

Adaptive Management: Needs and Solutions

Igor Linkov
Christy Foran
Laure Canis
Lynn Scarlett
Todd Bridges

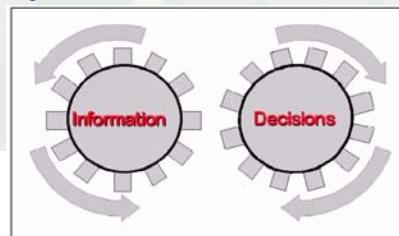
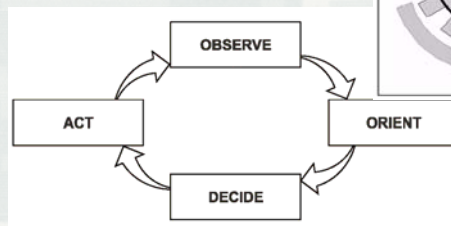


US Army Corps of Engineers
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Decision Cycles

Information gathering and decision-making are two separate cycles

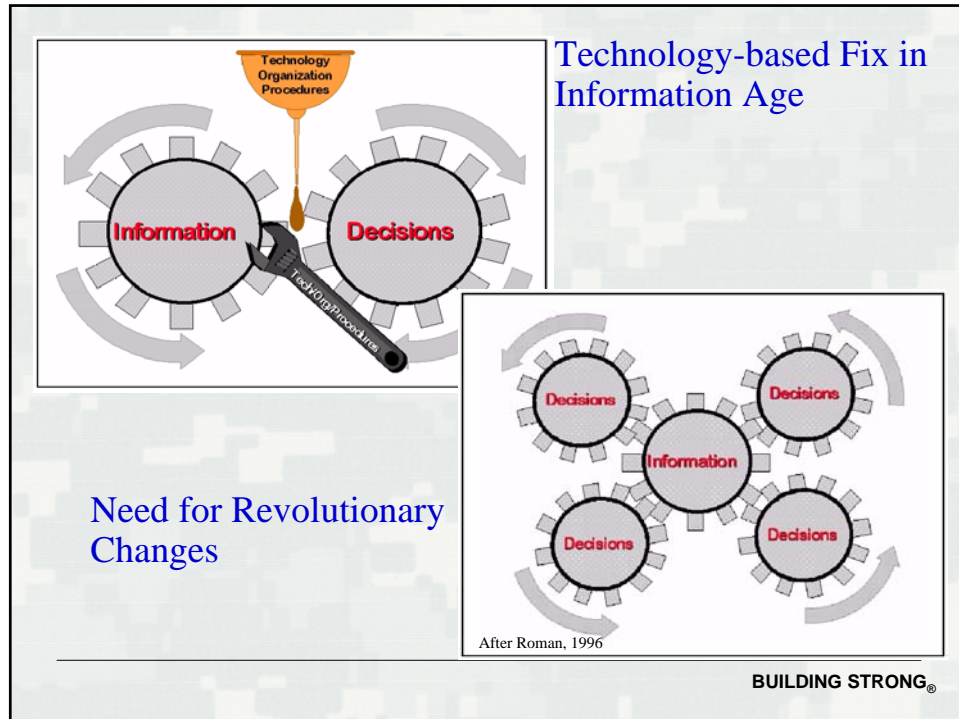


After Roman, 1996

	<i>Revolutionary War</i>	<i>Civil War</i>	<i>World War II</i>	<i>Gulf War</i>	<i>War of Tomorrow</i>
Observe	Telescope	Telegraph	Radio/Wire	Near Real Time	Real Time
Orient	Weeks	Days	Hours	Minutes	Continuous
Decide	Months	Weeks	Days	Hours	Immediate
Act	A Season	A Month	A Week	A Day	Less Than An Hour

Source: Sullivan, Gordon R. and James M. Dubik, *War in the Information Age*.

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Value of Information (Vol)

- Information has value if it might alter the evaluation of which alternative is optimal
- Vol analyses are undertaken to:
 - ▶ Determine if the decision is sensitive to a particular source of uncertainty
 - ▶ Determine how much to invest in eliminating or reducing the uncertainty
 - ▶ Identify which uncertainties should be resolved first
- Should monitoring be conducted and how much should be invested in the sampling effort?



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Adaptive Management: Needs



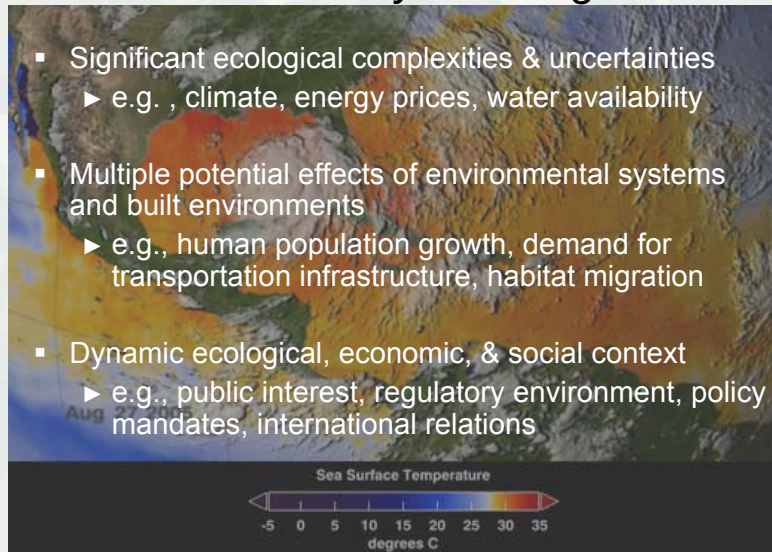
Resource Management Context

- ▶ Uncertainty
- ▶ Rapid Change
- ▶ Complexity



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Adaptive Management: 21st Century Challenges



Hurricane Katrina image from NASA Vision website



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Adaptive Management: 21st Century Challenges



- Alternative management plans can produce changes at many scales across many landscapes
- Alternative plans present uncertain benefits and potentially unintended consequences



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What is Adaptive Management?

- Adaptive management is a decision framework for addressing uncertainties by:
 - ▶ collecting information relevant to management goals during action implementation;
 - ▶ modifying the course of action to enhance results based on collected information and analysis.



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Adaptive Management Current Use and Misuse

Restoration of a Marsh

Plan based on existing conditions:

- currently successful species
- current sea level, storm severity

“Adaptive Management” approach: Fix if it fails

- detected through monitoring
(often just engineering specifications)



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Adaptive Management in Practice Critiques and Challenges

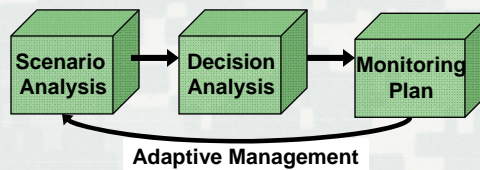
- Lack of clear nexus between adaptive management plans and resource management needs
- Lack of process for scientific feedback to affect management decisions
- Lack of prioritization of monitoring needs
- Lack of framework for integrated learning



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Enhanced Adaptive Management Key Requirements

- **Scenario analysis** to define potential ranges of future conditions
- **Decision analysis** to structure in advance key conditions that may require changes in management strategies
- **Monitoring plan** to collect data that informs management decisions about key conditions



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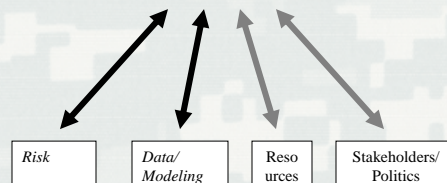
Enhanced Adaptive Management Benefits of Decision Analysis

Decision Maker(s)



Decision Analytical Frameworks

- Agency-relevant/Stakeholder-selected
 - Currently available software
- Variety of structuring techniques
- Iteration/reflection encouraged
- Identify areas for discussion/compromise



Sharing Data, Concepts and Opinions



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Management using Decision Analysis (DA)

Determine conditions for “successful” marsh

- species breeding conditions (size, vegetation, etc.)
- vegetation settlement/growth conditions
- stabilization, erosion control

Conditions for restoration “success” determine the design/management

- best/optimal design alternative encompasses conditions
- validate design through “performance” monitoring



Note: measurement of species abundance, etc. under these conditions is not “adaptive management” as it does not inform future actions.



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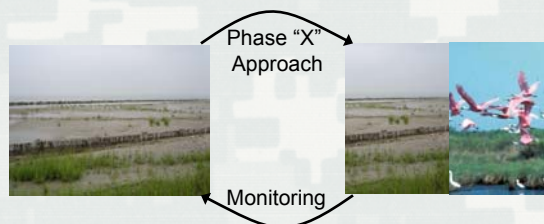
Adaptive Management using DA

Model conditions for “successful” marsh

- relationship (with error) between condition and breeding population
- vegetation growth dependence on abiotic conditions
- grade vs. rate of erosion, dependence on precipitation

Most probable “successful” conditions determine Phase 1 approach

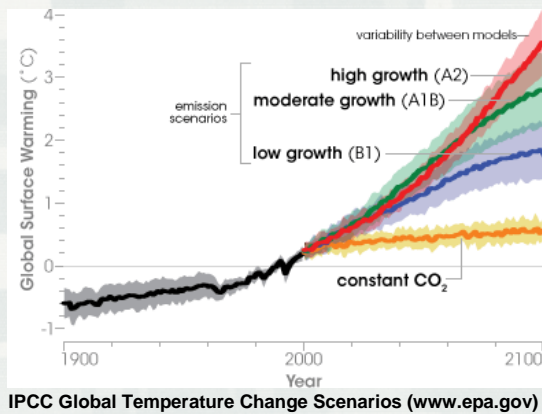
- incorporate optimal conditions from model
- monitor conditions, populations, growth, erosion, precipitation
- update the relationships, certainty of models based on monitoring
- alter marsh management for new “optimal” conditions from models



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Enhanced Adaptive Management Benefits of Scenario Analysis

- Identification of critical future conditions that require a change in the management approach



- Ranges and limits for the needs of the management approach
- The relationship between uncertainty and operational objectives



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Adaptive Management using DA and Scenario Analysis

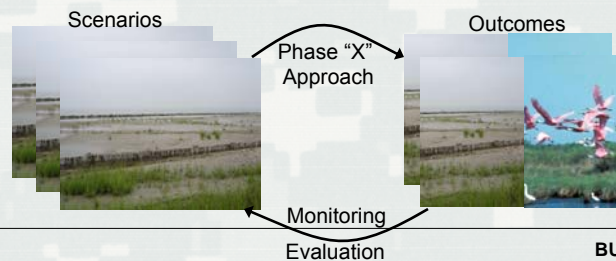
Model conditions for “successful” marsh

Develop future “scenarios” to evaluate design/management plans

- range of future temperatures, precipitation, habitats
- range of future sea levels, storm severity, inundation
- range of potential land use constraints, population growth

Choose most robust, probable “successful” conditions for Phase 1 approach

- monitor conditions, populations, growth, erosion, precipitation
- alter marsh management conditions according to updated models



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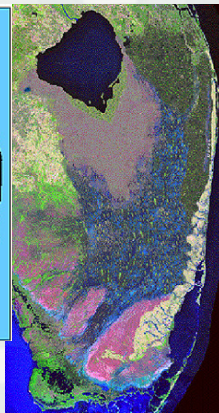
Everglades Adaptive Management

- ▶ Sophisticated hydrologic and ecological models but not well used to inform management actions
- ▶ Criticized for limited opportunity to “learn from” actions

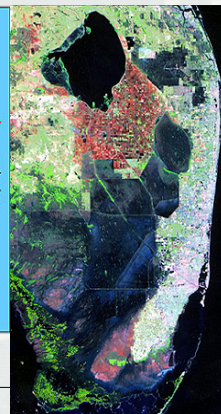
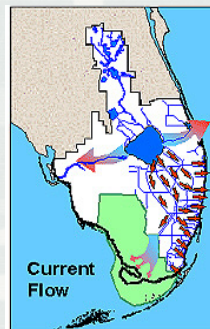


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Everglades Adaptive Management

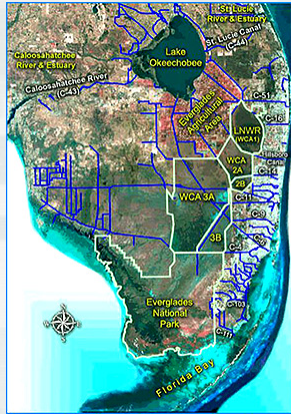


Levee and canal flood protection cut water flow, resulting in ecological damage.



Everglades Management Alternatives

Alternative actions that could be taken to control water level include degradation of levees and backfilling canals.



- Alt 1 – minor canal fill
- Alt 2 – major canal fill
- Alt 3 – minor levee degradation
- Alt 4 – major levee degradation



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Everglades Management Scenarios

Land use

Different drivers are used a scenarios that impact the management decisions.

Extreme events

These directly and indirectly (through uncertainties) impact the objectives.

Rainfall

The simplest scenarios would be combinations of high, medium and low levels for each driver.



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Everglades Adaptive Management Decision Model Parameters

-Decision objectives: restore ecosystem, maintain flood protection, minimize monetary costs

-Decision alternatives:

- Different degrees of degradation for levees and backfilling for canals (minor, major) for each of the 2 periods
- No monitoring plan or depth monitoring plan during period 1

- Uncertainties linked with water:

- Water nutrients (Too low, Normal, Too High)
- Water salinity (Too low, Normal, Too High)
- Water depth (Too low, Normal, Too High)

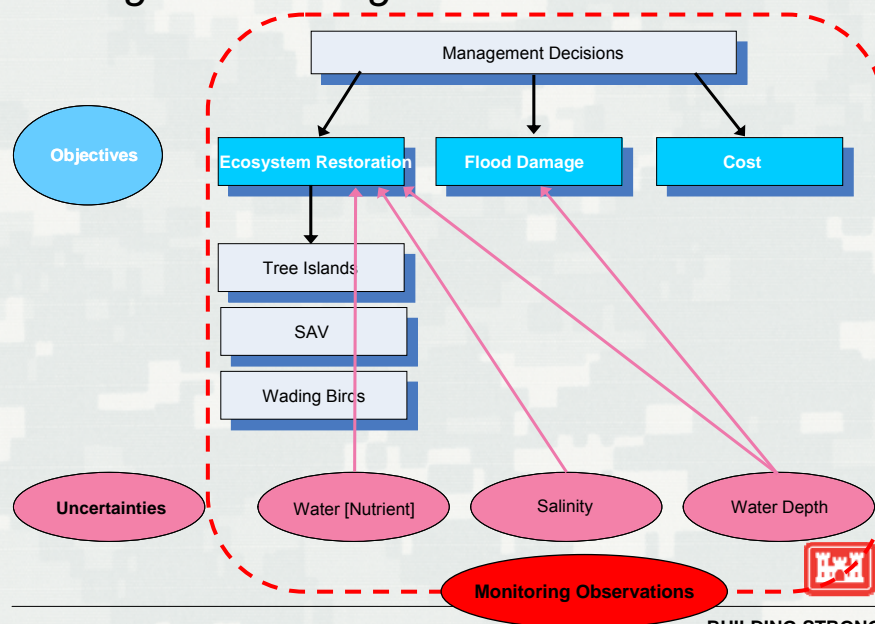
- Driver/Scenario: rain

- Management Timeframe: two periods

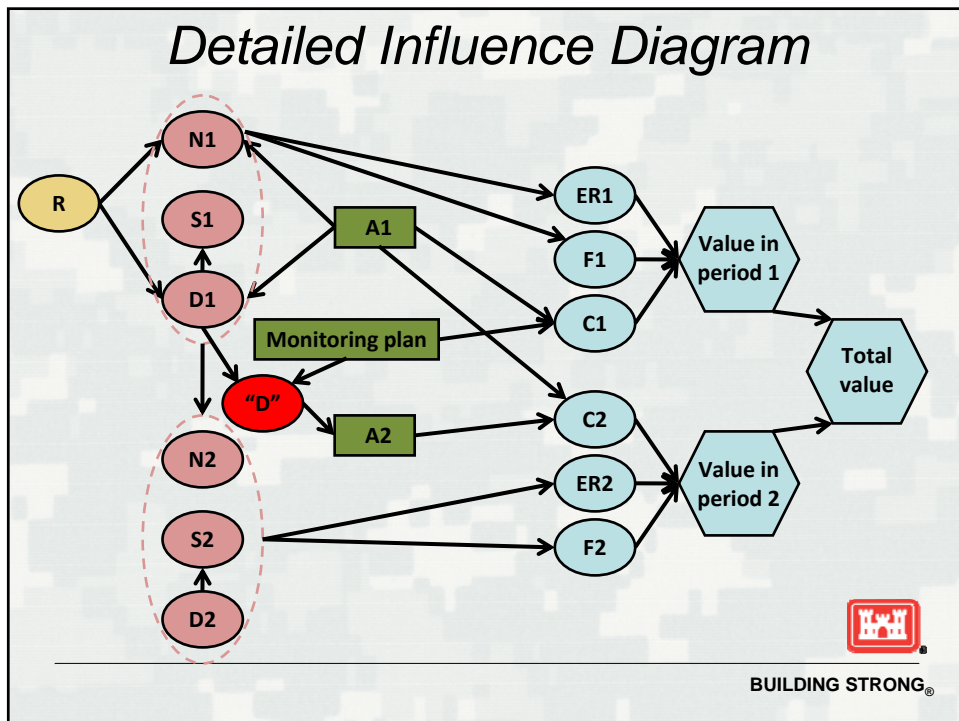
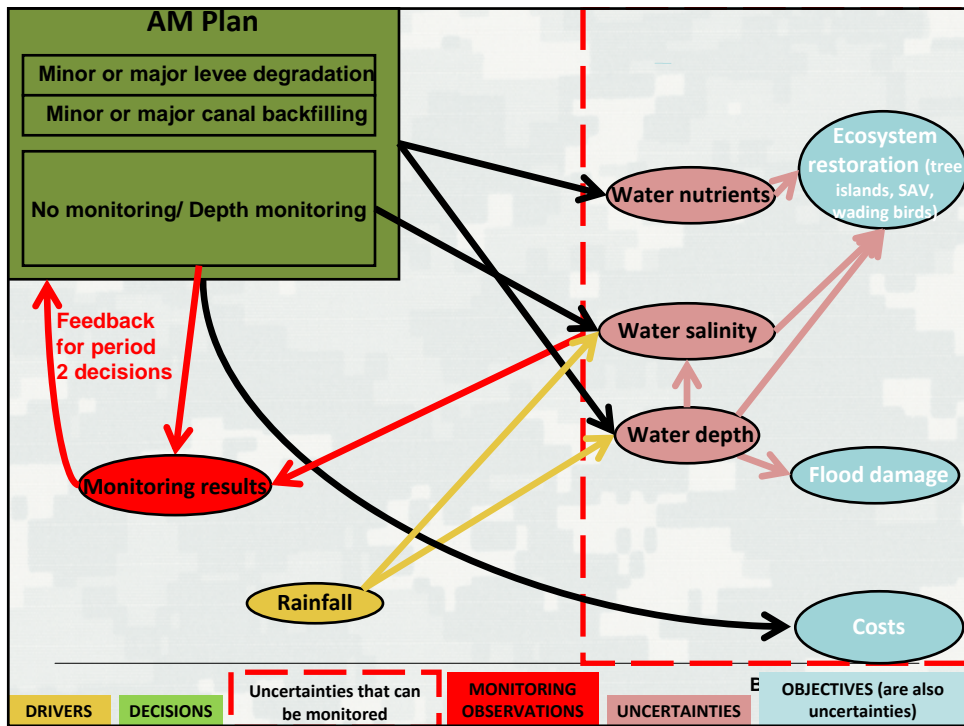
Alternative	Levee degradation	Canal backfilling
1	Minor	Minor
2	Major	Minor
3	Minor	Major
4	Major	Major

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Everglades Management Decision Context



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Model Results

Without dynamic monitoring

Period 1 Alternative	1	2	3	4
Value	11.56	11.53	10.78	10.42
Corresponding Period 2 Alternative	1	2	3	4

With the dynamic monitoring plan

Period 1 Alternative	1	2	3	4
Value	11.46	11.61	10.77	10.60
Corresponding Period 2 Alternative	1	1 if "D"=3, else 2	1 if "D"=3, else 3	1 if "D"=3, else 4

Without Monitoring, Select Alternative 1
 The best decision is: Monitor Depth, Period 1 Alternative=2,
 Period 2 Alternative=1 if "D"=3, otherwise stay with Alternative 2



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Current "Adaptive Management" vs Enhanced Adaptive Management

Currently:

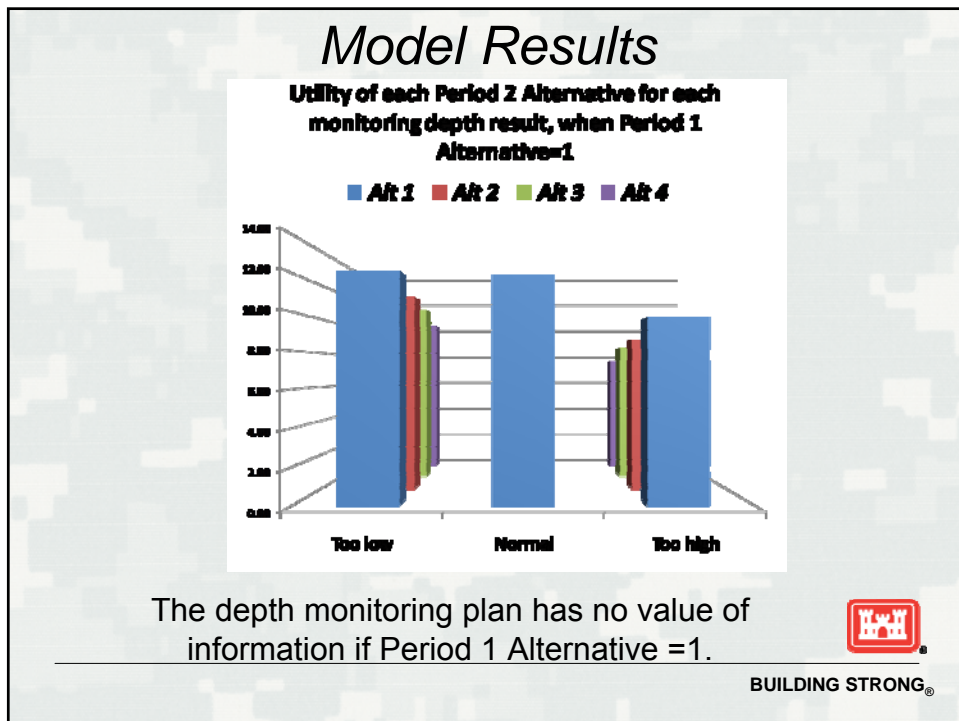
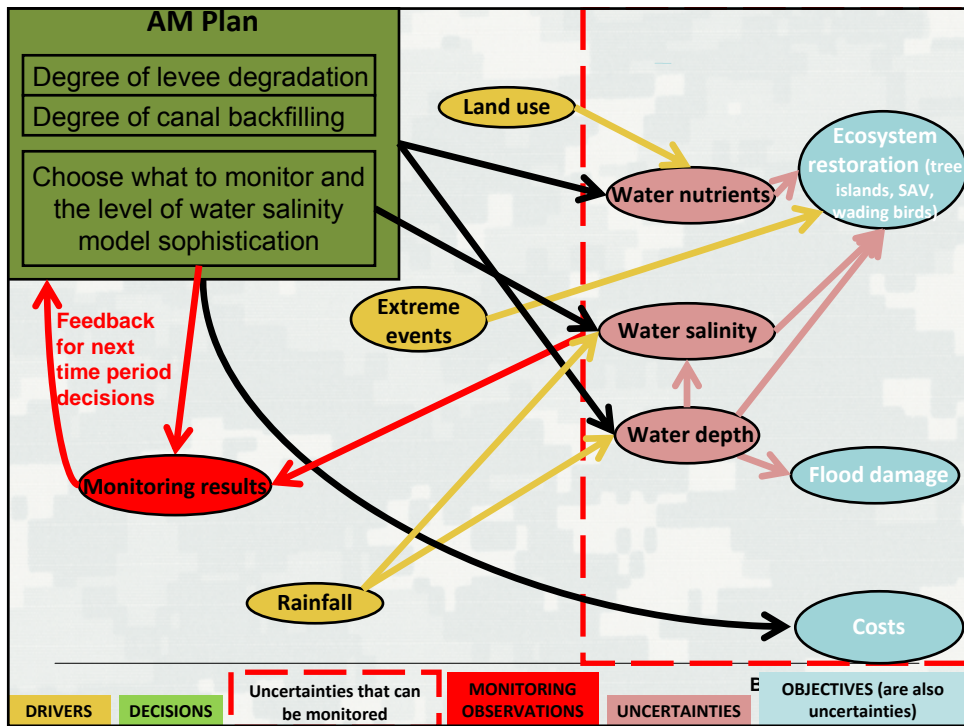
- monitoring ecosystem outcomes and engineering results
- association with management plan is dependent on current conditions

Enhanced:

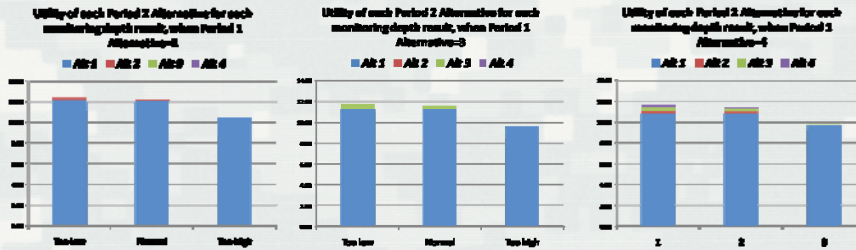
- dynamically adjust course of action
- utilize predictive value of models
- robust under uncertainty and changing conditions



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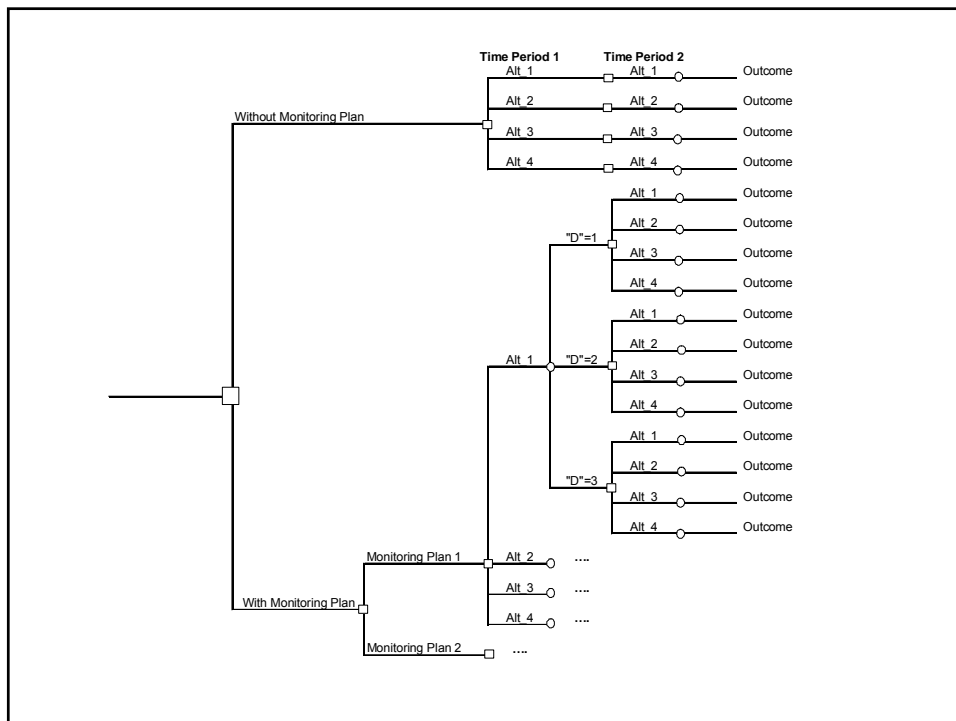
Model Results



The depth monitoring plan has a positive Vol if
Period 1 Alternative=2,3 or 4.
But is it worth its costs?



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Why Adaptive Management?

- Promotes flexible decision making in the face of uncertainty
 - ▶ i.e., use of weather forecast to determine if an umbrella is necessary
- Provides opportunity for iterative learning through careful monitoring of the effects of management options
 - ▶ i.e., necessity of consulting a forecast or having umbrella available under certain conditions
- Advances understanding of ecological, biological, or social processes in light of specific operations or policies
 - ▶ i.e., determine the accuracy/utility of weather forecasting



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