Scenario Analyses in Ecological Modeling and Management Planning

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Objectives

- Highlight the utility of scenario analysis as a tool for addressing uncertainty in potential project outcomes

- Describe examples of different types of scenario analysis

- Present the application of scenario analyses in water resource management project planning and decision making

What is a Scenario Analysis?

- A method for exploring alternative futures and trajectories in systems

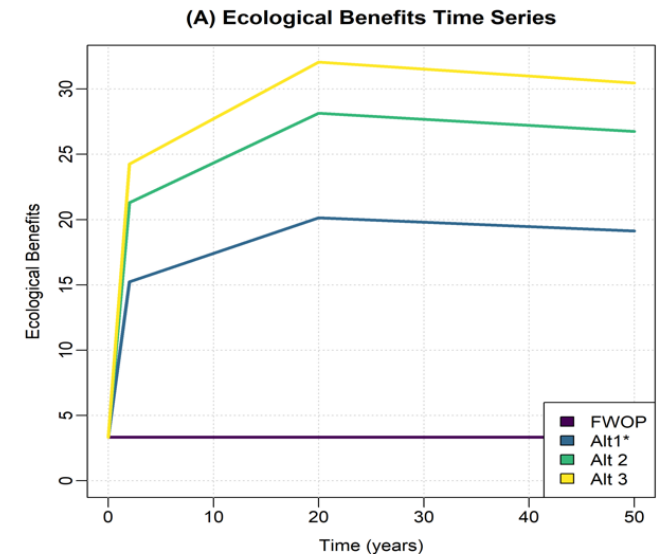- A tool to evaluate how potential project outcomes compare to each other

How can a Scenario Analysis be Used?
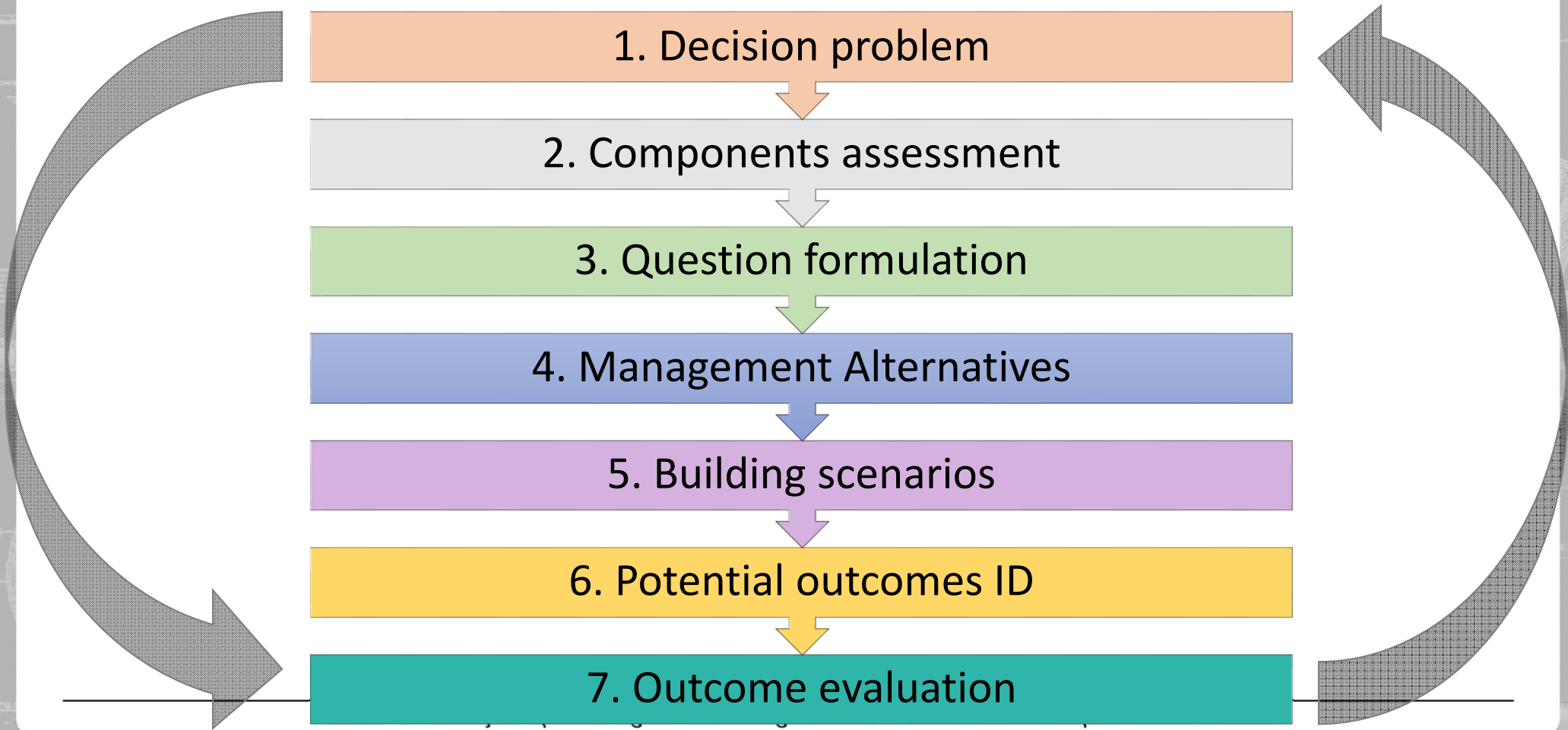
In project planning:

- For decision support and strategic planning

- Science and research during assessments, exploration, and speculation for processes

- To consult with experts, stakeholders, or the public

In general:

- Science communication

- Education
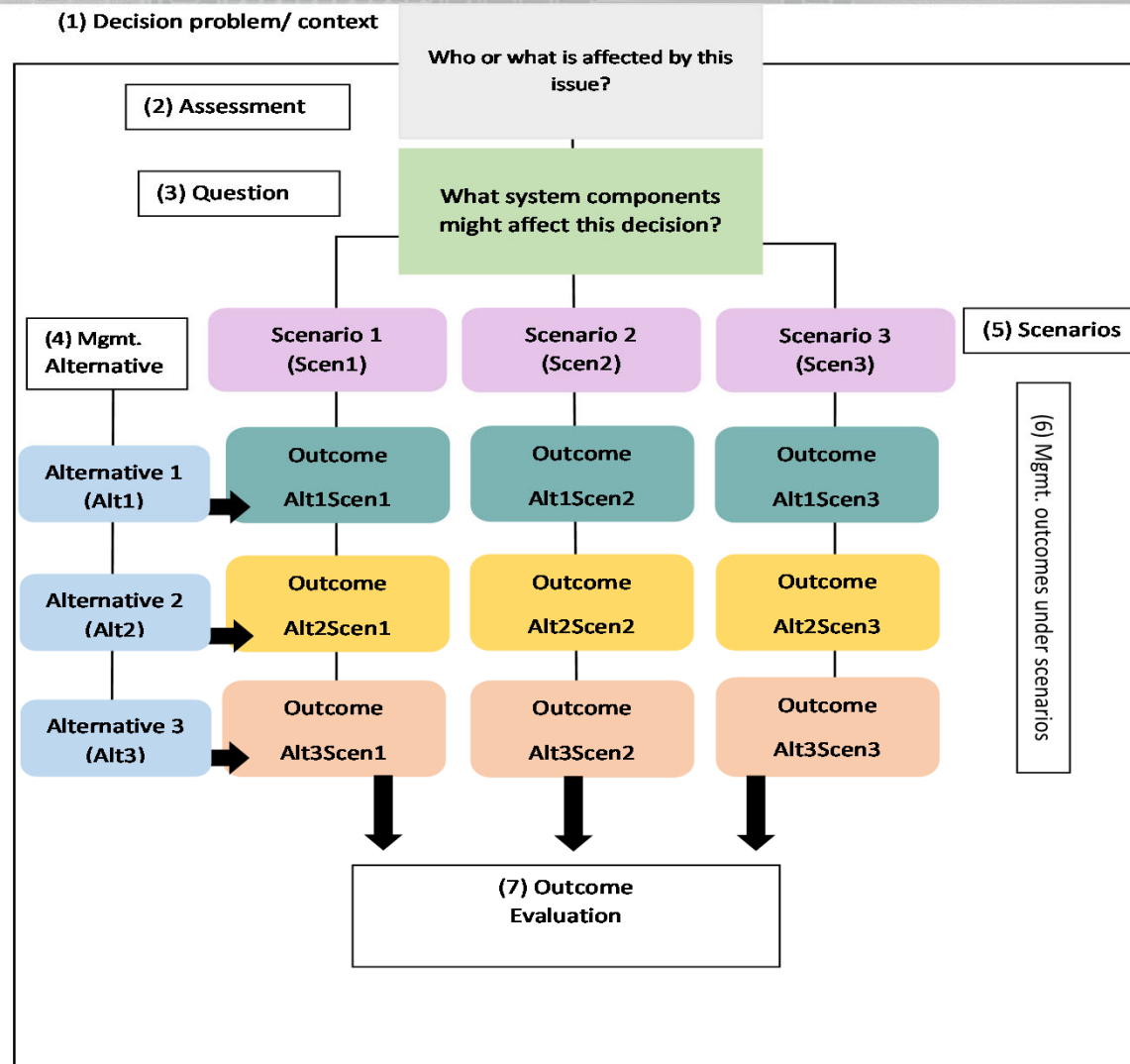
- Public information and outreach

Mechanics of Scenario Analysis

1. Decision problem

2. Components assessment

3. Question formulation

4. Management Alternatives

5. Building scenarios

6. Potential outcomes ID

7. Outcome evaluation

Building Scenarios

5a. Articulate system narratives

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5b. Link system dynamics

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5c. List possible scenarios

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* 5d. Connect scenarios with mgmt. alternatives

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5e. Build a qualitative model

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** 5f. Choose input parameters

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** 5g. Build quantitative model

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(1) Decision problem/ context

(2) Assessment

Who or what is affected by this issue?

(3) Question

What system components might affect this decision?

(4) Mgmt. Alternative

| Scenario 1 (Scen1) | Scenario 2 (Scen2) | Scenario 3 (Scen3) | **(5) Scenarios** |

Alternative 1 (Alt1)

Outcome Alt1Scen1 | Outcome Alt1Scen2 | Outcome Alt1Scen3

(6) Mgmt. outcomes under scenarios

Alternative 2 (Alt2)

Outcome Alt2Scen1 | Outcome Alt2Scen2 | Outcome Alt2Scen3

Alternative 3 (Alt3)

Outcome Alt3Scen1 | Outcome Alt3Scen2 | Outcome Alt3Scen3

(7) Outcome Evaluation

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Considerations

- Scenario analysis does NOT predict system futures

- Once scenarios are built and modeled, additional risk analyses may be conducted to explore potential negative effects of scenarios and management alternatives

- Scenarios do not have equal probabilities

- A baseline scenario should be included to compare outcomes (e.g., FWTP, business as usual, no social distancing)
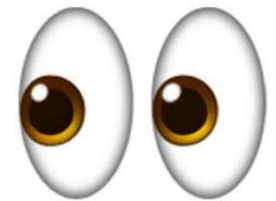
Best Practices in Scenario Analysis

Adapted from the USACE guidance for sea level rise guidance (USACE 2011):

• Multiple scenarios help address uncertainties for which no reliable or credible probabilities can be obtained

• Assumptions must be explicitly documented

• Alternatives should be considered and evaluated for the entire range of possible scenarios

• Sensitivity and risk of management actions to different scenarios should be evaluated

Examples of scenario analysis
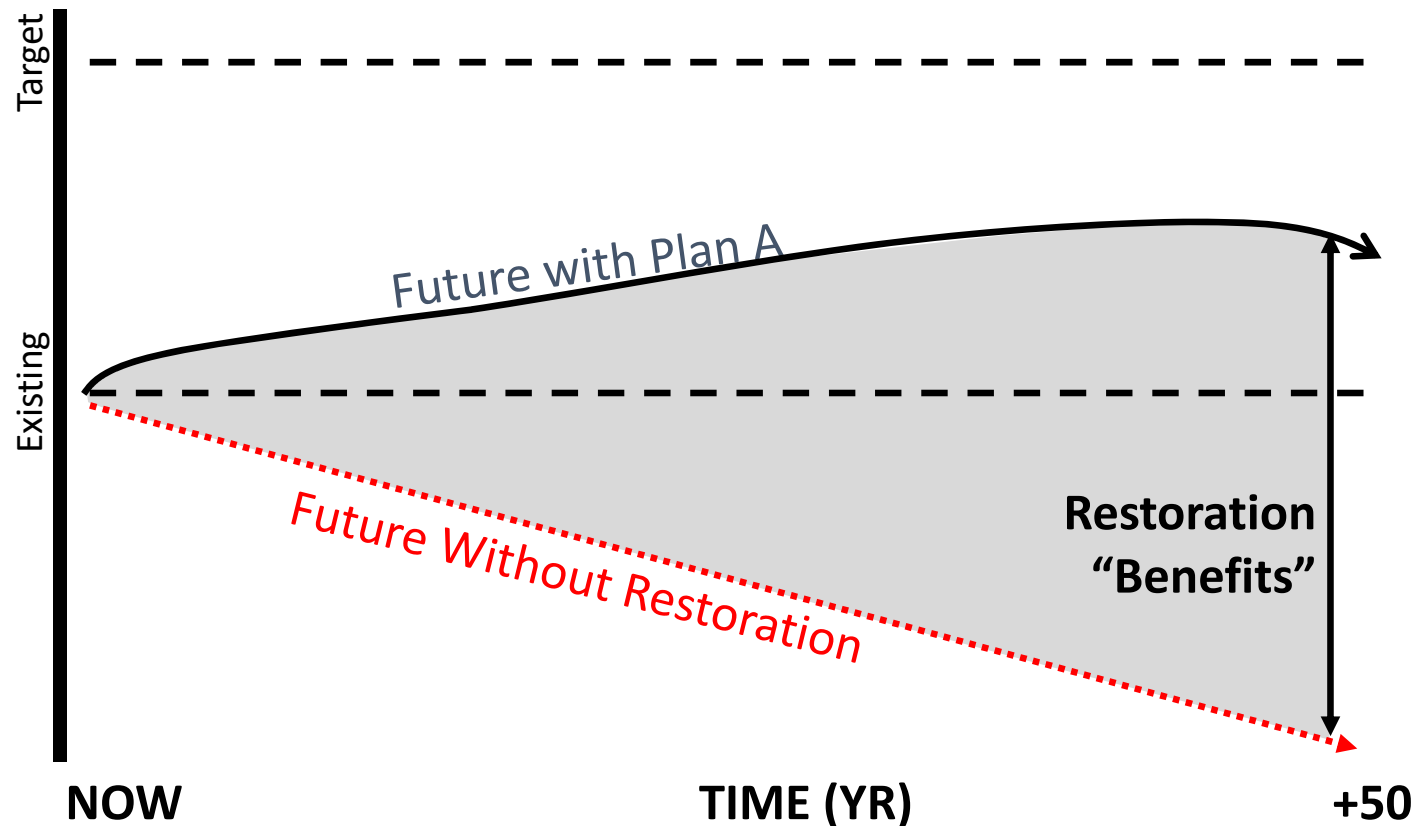
- Worst and best case scenarios
- Climate change
- Land-use change
- Biodiversity
- Disease outbreak

Semi-qualitative example: anadromous fish

Decision Problem:

• Habitat restoration for sensitive anadromous fish

Assessment:

• Endangered anadromous fish in a US northwestern watershed

Question:

• How do hydrological changes affect the ecological outcomes of the management alternatives in this restoration project?

Management alternatives:

• "No Action" plan, ⬆ river connectivity at all dams, reforesting 100m of riparian buffer

Semi-qualitative example: anadromous fish

Building scenarios:

- Plausible futures were constructed using historical rain gauge data as a proxy for hydrological change

Potential outcomes:

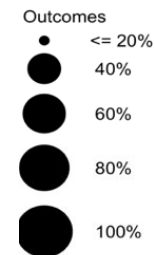- Ecological outcomes were plotted in a bubble chart

Outcome evaluation:

- Stakeholders evaluated if alternatives or scenarios improved the habitat quality and assessed tradeoffs between alternatives under different scenarios

Quantitative example: freshwater mussel

Decision Problem:

- Freshwater mussels are the most imperiled taxa in the United States and occur in the majority of all the river systems in the US.

Assessment:

- USACE needs to develop a model to forecast impacts and benefits of project actions on freshwater mussel communities and is flexible enough to cover North American freshwater mussel

Question:

- How will different USACE ecosystem restoration activities affect not only the mussel species but also other sensitive species in the region?

Management alternatives:

- Alternatives were assess by how the habitat suitability index increases or decreases with changes in the individual variable HSI ratings.

Quantitative example: freshwater mussel

Building scenarios:

- Decided upon during the workshop and included different environmental parameters
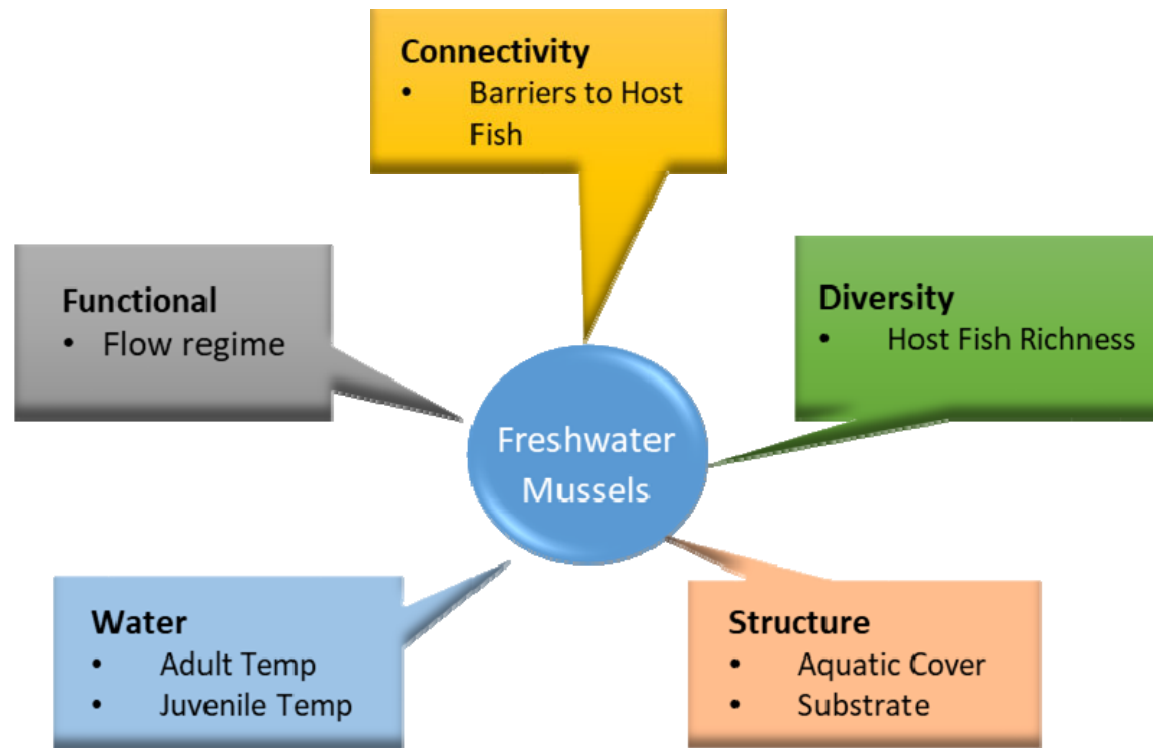
Potential outcomes:

- Derived from communication among the workshop participants as ranges in HSI that would be considered acceptable for a proposed ecosystem restoration

Evaluate outcome:

Was completed after the model had been completed and the total HSI had been evaluated

Qualitative model

Quantitative model

	Fish Species Richness	Large			
		Baseline	0	Year	1
Variable	Description	Data	HSI	Data	HSI
V1	Aquatic Cover	20	0.25	45	0.79
V4	Substrate	Poor	0.25	Suboptimal	0.75
V3	Adult Temperature	25	1.00	25	FALSE
V2	Juvenile Temperature	35	0.03	35	0.03
V5	Flow Regime	Present	1.00	Present	1
V6	Connectivity	Yes	1.00	Yes	1.00
V8	Large Rivers	50	1.01	50	1.01
HSI			**0.43**		**0.54**

Takeaways:

- Used to compare potential project outcomes and to aid the determination of future strategies and actions of different projects.

- Scenarios do not predict futures

- The goal is to best understand the uncertainty that can alter the decisions we make (at least in feasibility).

- Assumptions must be documented and communicated

- Scenarios are not equal in probability

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