Wetland Management Decision-Making for Multiple Objectives

Shorebird Ecology and Management Workshop

Gumbo Flats, Lambert, MS

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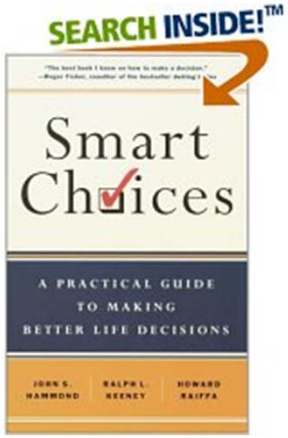
MANOMET
Center for Conservation Sciences

What is Structured Decision Making?

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

– Ralph Keeney



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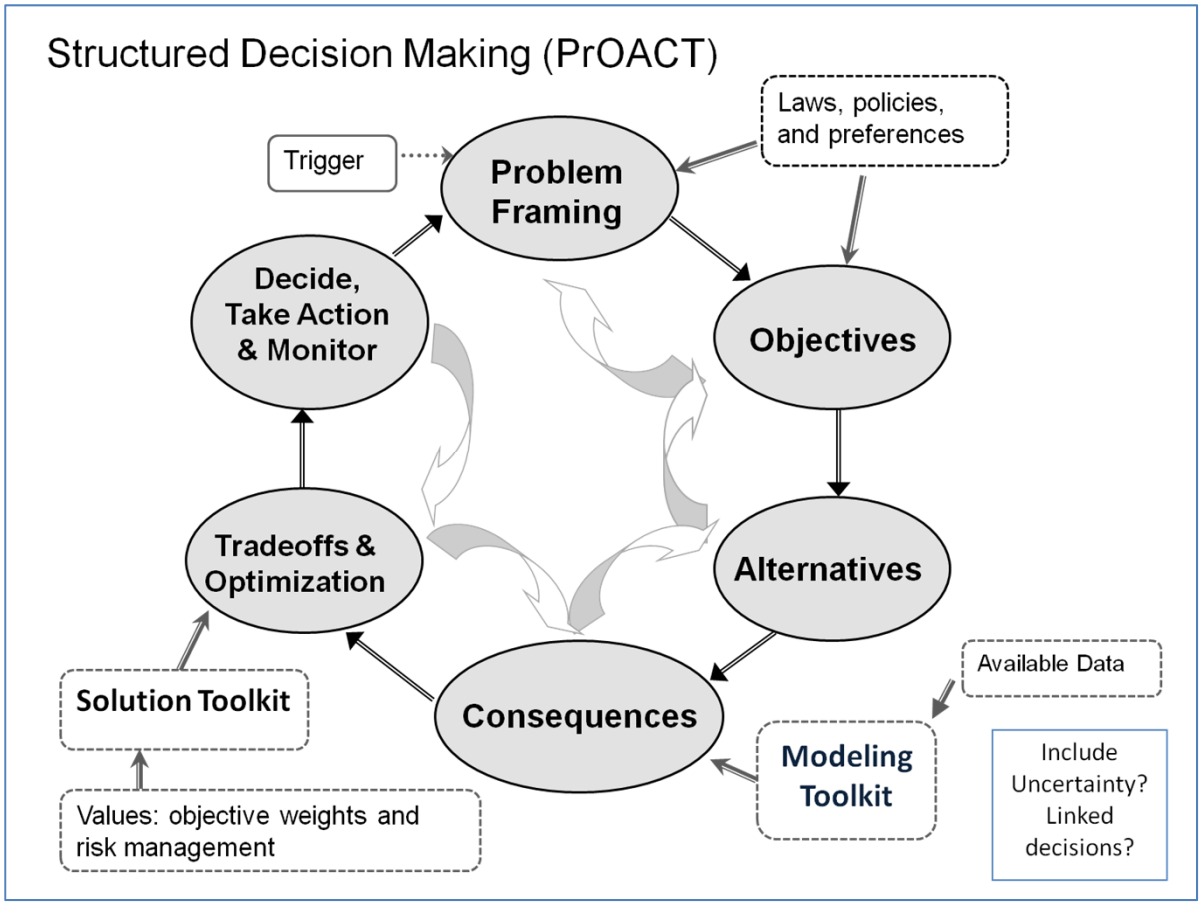


Problem Definition

Objectives

Alternatives

Consequences (Predictive model)

Trade-offs (Find a Solution → Decide and Implement)

Monitoring

Reference: *Smart Choices* by Hammond, Keeney, and Raiffa

Structured Decision Making for Coastal Delaware Wetland Management Under Uncertainty From Sea Level Rise

Jim Lyons[1] and Kevin Kalasz[2]

[1]U.S. Fish and Wildlife Service
[2]Delaware Division of Fish and Wildlife

Step 1. Problem Framing

- Multiple management objectives
  - Shorebirds, waterfowl, fish, marsh birds, etc., etc.
- Many impoundments (27 impoundments on public land in Delaware; 16,000 acres)
- Many management actions are possible
  - Early season drawdown, late season…
- Complex natural systems
  - Environmental variation, etc., etc.
- Climate change and sea level rise?

Structured Decision Making Team (Expert Panel)

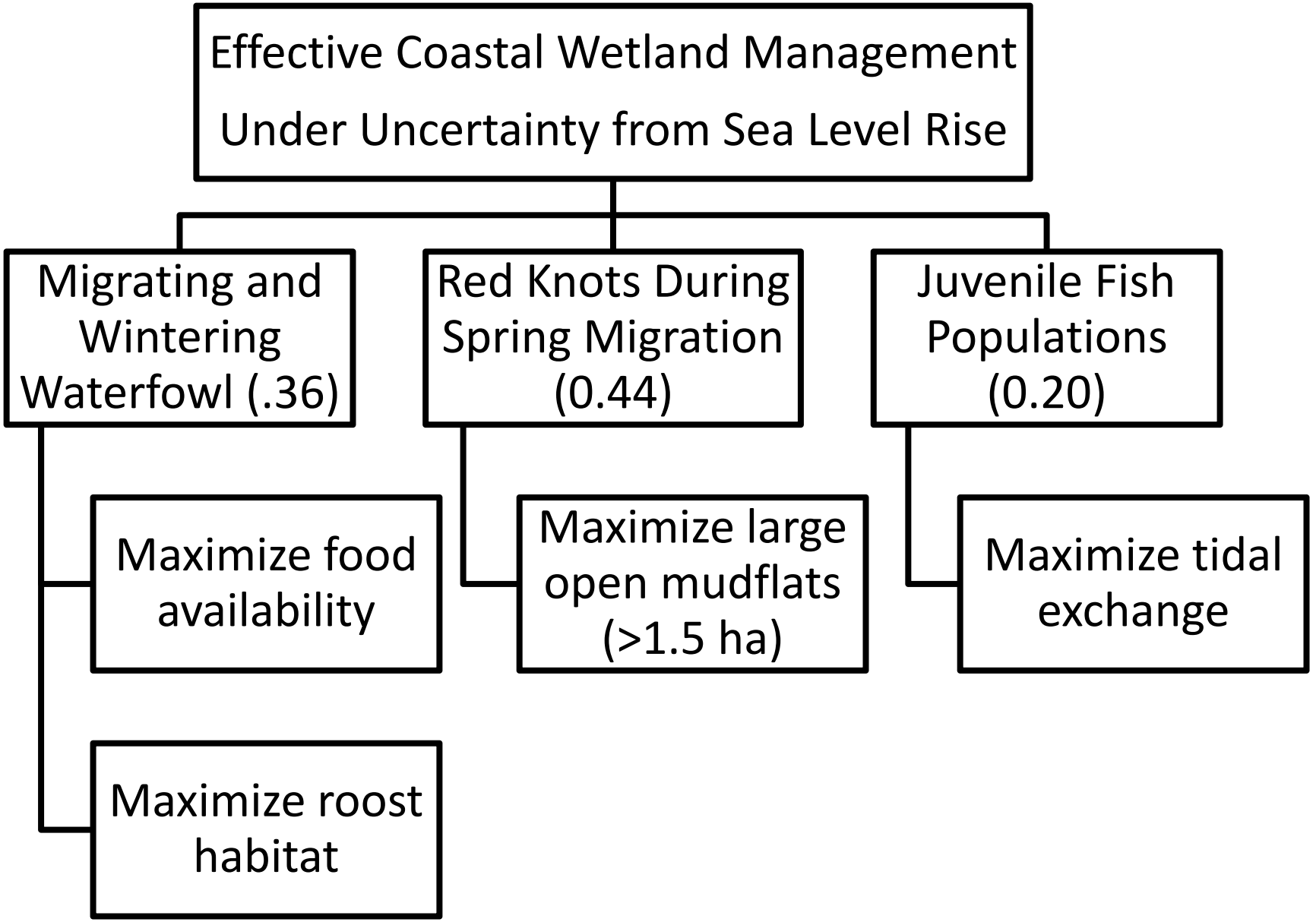
Greg Breese	Shorebird	USFWS
John Clark	Fisheries	DE DFW
Matt Dibona	Waterfowl	DE DFW
Rob Hossler	Waterfowl	DE DFW
Bill Jones	Fisheries	DE DFW
Kevin Kalasz	Shorebird	DE DFW
Bob Meadows	Mosquito Control	DE DFW
Michael Stroeh	Refuge Manager	USFWS
Bart Wilson	Water Resources	DE DFW

Prototype in 4 days

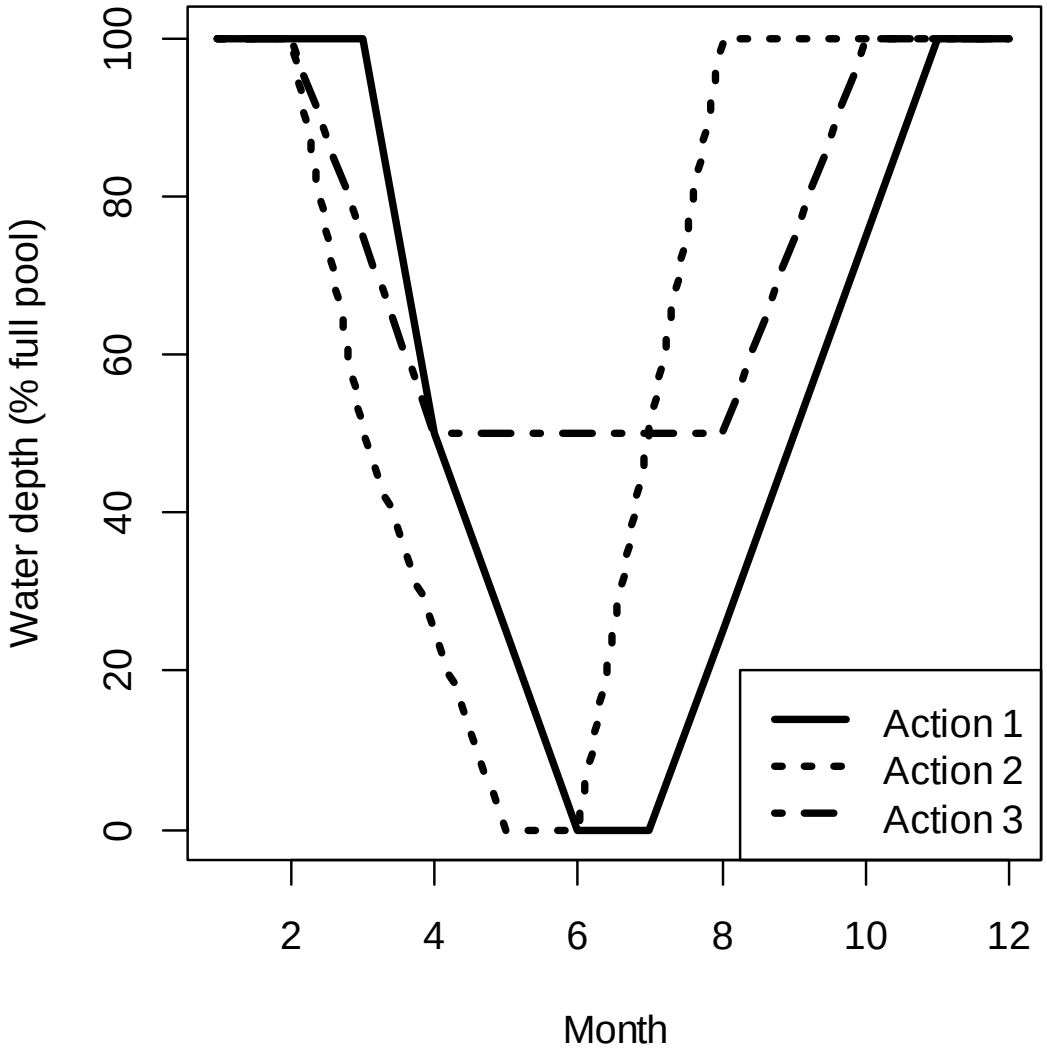
- 4 impoundments (of 22 available)
- 3 objectives (of many possible)

For today, ignore uncertainty related to sea level rise, etc.

Step 2. Objectives



Step 3. Management Actions 1, 2, & 3



Management Actions

#1. Waterfowl drawdown

#2. Shorebird drawdown

#3. "Delaware saline" DD

Impoundments

"Little Creek"

"Logan"

"Unit III"

"Raymond"

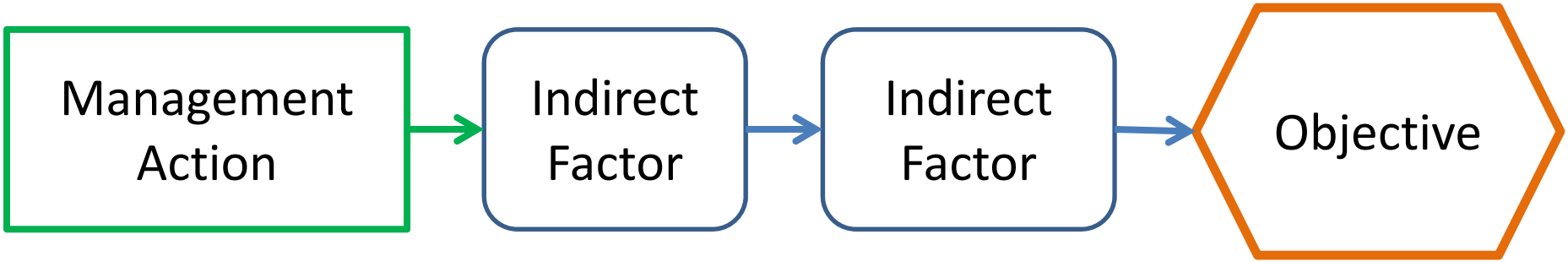
Step 3. Management Actions

Impoundment	Management Action
Little Creek	(Action 1) Waterfowl drawdown
	(Action 2) Shorebird drawdown
	(Action 3) DE Saline drawdown
	(Action 4) Replace water control structure, repair dike, sediment control, & A1
	(Action 5) Replace water control structure, repair dike, sediment control, & A2
	(Action 6) Replace water control structure, repair dike, sediment control, & A3
Logan	(Action 1) Waterfowl drawdown
…	…

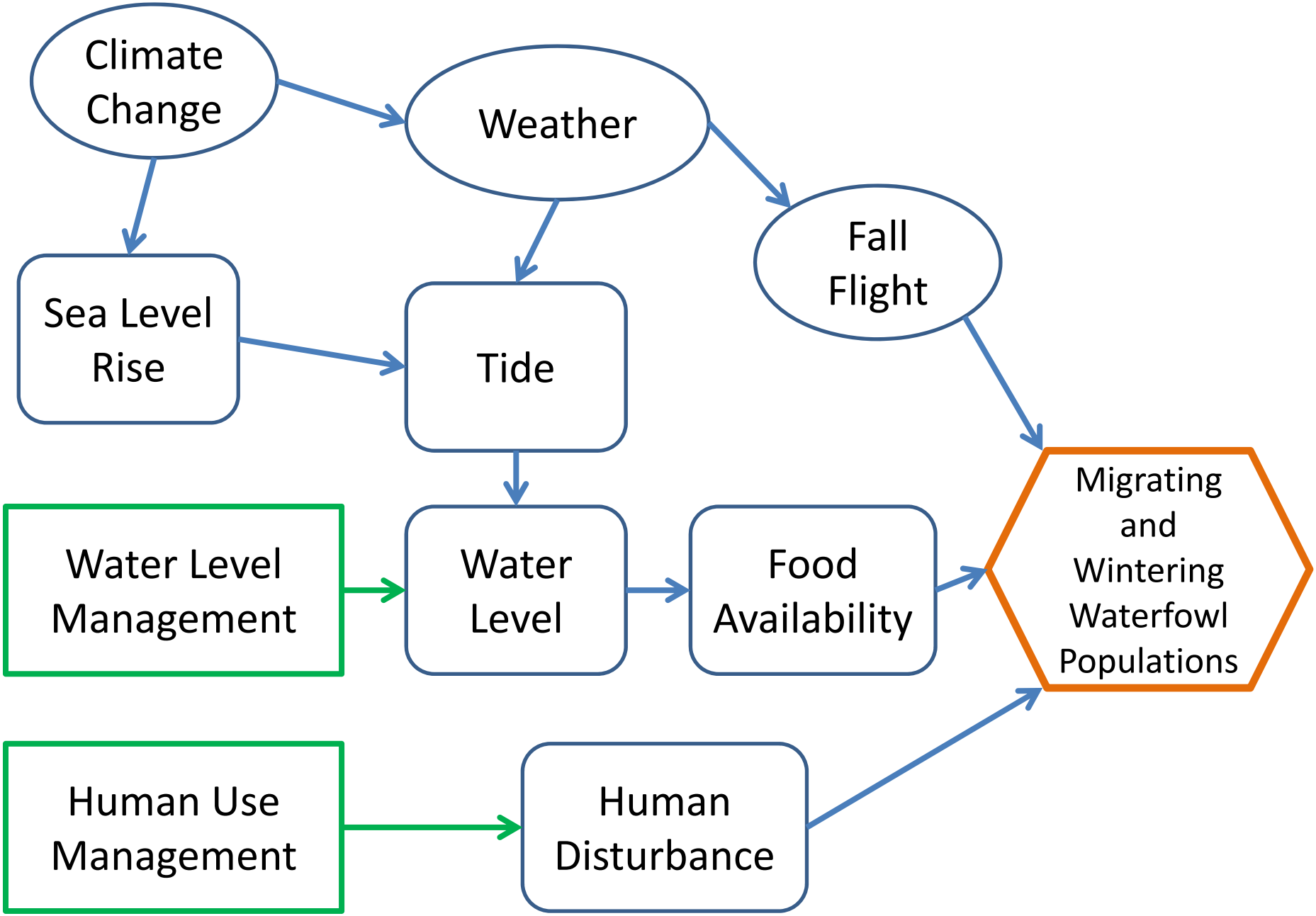
Step 4. Consequence Table

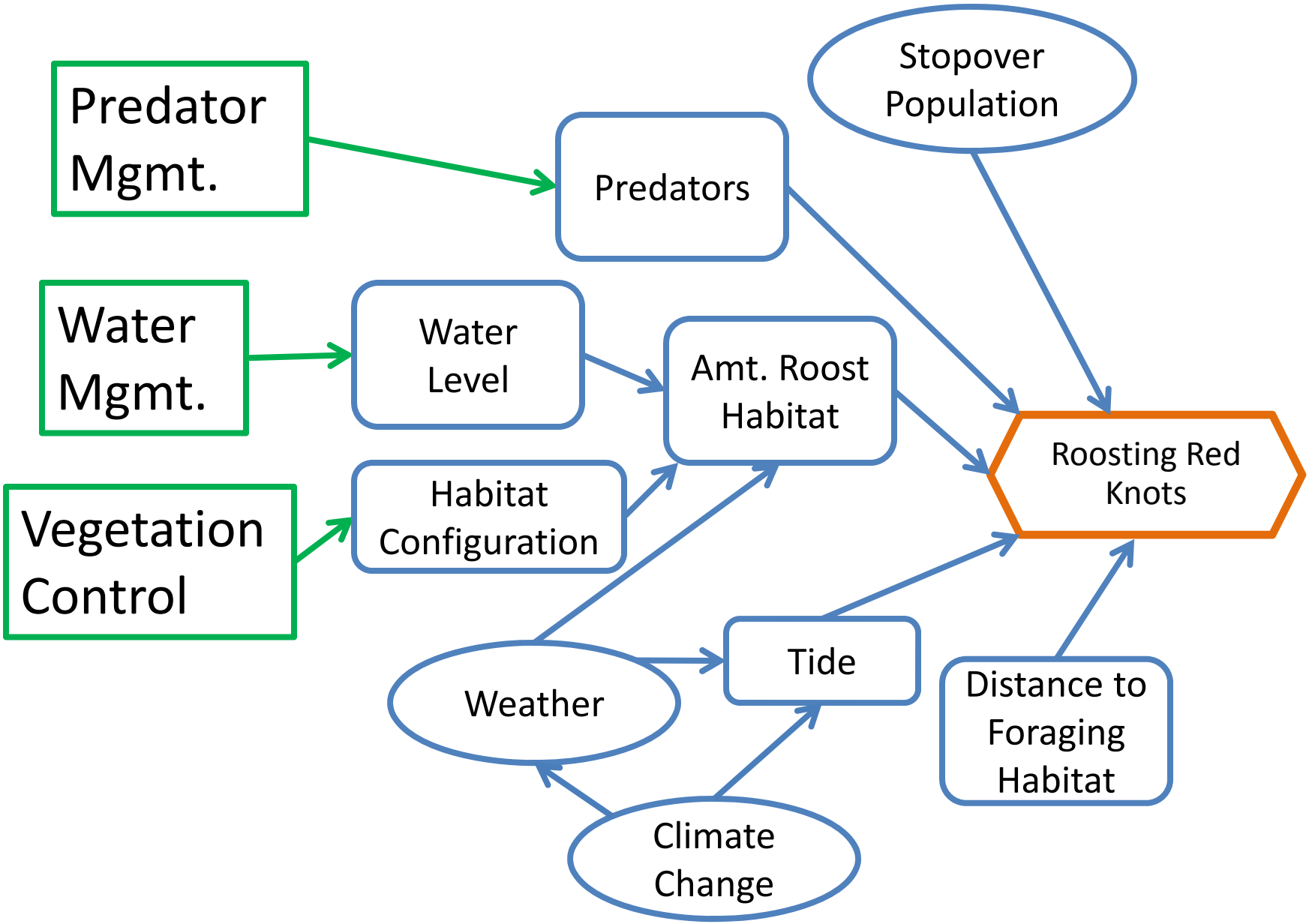
Impoundment	Management Action	Objective		
		Waterfowl	Red Knots	Fish Pops
Little Creek	(A1) Waterfowl drawdown	?	?	?
	(A2) Shorebird drawdown			
	(A3) DE Saline drawdown			
	(A4) Replace water control structure, repair dike, sediment control, & A1			
	(A5) Replace water control structure, repair dike, sediment control, & A2			
	(A6) Replace water control structure, repair dike, sediment control, & A3			
Logan	(A1) Waterfowl drawdown			
…	…			

Consequences: Influence Diagrams



An influence diagram is a conceptual model.


Climate Change
Weather
Fall Flight
Sea Level Rise
Tide
Water Level Management
Water Level
Food Availability
Migrating and Wintering Waterfowl Populations
Human Use Management
Human Disturbance


Predator Mgmt.
Predators
Stopover Population
Water Mgmt.
Water Level
Amt. Roost Habitat
Roosting Red Knots
Vegetation Control
Habitat Configuration
Weather
Tide
Distance to Foraging Habitat
Climate Change

Consequence Table

		Objective		
Imp	Mgmt Action	Waterfowl	Red Knots	Fish Pops
Little Creek	(A1) Waterfowl drawdown	690	410	0.06
	(A2) Shorebird drawdown	530	615	0.06
	(A3) DE Saline drawdown	293	0	4.91
	(A4) Replace water control structure, repair dike, sediment control, & A1	680	410	0.06
	(A5) Replace water control structure, repair dike, sediment control, & A2	481	615	0.06
	(A6) Replace water control structure, repair dike, sediment control, & A3	283	0	4.91
Logan	(A1) Waterfowl drawdown	1408	656	0.1
	⋮	⋮	⋮	⋮

Consequence Table

		Objective			
Imp	Management Action	Waterfowl	Red Knots	Fish Pops	Cost ($1000)
Little Creek	(A1) Waterfowl drawdown	690	410	0.06	5
	(A2) Shorebird drawdown	530	615	0.06	5
	(A3) DE Saline drawdown	293	0	4.91	7
	(A4) Replace water control structure, repair dike, sediment control, & A1	680	410	0.06	800
	(A5) Replace water control structure, repair dike, sediment control, & A2	481	615	0.06	800
	(A6) Replace water control structure, repair dike, sediment control, & A3	283	0	4.91	800
Logan	(A1) Waterfowl drawdown	1408	656	0.1	10
	⋮	⋮	⋮	⋮	⋮

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Problem Definition

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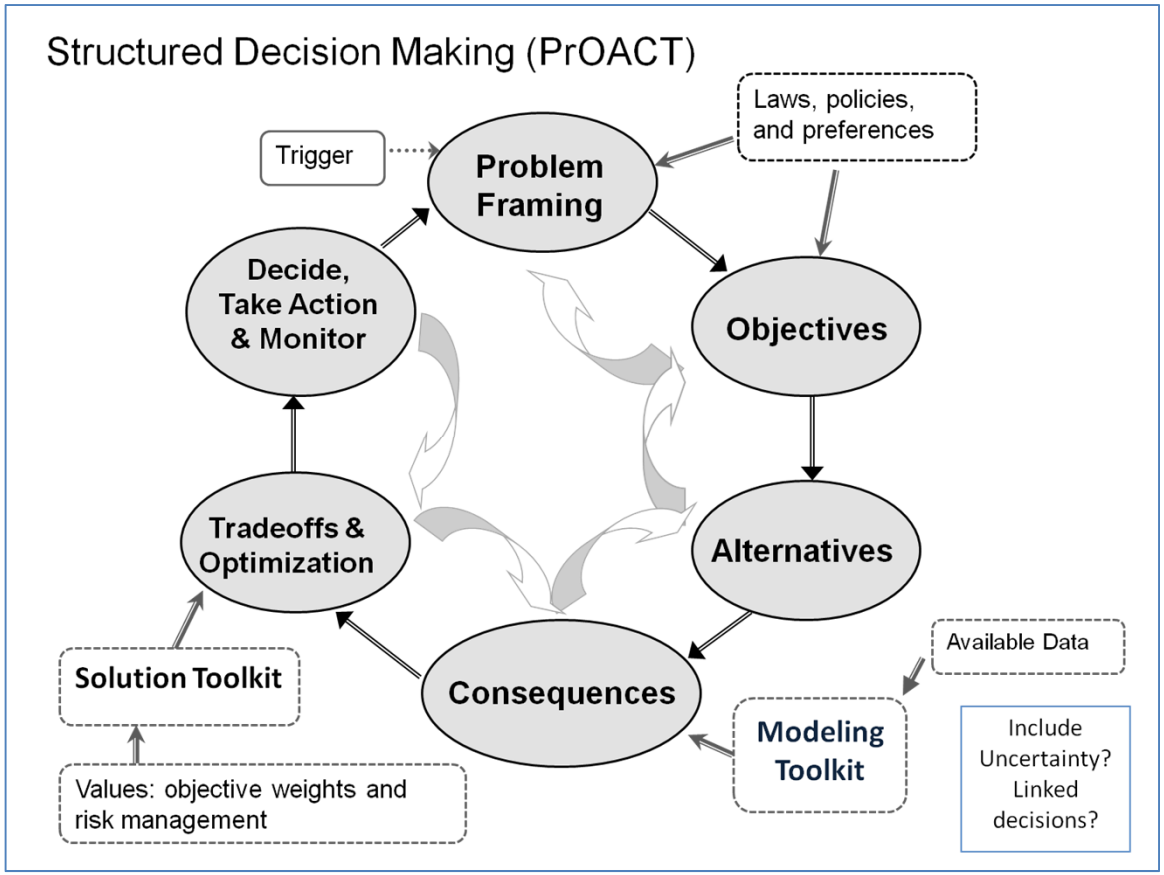
Consequences (Predictive model)

Trade-offs (Solution → Decide and Implement)

Monitoring



Reference: *Smart Choices* by Hammond, Keeney, and Raiffa

Trade-offs

- Apples to Oranges
  1. Maximum waterfowl count during winter
  2. Mean count of roosting Red Knots
  3. Ratio of fish density inside and outside WCS
- All Apples
  - Use a value function to convert to common scale
  - Range 0 to 1
  - From worst outcome to best outcome
- Sum "value" for each objective for "Total Management Benefit"

Example Management Action Portfolio "A": Waterfowl Drawdown in All Impoundments

Mgt. Unit	Management Action	Mgt. Benefit	Cost ($K)
Little Creek	#1:Waterfowl DD	?	?
Logan	#1:Waterfowl DD	?	?
Unit III	#1:Waterfowl DD	?	?
Raymond	#1:Waterfowl DD	?	?
Total Management Benefit & Cost		?	?

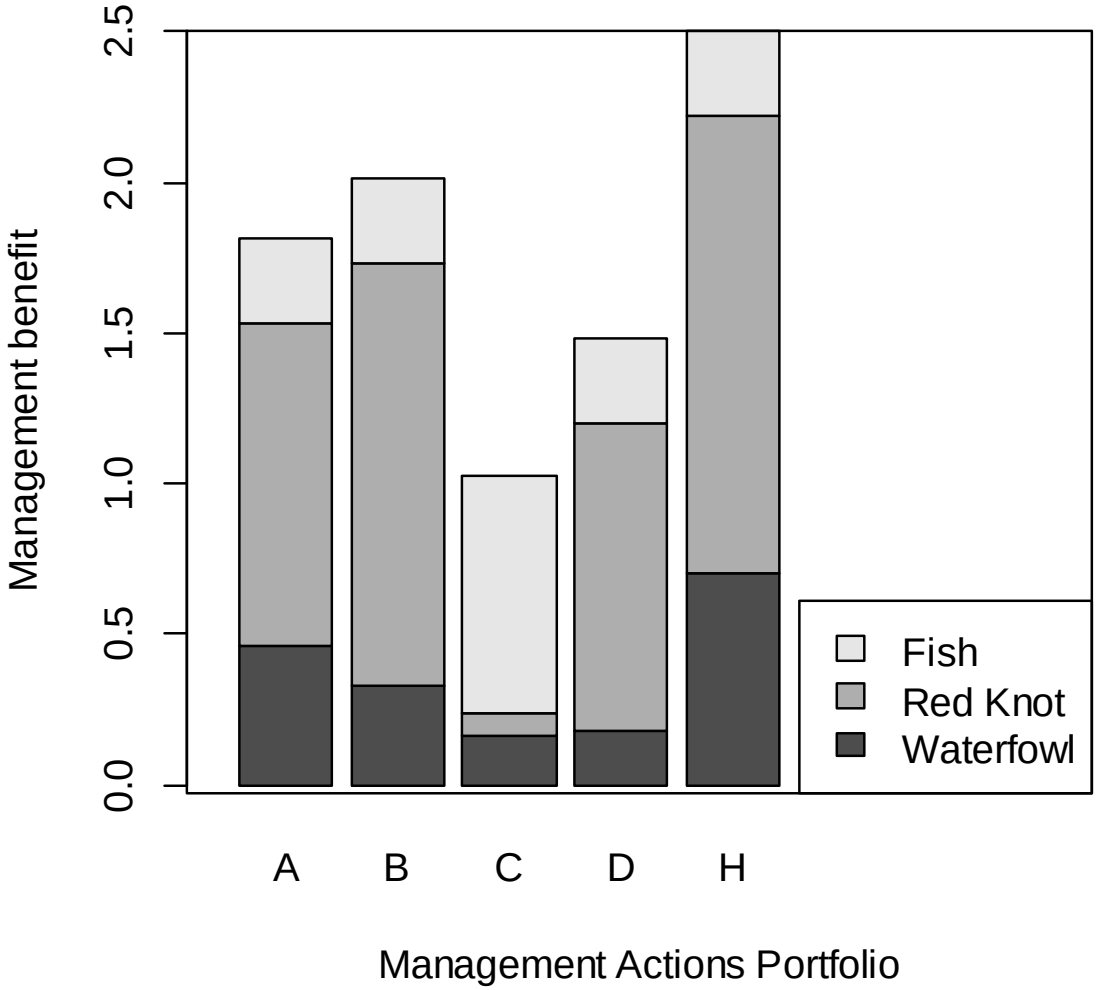
Example Management Action Portfolio "A": Waterfowl Drawdown in All Impoundments

Mgt. Unit	Management Action	Mgt. Benefit	Cost ($K)
Little Creek	#1:Waterfowl DD	0.598	$5
Logan	#1:Waterfowl DD	0.548	$10
Unit III	#1:Waterfowl DD	0.641	$23
Raymond	#1:Waterfowl DD	0.038	$2
Total Management Benefit & Cost		1.826	$40

Example Portfolio "B":
Waterfowl DD in 2 units, Shorebird DD in 2 units

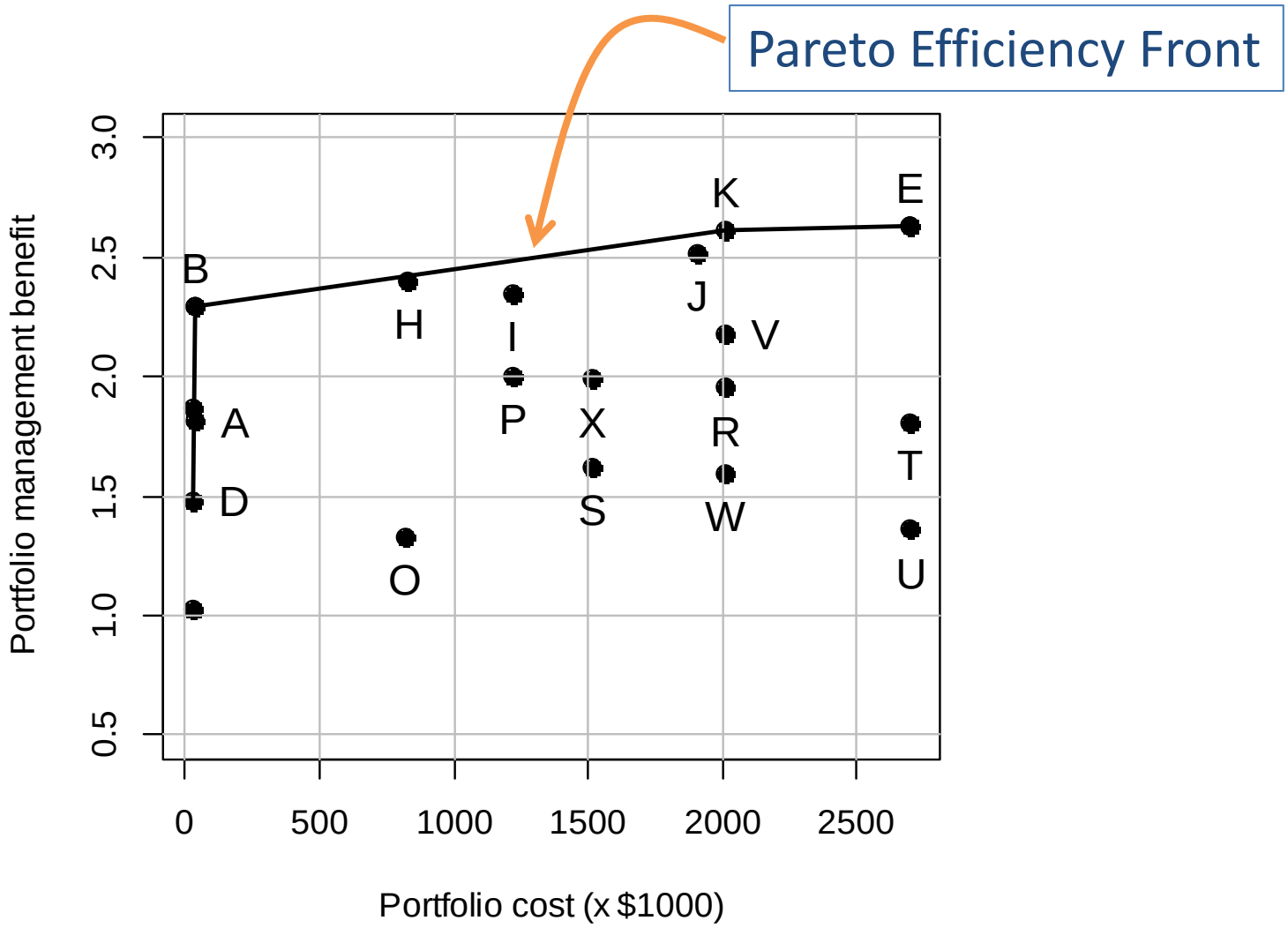
Mgt. Unit	Management Action	Mgt. Benefit	Cost ($K)
Little Creek	#1:Waterfowl DD	0.598	$5
Logan	#1:Waterfowl DD	0.548	$10
Unit III	#2: Shorebird DD	0.747	$15
Raymond	#2: Shorebird DD	0.121	$2
Total Management Benefit & Cost		2.015	$32

Portfolio Relative Benefits

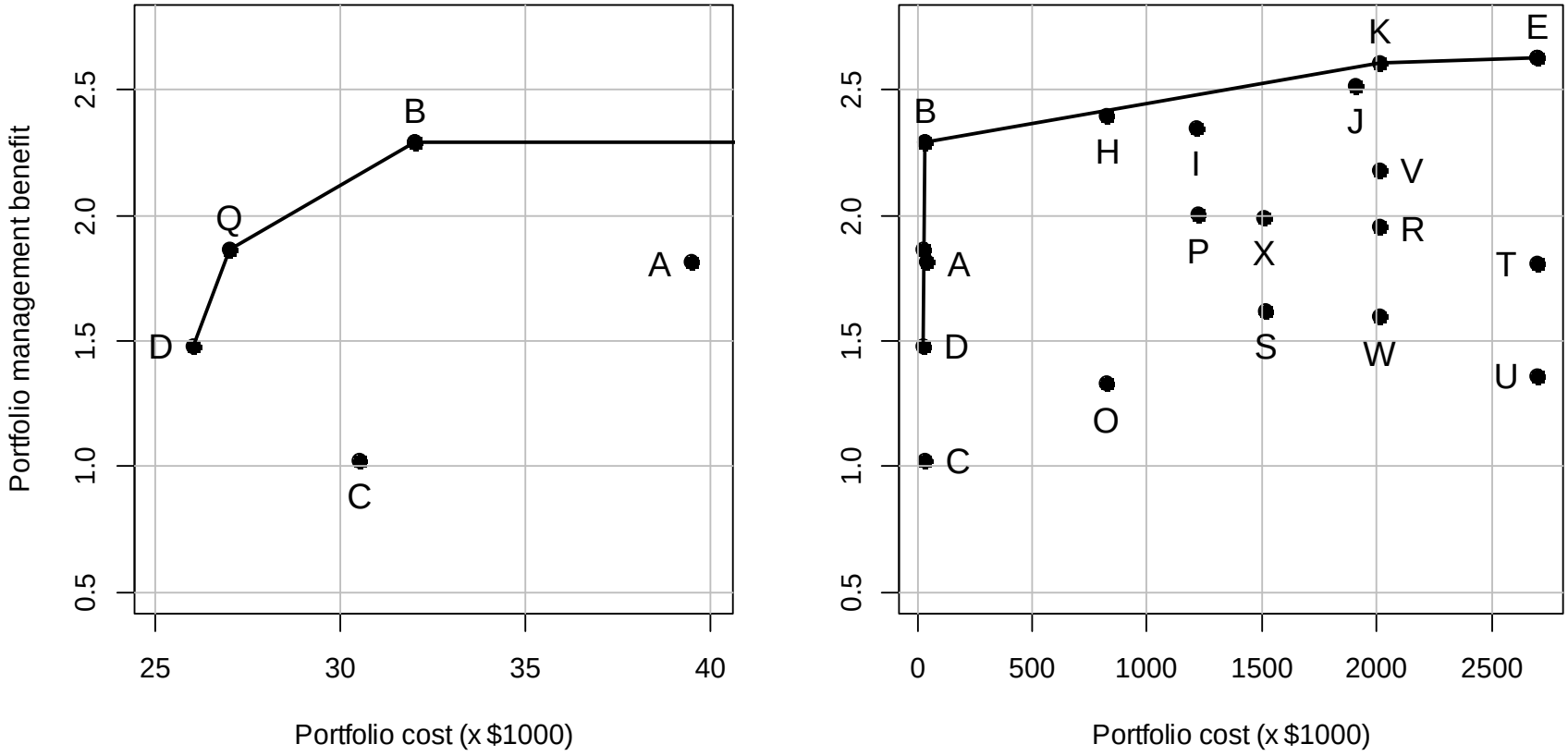


Portfolio	Description
A	Waterfowl DD everywhere
B	Waterfowl & Shorebird
C	DE Saline DD everywhere
D	Minimum cost everywhere
H	$2.5M cost constraint (Invest in Unit III first.)

Solution 1:
Pareto Efficiency Analysis



Pareto Efficiency Analysis



Solution 2:
"Constrained Optimization"

Three components

1. Objective function, e.g. "maximize total management benefit across impoundments")
2. Set of constraints, e.g.
   Cost < $50,000
   Moist-soil acres > 1,000
   Average shorebird count > 500
3. Decision variable

Step 6. Monitoring

- In our case we did not have the monitoring data we needed to build a model, so we used → expert judgment.
- Monitoring data can be used to update the consequence table over time.
- Also possible to test competing hypotheses about system dynamics and learn over time (adaptive management).

Summary

- We created a decision support system for multiple management units
- We addressed multiple objectives
- Predicted outcomes (modeling) using expert judgment
- We used a portfolio approach to selecting management actions
- Our prototype can be expanded to include more objectives, more impoundments, etc.