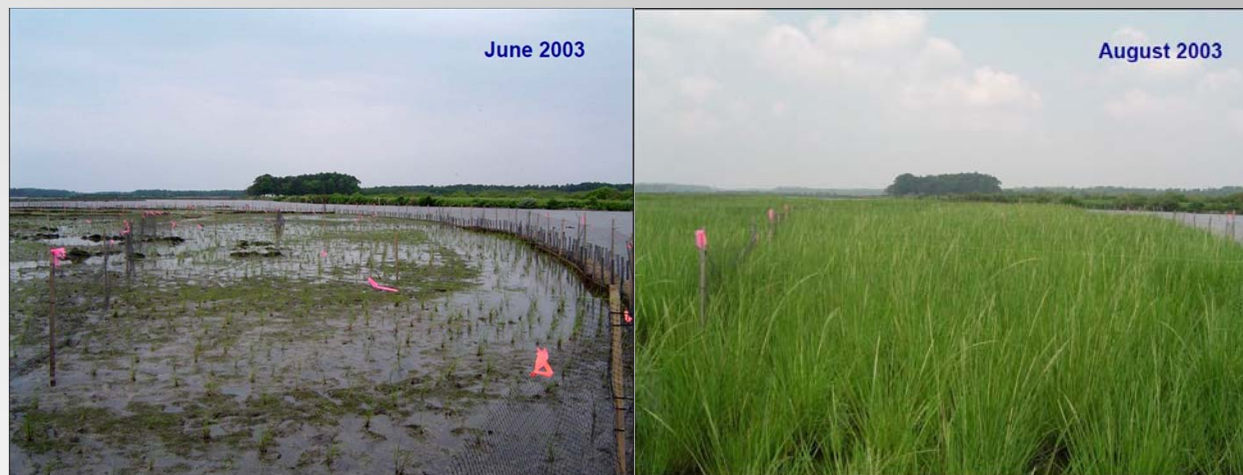# Response Functions in a Proposed Ecosystem Services Analysis Framework
## for the US Army Corps of Engineers

Lisa Wainger[1], Anna McMurray[1],

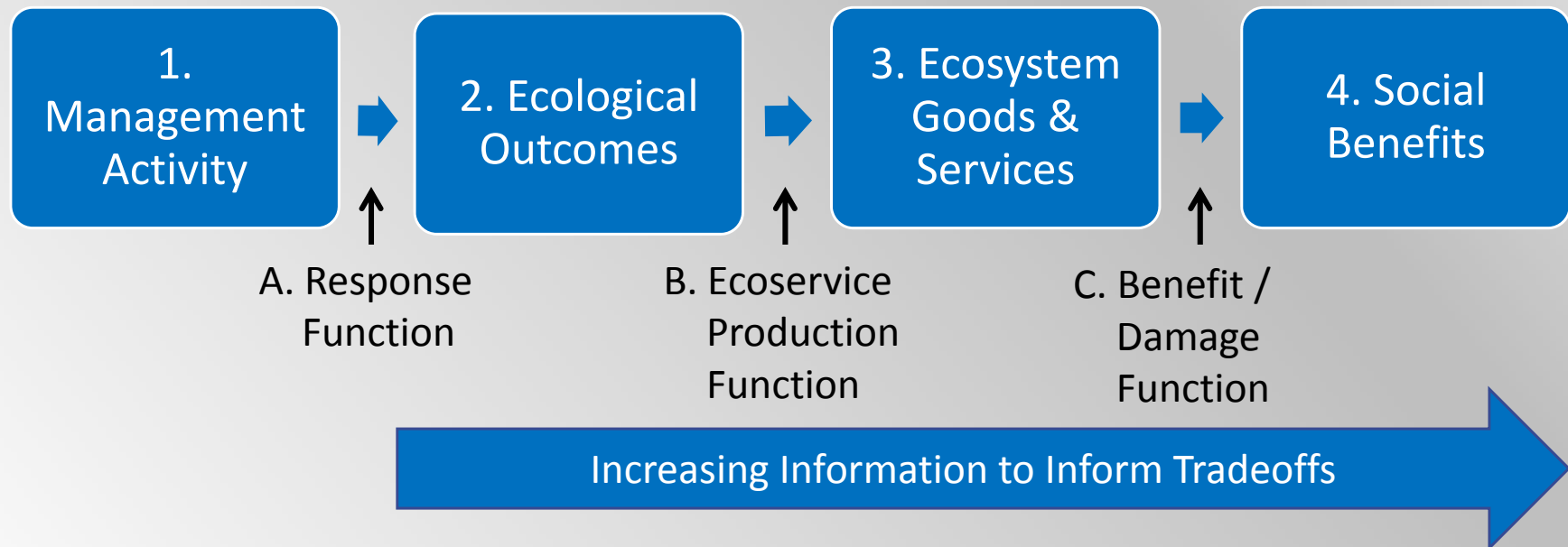Elizabeth Murray[2], Janet Cushing[3]

[1]*University of Maryland Center for Environmental Science*

[2]*U.S. Army Engineer Research and Development Center*

[3]*U.S. Army Institute for Water Resources*
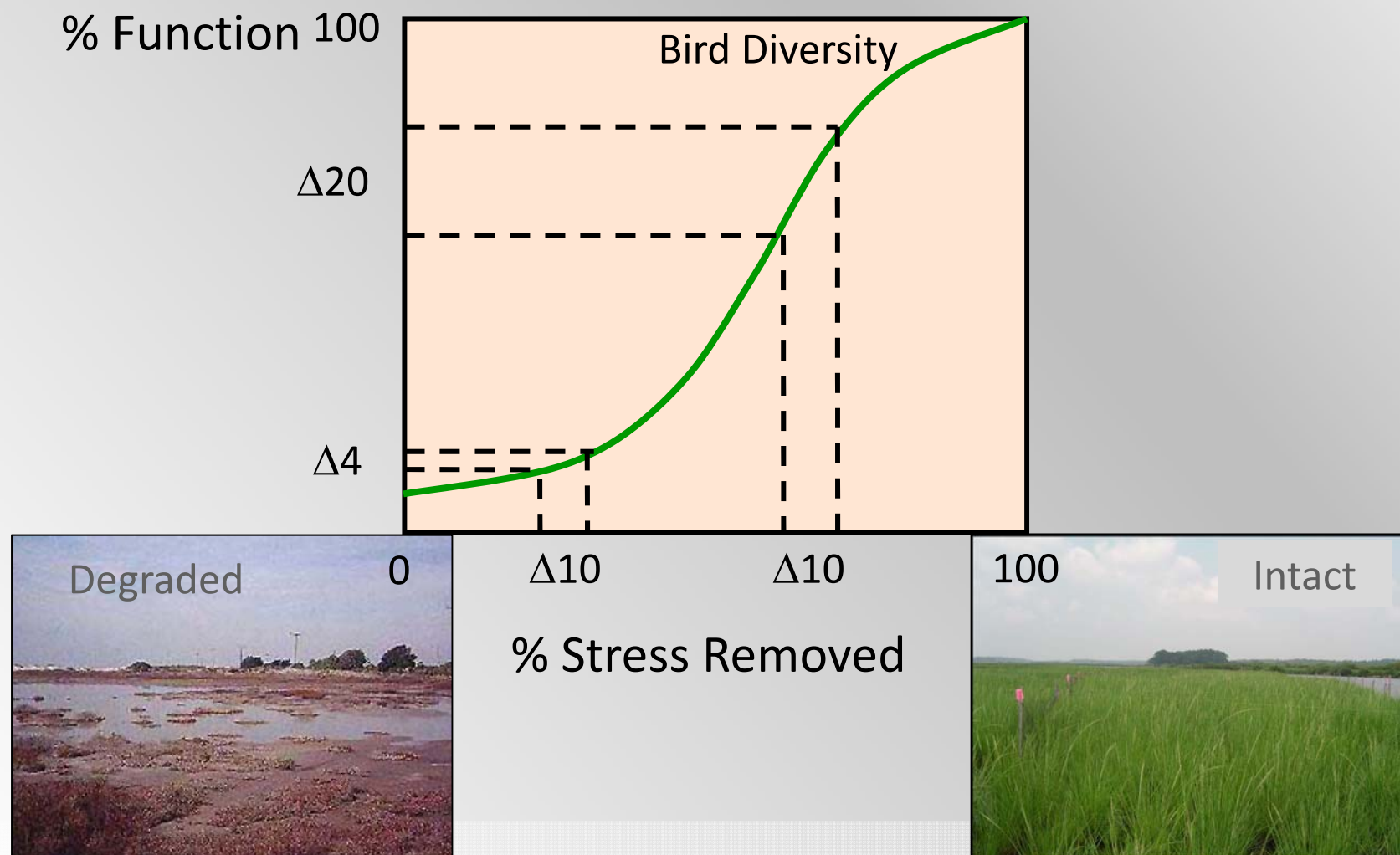
June 2003 — August 2003

# Determining Ecosystem-Derived Economic Benefits from Projects

# Restoration Response Functions
## Targeting to achieve greatest return on investment



% Function

Bird Diversity

100

Δ20

Δ4

Degraded

0        Δ10        Δ10        100        Intact

% Stress Removed
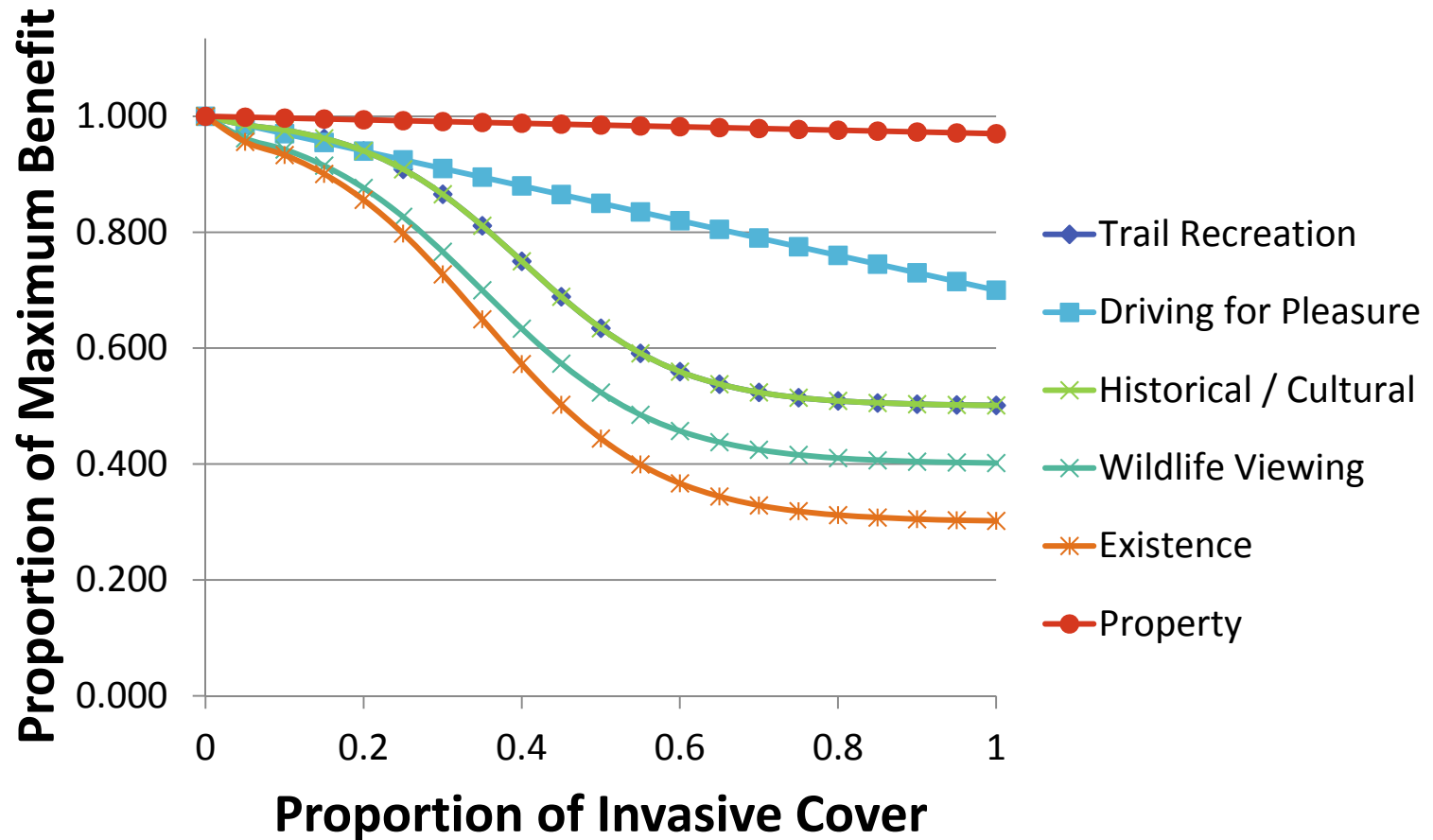
# Stressor Response Functions
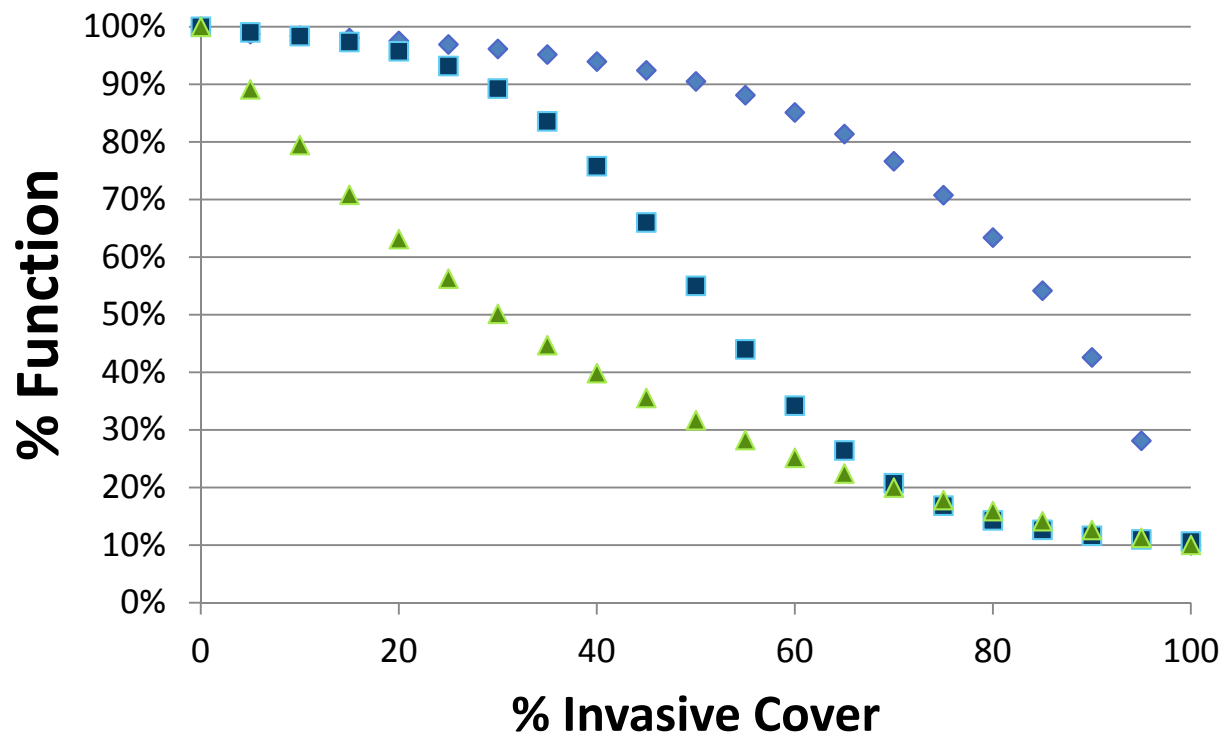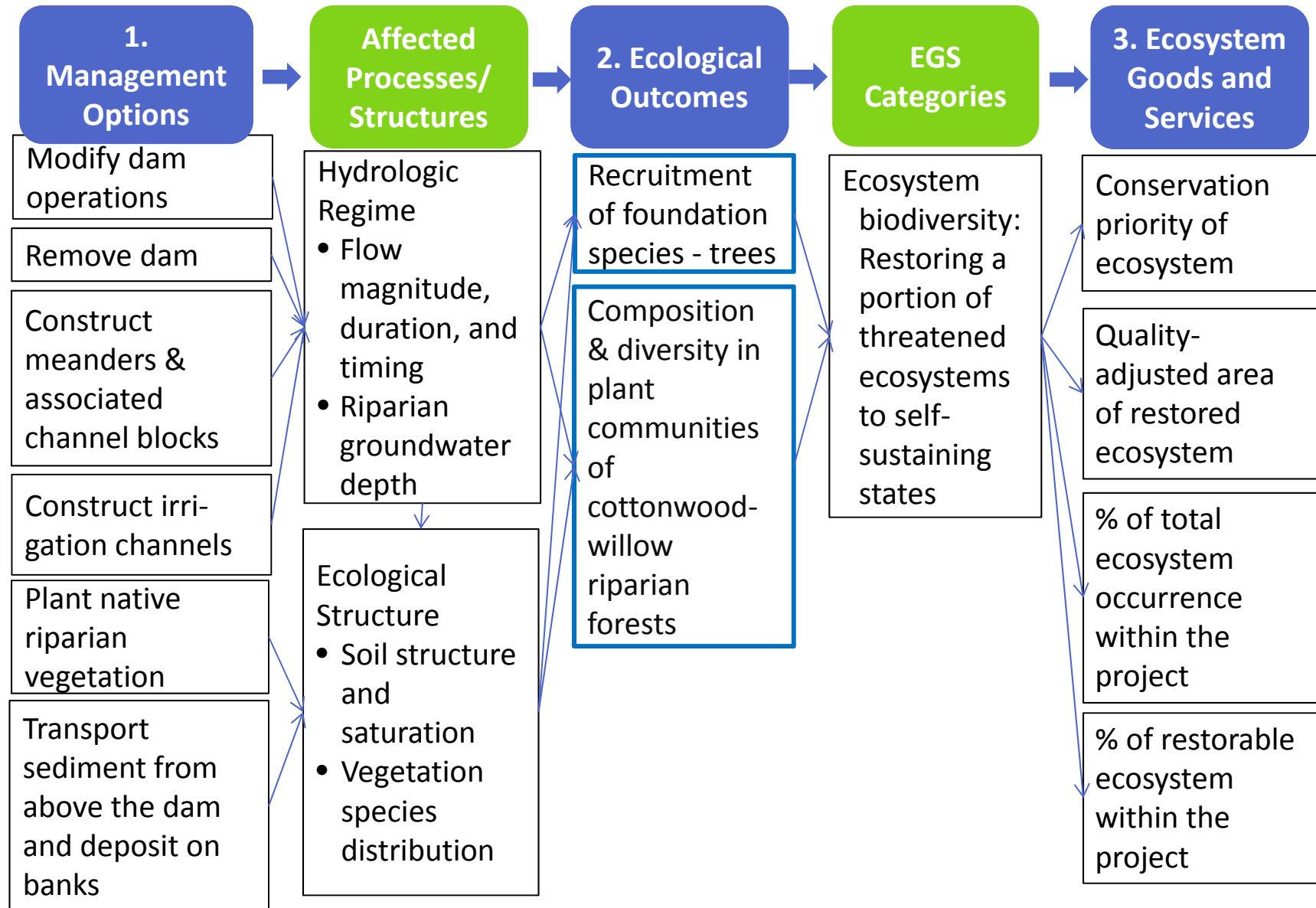
Economic Damage Functions
Differ from biophysical response functions

# Conceptual models linking management options to beneficial outcomes

| 1. Management Options | Affected Processes/ Structures | 2. Ecological Outcomes | EGS Categories | 3. Ecosystem Goods and Services |
|---|---|---|---|---|
| Modify dam operations | Hydrologic Regime | Recruitment of foundation species - trees | Ecosystem biodiversity: Restoring a portion of threatened ecosystems to self-sustaining states | Conservation priority of ecosystem |
| Remove dam | • Flow magnitude, duration, and timing | Composition & diversity in plant communities of cottonwood-willow riparian forests | | Quality-adjusted area of restored ecosystem |
| Construct meanders & associated channel blocks | • Riparian groundwater depth | | | % of total ecosystem occurrence within the project |
| Construct irri-gation channels | Ecological Structure | | | % of restorable ecosystem within the project |
| Plant native riparian vegetation | • Soil structure and saturation | | | |
| Transport sediment from above the dam and deposit on banks | • Vegetation species distribution | | | |

# Response function models for non-use services

| Ecological Outcome Metric | Models |
|---|---|
| **Recruitment of foundation plant species** | Hydrologic Engineering Center River Analysis System (HEC-RAS) & Hydrologic Engineering Center Ecosystem Functions Model (HEC-EFM) |
| **Composition and diversity in plant communities** | Hydrogeomorphic Model (HGM) - Characteristic Plant Communities function for Cottonwood-Willow and Mesquite Communities (Webb & Burks-Copes 2009) |

# Response function model results
# Recruitment of foundation trees

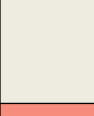| Acres with soil moisture sufficient for tree recruitment | | | | |
|---|---|---|---|---|
| Future without project | Alternative A | Alternative B | Alternative C | Alternative D |
| 20 | 20 | 60 | 60 | 80 |

# Response function model results
# Composition and diversity in plant communities of riparian forests

| Plant community composition & diversity functional capacity index (FCI) and acreage | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Future without project | | Alternative A | | Alternative B | | Alternative C | | Alternative D | |
| FCI | Acres | FCI | Acres | FCI | Acres | FCI | Acres | FCI | Acres |
| 0.84 | 20 | 0.84 | 20 | 0.9 | 20 | 0.9 | 20 | 0.9 | 20 |
| 0 | 180 | 0.4 | 20 | 0.55 | 50 | 0.72 | 180 | 0.82 | 180 |
| - | - | 0 | 160 | 0 | 130 | - | - | - | - |

# Example MCDA Results
## Project alternatives

**Key**

- ■ Large positive impact
- ■ Moderate positive impact
- ■ Small positive impact
- ■ No change
- ■ Small negative impact
- ■ Moderate negative impact
- ■ Large negative impact

|  | Alt A | Alt B | Alt C | Alt D | Alt E |
|---|---|---|---|---|---|
| Riparian ecosystem sustainability | 0 | 10 | 14 | 14 | 14 |
| Aquatic ecosystem sustainability | 0 | 8 | 8 | 19 | 19 |
| Roundtail Chub Viability | 0 | 4 | 4 | 9 | 9 |
| Southwestern Willow Flycatcher Viability | 0 | 0 | 8 | 10 | 10 |
| Property protection from floods | 0 | 0 | 3 | 10 | 10 |
| General recreation | 0 | 0 | 5 | 5 | 5 |
| Recreational birding | 0 | 0 | 5 | 5 | 5 |
| **Aggregate Score** | **0** | **22** | **47** | **72** | **72** |

# Conclusions

- Functional understanding is adequate to support decisions for some services

- Need to strengthen ability to:

  - Screen for effectiveness of management measures

    - Non-linearities in production of beneficial outcomes

  - Evaluate joint production of multiple services

    - Complementary /competition among services

- Major data gap: models reflecting probable outcomes given uncertainties (e.g., population viability analyses)