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Πρακτικές και μέθοδοι συστημάτων βελτιστοποίησης διαχειριστικών μέτρων

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Presentation Outline

- What is Operations Research?
- Why is it (Optimization) needed?
- Optimization in Environmental Management
- Approaches / Procedures / Models
- Types of Results to be expected
- Current Status
- Next Steps

Jargon, jargon, and more jargon…

- Operations Research
- Optimization
- Mathematical Programming
- Systems Analysis

What is Operations Research?

- "Operations Research is the application of advanced analytical methods to help make better decisions."

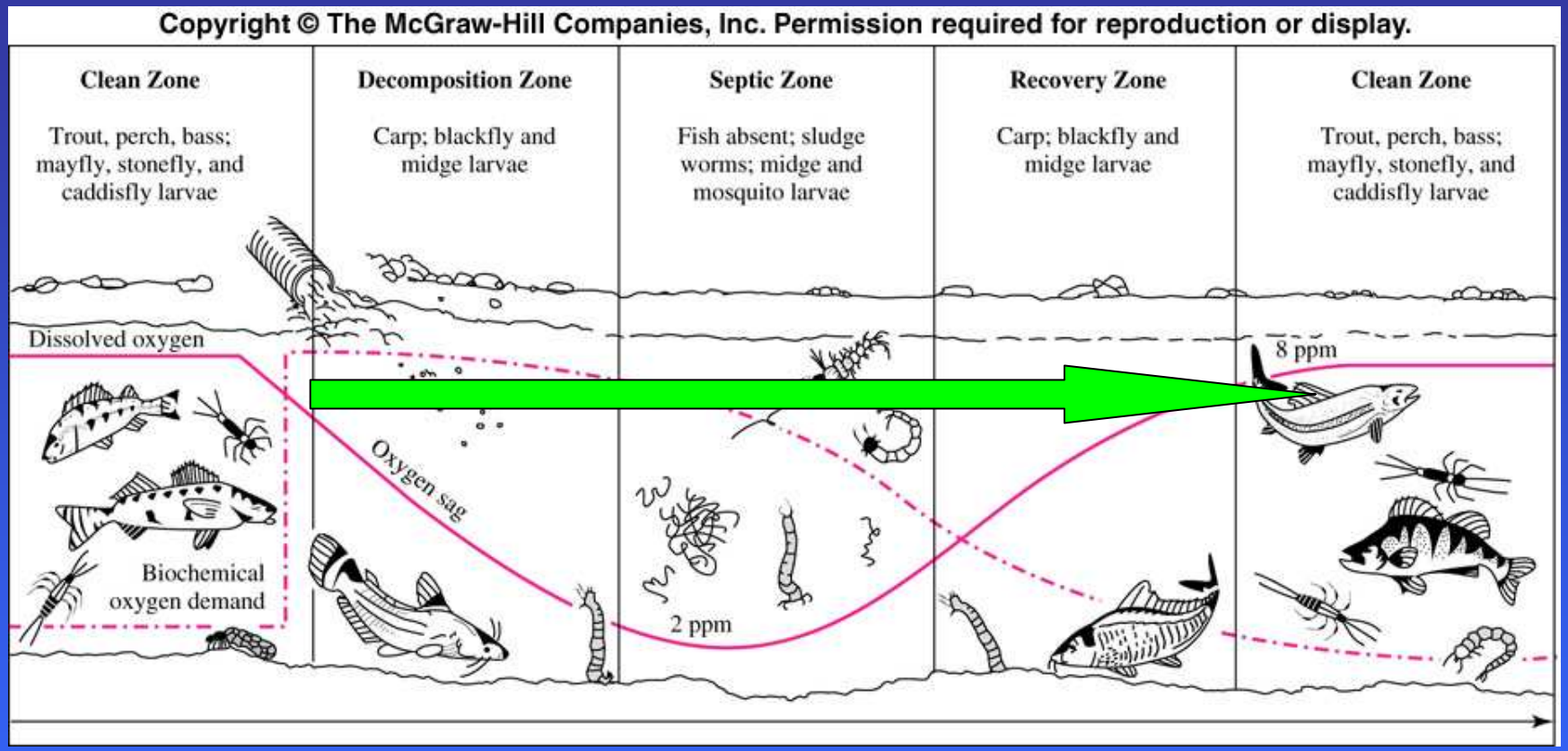
- Alternative 'Definition'
  - "The science of decision making."

A brief history lesson…
(born out of necessity)

- World War II **problems**
  - Deployment of radar, management of convoys, bombing, mining, training schedules, resupplying the front lines, …
- World War II **solutions**
  - Scientists and Engineers were called in to apply mathematics and the scientific method to these Military Operations problems
- What since then?
  - Transportation Industry
  - Telecommunications
  - Industrial Production
  - And finally…

Optimization in Environmental Management

Descriptive models



- **Descriptive model** of the system as a hypothesis of how the system could work, or try to estimate how an unforeseeable event could affect the system.

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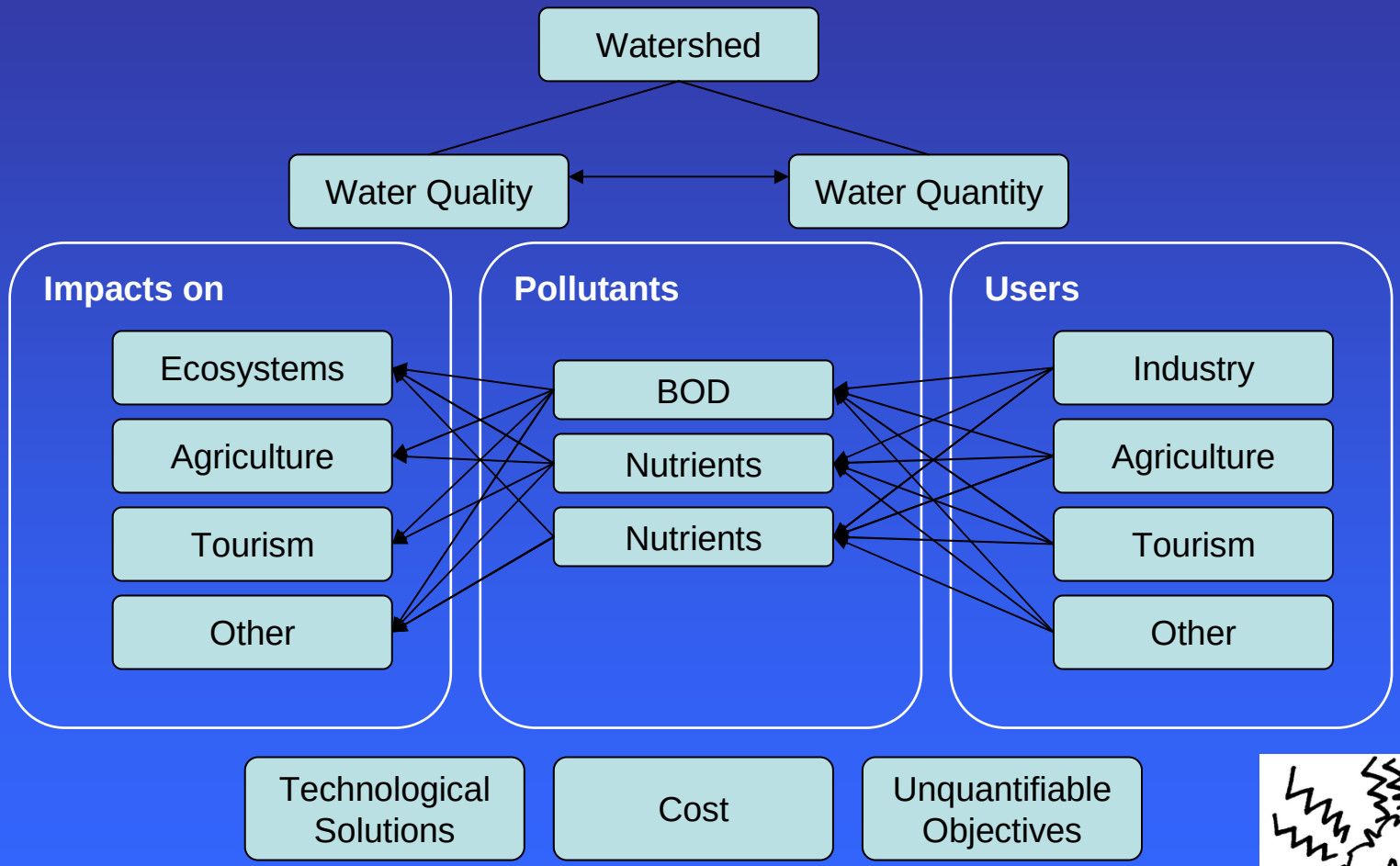
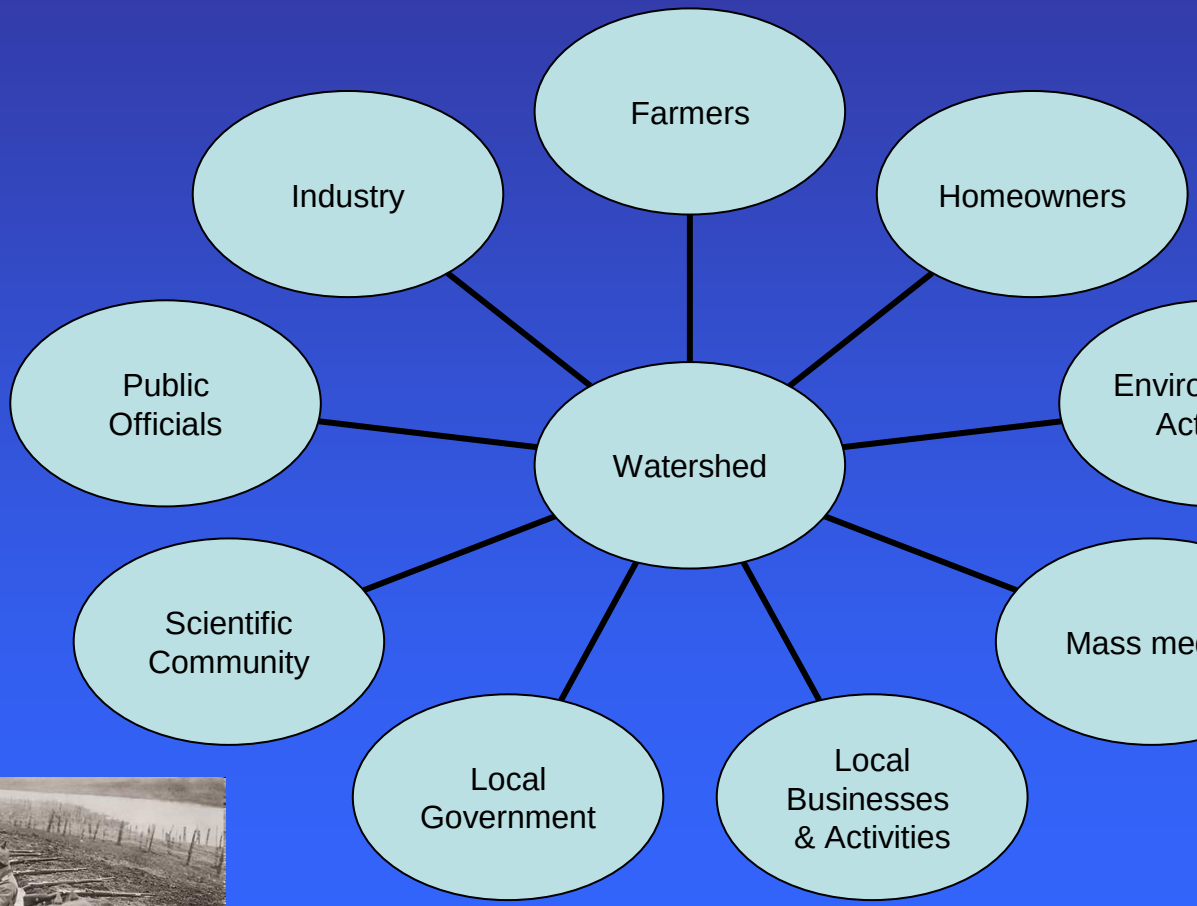
Water Management Issues (a world of complexity)



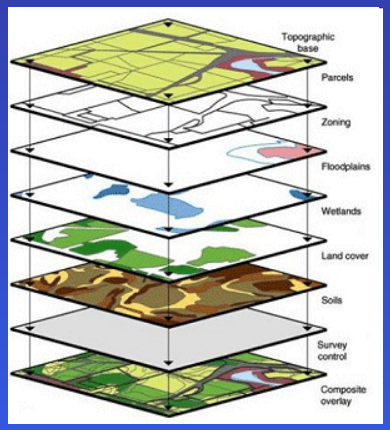
Water Management Stakeholders (a world of conflict)



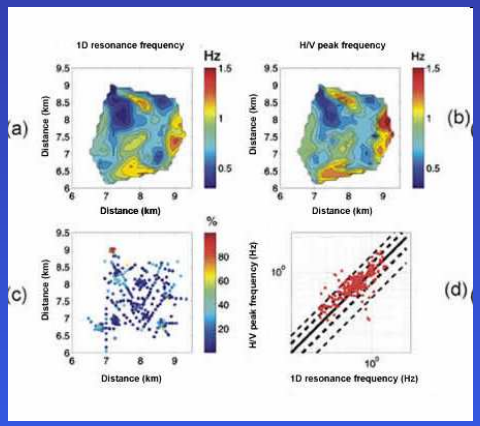
How it all ties together…

(the architecture of a DSS applied to an environmental system)

GIS

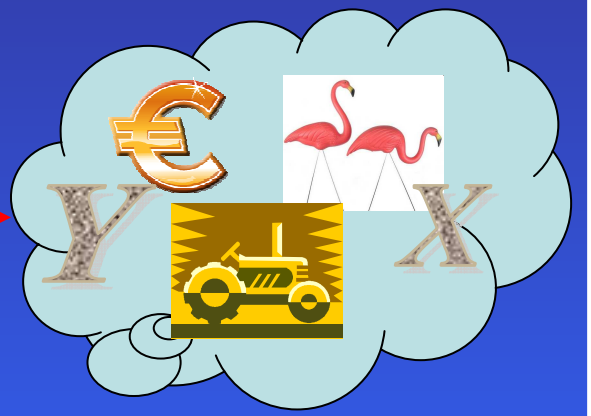


Simulation Modules

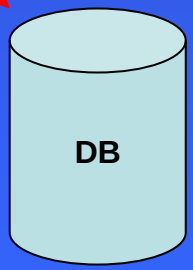


- Hydraulic Model
- Hydrologic Model
- Water Quality Model
- Black Box Models
- Ecological Models
- Etc …

Optimization Modules

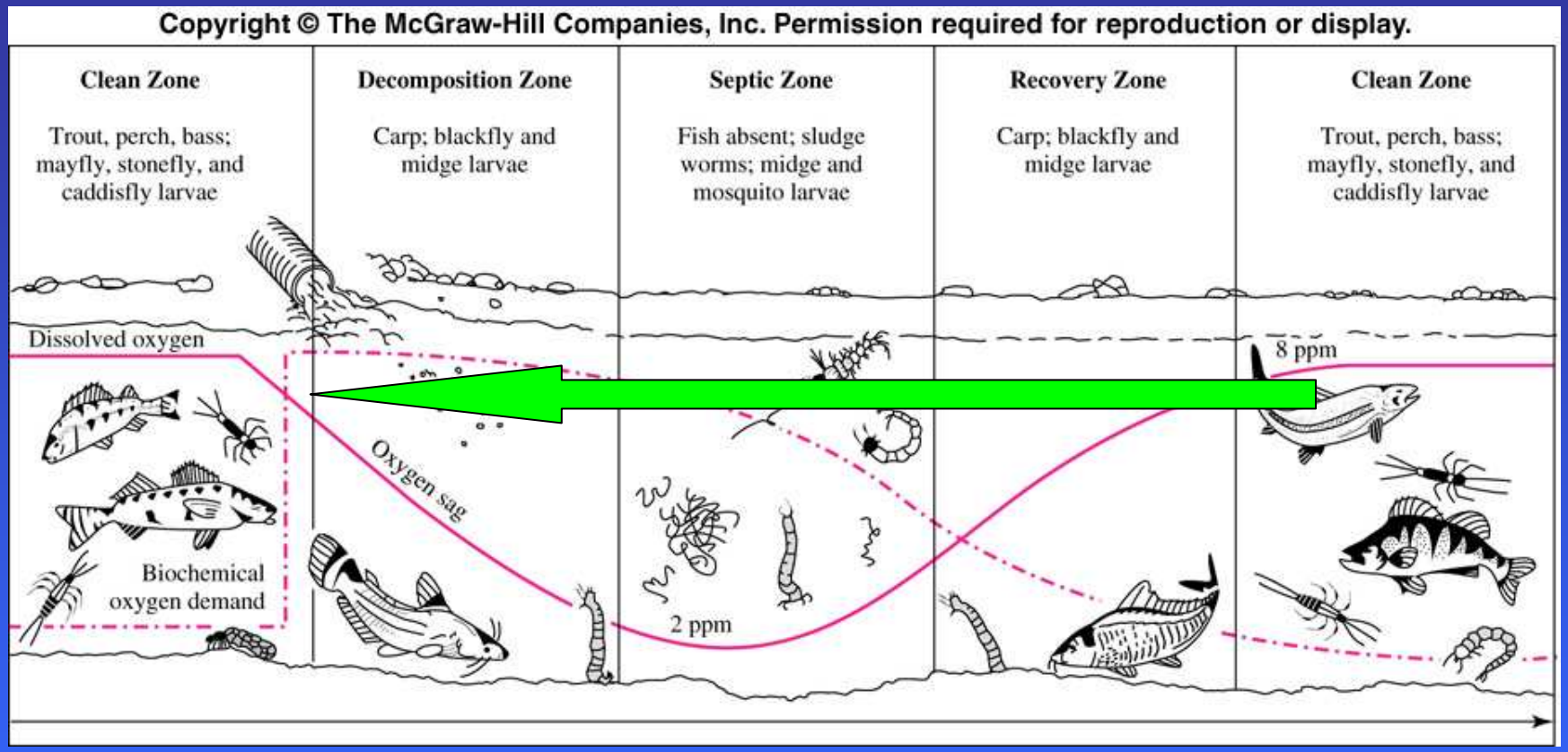


- Decision Variables
- Objectives
- Constraints
- Economic, social, legislative & environmental aspects



Database

Decision models



- **Decision model** for the decision maker to develop insight into the decision and determine a clear course of action

How does an Optimization Model look like?

The following is a mathematical formulation of a decision model:

Minimize: $$\sum_{f=1}^{N}\sum_{t=1}^{n} C_{f,t} X_{f,t} \qquad (1)$$

Subject to:

$$\sum_{t=1}^{n} X_{f,t} = 1 \qquad \forall f \qquad (2)$$

$$\sum_{f=1}^{N}\sum_{t=1}^{n} \left[X_{f,t} \left(100\% - R_t^p\right) W_f^p \right] \le T^p \qquad \forall p \qquad (3)$$

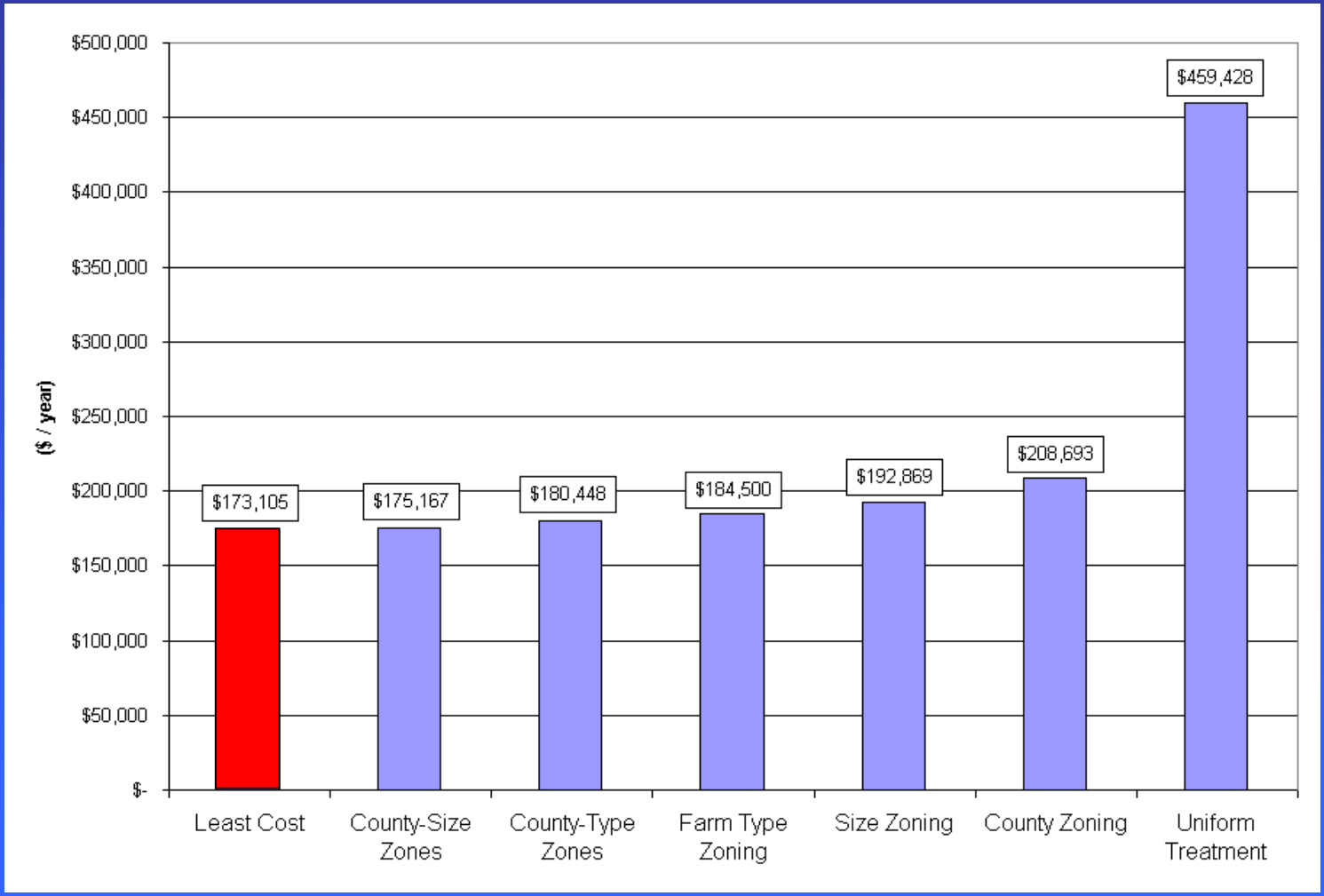
$$X_{f,t} \in \{0,1\} \qquad \forall f, \forall t \qquad (4)$$

Types of results to be expected from Optimization Procedure

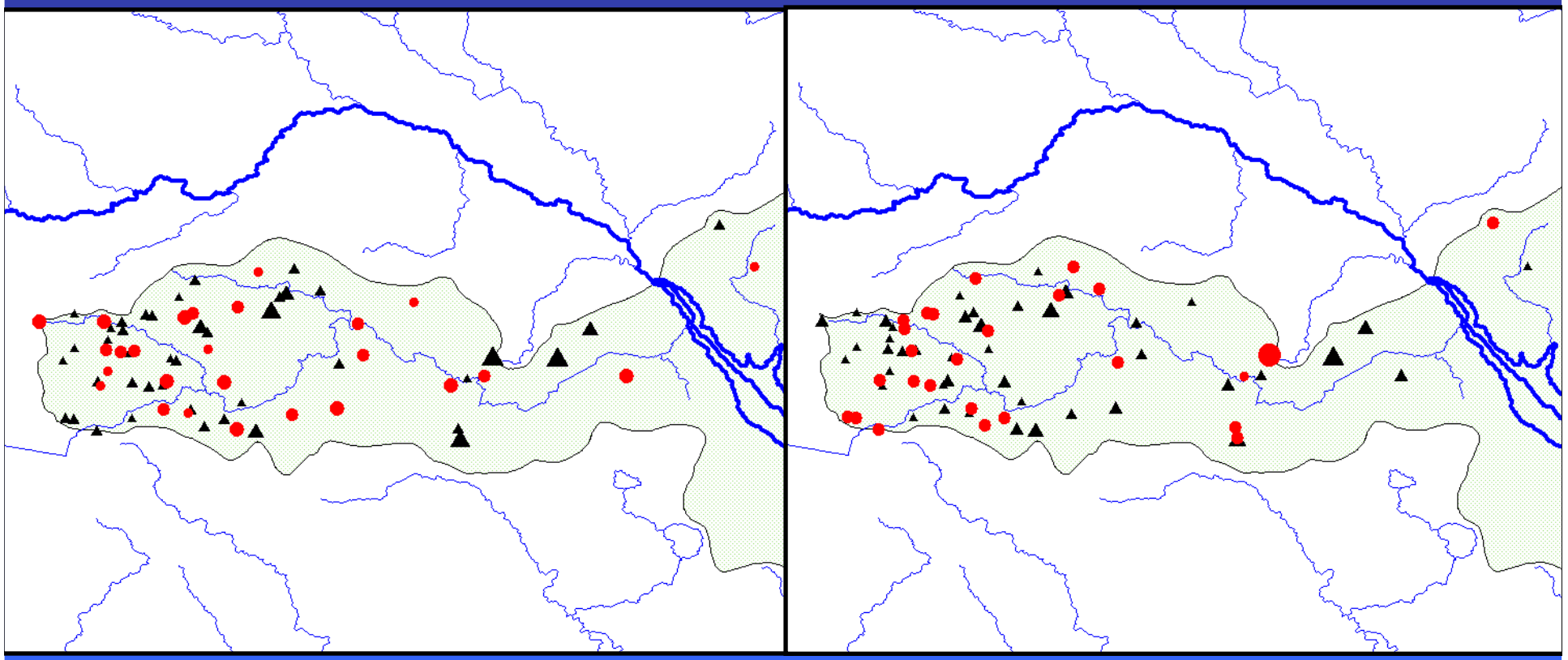
A bunch of numbers…

15% cost deviation from initial least cost		LEAST COST SOLUTION (Basic)				LEAST COST SOLUTION (Alt#1: 70-26)				LEAST COST SOLUTION (Alt#2: 96-36.5)			
Operation Type	Number of pigs	AL	D (AL)	CW (AL)	SBR(AL)	AL	D (AL)	CW (AL)	SBR(AL)	AL	D (AL)	CW (AL)	SBR(AL)
Farrow-to-Finish	100	1	0	0	0	0	1	0	0	0	0	1	0
Farrow-to-Finish	250	1	0	0	0	0	1	0	0	0	0	1	0
Farrow-to-Feeder	350	1	0	0	0	1	0	0	0	0	1	0	0
Farrow-to-Feeder	525	1	0	0	0	0	1	0	0	0	0	1	0
Farrow-to-Finish	560	1	0	0	0	0	1	0	0	0	0	1	0
Farrow-to-Finish	1200	1	0	0	0	1	0	0	0	0	1	0	0
Feeder-to-Finish	1200	1	0	0	0	1	0	0	0	0	1	0	0
Farrow-to-Feeder	1220	1	0	0	0	0	1	0	0	1	0	0	0
Farrow-to-Finish	1250	1	0	0	0	1	0	0	0	0	0	1	0
Farrow-to-Feeder	1250	1	0	0	0	0	1	0	0	1	0	0	0
Farrow-to-Feeder	1250	1	0	0	0	0	1	0	0	1	0	0	0
Feeder-to-Finish	1340	1	0	0	0	1	0	0	0	0	0	1	0
Feeder-to-Finish	1440	1	0	0	0	1	0	0	0	0	0	1	0
Feeder-to-Finish	1440	1	0	0	0	1	0	0	0	0	0	1	0
Farrow-to-Finish	1450	1	0	0	0	1	0	0	0	0	0	1	0
Feeder-to-Finish	1490	1	0	0	0	0	1	0	0	1	0	0	0
Feeder-to-Finish	1650	1	0	0	0	1	0	0	0	0	0	1	0
Boar-Stud	1700	1	0	0	0	1	0	0	0	0	0	1	0
Farrow-to-Feeder	2000	1	0	0	0	1	0	0	0	0	0	1	0
Farrow-to-Weanling	2000	1	0	0	0	1	0	0	0	0	0	1	0
Feeder-to-Finish	2000	1	0	0	0	1	0	0	0	0	0	1	0
Feeder-to-Finish	2000	1	0	0	0	1	0	0	0	0	0	1	0
Farrow-to-Finish	2000	1	0	0	0	1	0	0	0	0	0	1	0
Feeder-to-Finish	2160	1	0	0	0	1	0	0	0	0	0	1	0
Feeder-to-Finish	2400	1	0	0	0	1	0	0	0	0	0	1	0
Farrow-to-Weanling	2400	1	0	0	0	1	0	0	0	0	0	1	0

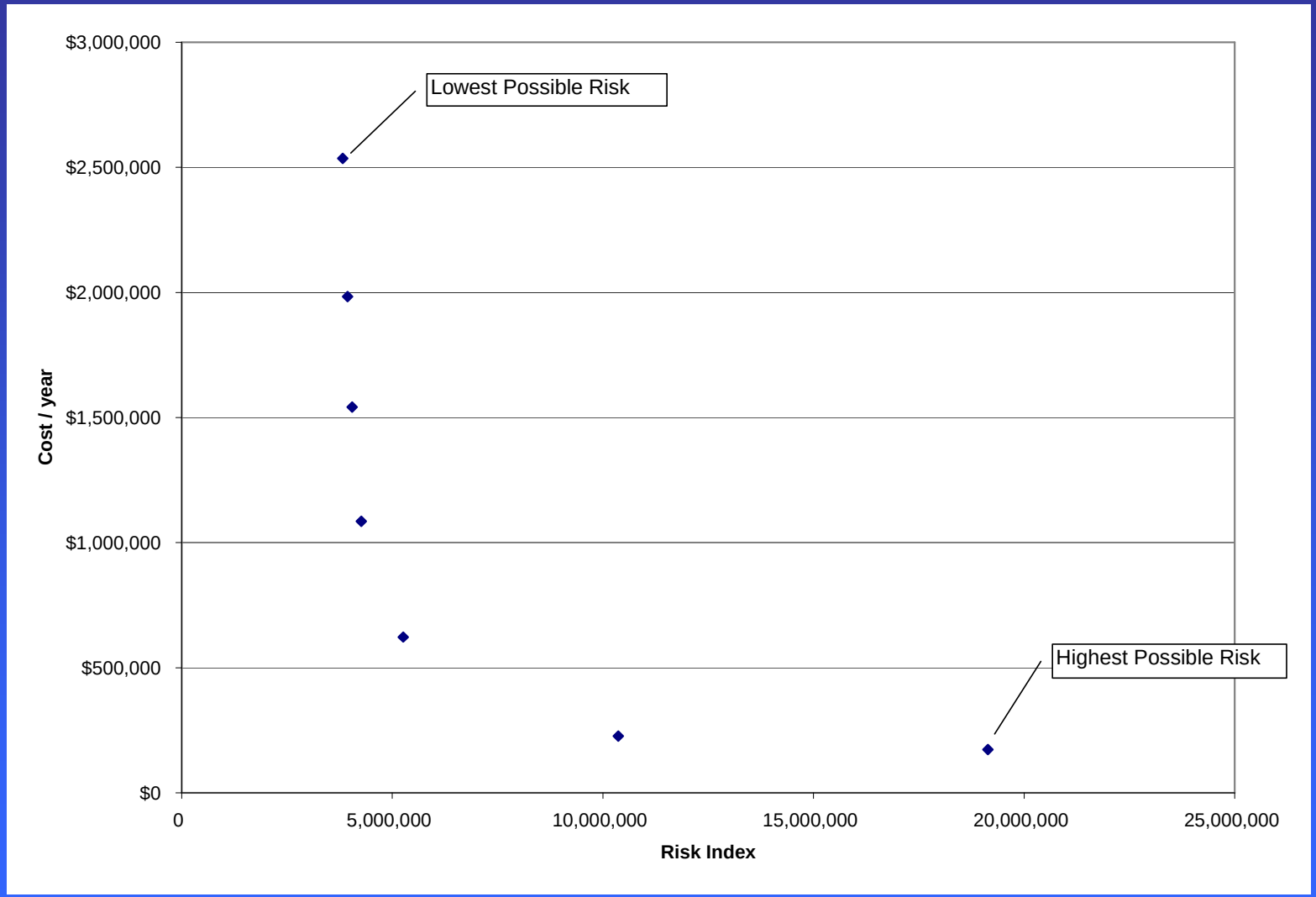
Benefits of Optimization (the Objective Space)



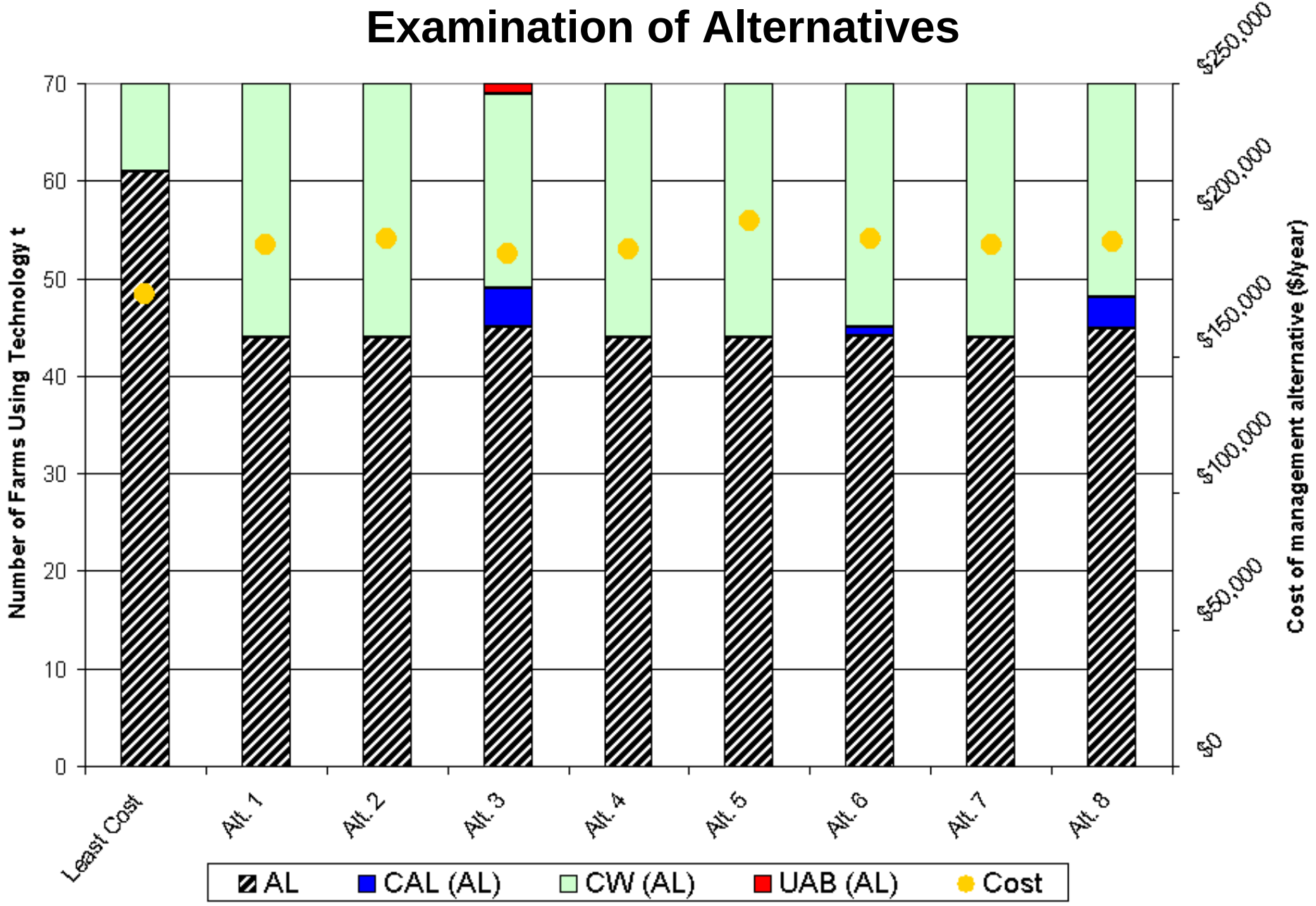
Benefits of Optimization (the Decision Space)



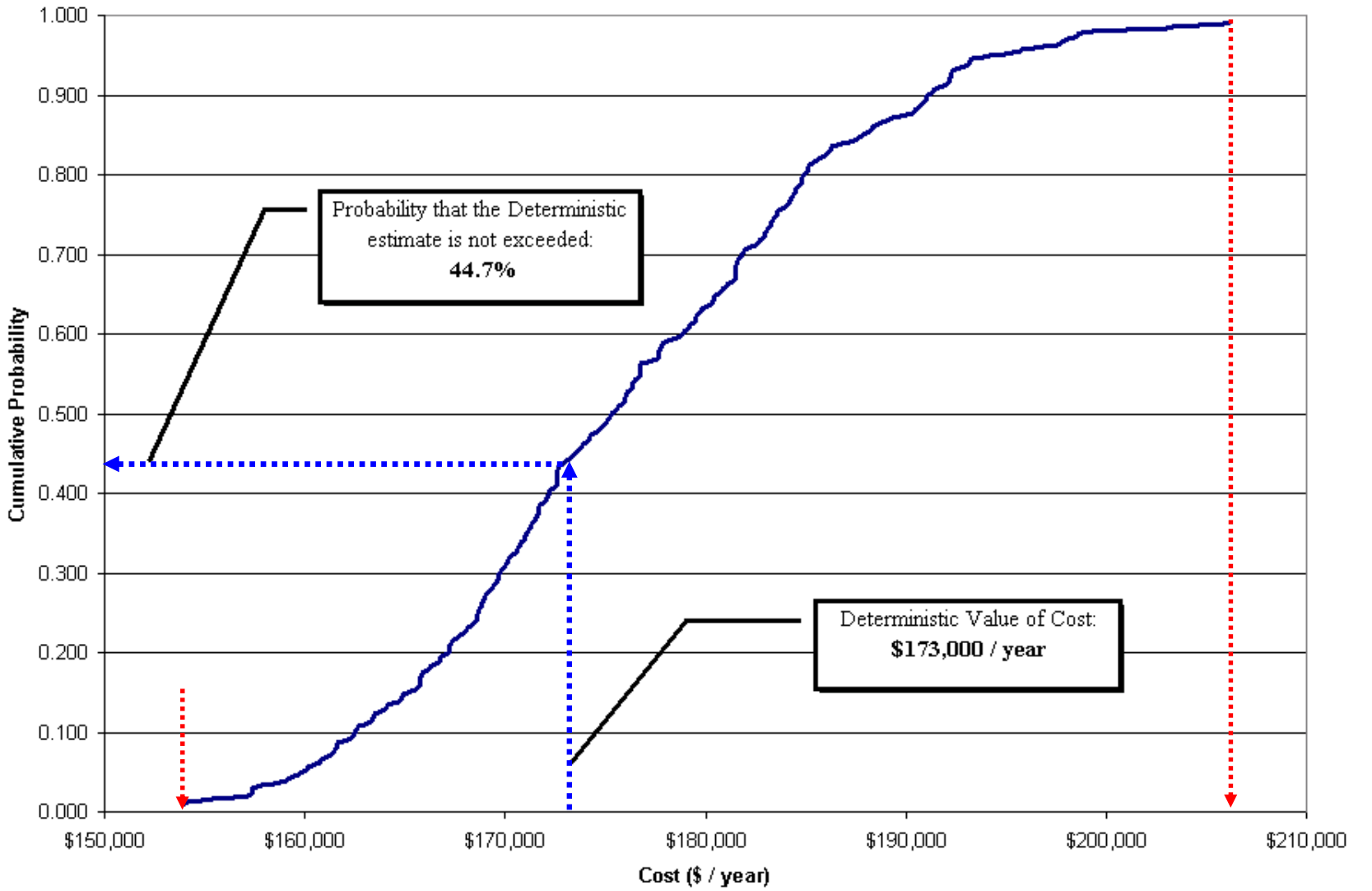
The Tradeoff Curves



Examination of Alternatives



Uncertainty Analysis



Optimization Work Task; Current status

- A working dilemma:
  - A new model?
    - Probably a Mixed Integer Programming Procedure
    - Not a DSS (especially as GUIs are concerned)
  - An existing model / DSS (appropriately modified)
    - WEAP (Stockholm Environmental Institute)
    - WSM300 (German university group)
    - Elbe-DSS (U. of Osnabruck)
    - …
    - USEPA's Framework for Identifying Optimal TMDL Allocations
- Questionnaire - information from stakeholders

Optimization Work Task; Future Steps
(we've only just began)

- Reinforcement of research team
- Conceptual model finalization

I need you!!

(Importance of Stakeholder input in model definition)

- Objectives
  - Minimization of costs
  - Maximization of benefits
  - …
- Constraints
  - Environmental regulations and TMDLs
  - Other “Red-lines”
  - …
- Parameters & coefficients of decision variables
  - Unit costs
  - Correlations between pollutants and functions of ecosystems
  - …
- Management Scenarios Definition

Questions?

Comments?

Insults?