



University of Missouri

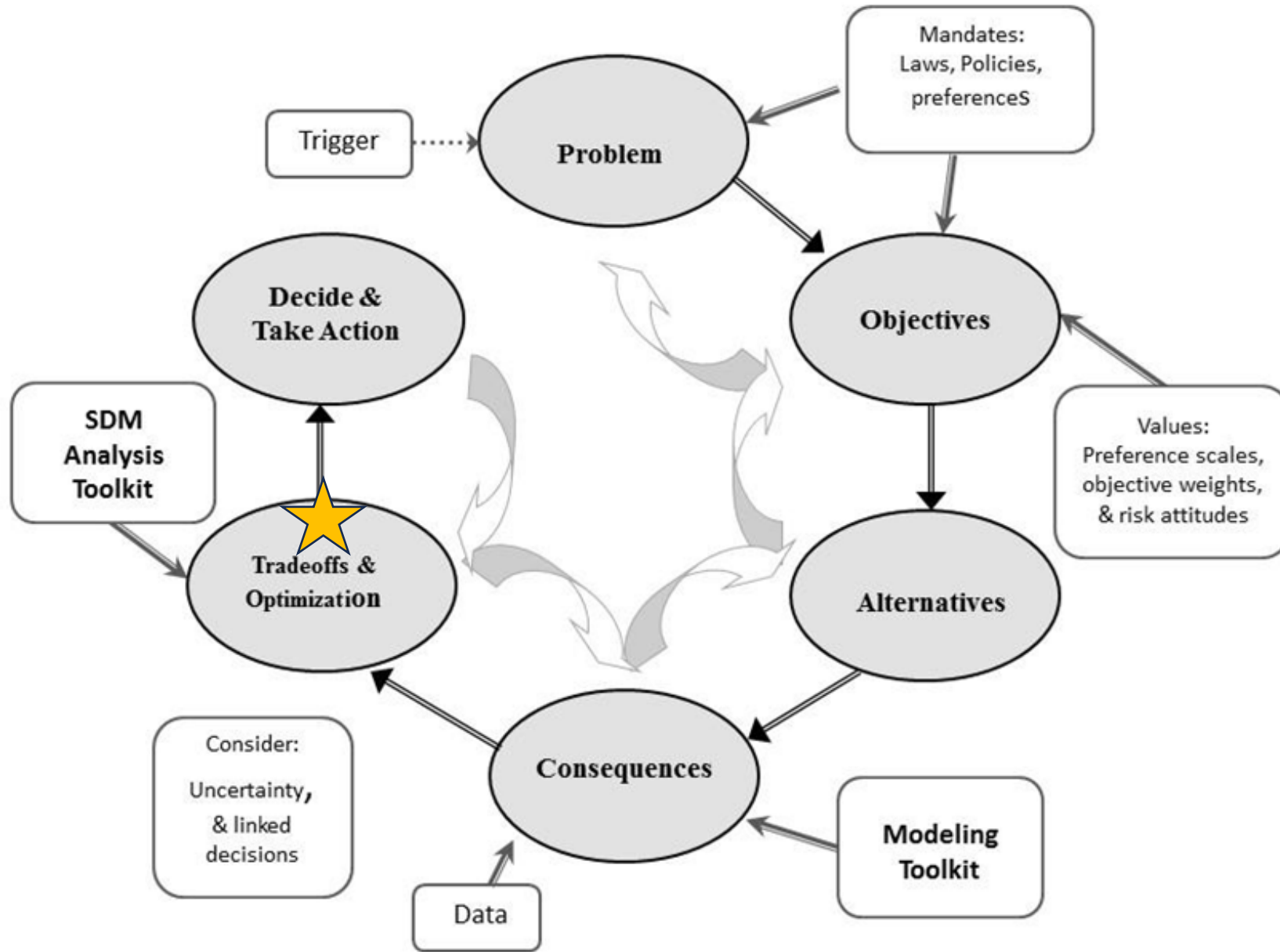
# Tradeoffs

## **Module 6:**

Brielle K Thompson & Michael E Colvin

Workshop: An overview of Structured Decision Making for natural resources,  
Midwest Fish and Wildlife Conference 2025, St. Louis, MO

Modified from: Fundamentals of Structured Decision Making TWS Conference Workshop 2023 & an  
Overview of Structured Decision-Making Washington Department of Fish and Wildlife 2022-2023



Source: Jean Fitts Cochrane

# Tradeoffs

“How much you would give up on one objective in order to achieve gains on another objective”

- Gregory et al. 2012

# Role of analytical methods in tradeoff analysis

- Identify “best” (optimal) solution
  - Ties together alternatives, objectives, and predicted consequences
  - How do you integrate all the components?
- Easiest with a single objective
- Easiest without uncertainty
- Solution method depends on the structure of the problem

# Analytical approaches

	Approach
Single Objective	<ul style="list-style-type: none"><li>• Deterministic optimization</li></ul>
Multiple Objectives	<ul style="list-style-type: none"><li>• Multiple Attribute Utility</li><li>• Simplification</li><li>• SMART</li><li>• Pareto frontier analysis</li></ul>
	Negotiate among most efficient alternatives

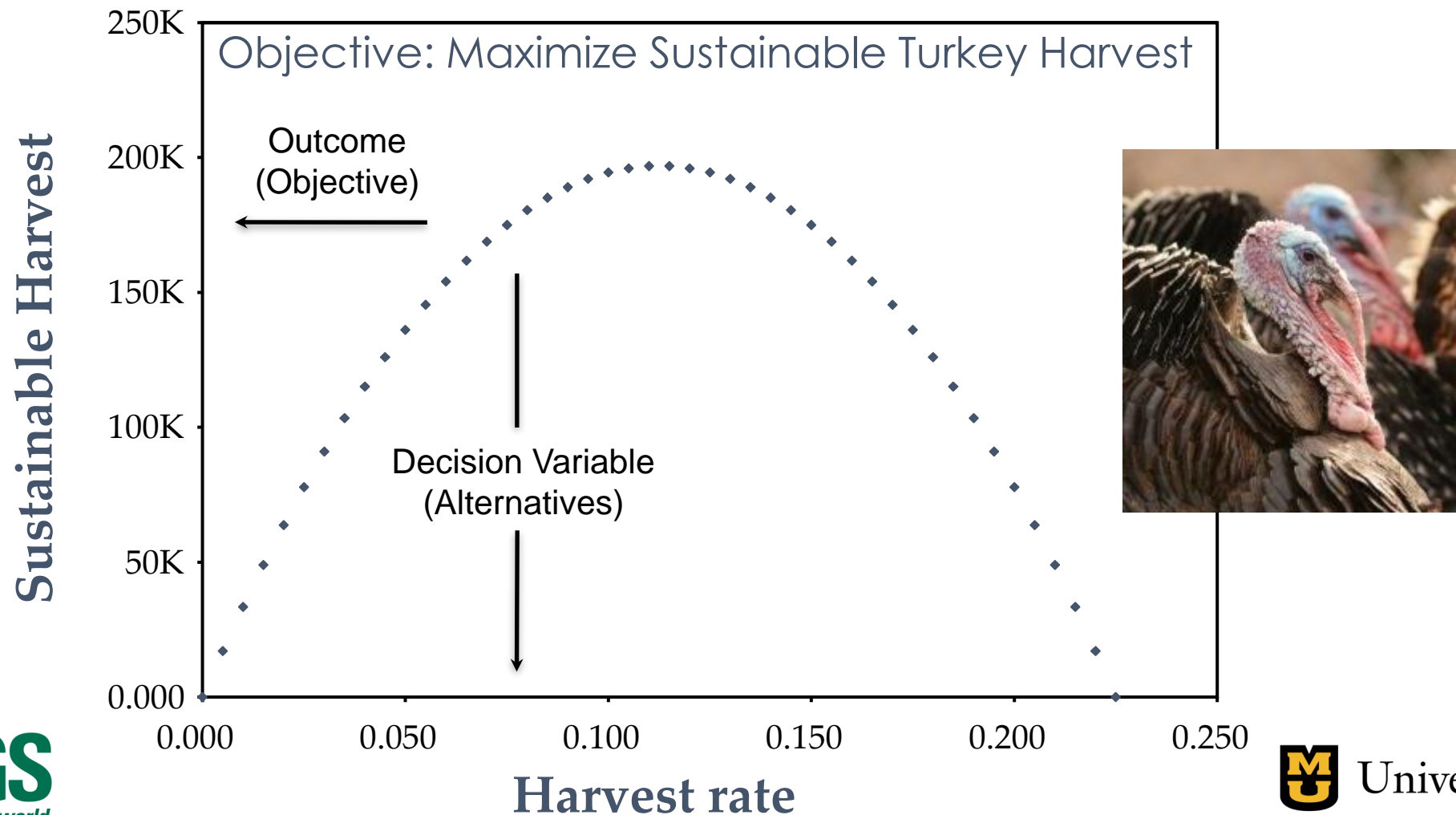
↓  
Increased  
complexity

# Single objective approach:

- Used when we have a single continuous decision variable (i.e., alternatives)
  - e.g., harvest rate, amount of herbicide to apply, size of biocontrol release, etc.
- Predict outcomes (i.e., objective) are a function of the decision variable
- Optimization solution methods:
  - Graphical
  - Closed-formed solutions (calculus/differentiation)
  - Numerical solutions (mathematical search methods)
  - Constrained optimization (mathematical solution)

# Single objective approach:

- Graphical optimization:



# Single objective approach:

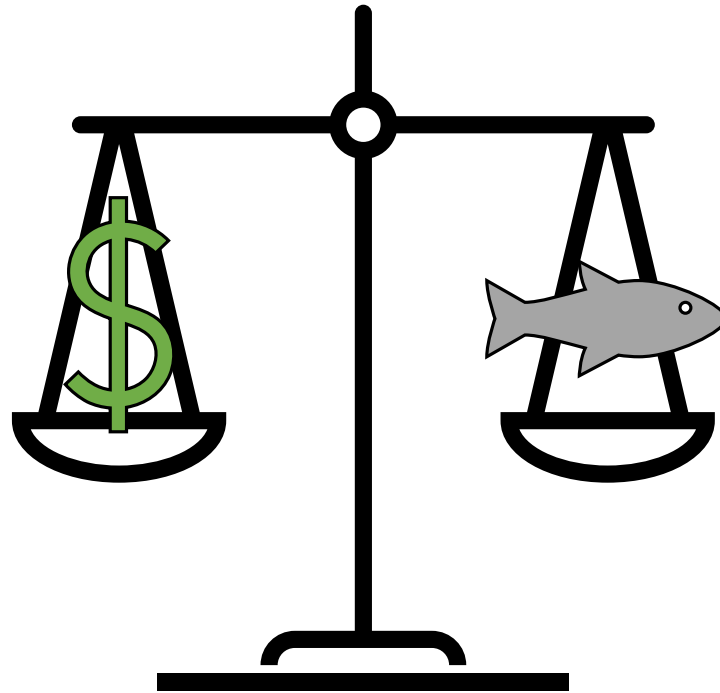
Question: Can you think of an example of a single objective problem?

- Not very common in natural resource management.
- Single objectives are easier to optimize, so we may want to reduce multiple objective problems to make them easier to solve.



# Multiple objective tools

- Nearly all natural resource management problems are multiple-objective problems



# Multiple objective tools

A. Simplify the problem as much as possible

1. Remove dominated alternatives
2. Remove irrelevant objectives
3. Make even swaps

B. Reduce to a single objective if possible

C. Negotiate a solution from a set of best compromises

D. Evaluate trade-offs explicitly

# A. Simplify the problem

## 1. Remove dominated alternatives:

- i.e., another alternative performs the same or better on all objectives

# A. Simplify the problem (EXAMPLE)

**1. Remove dominated alternatives** (another alternative performs the same or better on all objectives)

Objectives	Direction	Alternatives			
		Status quo	Minor repair	Major repair	Re-build
Cost (\$M)	Min				
Environmental Benefit (0-10)	Max				
Disturbance (0-10)	Min				
Silt runoff (k ft <sup>3</sup> )	Min				
Water Retention (MG)	Max				

# A. Simplify the problem (EXAMPLE)

**1. Remove dominated alternatives** (another alternative performs the same or better on all objectives)

Objectives	Direction	Alternatives			
		Status quo	Minor repair	Major repair	Re-build
Cost (\$M)	Min	0	2	12	20
Environmental Benefit (0-10)	Max	1	3	10	10
Disturbance (0-10)	Min	0	1	7	10
Silt runoff (k ft <sup>3</sup> )	Min	5	1	3	3
Water Retention (MG)	Max	41	41	41	39

# A. Simplify the problem (EXAMPLE)

**1. Remove dominated alternatives** (another alternative performs the same or better on all objectives)

Objectives	Direction	Alternatives			
		Status quo	Minor repair	Major repair	Dominated Alternative Re-build
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# A. Simplify the problem

## 1. Remove dominated alternatives:

- i.e., another alternative performs the same or better on all objectives

## 2. Remove irrelevant objectives:

- i.e., performance measures of that objective does not vary over alternatives
- This isn't to say the objective isn't important to you, just that it doesn't help discern among the alternatives currently considered.

# A. Simplify the problem (EXAMPLE)

## 2. Remove irrelevant objective

Objectives	Direction	Alternatives			
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Irrelevant Objective

# A. Simplify the problem (EXAMPLE)

- **Simplified problem:**

Objectives	Direction	Alternatives		
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- i.e., performance measures of that objective does not vary over alternatives
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## 3. Make even swaps:

- If two objectives are in the same unit, then combine outcomes

# A. Simplify the problem (EXAMPLE)

## 3. Even swaps

Convert silt runoff to cost @ \$0.5M / k ft<sup>3</sup>

Objectives	Direction	Alternatives		
		Status quo	Minor repair	Major repair
Cost (\$M)	Min	0	2	12
Environmental Benefit (0-10)	Max	1	3	10
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Silt runoff (k ft <sup>3</sup> )	Min	5	1	3

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Objectives	Direction	Alternatives		
		Status quo	Minor repair	Major repair
Cost (\$M)	Min	0	2	12
Environmental Benefit (0-10)	Max	1	3	10
Disturbance (0-10)	Min	0	1	7
Silt runoff (k ft <sup>3</sup> )	Min	<del>5</del> 2.5 M	<del>4</del> 0.5 M	<del>3</del> 1.5 M

# A. Simplify the problem (EXAMPLE)

## 3. Even swaps

Convert silt runoff to cost @ \$0.5M / k ft<sup>3</sup>

Objectives	Direction	Alternatives		
		Status quo	Minor repair	Major repair
Cost (\$M)	Min	0 + 2.5	2 + 0.5	12 + 1.5
Environmental Benefit (0-10)	Max	1	3	10
Disturbance (0-10)	Min	0	1	7
Silt runoff (k ft <sup>3</sup> )				

## B. Reduce to a single objective

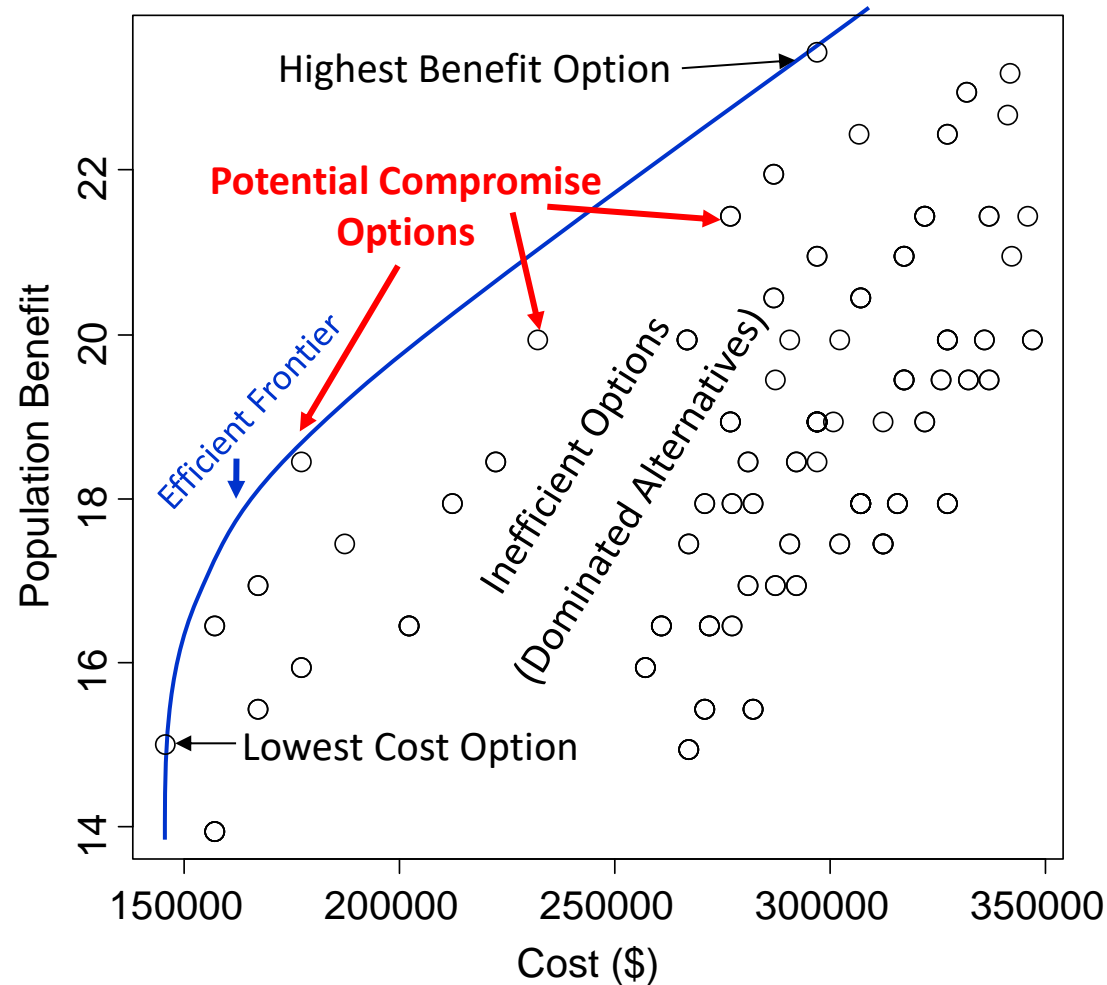
- Tip: Convert all objectives but one to constraints
  - Example: don't spend more than \$2.5M
  - Keep disturbance at or below 3
  - Then take the maximum environmental benefit

Objectives	Direction	Alternatives		
		Status quo	Minor repair	Major repair
Cost (\$M)	Min	2.5	2.5	13.5
Environmental Benefit (0-10)	Max	1	3	10
Disturbance (0-10)	Min	0	1	7

# C. Negotiate a solution from a set of best compromises

- With  $>$  two objectives we can do **pareto frontier analysis**

Example:  
Cost  
vs  
Population  
benefit



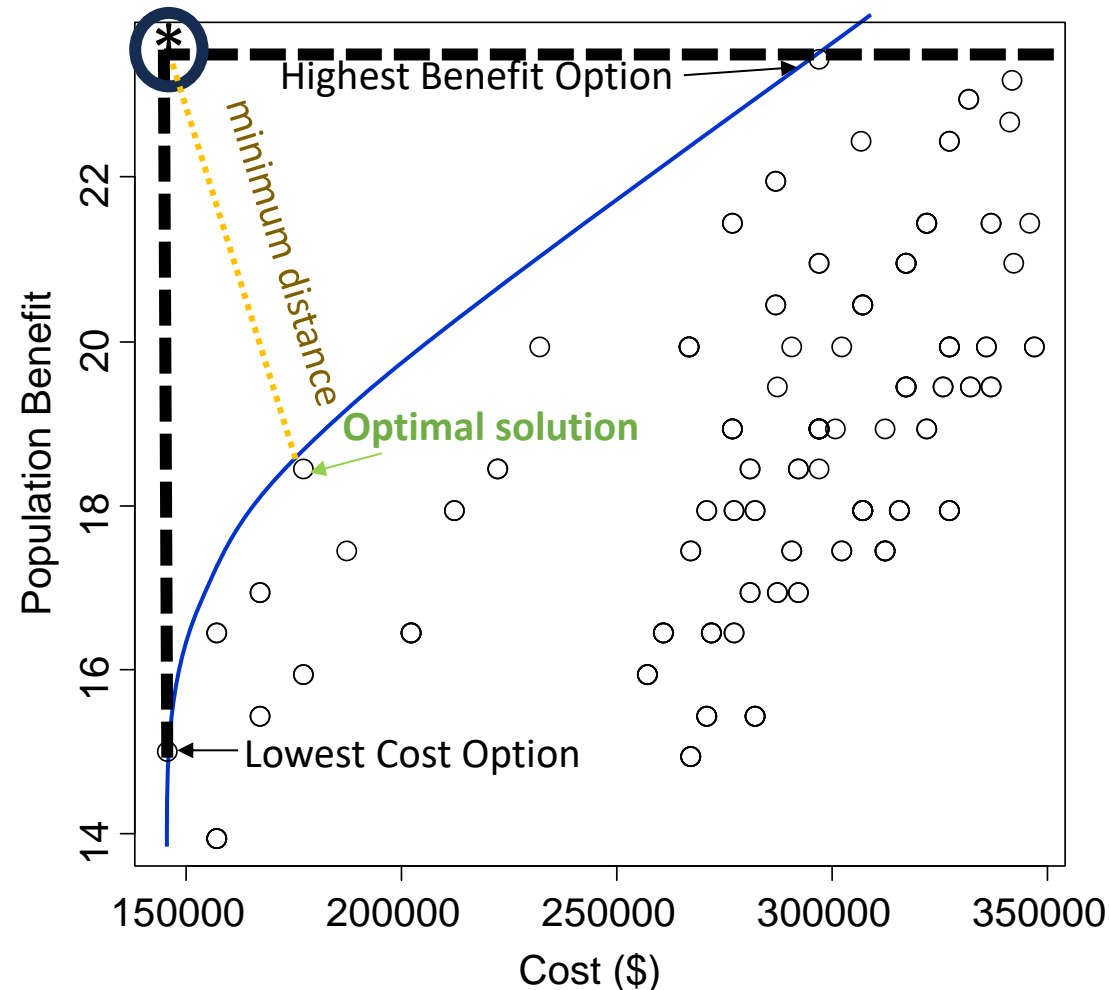
○ = outcome of each alternative



# C. Negotiate a solution from a set of best compromises

- With > two objectives we can do pareto frontier analysis

Example:  
Cost  
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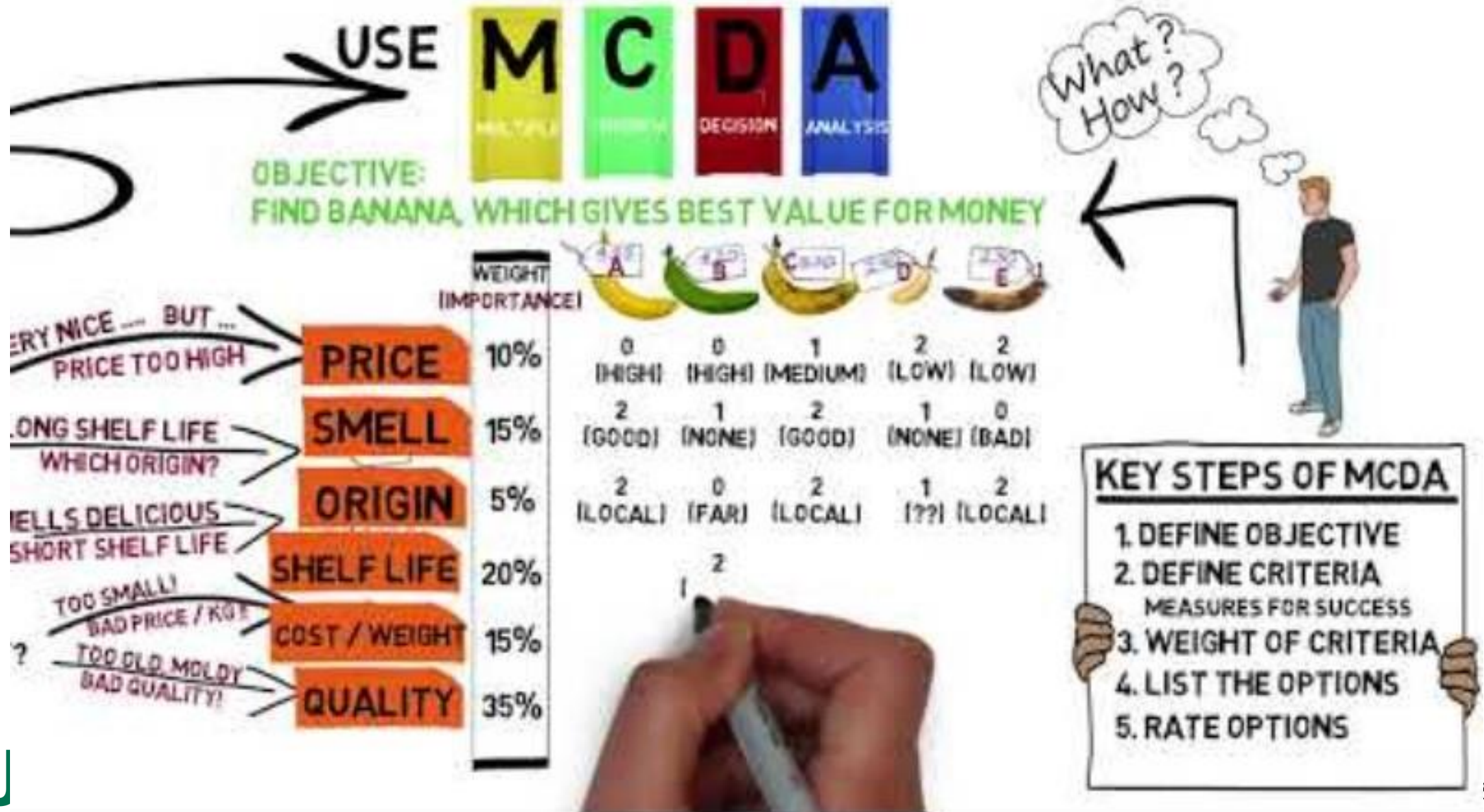
○ = outcome of each alternative

If cost and population benefit are deemed equal, we can find the **optimal solution** as the minimum distance between the ideal point (\*)

## D. Evaluate trade-offs explicitly

- Multicriteria decision analysis:
  - Offers tools to evaluate multiple objective problems
- A variety of tools exist (beyond the scope of this workshop)
  - Outranking methods
  - Analytic Hierarchy Process
  - Multi-attribute value/utility theory
  - SMART (simple multi-attribute rating technique)

# 3-minute intro to MCDA



# Case study: (Runge et al. 2011)

- See attachment of case study description (CaseStudyDescription.pdf)

## Exercise: Evaluate tradeoffs

Hint: Are there any irrelevant objectives, dominated outcomes, even swaps?

**Objective** [measurable attribute] {Direction}

	<b>Alternative</b>	<b>Respect Life</b>	<b>HBC Recovery</b>	<b>Wilderness Disturbance</b>	<b>Cost</b>
		[0-10 scale]	[P(N>6000)]	[User-days]	[M\$/5-yr]
		{Max}	{Max}	{Min}	{Min}
<b>A</b>	<b>No action</b>	<b>6.00</b>	<b>0.2</b>	<b>0</b>	<b>0</b>
<b>B</b>	<b>Alternative B</b>	<b>7</b>	<b>0.3</b>	<b>30</b>	<b>2.5</b>
<b>C</b>	<b>Alternative C</b>	<b>6</b>	<b>0.3</b>	<b>40</b>	<b>3</b>
<b>D</b>	<b>Alternative D</b>	<b>9.5</b>	<b>0.3</b>	<b>50</b>	<b>4.5</b>
<b>E</b>	<b>Alternative F</b>	<b>9</b>	<b>0.25</b>	<b>60</b>	<b>2</b>