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A Structured Process for Making Decisions

Jean Cochrane

SDM Workshop
NCTC, 10-14 August 2009

What is Structured Decision Making?

"A formal application of common sense for situations too complex for the informal use of common sense."

R. Keeney

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What makes decisions hard?

- The objectives may be complex or contradictory, or in dispute
- The system may be poorly known
- Events and outcomes may be highly uncertain
- You may not know all the possible actions
- Even knowing all the other components, the solution (optimization) may be difficult to figure out

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Structured Decision Making

- Is a formal method for analyzing a decision, by breaking it into components
- Helps identify where the impediments to a decision are, to focus effort on the right piece
- Provides a wide array of analytical tools for dealing with particular impediments

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Two Key Elements

- Problem decomposition
  - Break the problem into components
    - Separating policy from science
  - Complete relevant analyses
  - Recompose the parts to make a decision
- Values-focused
  - The objectives (values) are discussed first, and drive the rest of the analysis
  - This contrasts with intuitive decision-making, which usually jumps straight to the alternatives and relies on many mental ‘short-cuts’

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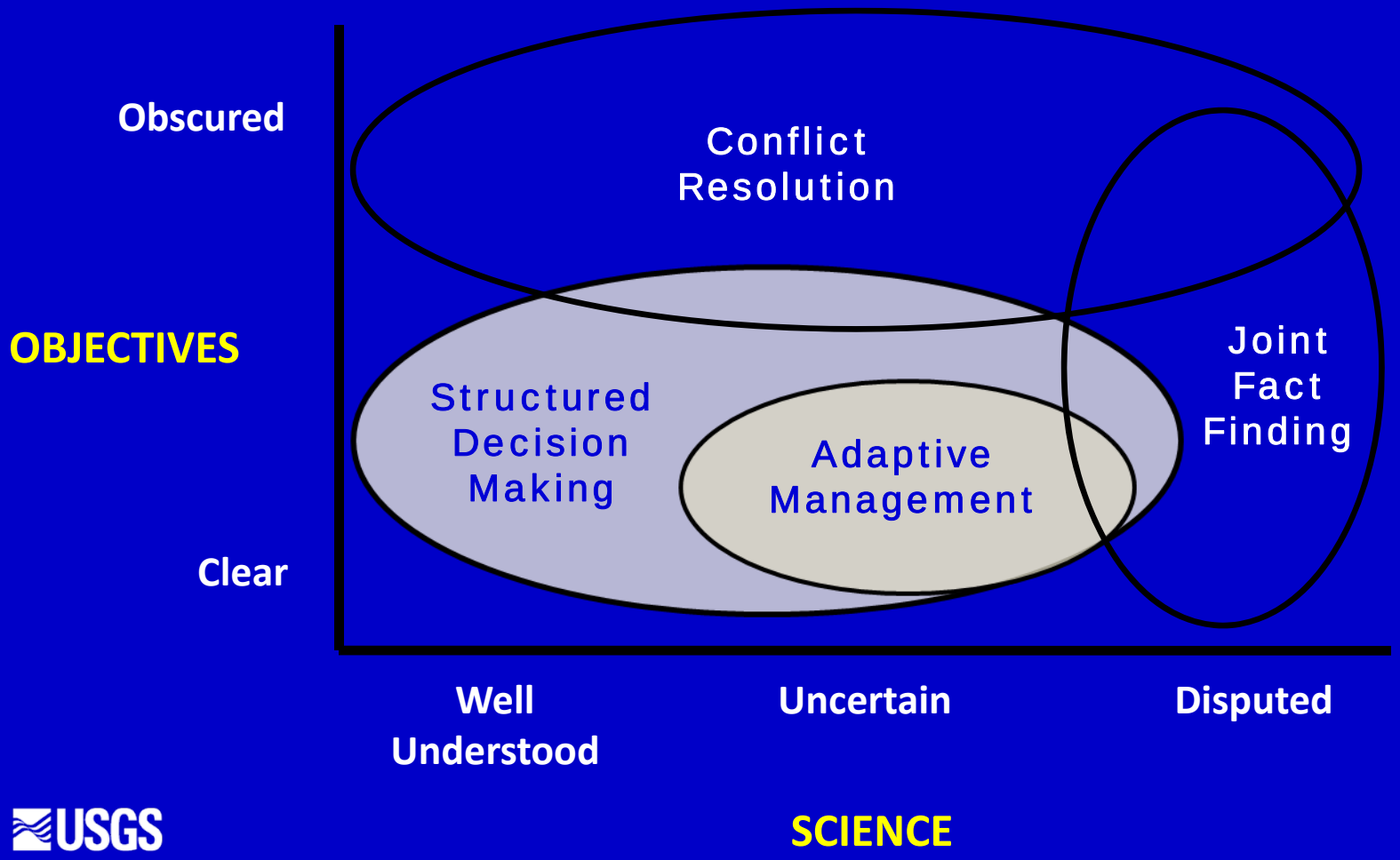
When is SDM appropriate?



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What decisions is SDM good for?

- Tiny ones
  - 1 person at their desk, an hour
  - Fine-tuning an impoundment drawdown schedule
- Little ones
  - Field office, days to weeks
  - Bull trout Section 7 workload allocation
- Middle-sized ones
  - Regional problems, months of analysis
  - R4/R5 coordinated monitoring of migratory birds
- Big ones
  - National scope, years
  - Waterfowl harvest regulations, multi-party watershed planning

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Benefits of SDM

- Decision processes that are
  - Deliberative, thorough, robust
  - More likely to achieve objectives
  - Explicit, transparent, able to be documented, replicable (process)

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Outline

- Defining the Problem
- Objectives
- Actions
- Consequences (models)
- Trade-offs and optimization
- Additional steps
- Summary

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Defining the Problem

Framing the Problem

- Who is the decision maker?
- What are the legal and regulatory contexts?
- Identify the decision's essential elements
  - Scope and scale
  - Timing and frequency
- Understand what other decisions are linked to this one

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Problem Framing

Bad River watershed, Wisconsin
Culvert replacement problem (prioritizing)

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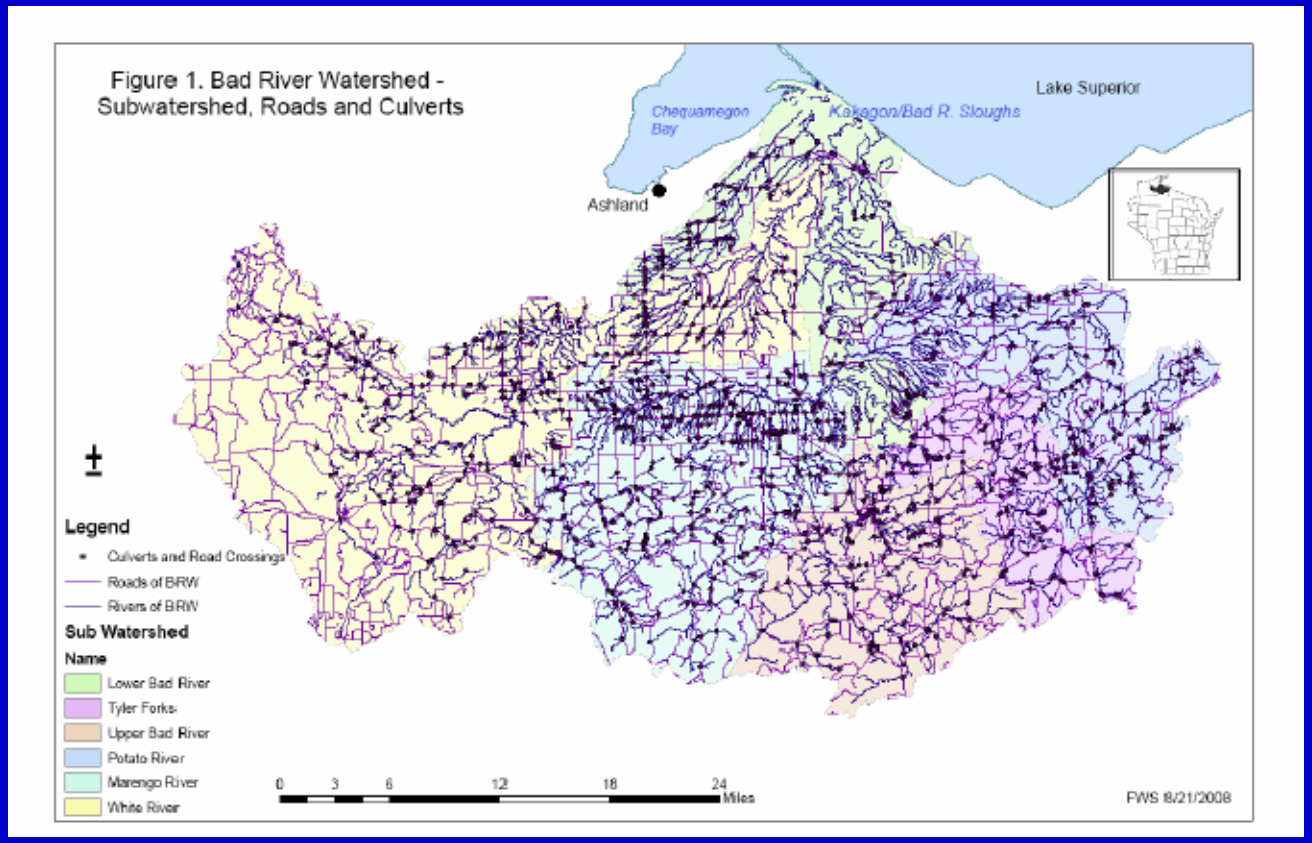
New Problem Framing

Bad River watershed, Wisconsin
Fish passage management – by subwatershed



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Lacey FO Bull Trout Section 7

- Prioritizing consultations
- Allocating staff time
- Lesson rocess

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Classes of Problems

	No Uncertainty	With Uncertainty
Single Objective	Management Science; optimization tools	Classic Decision Analysis; decision trees
Multiple Objectives	Multi-attribute tradeoff tools & complex optimization	Multiple objective tools with variable inputs

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Objectives

Objectives

- Explicit statement allows focused evaluation, discussion, and negotiation
- The objective drives everything else
- Focus on setting objectives first, before discussing alternatives
- Separate fundamental from means objectives

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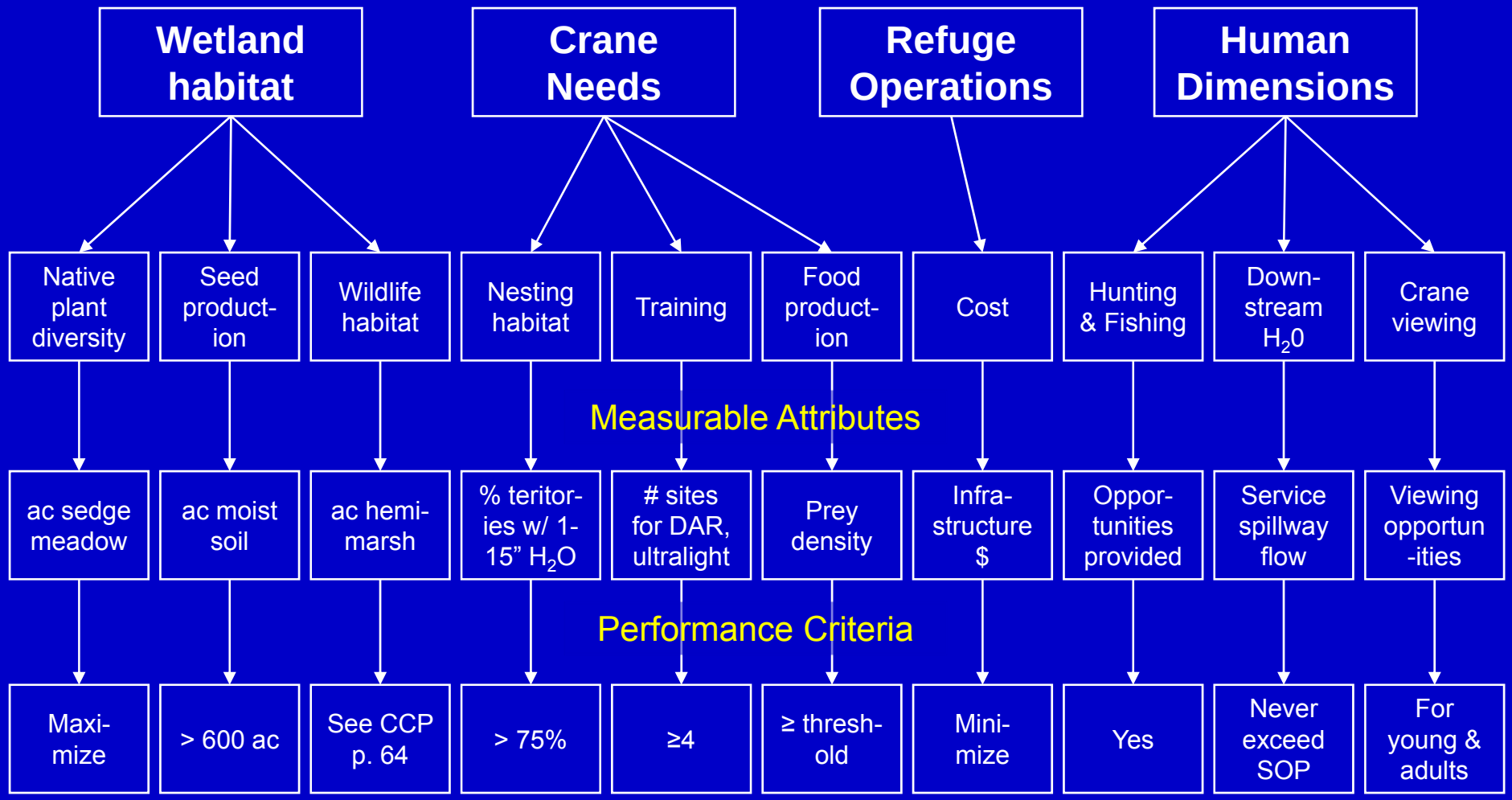
Necedah NWR Impoundments
Objectives Hierarchy



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Alternative Actions

Potential actions

- Sometimes the list of potential actions is clear
  - But often, generating such a list is a fundamental challenge
  - Often the range of options initially discussed is unnecessarily narrow
- Ask, how can the objectives be achieved?
  - Use the fundamental objectives to generate alternative actions to consider
  - Challenge apparent constraints
  - Don’t anchor on the initial set of options
  - Develop creative & unique alternatives before assessing feasibility and efficacy

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Consequences (Models)

Consequence Table

Expected Return	Actions			
Objectives	Status quo	Minor repair	Major repair	Re-build
Cost ($M)	0	5	12	20
Environmental Benefit (0-10)	1	3	10	10
Disturbance (0-10)	0	1	7	10
Silt runoff (k ft^3)	3	1	5	5
Water Retention (MG)	41	42	40	41

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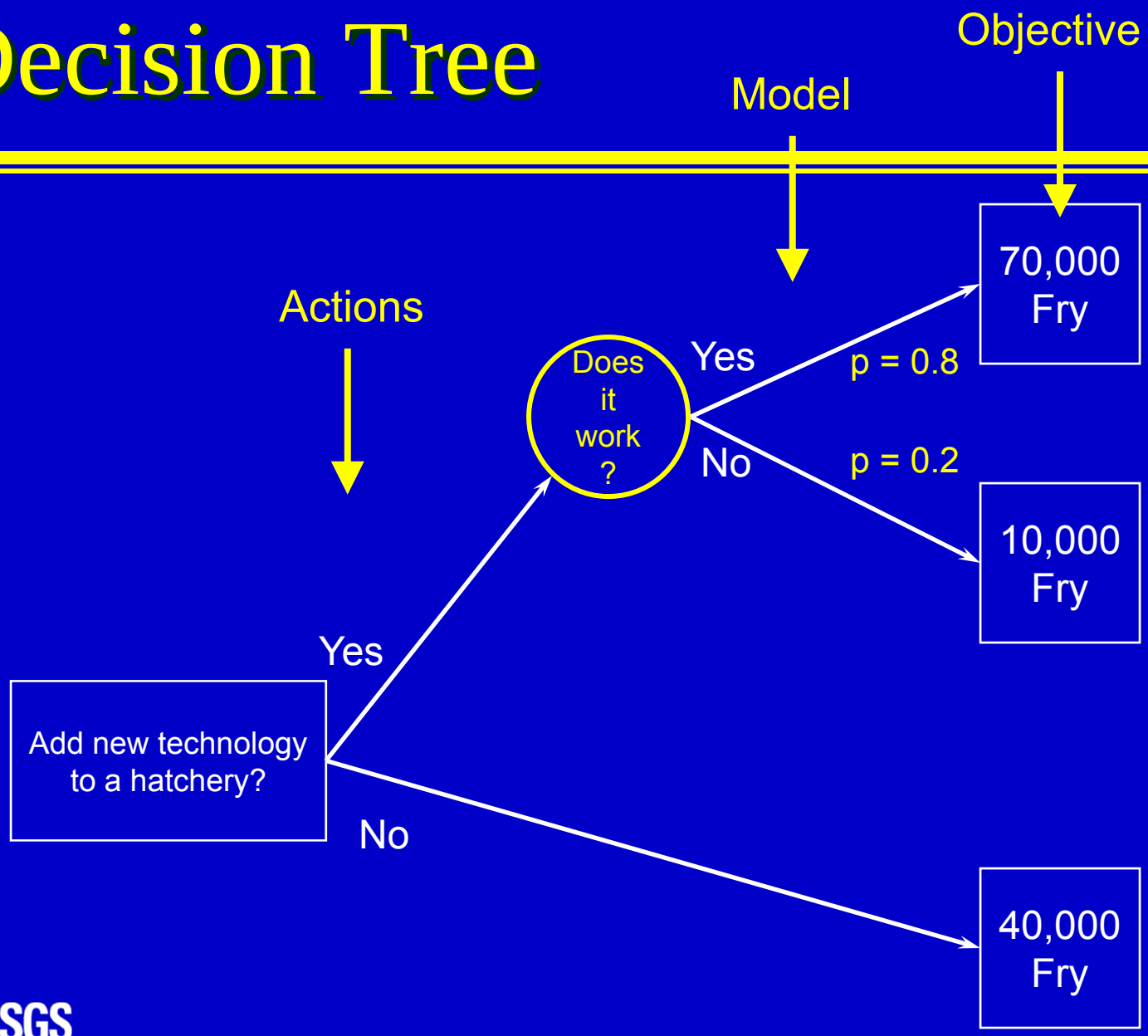
Decision Tree



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The Role of Modeling

- Models link actions to outcomes that are relevant to the objectives
  - Models make projections
- The decision context provides guidance about how to construct the model
- Wide range of types of models

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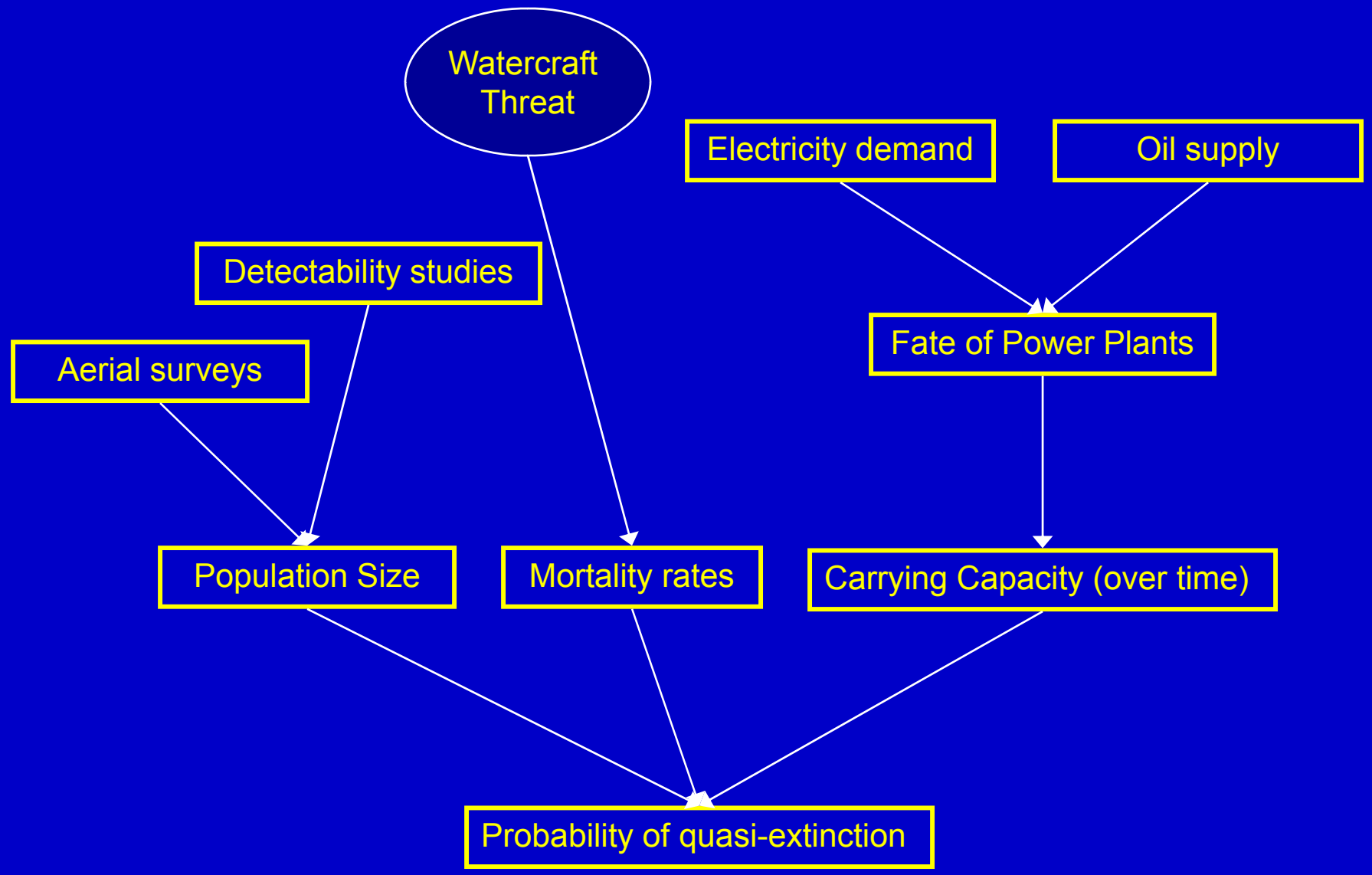
Influence Diagrams & Bayes Nets



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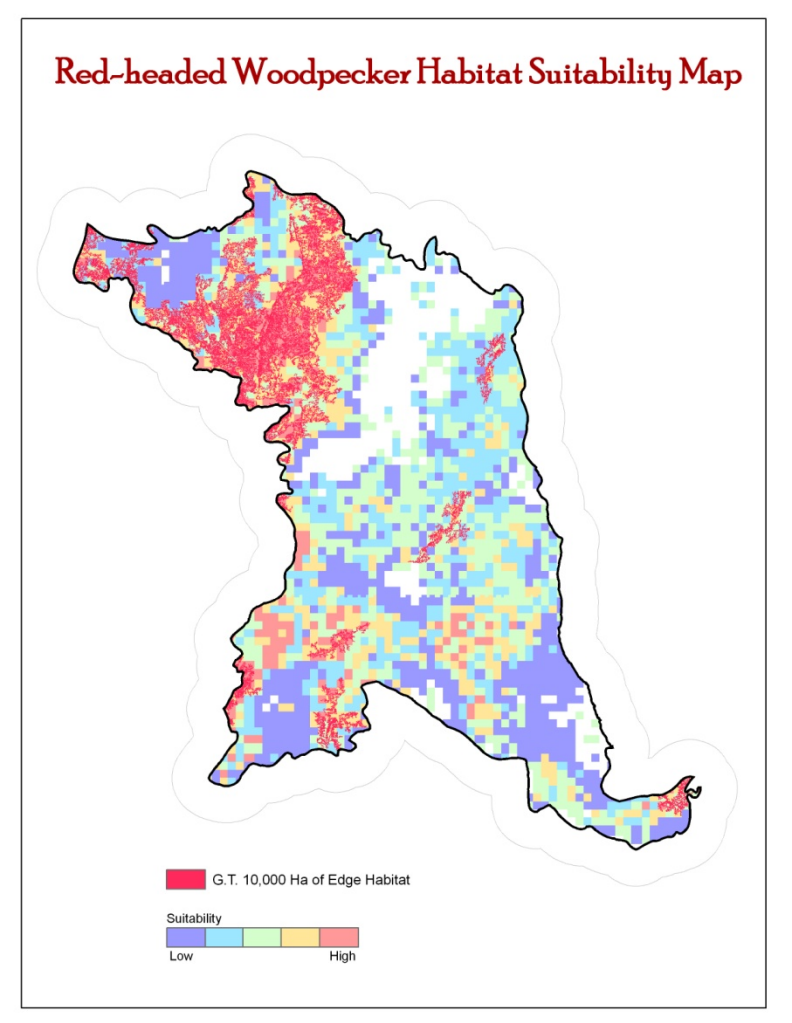
Habitat Models

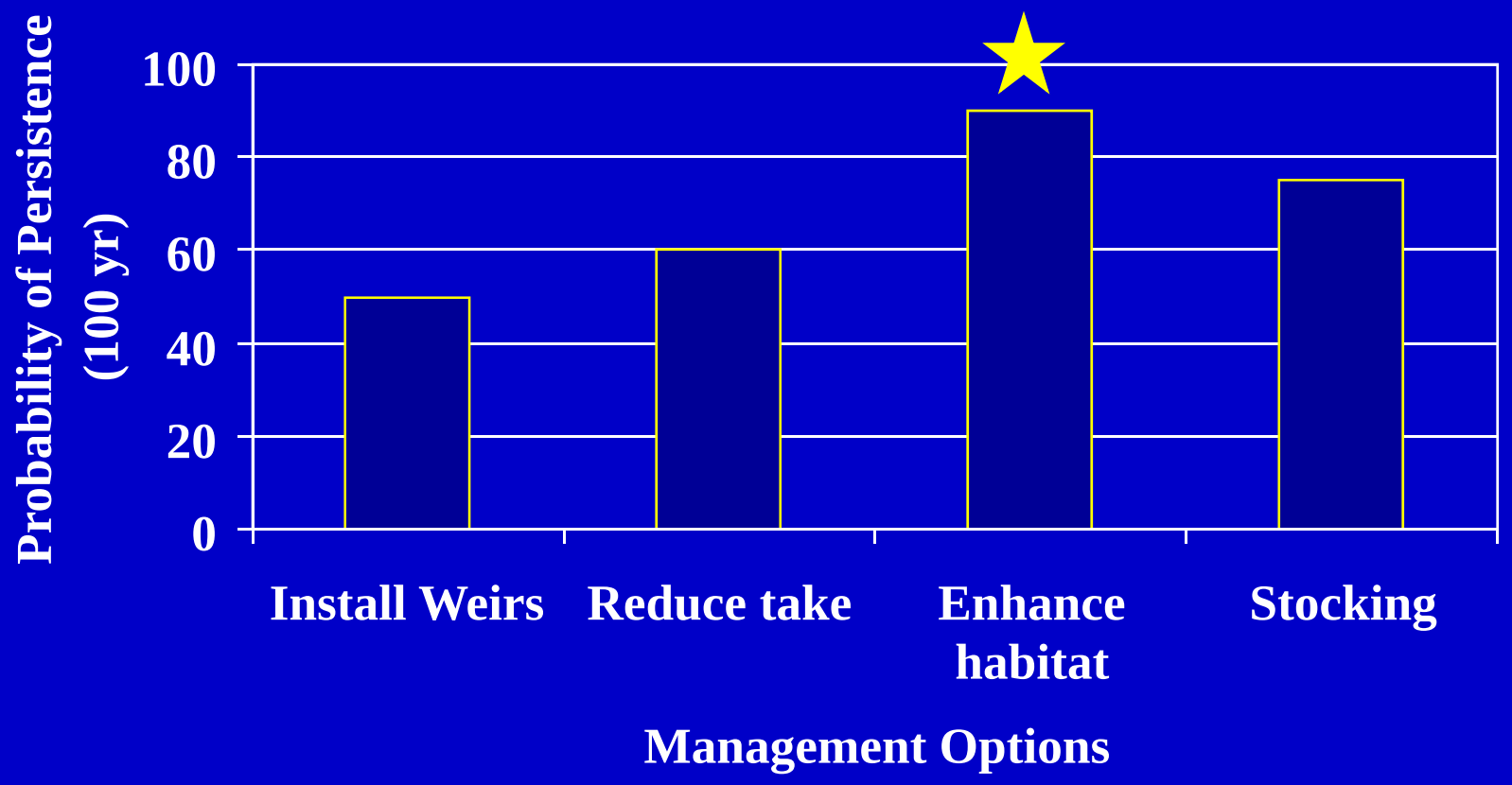


Source: Mary Mitchell, FWS/R3

Trade-offs and Optimization

How do we “solve” a structured decision problem?

Optimization (by inspection)



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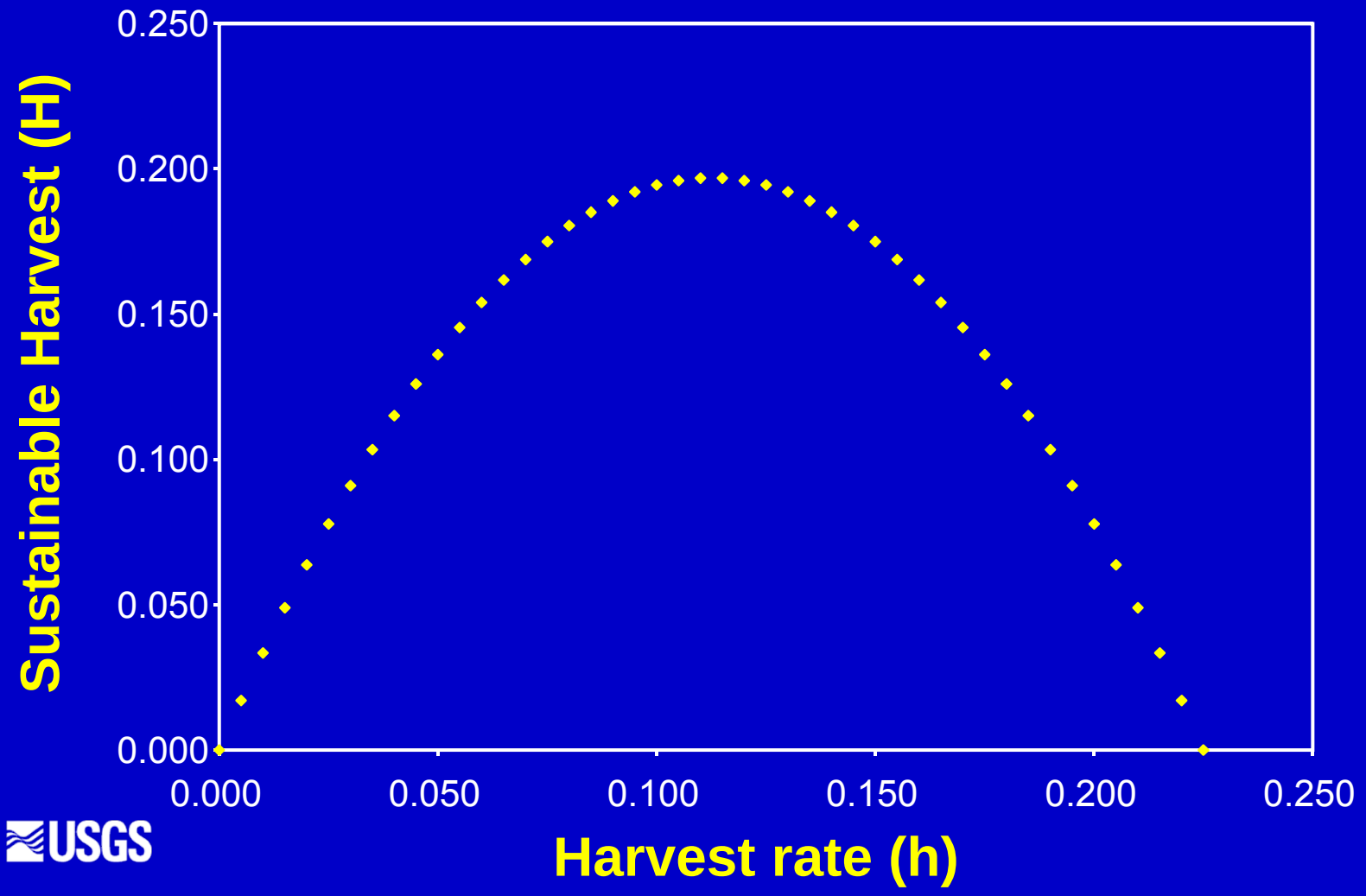
Single-objective Problems



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Multiple-objective Problems

Expected Return	Actions			
Objectives	Status quo	Minor repair	Major repair	Re-build
Cost ($M)	0 + 1 = 1	5	12 + 2 = 14	20
Environmental Benefit (0-10)	1	3	10	10
Disturbance (0-10)	0	1	7	10
Silt runoff (k ft^3)	3 – 2 = 1	1	5 – 4 = 1	5
Water Retention (MG)	41	42	40	41

Dominated Alternative

Irrelevant Objective

Even Swap

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Additional Steps

1. Recognize Uncertainty

- Smart choices don't always result in good outcomes
  - Because of uncertainty
- Need to explicitly build uncertainty into decision analysis
  - Quantitative expression of uncertainty
  - Risk attitudes: making decisions in the face of uncertainty about outcomes

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2. Avoid Psychological Traps

- Making Choices
  - Status quo bias
  - Sunk costs
  - Escalation of commitment
  - Confirmation bias
- Assessing probabilities
  - Anchoring
  - Availability bias
  - Ignoring base-rate frequencies

e.g., Long-standing monitoring programs on Refuges

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3. Linked Decisions

- Often, we have a series of dependent decisions to make
  - A decision early on can affect the options available later, as well as the state of the system at a later time
- Analyzing such decisions separately can lead to suboptimal decisions

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Adaptive Management

- All management decisions are made without perfect knowledge
- This uncertainty is what makes decisions difficult
- Any management decision can potentially provide the chance to learn
- Iterated decisions can be adaptive

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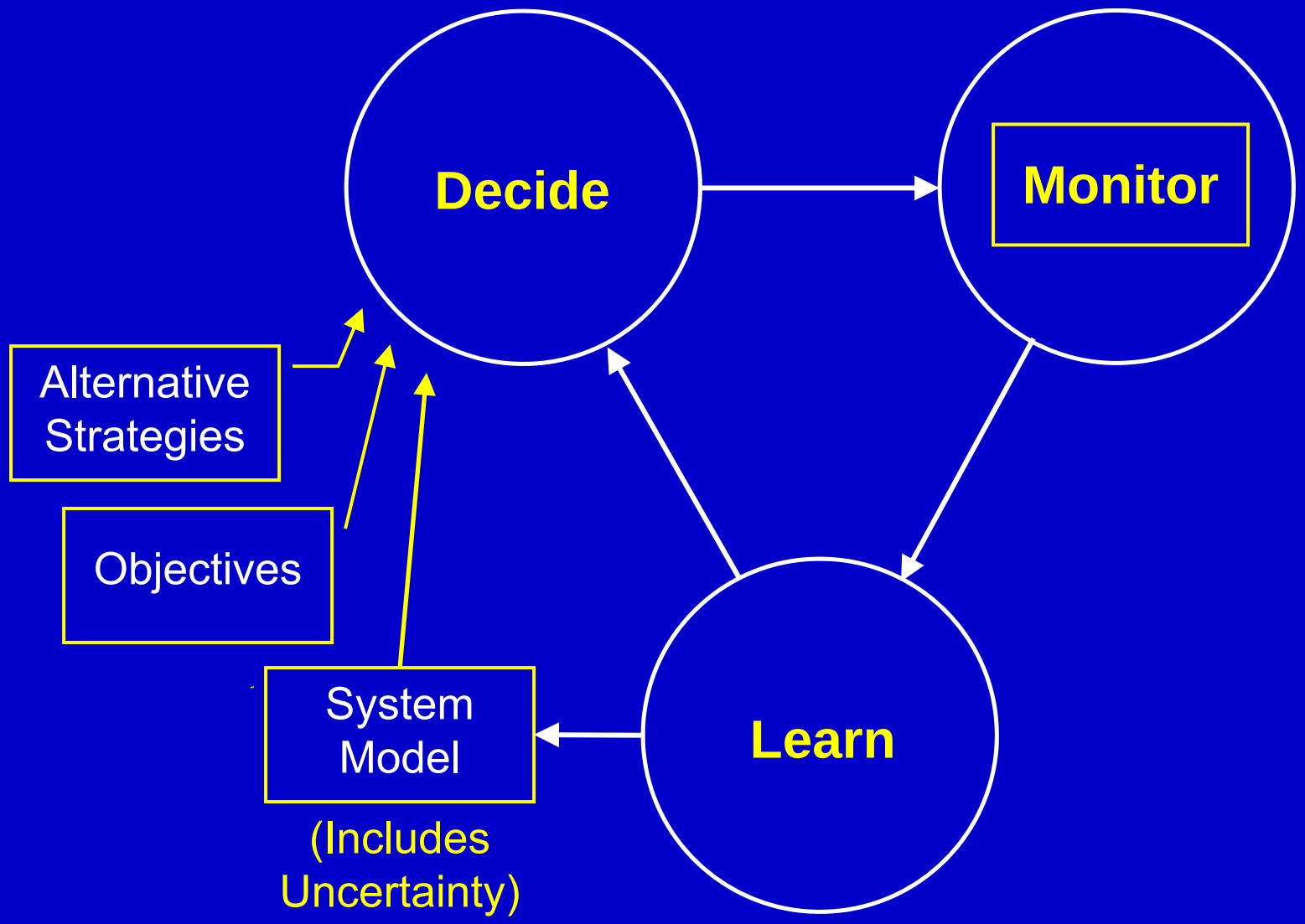
Adaptive Decision Making



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4. Sensitivity Analysis

- Examine how the optimal decision and the expected performance are affected by
  - Assumptions
  - Parameters in the models
  - Levels of uncertainty
  - Weights on objectives
  - The problem framing itself
- Ask whether the decision is robust to uncertainty
  - If not, consider revising aspects of the problem

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5. Review and Revise

- Decision analysis can be iterative
  - Develop a prototype
  - Perform sensitivity analysis
  - Revise as appropriate
- Work from broad levels to details
  - Get the framework right, first

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Summary

PrOACT+

- A guide for defensible decision-making
  - Problem decomposition
  - Values-focused thinking
- Steps
  - Problem
  - Objectives
  - Actions
  - Consequences
  - Trade-offs
  - Additional steps

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Risk

- All of the decisions we are faced with are made under uncertainty
  - Therefore they contain risk
- We need to be good at discussing and understanding risk
- Risk decisions reflect risk tolerance
  - Need to understand the willingness of agencies and individuals to take risks

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Roles

- Policy
  - Decision maker
  - Stakeholders
  - Subject matter experts (e.g., legal)
- Science
  - Subject matter expert (biological)
  - Modeling expert
- Integration
  - Decision maker
  - Decision analyst
  - Facilitator

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Goal

- Improvement, not perfection
- We hope to use a structured process to improve the quality of our decisions
  - But we don’t expect to ever be perfect
  - It’s difficult to escape our limitations as decision-makers

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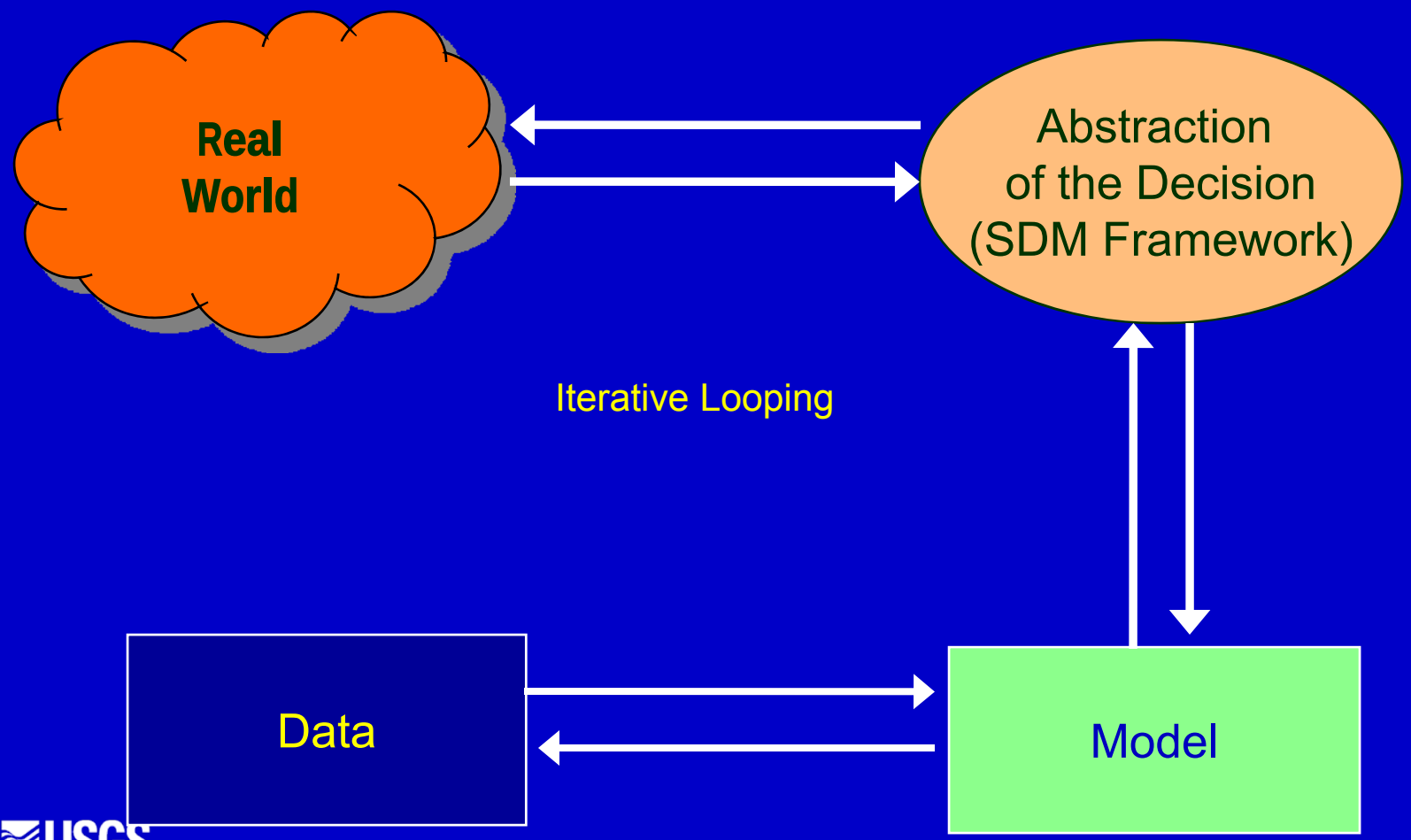
Rapid Prototyping

Structured Decision Making



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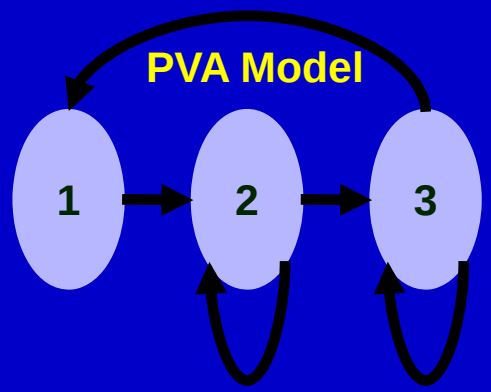
Atlantic Salmon Recovery SDM

Consequence Matrix			
Altern	Objectives		
	Persist	Distrib	Econ
Dam	20	.35	20
Stock	14	.57	13

Data



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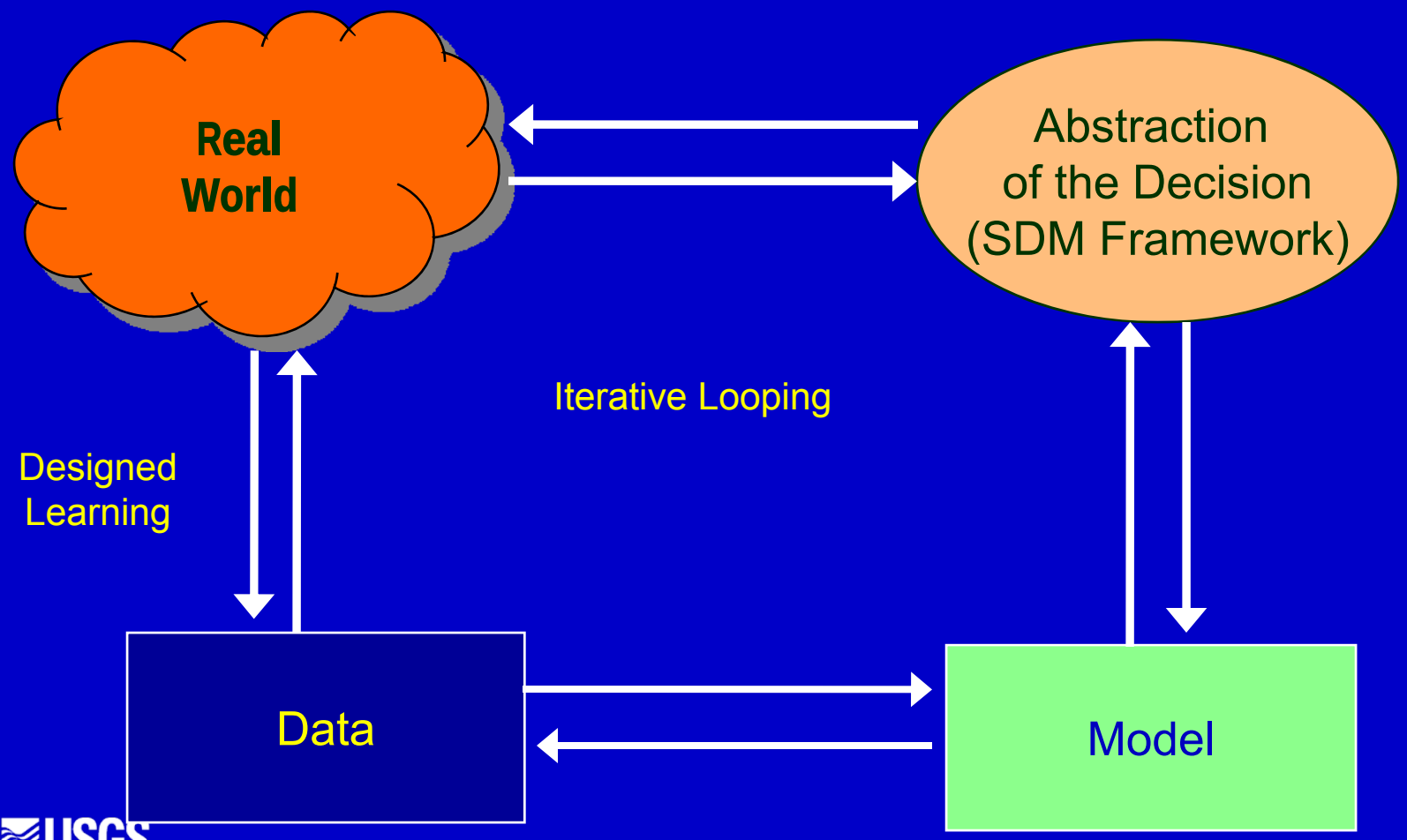
Adaptive Management



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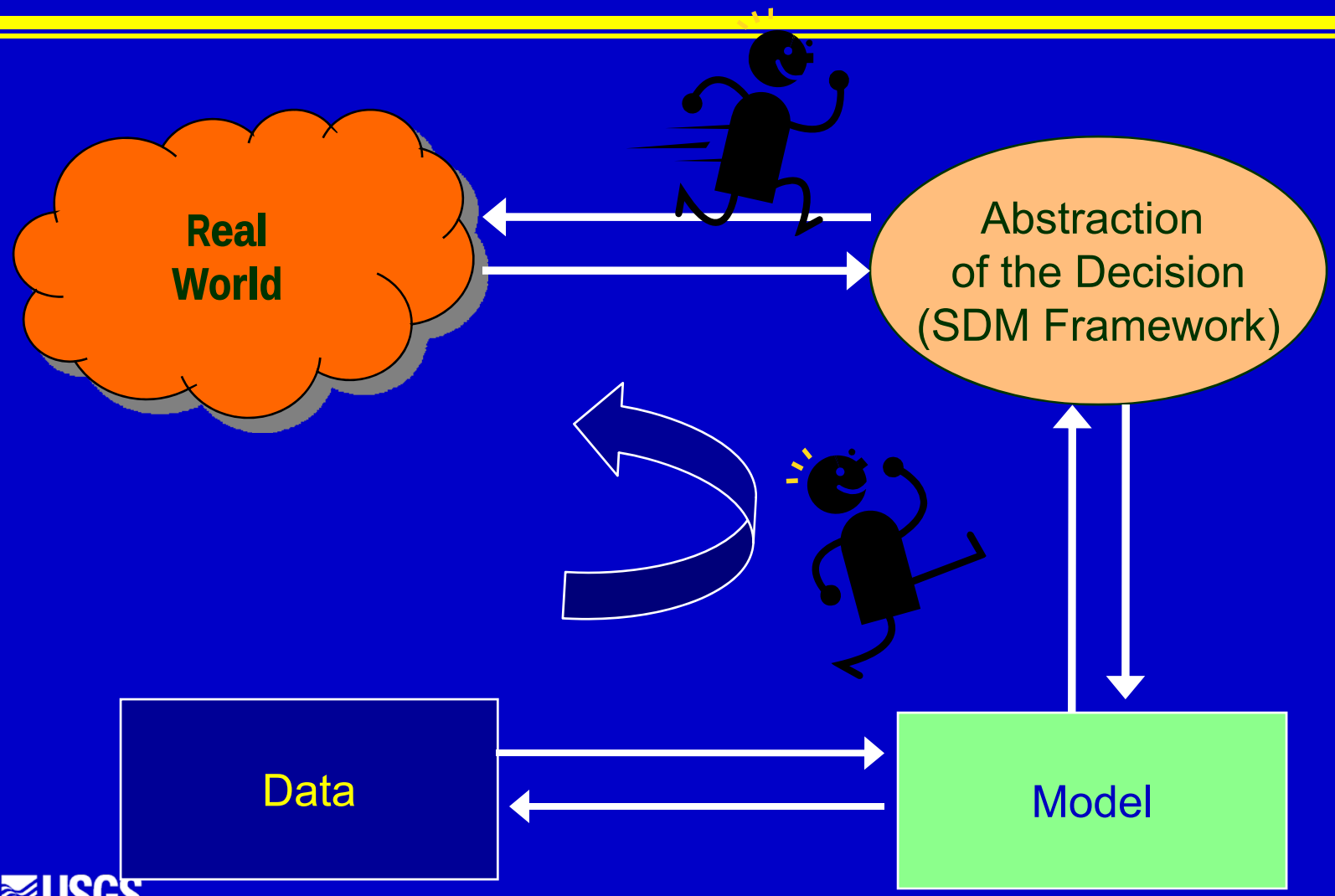
RAPID PROTOTYPING



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Rapid Prototyping

- Get around the track as fast as you can the first time
  - Include all the elements of a structured decision, but keep them very simple (find the skeleton)
  - Focus on the key elements
  - Use placeholders and guesses to keep going
- See how it works
  - Check back to Real World – is this abstraction working?
  - Discover what needs to be improved

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Rapid Prototyping

- You learn about and improve your framework by trying it
  - Build iteratively
  - Increase complexity thoughtfully *(if at all)*
- Low risk – high return approach
  - It doesn't matter if you're wrong the first time, you can start over with little loss
  - Don't invest more than you need to
  - Understand what you are doing

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