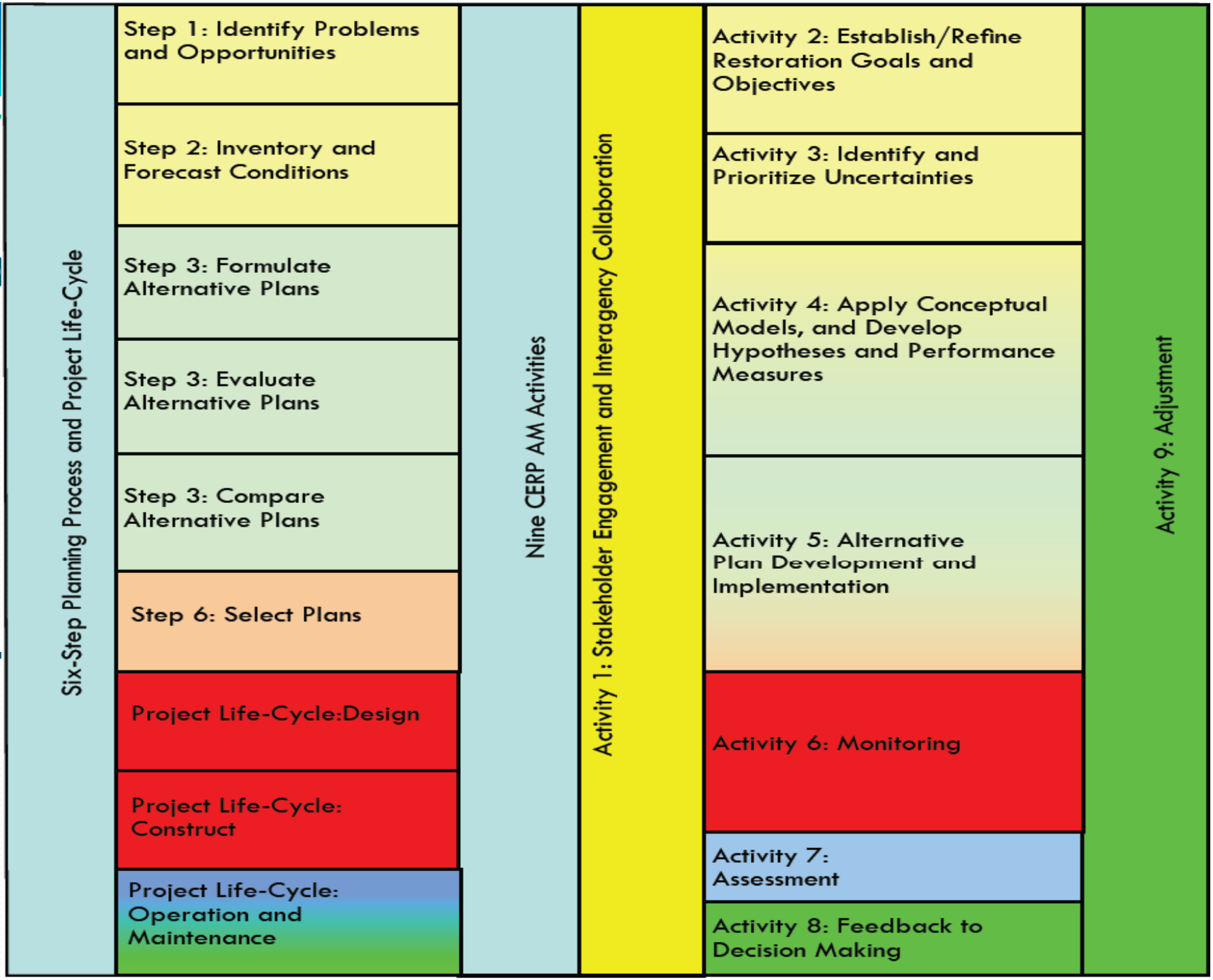
1. Pearlstine and Mazzotti, 2003 - Paper on Spatially-Explicit Decision Support System for Everglades Risk Assessment and Restoration; and
2. 2010 RECOVER Discussions on Decision Analysis Tool Development

- Need to understand uncertainty and risk in decision context
- Need to have information organized spatially and temporally
- Need sensitive metrics and tools to show differences in alternatives
- Needs to plug into benefits analyses for Congress
- Need to allow public and policy makers to have input on weighting factors (separate science and policy/management judgments).

Spatial Decision Support Systems and MCDA

- Decision Support Systems (DSS) – Integrate multiple information sources (different models; surveys; real-time or simulation) to evaluate potential results or assess actual results.
- Spatial DSS (SDSS) – Integrate Geographical Information Systems in a decision support system context to integrate multiple information sources (criteria) spatially
- MCDA and SDSS – provide a context for organizing the information into a decision matrix that integrates separate information feedback {the science input (SDSS and evaluation/assessment of that information)} and stakeholder and management policy views
  - SWFFS (Pearlstine et al., 2006) http://edis.ifas.ufl.edu/pdffiles/UW/UW23500.pdf

CERP Adaptive Management

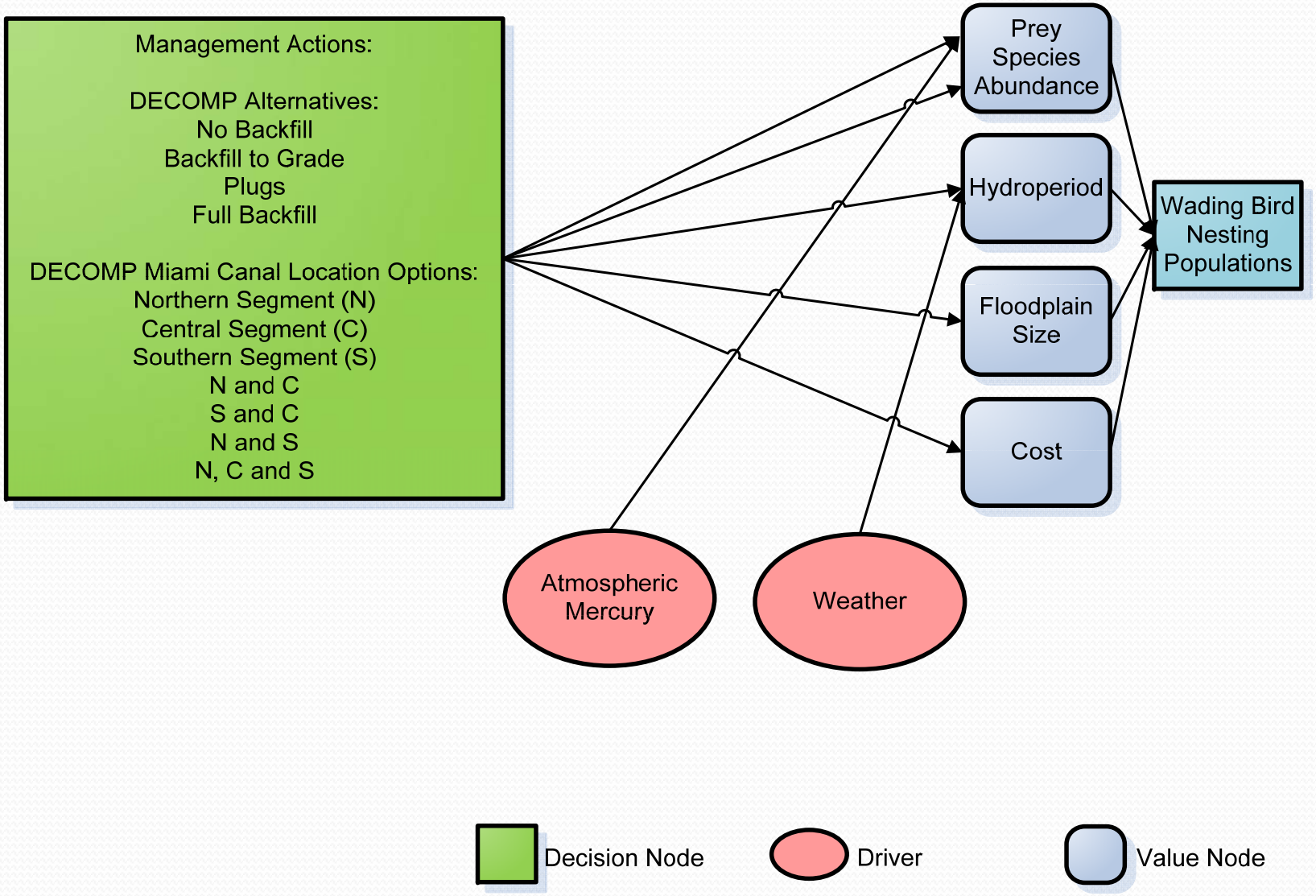


Questions?

MCDA and Adaptive Management Scope

- Value of Information in reducing uncertainty
- Develop decision frameworks that link projects, expected results, monitoring of actual results, to potential decision-making options
- Ability to incorporate stakeholder and decision-maker values in order to weight objectives

Basic Influence Diagram for Adaptive Management Model for the Wading Birds Hypothesis Cluster

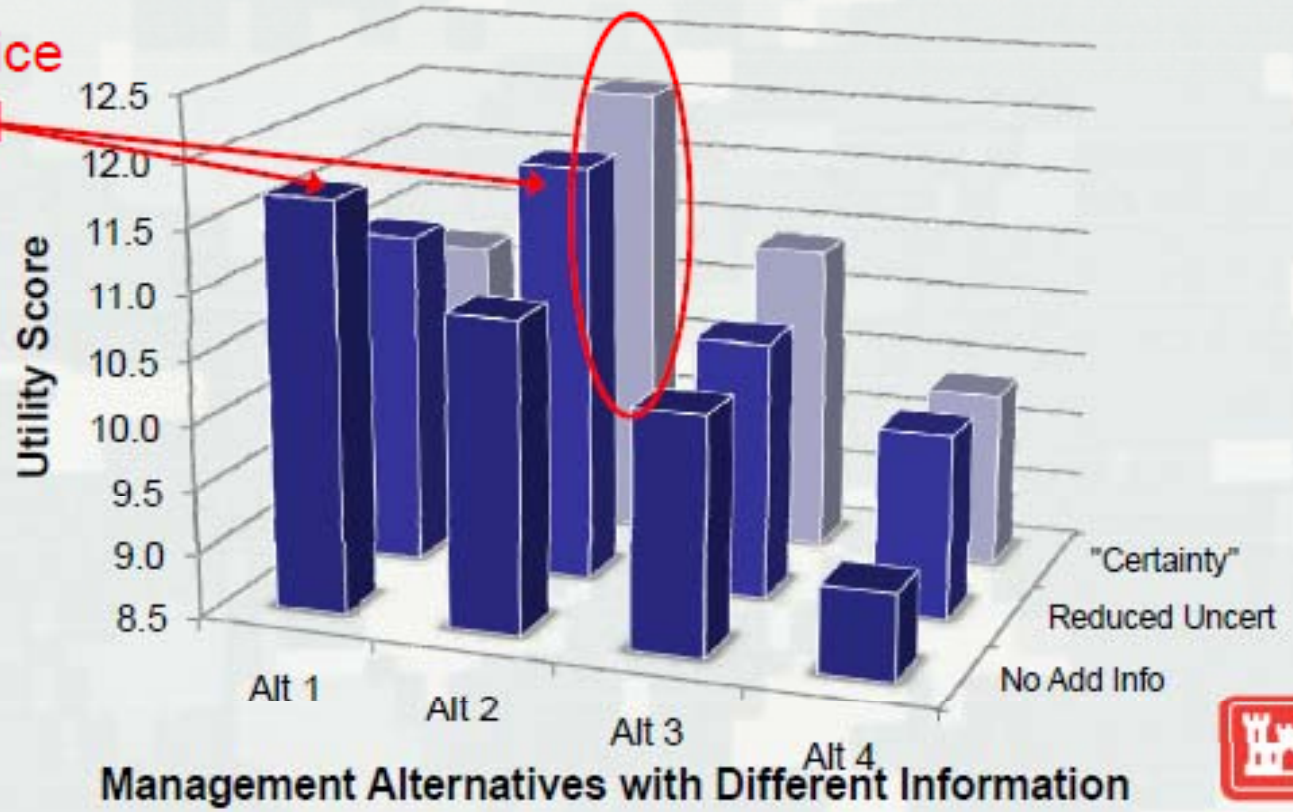


Effect of Reducing Uncertainty

What is the utility value of a reduction in uncertainty of the effects of a particular management alternative? In other words, if you know the implication of your actions with more certainty, what is the relative value.

Change in choice with reduced uncertainty.

Quantified value of perfect information (certainty).



Linkov, et al., 2010. Enhanced Adaptive Management Webinar

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MCDA and Adaptive Management

People, Process and Tools

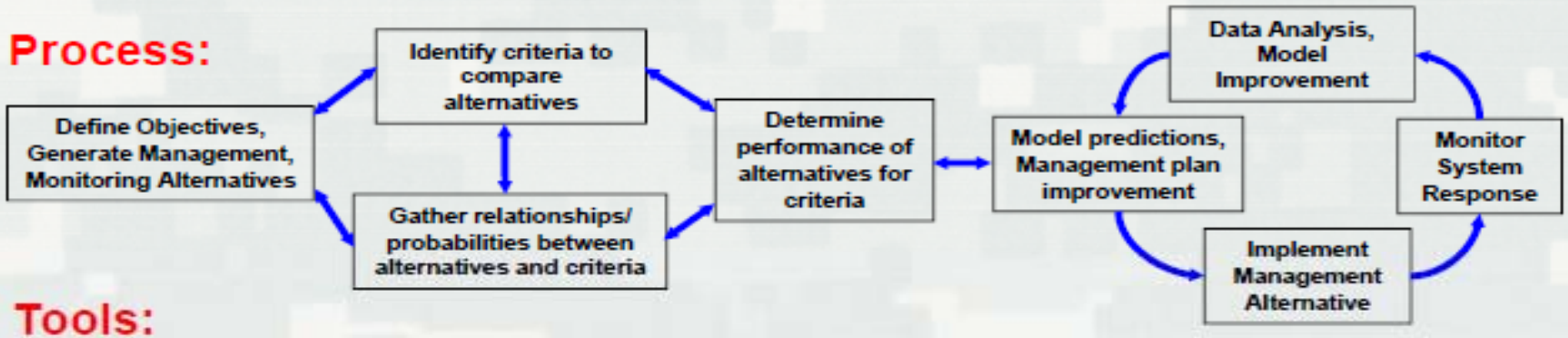
People:

Policy Decision Maker(s)

Scientists and Engineers, Decision Analysts

Stakeholders (Public, Business, Interest groups)

Process:



Tools:

Environmental Assessment/Modeling (Risk/Ecological/Environmental/Simulation)

Decision Analysis/Scenario Analysis/Optimization of Monitoring

Timeline*:

6 – 12 months — 1 project management cycle

***Duration/cost depends on complexity of application**

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Linkov, et al., 2006. Environment International 32: 1072-1093