



University of Missouri

# Week 4:

## Alternatives & Consequences Steps of PrOACT

**Instructor:** Brielle K Thompson

**Course:** NAT\_R 8001 Decision Analysis for Research and  
Management of Natural Resources

# Review of last week

- Discussed the Objectives step of SDM
- Process for identifying objectives
  1. Articulate goals & concerns
  2. Convert goals & concerns to objectives
  3. Structure objectives
    - 3a. Classify and distinguish types of objectives
    - 3b. Create an objectives hierarchy
  4. Create measurable attributes for each objective

*Repeat as needed*

- Pieces of an objective:

Direction + what is desired + attribute

(Maximize/  
Minimize)

(Natural/ constructed/  
proxy scale units)

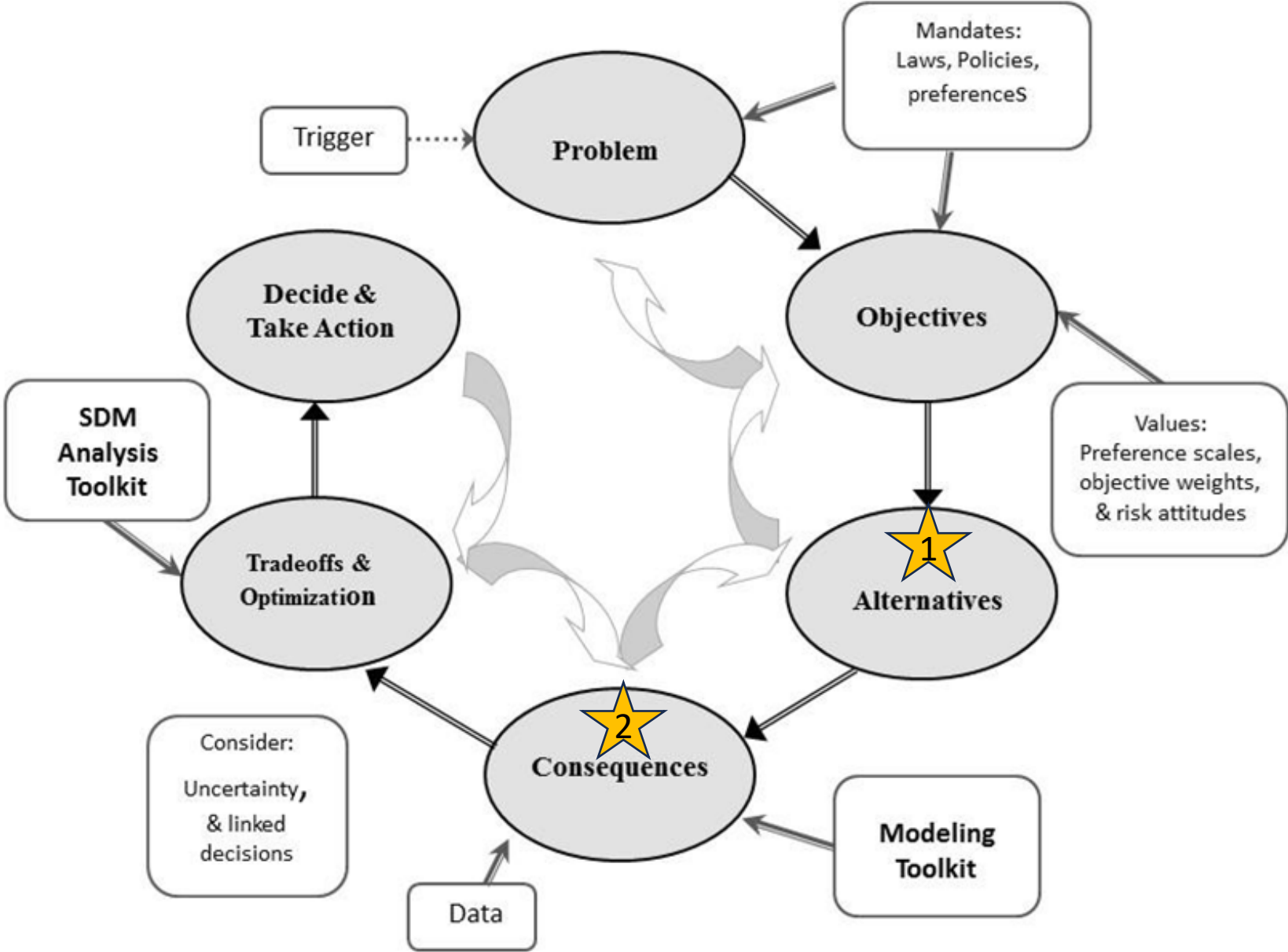


# Review of last week

- **Why do we need objectives?**
  - Helps justify why we choose a specific alternative
- **Why is it hard to articulate objectives?**
  - We think we already know what we want
  - We often overlook the “why we care” step in scientific research and focus on methodology to solve a problem
- **Why organize objectives:**
  - Separating fundamental and means objectives:
    - Helps us realize that there are multiple ways to achieve an overarching goal (this will help us generate creative alternatives)
  - Process objectives = makes sure our decision is carried out in a respectful manner
  - Strategic objectives = makes sure we follow the law or agency mandates



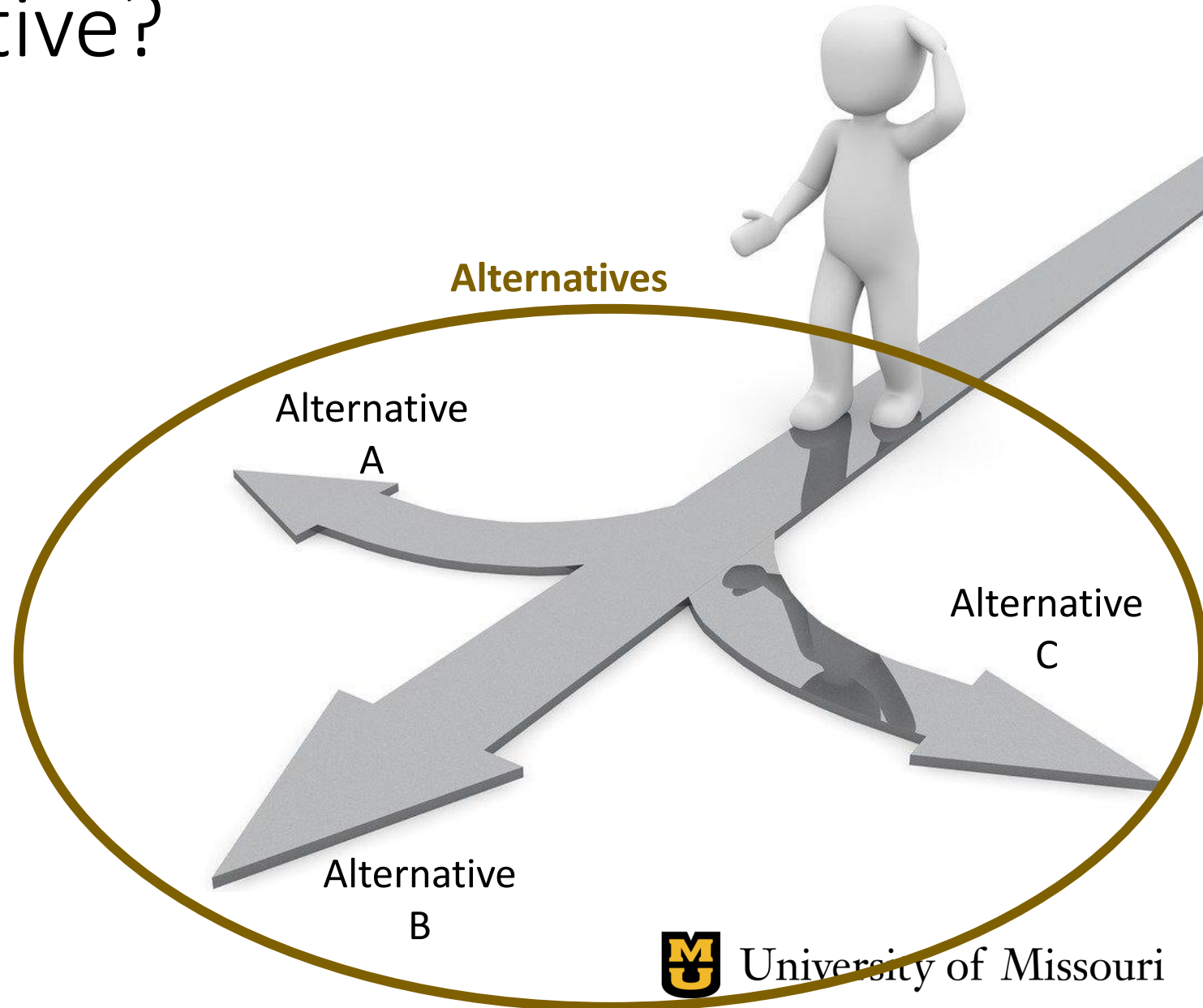
Today:  
Learn about  
the  
Alternatives &  
Consequences  
step



Source: Jean Fitts Cochrane

# What is an alternative?

- Alternative (singular)
  - A potential solution to a decision problem
- Alternatives (plural)
  - The set of potential solutions to a decision problem



# Importance of good alternatives

- “The action selected will only be as good as the best alternative that is considered”
- A good alternative is one that provides a good chance of achieving objectives
- Good alternatives are:
  - Values-focused
  - Fully specified
  - Internally coherent
  - Distinct



# Good alternatives require

- **Imagination**

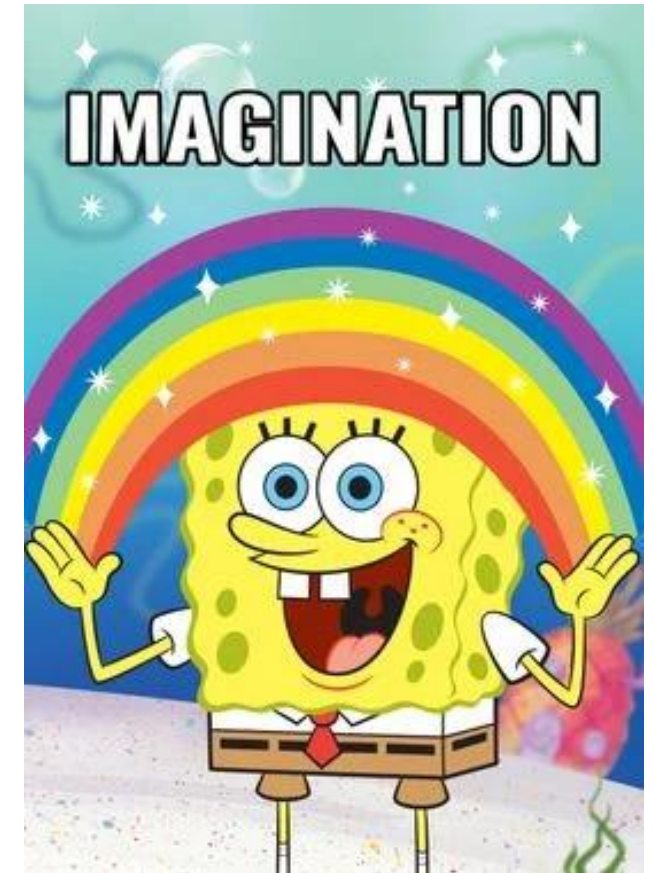
- Beware of the tendency to limit our ideas to what are thought to be 'practical' alternatives

- **Creativity**

- Think of the widest range of possible alternatives
- Don't let preconceived ideas or constraints be limiting

**To promote creativity – conduct a game:**

Make group list 10 things they can do with [X = a pizza box, shoelace, etc.] and reward the most creative solution



Displate



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# Challenges to identifying alternatives

- Falling prey to cognitive biases (e.g., status quo bias)
- Accepting real or perceived constraints
- Evaluating alternatives prematurely

**DON'T  
STICK  
TO THE  
STATUS  
QUO**

Tenor

# Activity – Don't stick to the status quo!

**Think of a new creative alternative that is different from the status quo**

## Status quo:

**A wetland restoration project currently excludes public access to protect sensitive species**

**A park currently allows recreational fishing year-round with no catch limits.**

**The forest is managed primarily for timber production and clearcutting is used as the standard harvesting method every 30 years**

## Think of a new alternative:

# Suggestions to identify alternatives

## 1. Focus on objectives and address conflicting objectives

- Create alternatives to achieve the best possible consequences for each objective, one at a time.
- Then, create hybrid alternatives to satisfy more than one objective. Include conflicting objectives.

# Suggestions to identify alternatives

## 1. Focus on objectives and address conflicting objectives

### Example: Rare Snakes

- Problem/concern:
  - Many rare snakes are killed during capture
- Objectives:
  - Minimize capture mortality
  - Maximize pet industry
- Alternatives:
  - Status quo – do nothing
  - Ban sale of snakes
  - Others?



Potentially  
conflicting!!

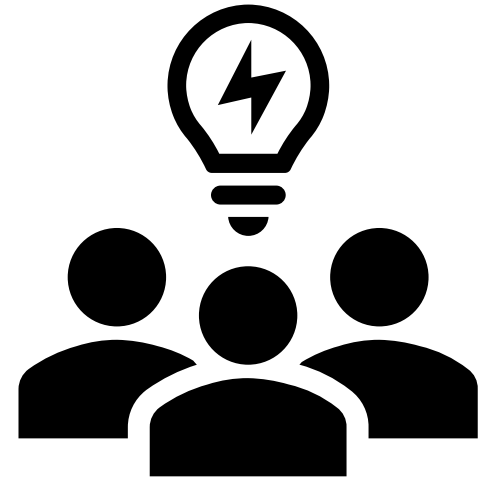


# Suggestions to identify alternatives

## 2. Challenge constraints

### Tips:

- Distinguish real and perceived constraints
- Don't anchor on initial set of options
- Don't evaluate – just develop
- Give people time and permission to be creative



# Suggestions to identify alternatives

## 2. Challenge constraints

Activity – create alternatives despite constraints

### Example: Bird translocation

Which of several islands should an endangered bird be translocated?

- **Perceived constraint:** Introduced predators on Island A make it unsuitable
- In groups: come up with 2 creative alternatives?



# Suggestions to identify alternatives

## 3. Create groups of alternatives

- Groups of alternatives includes portfolios and strategies

### JARGON ALERT!!

- **Alternatives** = general term for complete, comparable solutions to a decision problem
- **Actions** = individual options of an alternative
- **Strategies and Portfolios** = combinations of actions
  
- **A single strategy and a single portfolio = a single alternative**

# Suggestions to identify alternatives

## 3a. Creating portfolios

- Portfolio: a combination of **like** elements arranged in a set
- The elements themselves can be actions
  - e.g., set of research projects, funding allocation
- The combination now represents a single alternative
  - e.g., stock portfolio
- Constraints often limit number of possible portfolios
  - e.g., total budget for allocation across projects

# Suggestions to identify alternatives

## 3a. Creating portfolios

Example: portfolios for invasive species removal

Portfolio Alternatives

Target species to remove	
A	<b>Portfolio 1</b>
B	<b>Portfolio 2</b>
C	<b>Portfolio 3</b>
D	<b>Portfolio 4</b>
Action 1 in Portfolio 5 Action 2 in Portfolio 5	<b>A + B</b> <b>Portfolio 5</b>
...	
B+C+D	<b>Portfolio N-1</b>
A+B+C+D	<b>Portfolio N</b>

*Combination of like elements*

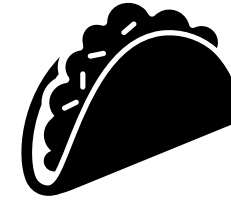


# Suggestions to identify alternatives

## 3b. Creating strategies

- Strategy: alternatives combining multiple **unlike** elements:
- Strategy table:
  - 1) Group actions into themes (columns)
  - 2) Create distinct strategies that represent different approaches or emphasize different objectives
  - 3) Select the actions in each theme that fit each strategy
  - 4) Combine selected elements into a strategy
  - 5) Repeat steps 2-4 to create all strategies

## 3b. Creating strategies

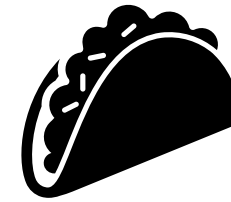


- Strategy table: Chipotle menu

<i>Themes of ingredients:</i>	<i>Meat</i>	<i>Rice, Beans, and Veggies</i>	<i>Top It Off</i>
	None	Brown rice	None
	Steak	White rice	Salsa (Mild)
	Carnitas	Black beans	Salsa (Hot)
	Chicken	Pinto beans	Sour cream
	Barbacoa	Fajita veggies	Tomatillo
			Chili-Corn salsa
			Lettuce
			Guacamole
			Cheese



# 3b. Creating strategies

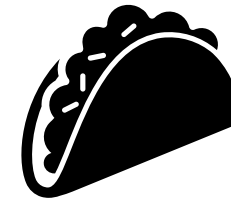


- Strategy table: Chipotle menu

<i>Themes of ingredients:</i>	<i>Meat</i>	<i>Rice, Beans, and Veggies</i>	<i>Top It Off</i>
Strategies (aka burritos): <u>“Brielle’s favorite”</u>	None Steak Carnitas <u>Chicken</u> Barbacoa	<u>Brown rice</u> White rice <u>Black beans</u> Pinto beans <u>Fajita veggies</u>	None <u>Salsa (Mild)</u> Salsa (Hot) Sour cream Tomatillo Chili-Corn salsa <u>Lettuce</u> <u>Guacamole</u> <u>Cheese</u>



# 3b. Creating strategies

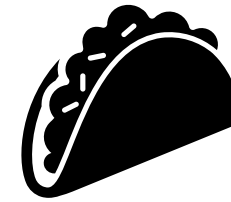


- Strategy table: Chipotle menu

<i>Themes of ingredients:</i>	<i>Meat</i>	<i>Rice, Beans, and Veggies</i>	<i>Top It Off</i>
Strategies (aka burritos): <u>“The Barnyard”</u>	None <u>Steak</u> <u>Carnitas</u> <u>Chicken</u> Barbacoa	Brown rice <u>White rice</u> Black beans <u>Pinto beans</u> Fajita veggies	None Salsa (Mild) <u>Salsa (Hot)</u> Sour cream Tomatillo Chili-Corn salsa Lettuce Guacamole Cheese



# 3b. Creating strategies

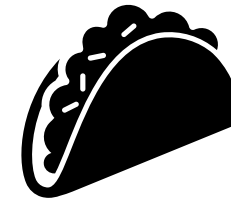


- Strategy table: Chipotle menu

<i>Themes of ingredients:</i>	<i>Meat</i>	<i>Rice, Beans, and Veggies</i>	<i>Top It Off</i>
Strategies (aka burritos): <u>“The Veggie”</u>	<p><b><u>None</u></b></p> <p>Steak</p> <p>Carnitas</p> <p>Chicken</p> <p>Barbacoa</p>	<p><b><u>Brown rice</u></b></p> <p>White rice</p> <p><b><u>Black beans</u></b></p> <p><b><u>Pinto beans</u></b></p> <p><b><u>Fajita veggies</u></b></p>	<p>None</p> <p><b><u>Salsa (Mild)</u></b></p> <p>Salsa (Hot)</p> <p><b><u>Sour cream</u></b></p> <p>Tomatillo</p> <p><b><u>Chili-Corn salsa</u></b></p> <p><b><u>Lettuce</u></b></p> <p><b><u>Guacamole</u></b></p> <p><b><u>Cheese</u></b></p>



# 3b. Creating strategies

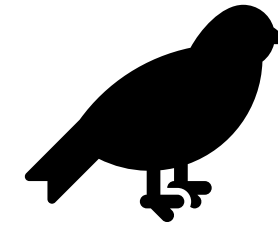


- Final strategy table: Chipotle menu

Alternative Strategies

Themes→ ↓ Strategies	<i>Meat</i>	<i>Rice, Beans, and Veggies</i>	<i>Top It Off</i>
Brielle's Favorite	Chicken	Brown rice, Black beans, Veggies	Salsa (mild), Chili-corn, Lettuce, Guacamole, Cheese
The Barnyard <small>Meat action for the Barnyard strategy</small>	Steak, Carnitas, Chicken	White rice, Pinto beans	Salsa (hot), Cheese
The Veggie	None	Brown rice, Black beans, Pinto beans, Veggies	Salsa (mild), sour cream, Chili-corn, Lettuce, Guacamole, Cheese

# 3b. Creating strategies

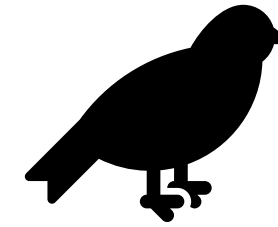


- Example: Threatened species recovery

<i>Themes:</i>	<i>Habitat Protection</i>	<i>Predator Control</i>	<i>Enhance Population</i>	<i>Alternative Economic Activity</i>
	Status Quo	Status Quo Harvest (5%)	None	None
	Ban logging in critical habitat	Increase harvest rate of predator to 10%	Maternity Pens	Promote sustainable harvest of species through lottery
	Develop linkage corridors	Increase harvest rate of predator to 50%	Captive Breeding Translocate	Promote non-consumptive recreation



# 3b. Creating strategies



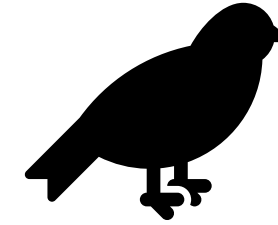
- Final strategy table for threatened species recovery,

Themes→ ↓ Strategies	<i>Habitat Protection</i>	<i>Predator Control</i>	<i>Enhance Population</i>	<i>Alternative Economic Activity</i>
Status Quo	Status Quo	Status Quo Harvest (5%)	None	None
“On the Go” (Dispersal)	Develop linkage corridors	Increase harvest rate of BNEG to 10%	Translocate	Promote non-consumptive recreation
Increase Pop to Carrying Cap	Ban logging in critical habitat	Increase harvest rate of BNEG to 50%	Captive Breeding	Promote non-consumptive recreation



# Activity – create more strategies

Task: create 1 new strategy based on the following table



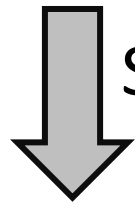
- Example: Threatened species recovery

<i>Themes:</i>	<i>Habitat Protection</i>	<i>Predator Control</i>	<i>Enhance Population</i>	<i>Alternative Economic Activity</i>
	Status Quo	Status Quo Harvest (5%)	None	None
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	Develop linkage corridors	Increase harvest rate of predator to 50%	Captive Breeding Translocate	Promote non-consumptive recreation



## -----THEMES-----

a) Trout management	b) HBC habitat	c) Recreation
1. None	1. None	1. No changes
2. 25 fish/acre killed	2. Plant native vegetation	2. Remove 50 boating days per year
3. 50 fish/acre killed	3. Build sediment curtain	3. Close wilderness areas for 1 year
4. 25 fish/acre removed via helicopter		4. Prohibit boating for 1 year
5. 50 fish/acre removed via helicopter		



Strategy table:

Strategy	A) Trout management	B) HBC habitat	C) Recreation
A (none)	a1	b1	c1
B	a2	b2, b3	c2
C	a3	b2, b3	c3
D	a4	b2, b3	c4
E	a5	b2	c3, c4

Example: Humpback Chub (HBC) recovery in invasive trout waters ([Runge et al. 2011](#))

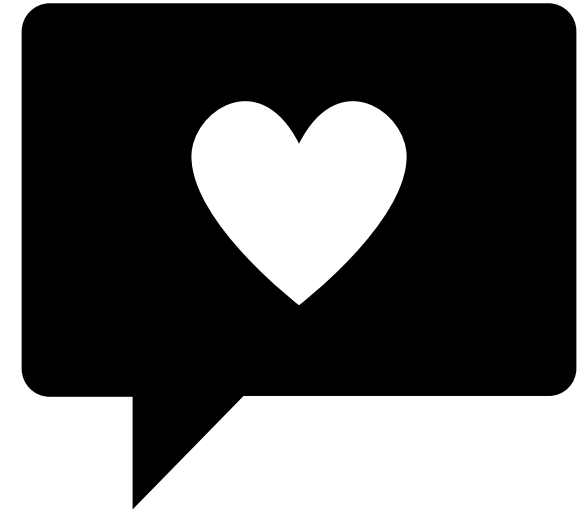
Adapted, modified, and simplified from Runge et al. 2011



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## 4. Revisit objectives

- Once you generate initial set of alternatives:
  - Be sure you've properly separated fundamental from means objectives
  - Identify if additional objectives exist



# General tips:

- SDM is iterative, don't stop looking for alternatives
- Create first, evaluate later
- Consider alternatives that ...
  - Are an ongoing process
  - Gather more information
- Treat 'unique' alternatives as real and subject to the same evaluation as other alternatives

# Skills Check Task 1 – Create Alternatives

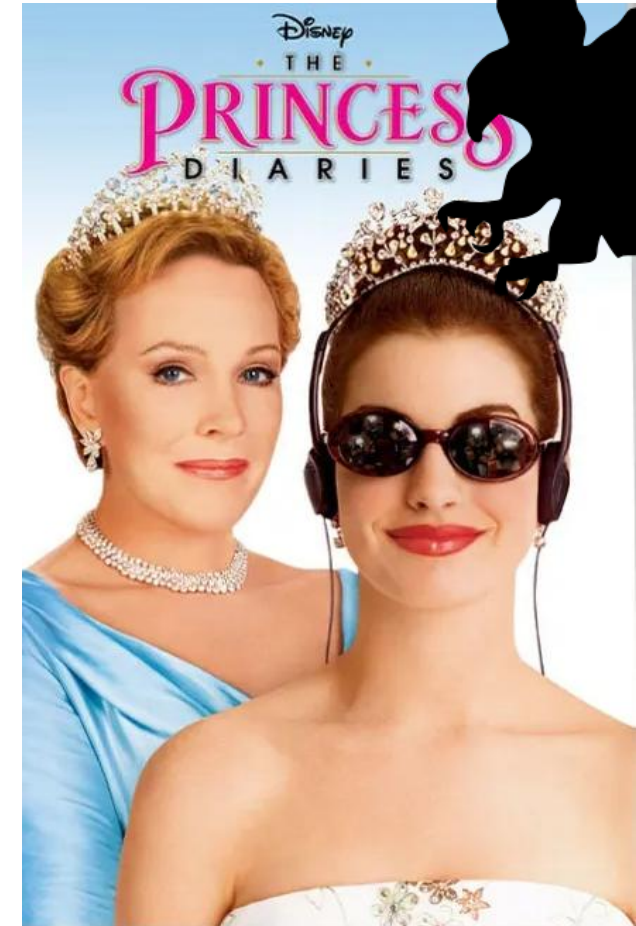
## Eagle reintroduction in Genovia

Consider this decision...

- **Decision maker:** Refuge manager who is also interested in stakeholder's perspectives & appeasing the royal crown
- **Trigger:** Eagle population is nearly extinct in Genovia
- **Actions:** Reintroduction, captive breeding, habitat management, etc
- **Constraints:** Budget
- **Consideration:** Nearby sport anglers (whose license sales fund conservation) like to fish on eagle prey
- **Frequency and Timing:** One time decision
- **Scope:** In two potential refuges in the kingdom (Refuge A or B)
- **Problem class:** Multiple objective with uncertainty

### Fundamental objectives:

- Maximize eagle persistence
- Minimize cost
- Maximize angler satisfaction



# Skills Check Task 1 – Create Alternatives



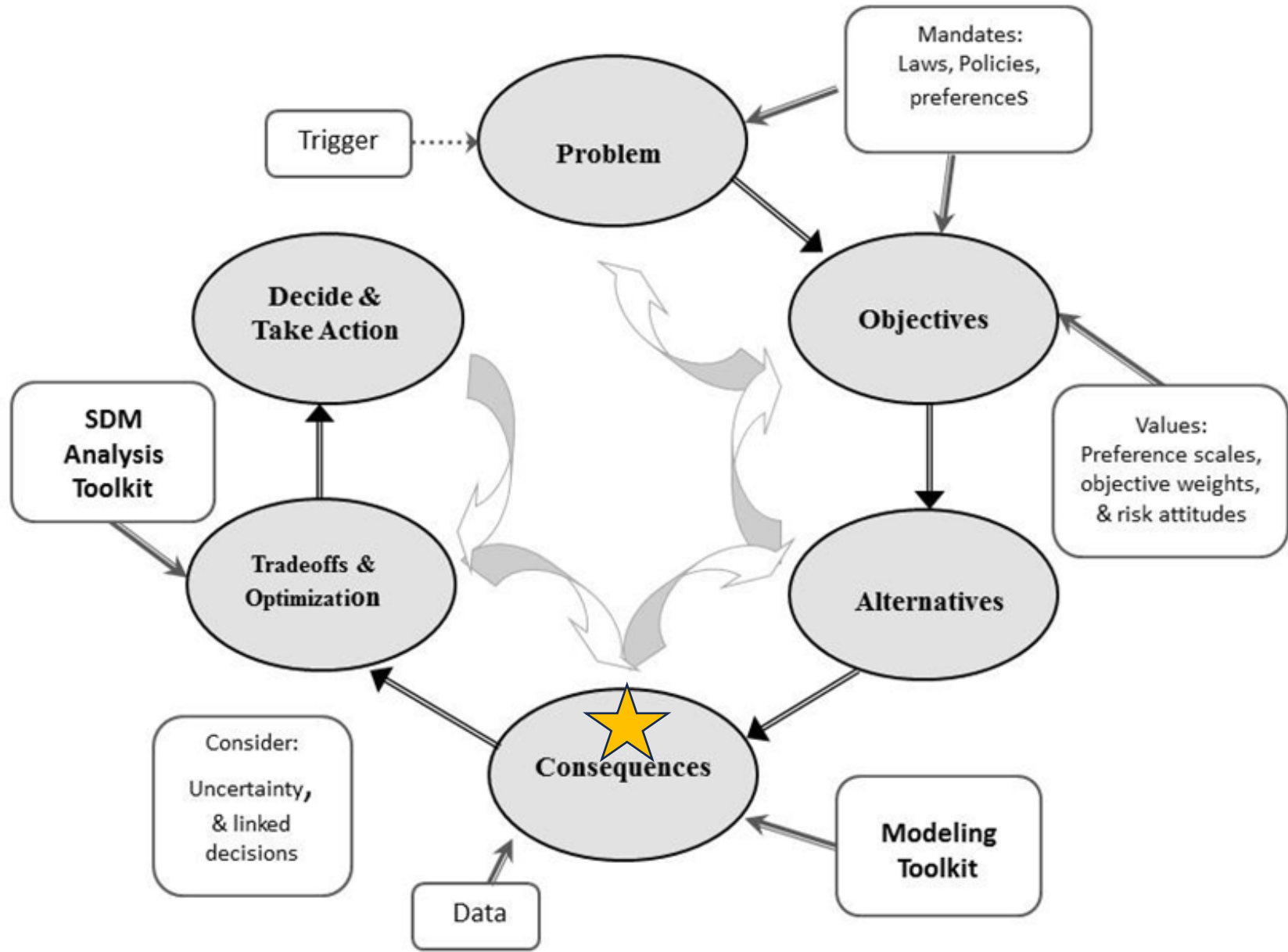
## Task 1: Create Alternatives (*use tables below as inspiration*)

*Add more!*

<i>Themes:</i>	<i>Reintroduction</i>			
	Status Quo (No reintroduction)			
	Reintroduce 20 birds in Refuge A			
	Reintroduce 20 birds in Refuge B			
	Reintroduce 10 in Refuge A & 10 in B			

*Add these!*

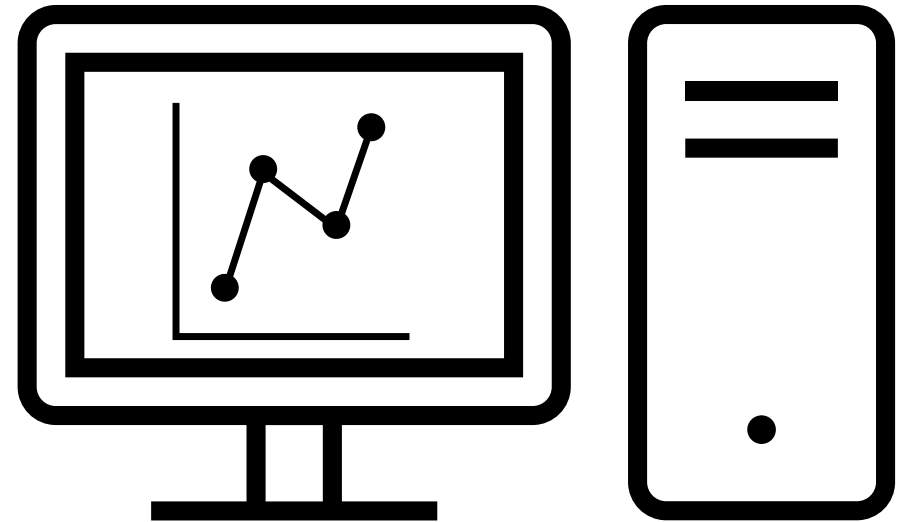
	<i>Themes</i> →	<i>Reintroduction</i>			
	↓ <i>Strategies</i>				
<i>Create 4 strategies</i>					



Source: Jean Fitts Cochrane

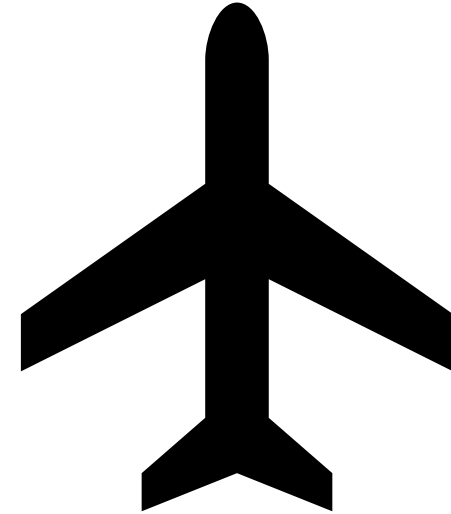
# The consequences step

- Consequences link objectives and alternatives
- Models (in SDM) are tools that help us predict consequences
- Not always complex:
  - Will I make an 8:30 meeting if I leave home at 7:45?
    - The model is my experience
    - Or the model is Google maps



# Simple example – set up

- I need to arrange a flight
- My objectives are:
  - Minimize price
  - Minimize flight duration
  - Minimize number of stops
  - Arrive before noon
  - Maximize quality of service
- I need to make predictions about each of these objectives
- Source of predictions:
  - Google flights: price, flight time, number of stops, and arrival time
  - TripAdvisor: airline service ratings



# Simple example – consequence table

Objectives	Attribute	Desired Direction	Alternatives		
			1	2	3
Price	Cost	↓			
Flight time	Duration	↓			
	Number of stops	↓			
Arrive before noon	Arrival time	threshold			
Service	Service rating: 1-5 (# of raters)	↑			

# Simple example – consequence table

Objectives	Attribute	Desired Direction	Alternatives		
			1	2	3
Price	Cost	↓	\$558	\$251	\$391
Flight time	Duration	↓	3h 40m	5h	5h 47m
	Number of stops	↓	nonstop	1	1
Arrive before noon	Arrival time	threshold	11:11am	4:40pm	10:57am
Service	Service rating: 1-5 (# of raters)	↑	2 (2121 raters)	2 (233 raters)	3 (1875 raters)

# Some Principles of Modeling in SDM

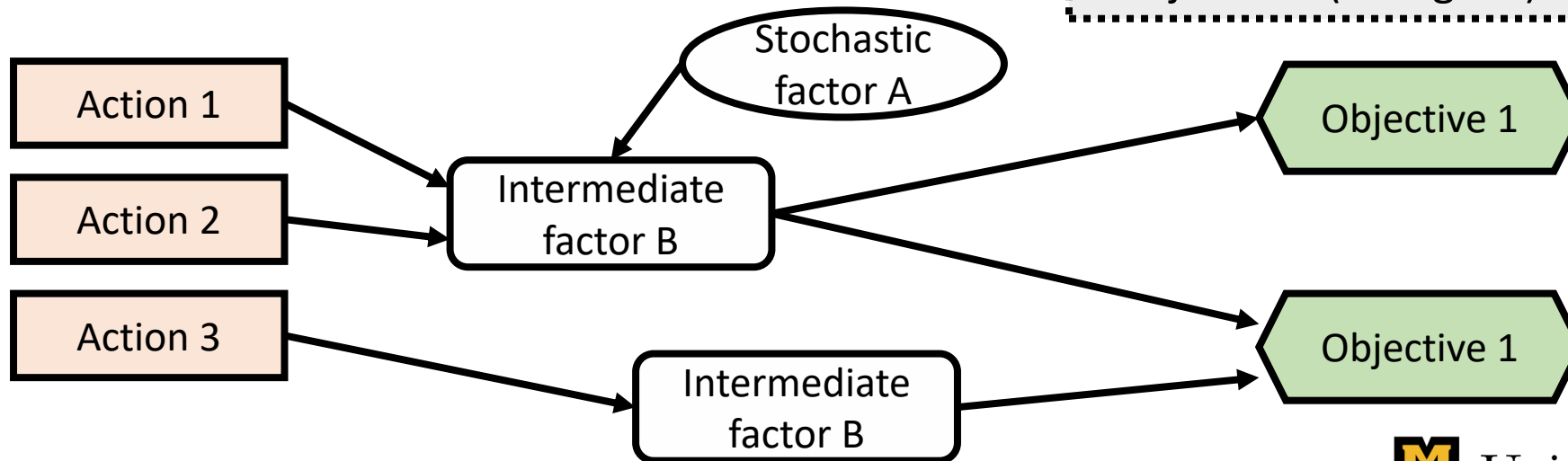
## Models should

1. Include 'hard data' (e.g., total cost) and subjective assessment (e.g., angler satisfaction) as appropriate
2. Make the most of available information, including expert judgment
3. Report appropriate level of precision
4. Incorporate relevant uncertainty
  - Structural (broad model assumptions) e.g., density dependence?
  - Parametric uncertainty e.g., what is the parameter's distribution?

# Influence Diagrams

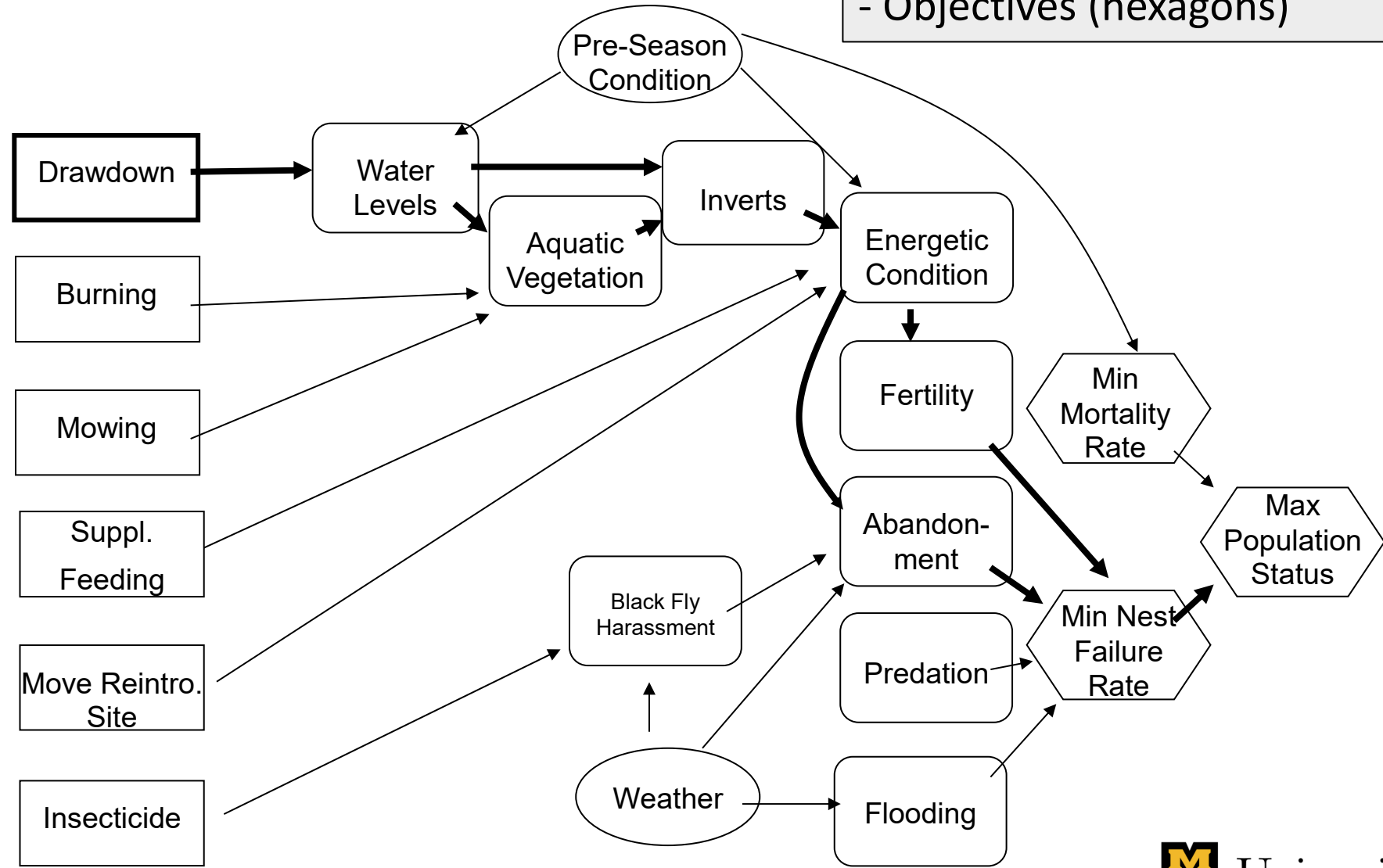
- Start with an influence diagram to develop a common understanding of the basic components of a model and the relationships between them
- Influence diagram:
  - Directed Acyclic Graph (DAG)
  - Conceptually link the actions to objectives
  - Distinguish between relationships of the system
  - Begin with objectives and move towards alternatives

- Actions (rectangles)
- Stochastic factors (ovals)
- Intermediate factors (rounded rectangles)
- Objectives (hexagons)



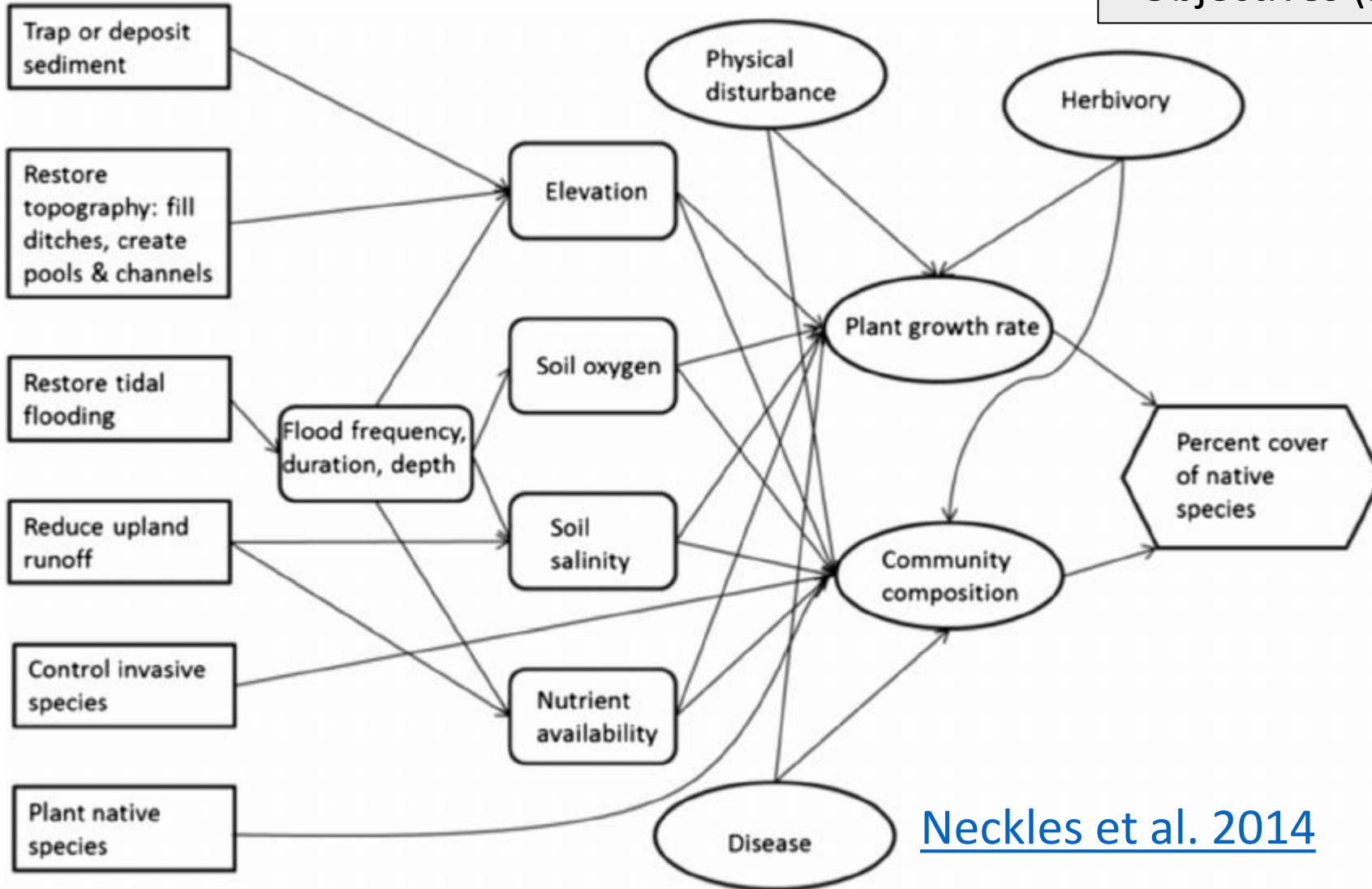
# Example: Crane Nest Failure

- Actions (rectangles)
- Stochastic factors (ovals)
- Intermediate factors (rounded rectangles)
- Objectives (hexagons)



# Example: Salt Marsh recovery

- Actions (rectangles)
- Stochastic factors (ovals)
- Intermediate factors (rounded rectangles)
- Objectives (hexagons)

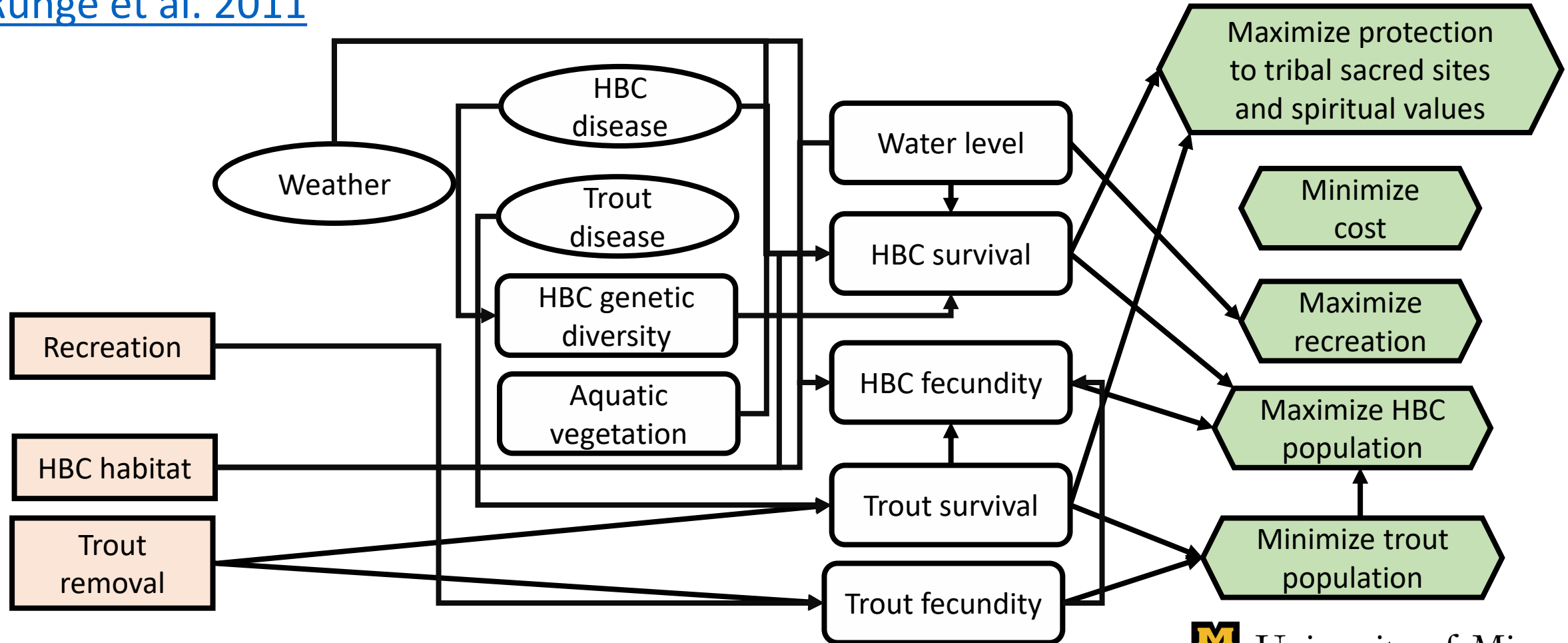


[Neckles et al. 2014](#)

# Example: Influence diagram

Adapted, modified,  
and simplified from  
[Runge et al. 2011](#)

- Actions (rectangles)
- Stochastic factors (ovals)
- Intermediate factors (rounded rectangles)
- Objectives (hexagons)



# Skills Check Task 2



- Actions (rectangles)
- Stochastic factors (ovals)
- Intermediate factors (rounded rectangles)
- Objectives (hexagons)

Maximize  
eagle  
persistence

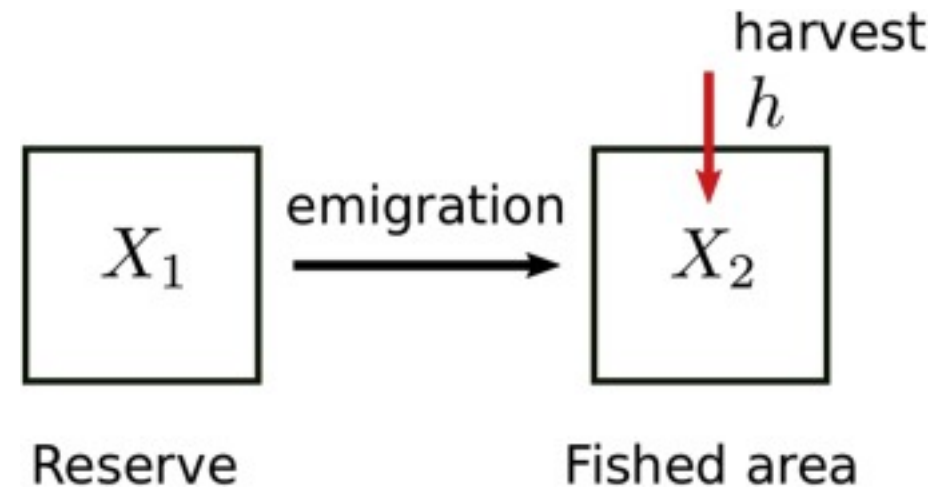
Minimize  
cost

Maximize  
angler  
satisfaction



# Modeling step

- A variety of models can be used to generate consequences (i.e. results)
- For example:
  - Population models (\*most common)
    - Discrete time population models
    - Integrated population models
    - Occupancy models
    - Etc!
  - Statistical models
  - Empirical data from experiments
  - Expert opinion/ expert elicitation
- Conduct rapid prototyping: start simple, adjust, and build up



da Silveira Costa & dos Anjos 2019

# Examples of models:

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## REVIEW

Conservation Science and Practice  
A Journal of the Society for Conservation Biology

WILEY

## Mechanistic invasive species management models and their application in conservation

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### Funding information

College of the Environment, University of Washington; Washington Cooperative Fish and Wildlife Research Unit; U.S. Geological Survey Invasive Species Program

### Abstract

Management strategies to address the challenges associated with invasive species are critical for effective conservation. An increasing variety of mathematical models offer insight into invasive populations, and can help managers identify cost effective prevention, control, and eradication actions. Despite this, as model complexity grows, so does the inaccessibility of these tools to conservation practitioners making decisions about management. Here, we seek to narrow the science-practice gap by reviewing invasive species management models (ISMMs). We define ISMMs as mechanistic models used to explore invasive species management strategies, and include reaction-advection-diffusion models, integrodifference equations, gravity models, particle transport models, nonspatial and spatial discrete-time population growth models, cellular automata, and individual-based models. For each approach, we describe the model framework and its implementation, discuss strengths and weaknesses, and give examples of conservation applications. We conclude by discussing how ISMMs can be used in concert with adaptive management to address scientific uncertainties impeding action and with multiple objective decision processes to evaluate tradeoffs among management objectives. We undertook this review to support more effective decision-making involving

Thompson  
et al. 2021

<https://conbio.onlinelibrary.wiley.com/doi/full/10.1111/csp2.533>



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# Consequence table

- Consequence tables = A convenient way to display predictions for multi-objective decisions
  - Matrix of predictions by objective and alternative
  - Can give us an overall sense of our alternatives
  - Facilitates solving multi-objective decisions

	<b>Alternative 1</b>	<b>Alternative 2</b>	<b>...</b>	<b>Alternative n</b>
<b>Objective 1</b>	<i>prediction</i>	<i>prediction</i>		<i>prediction</i>
<b>Objective 2</b>	<i>prediction</i>	<i>prediction</i>		<i>prediction</i>
<b>...</b>				
<b>Objective m</b>	<i>prediction</i>	<i>prediction</i>		<i>prediction</i>

# Example: consequence table

Gregory R and Long G. 2009. Using structured decision making to help implement a precautionary approach to endangered species management. Risk Analysis 29:518-532.

Objective	Attribute	Direction	Units	Status Quo	Preservation	Commercial	Terminal Benefits	Spread the Pain 1	Spread the Pain 2	Max Rebuilding	Spread the Pain 3	Sports Compromise
Conservation	% meeting Rec Plan Objective 1	H	%	73%	76%	82%	80%	72%	80%	84%	79%	81%
Conservation	% meeting Rec Plan Objective 2	H	%	32%	33%	33%	34%	31%	35%	34%	33%	34%
Conservation	No of returns in 2010	H	# 000	6.3	7.8	12.5	8.7	6.5	8.6	13.2	8.0	8.9
Conservation	No of returns in 2016-2019 (ave)	H	# 000	16.9	24.3	47.7	31.1	16.8	30.1	53.8	28.7	35.7
Conservation	Probability of extinction	L	%	2.4%	1.1%	0.0%	0.3%	3.4%	0.2%	0.0%	0.4%	0.2%
Conservation	% Enhanced fish 2010	L	%	27%	21%	56%	34%	26%	35%	52%	37%	46%
Conservation	% Enhanced ave fish 2016-2019	L	%	33%	29%	45%	41%	32%	42%	41%	45%	46%
Costs	Total Costs	L	\$ Yr An Ave \$00	\$ 171	\$ 309	\$ 588	\$ 488	\$ 171	\$ 523	\$ 588	\$ 328	\$ 500
Catch	Total Downstream	H	# 000	1,925	304	6,601	3,391	3,391	4,642	1,925	4,618	4,642
Catch	Total Upstream	H	# 000	637	2,884	504	2,365	2,365	2,335	3,054	2,131	2,335
Catch	Total First Nations	H	# 000	777	739	769	796	796	768	797	768	768
Jobs	Total FTEs	H	# FTEs	1.60	2.80	4.10	3.70	1.60	3.30	4.10	2.50	4.10

# Example: consequence table

Post van der Burg, M., and M. E. Colvin. 2024. Using structured decision making to assess management alternatives to inform the 2024 update of the Minnesota Invasive Carp Action Plan. Report 2024-1020, Reston, VA.

<https://pubs.usgs.gov/publication/ofr20241020>

Objective	Mean weight	Strategy																		
		1	8	12	5	7	6	9	10	2	4	18	13	17	16	14	15	3	11 (optimal strategy)	
Decrease invasive carp abundance	0.13	1.75 <sup>a</sup>	6.31	3.84	5.56	6.25	5.28	4.94	5.94	3.44	4.63	7.69	6.22	8.23	6.94	6.38	7.13	8.63 <sup>b</sup>	6.56	
Minimize negative effects on native mussels	0.07	4.38 <sup>a</sup>	6.50	7.13	6.75	7.38	6.56	6.00	6.69	5.19	6.56	7.38	7.13	7.63	6.97	7.50	6.94	8.50 <sup>b</sup>	6.88	
Minimize effects to native fish	0.13	3.63 <sup>a</sup>	5.56	6.50	5.50	5.81	5.44	5.38	5.75	4.44	5.41	6.56	6.22	6.69	6.34	6.56	6.44	7.38 <sup>b</sup>	6.31	
Minimize effects to native flora	0.07	6.25 <sup>a</sup>	6.81	7.81	6.56	6.88	7.06	6.88	7.22	6.69	6.56	7.63	7.56	7.72	7.72	7.44	7.84	8.19 <sup>b</sup>	7.56	
Maintain recreational opportunities	0.09	4.00 <sup>a</sup>	5.38	5.03	5.03	5.50	5.34	5.63	5.38	5.41	5.88	6.56	7.09	6.69	6.81	6.81	6.81	7.48 <sup>b</sup>	6.50	
Minimize negative effects to Minnesota river-based economies	0.07	3.75 <sup>a</sup>	6.63	5.22	5.56	6.38	5.47	5.81	6.38	5.03	5.19	7.25	7.16	6.94	6.75	6.13	6.63	8.48 <sup>b</sup>	6.75	
Minimize carp threats to public safety	0.08	4.00 <sup>a</sup>	6.44	4.97	5.91	6.19	6.16	6.00	6.63	5.16	5.56	7.88	6.91	7.75	7.13	6.88	7.13	8.04 <sup>b</sup>	6.75	
Minimize management threats to public safety	0.07	9.25 <sup>b</sup>	7.63	8.13	7.50	7.50	7.75	7.75	7.50	8.88	8.25	7.38	8.50	7.50	7.38	7.69	7.50	5.94 <sup>a</sup>	8.25	
Minimize negative effect to cultural practices	0.07	5.63 <sup>a</sup>	6.75	5.81	6.75	7.13	7.13	6.88	6.94	7.25	7.25	6.88	7.38 <sup>b</sup>	7.00	7.13	7.38 <sup>b</sup>	7.13	7.38 <sup>b</sup>	7.00	
Maintain access for underserved populations	0.06	7.13 <sup>a</sup>	8.00	7.91	8.31	8.25	8.50	8.44	8.50	8.38	8.75 <sup>b</sup>	8.13	8.63	8.25	8.50	8.25	8.63	8.38	8.50	
Minimize prevention and control costs of the action	0.07	8.75 <sup>b</sup>	2.25	5.57	4.44	2.00	4.13	5.56	3.16	7.81	6.50	1.64	4.38	1.64	3.29	5.07	3.29	0.50 <sup>a</sup>	5.21	
Minimize implementation time	0.10	10.00 <sup>b</sup>	2.31	3.81	3.63	2.13	3.31	3.56	2.88	10.00 <sup>b</sup>	6.75	2.13	2.38	2.00	4.13	3.88	4.44	1.13 <sup>a</sup>	7.13	
<b>Total score</b>	--	<b>5.41</b>	<b>5.75</b>	<b>5.76</b>	<b>5.79</b>	<b>5.81</b>	<b>5.81</b>	<b>5.85</b>	<b>5.91</b>	<b>6.22</b>	<b>6.23</b>	<b>6.36</b>	<b>6.44</b>	<b>6.46</b>	<b>6.50</b>	<b>6.54</b>	<b>6.58</b>	<b>6.66</b>	<b>6.86</b>	

<sup>a</sup>Maximum score of an objective (shaded yellow).

<sup>b</sup>Minimum score of an objective (shaded red).

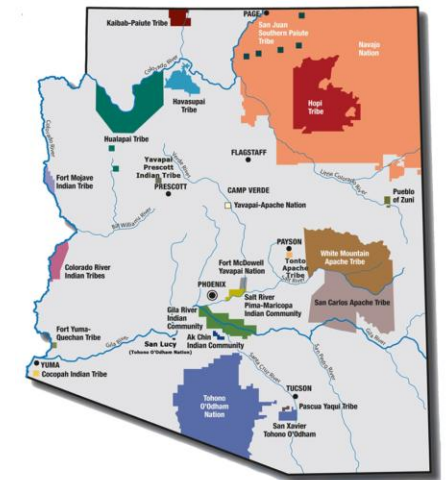


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# Models used in a Structured Decision: Example

**SDM project:** Non-native fish control below glen canyon dam to aid in humpback chub (HBC) recovery

Case study: ([Runge et al. 2011](#))



Arizona Department of Education



# Models used in a Structured Decision: Example

## OBJECTIVES

	Alternative	Respect Life	HBC Recovery	Wilderness Disturbance	Cost
		0-10 scale	P(N>6000)	User-days	M\$/5-yr
		Max	Max	Min	Min
A	No action	6.00	0.232	0	0
C <sub>2</sub>	LCR removal (lethal)	6.33	0.343	5003	3.17
C <sub>3</sub>	LCR removal (mix)	6.33	0.341	5037	3.53
C <sub>4</sub>	LCR removal (live, boat)	9.67	0.341	5003	3.38
C <sub>5</sub>	LCR removal (live, heli)	9.67	0.341	5154	4.65
D <sub>1</sub>	Removal curtain (lethal)	8.00	0.532	6824	3.47
D <sub>2</sub>	Removal curtain (mix)	6.33	0.532	6824	3.98
D <sub>3</sub>	Removal curtain (live)	9.67	0.532	6867	4.36
J <sub>1</sub>	Kitchen Sink I	1.67	0.555	6753	3.43
J <sub>1</sub> '	Kitchen Sink I w/ stock	1.67	0.536	6777	3.62
J <sub>2</sub>	Kitchen Sink II	1.67	0.555	6793	4.08
J <sub>2</sub> '	Kitchen Sink II w/ stock	1.67	0.536	6818	4.32
K	Zuni-Hopi-NPS	9.00	0.291	5400	3.03

Runge MC, Bean E, Smith DR, Kokos S. 2011. Non-native fish control below Glen Canyon Dam—report from a structured decision-making project. U.S. Geological Survey Open-File Report 2011-1012, 74 p.



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# Models used in a Structured Decision: Example

## **Objective 1: Be respectful of non-human life**

Reflects a value that taking life (rainbow trout, an invasive species) should be purposeful and done with good intent

## **Measurable attribute** (constructed scale):

10-point constructed scale considers the relative degree of respectfulness for the proposed end uses of fish taken

0 = strong lack of respect for the lives of the fish taken

10 = strong respect for the lives of the fish taken

## **Model:** expert elicitation

Representatives from three tribes scored the alternatives on this objective, integrating their cultural understanding

# Models used in a Structured Decision: Example

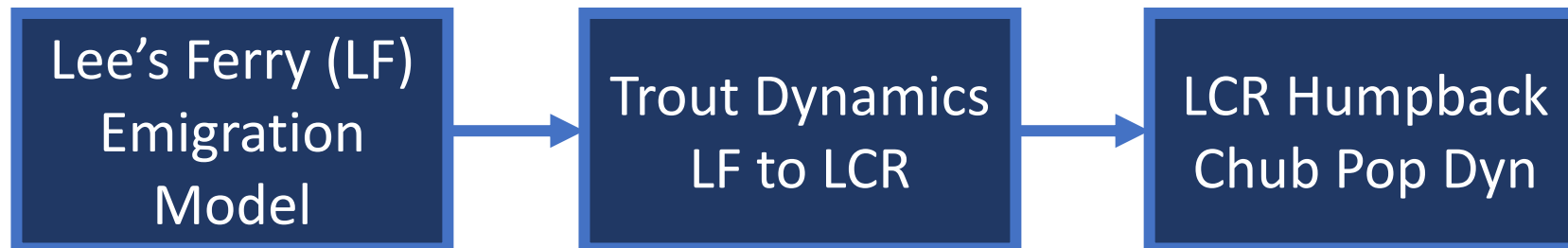
## Objective 2: Contribute to humpback chub recovery

### Measurable attribute (natural scale):

Probability of the adult humpback chub population remaining above 6000 over the next 30 years

### Model: Fish community dynamics model

Dynamics modeled in the Colorado River (LCR) below Glen Canyon Dam with a Population Viability Analysis (three sub-models)



# Models used in a Structured Decision: Example

## Objective 3: Minimize disturbance of wilderness experience as a result of non-native fish management in Grand Canyon NP wilderness

### **Measurable attribute** (constructed scale):

Penalized user-days/year in the wilderness area during boat/helicopter trips for removal.

Staff size\*number of days\*penalty factors (for activities that result in greater disturbance)

### **Model:** Nonnative fish population model

Included predictions of how many removal trips would be needed each year; multiply by the average staff size of a removal trip, the average length of a trip, and penalty factors

# Skills Check Task 3



		Alternative Strategies			
Objective	Measurable attribute	Strategy 1:	Strategy 2:	Strategy 3:	Strategy 4:
Maximize eagle persistence	# of eagles after 1 year				
Minimize cost	\$				
Maximize angler satisfaction	Constructed scale				

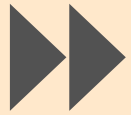
- A. Fill in the consequence table and score each outcome of each objective (it's okay to make up these numbers)
- B. What type of models would you use to calculate each of the objectives. Is there another objective that comes to mind for this problem? How would you calculate that one?

# Activity: think about your decision problem

- For your final project presentation, you will provide a slide of your Alternatives
  - Can you generate alternatives?
  - Can you think of portfolios or strategies for your problem?
- & You will provide a slide of your Consequences
  - Can you create an influence diagram?
  - Can you create a consequence table?
    - Don't worry about filling it in with real #s
- **Feel free to go back to your problem framing & objective steps!**

Review final  
presentation  
details

# Looking ahead:



**Next week:** I step of PrOACTI



**Weekly:** Work through a step of the PrOACT process/  
learn extra tools

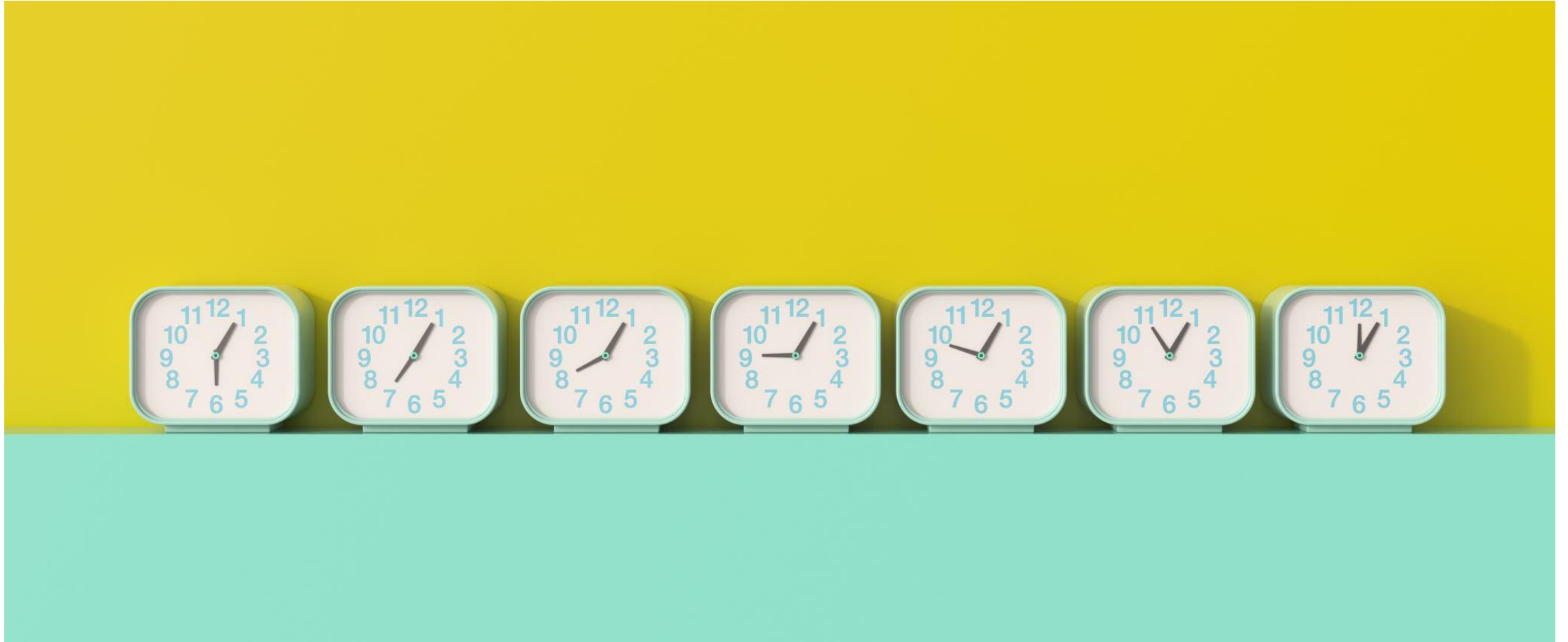


**Last week of class:**

Elevator pitch of your research project in  
terms of SDM/PrOACT

Note: Abridged PrOACT story slides with a star on the upper right  
are good examples to use for your presentation

# Extra time activities:



## Impoundment Repair

### *Problem*

- Decision maker: Refuge manager who is also interested in stakeholder's perspectives
- Trigger: Weir is not functioning adequately
- Actions: Status quo, Minor or Major weir repair, Rebuild Impoundment
- Constraints: Facilities funding available this year, not sure about future funding
- Frequency and Timing: One time decision, but could be revisited in the future if funding is available
- Scope: The impoundment and areas affected by the project
- Problem class: Multiple objective with uncertainty

# Activity

Developed by: Alex McInturff, Angela Matz,  
Mitch Eaton, Paul Barrett, Sarah J. Converse

## Impoundment Repair *Objectives*

Objective	Direction	Performance measure
Cost	Minimize	Dollars (\$M)
Environmental benefits	Maximize	Constructed scale (0 to 10)
Disturbance	Minimize	Constructed scale (0 to 10)
Silt runoff	Minimize	Thousand cubic feet (k ft <sup>3</sup> )
Water retention	Maximize	Million gallons (MG)

# Activity

Developed by: Alex McInturff, Angela Matz,  
Mitch Eaton, Paul Barrett, Sarah J. Converse

## Impoundment Repair *Alternatives*

- What are the alternatives for this problem?
- Are there additional alternatives? How would you develop them?

You are the manager of a National Wildlife Refuge and are in the process of deciding how to manage for an endangered lizard on the Refuge. The lizard seems to benefit from the disturbance associated with prescribed fire (though your budget for such activities is limited). Also, the species is susceptible to mortality on roads, but the Refuge receives substantial visitation by bird watchers, some of whom like to travel by car.

Given objectives:

- Minimize probability of extinction of the lizard

- Increase use of prescribed fire

- Minimize costs

- Minimize lizard road mortality

- Maximize birder satisfaction

- Maximize native bird species richness

Given alternatives:

- Spatial/temporal variations of road closures and prescribed burns

Identify characteristics of the models we would want to build, including: Inputs, Outputs, Model types

# Activity

# Reading discussion- Gregory et al. 2017 ch7

- What are the key characteristics of a “good” alternative in environmental decision-making?
- How do strategy tables help in organizing and comparing alternatives?
- What are some common pitfalls in generating alternatives, such as anchoring or premature screening?
  - How can we avoid these traps?