Consequences

Module 5:

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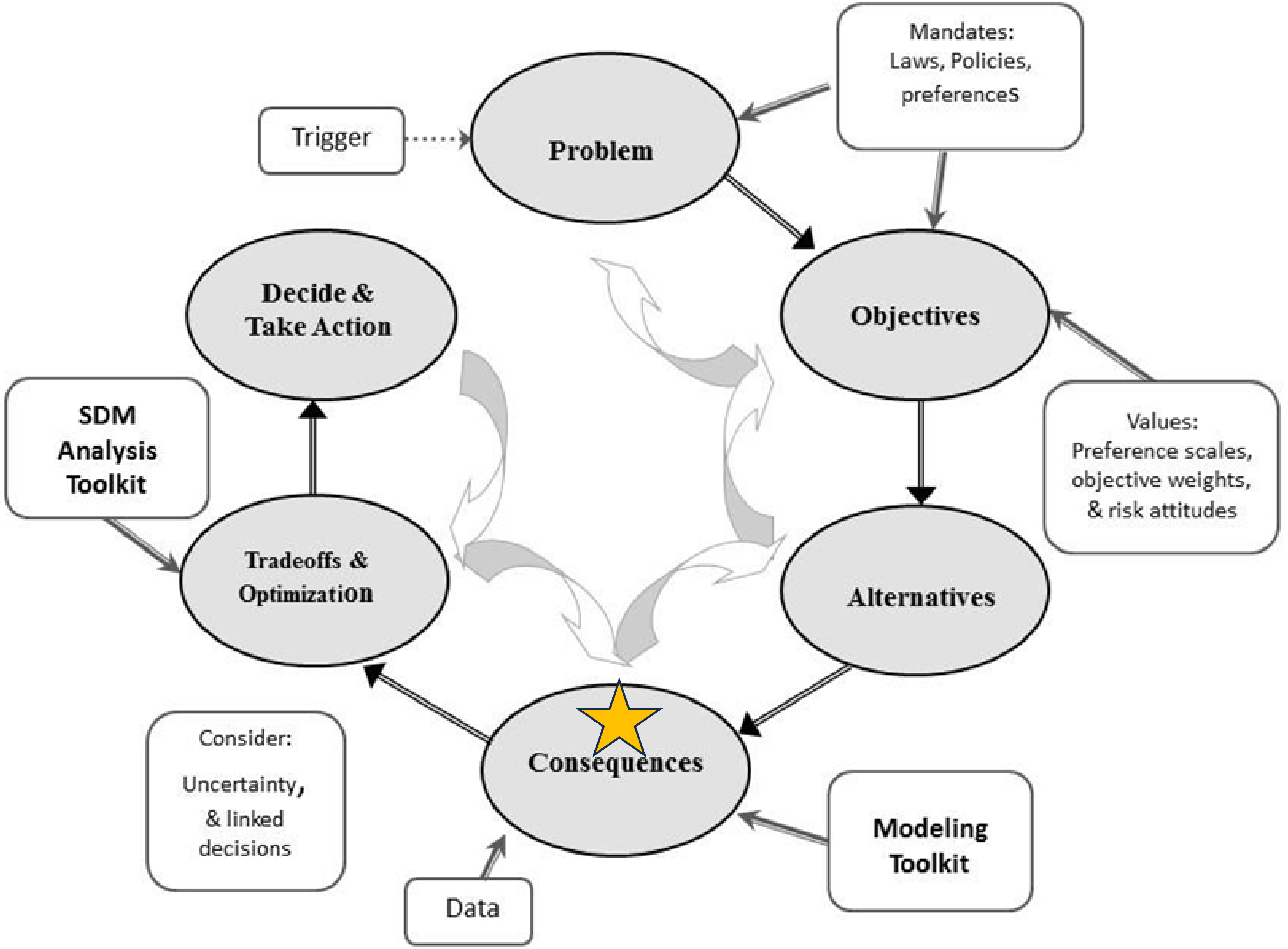
Workshop: An overview of Structured Decision Making for natural resources, Midwest Fish and Wildlife Conference 2025, St. Louis, MO

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

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The role of science in structured decisions

- Science allows us to make predictions about how the world works
- We call the tools we use to make predictions *models*
- Models can take many different forms, but all must support us in making predictions
  - If we choose alternative *X*, what will the effect be on objective *Y*?

Do Alternative *X* → **Science/Models** (our best assessment of how the world works) → Outcome for Objective *Y*

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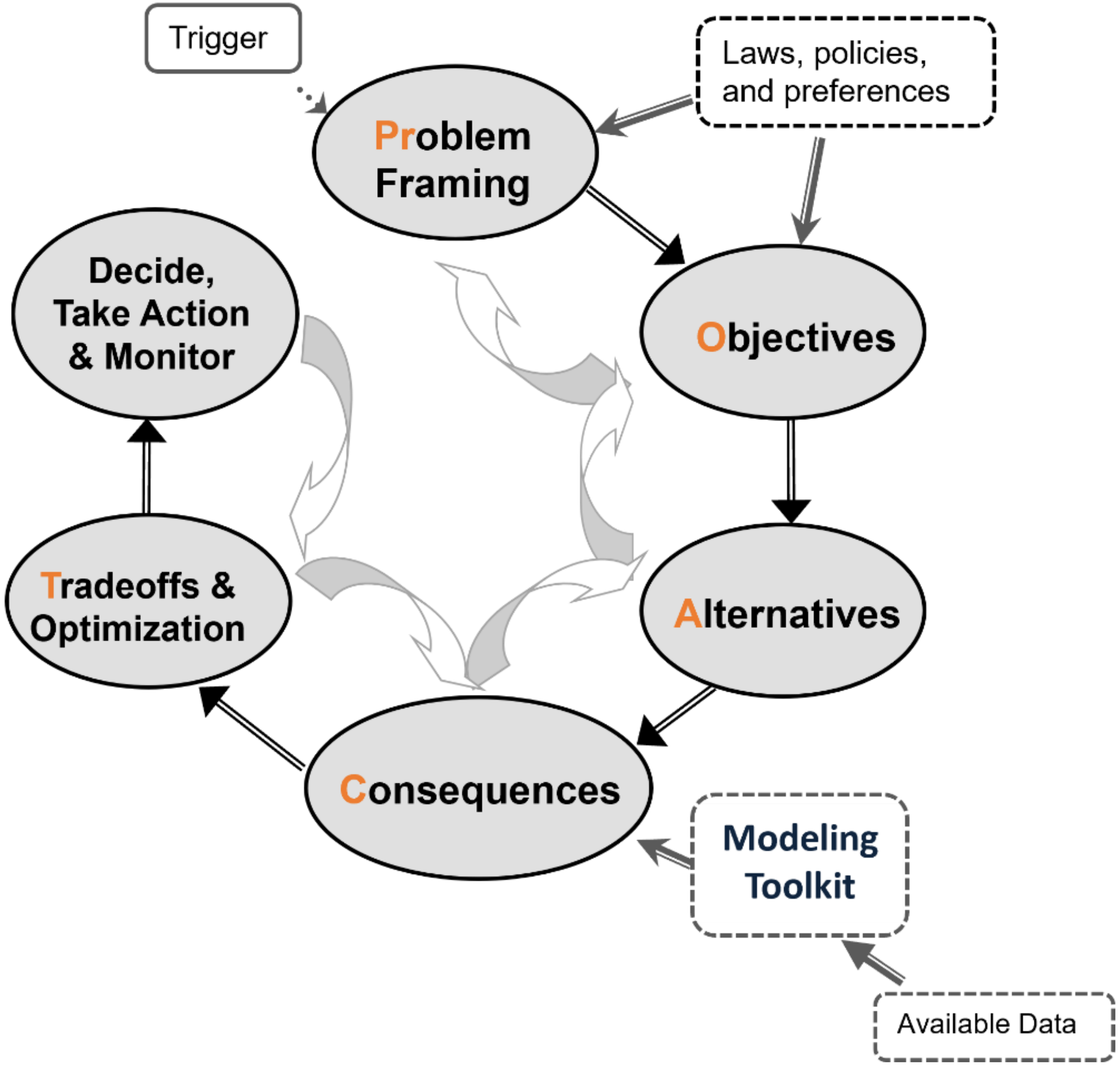
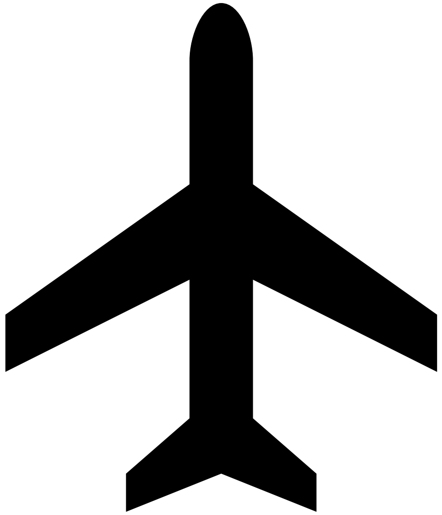
The consequences step

- Consequences link objectives and alternatives
- Models (in SDM) are tools that help us predict consequences
- Need not be complex in all cases
  - 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 – consequences

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 – consequences

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., airline service) as appropriate
2. Make the most of available information, including expert judgment
3. Report appropriate level of precision
4. Incorporate relevant uncertainty (e.g., structural, parametric uncertainty)

Some Principles of Modeling in SDM

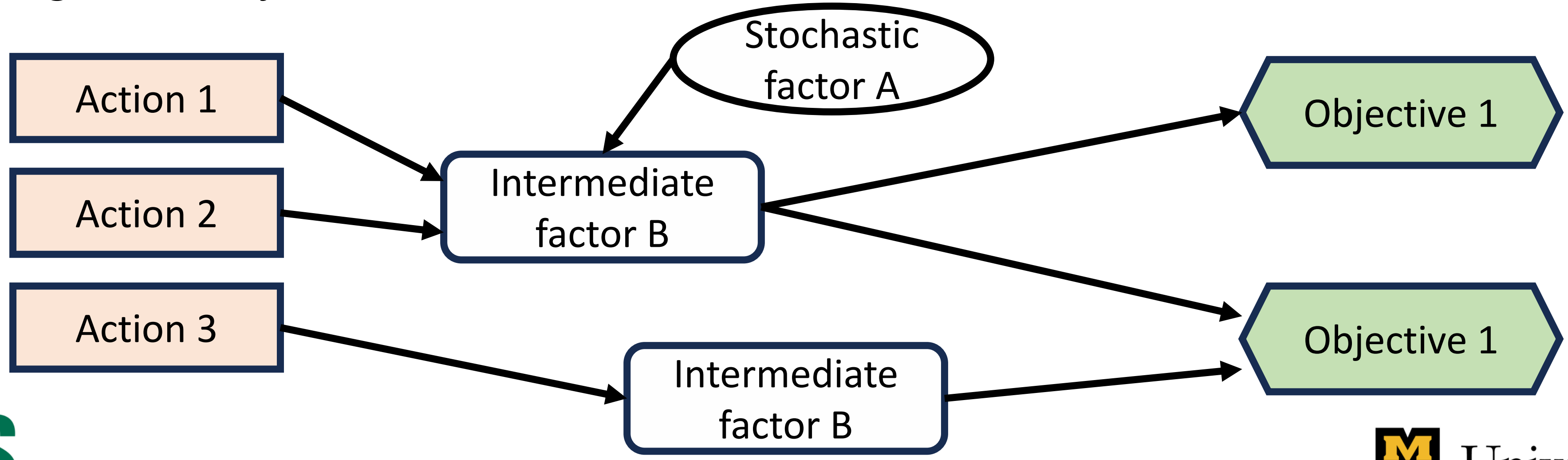
In designing a model, the important questions to ask are…

- <u>What will help me make better predictions?</u>
  - Ecological understanding is not the focus unless it improves prediction
    - As simple as possible but not simpler; as complicated as necessary but not more.
- <u>What are the pertinent model variables?</u>
  - Model inputs are essentially the alternatives
  - Model outputs are essentially the objectives
- <u>What uncertainty needs to be included?</u>
  - Focus on uncertainty that affects the decision
    - First model prototype often does not include uncertainty

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 that can and cannot be controlled
  - Begin with objectives and move towards alternatives



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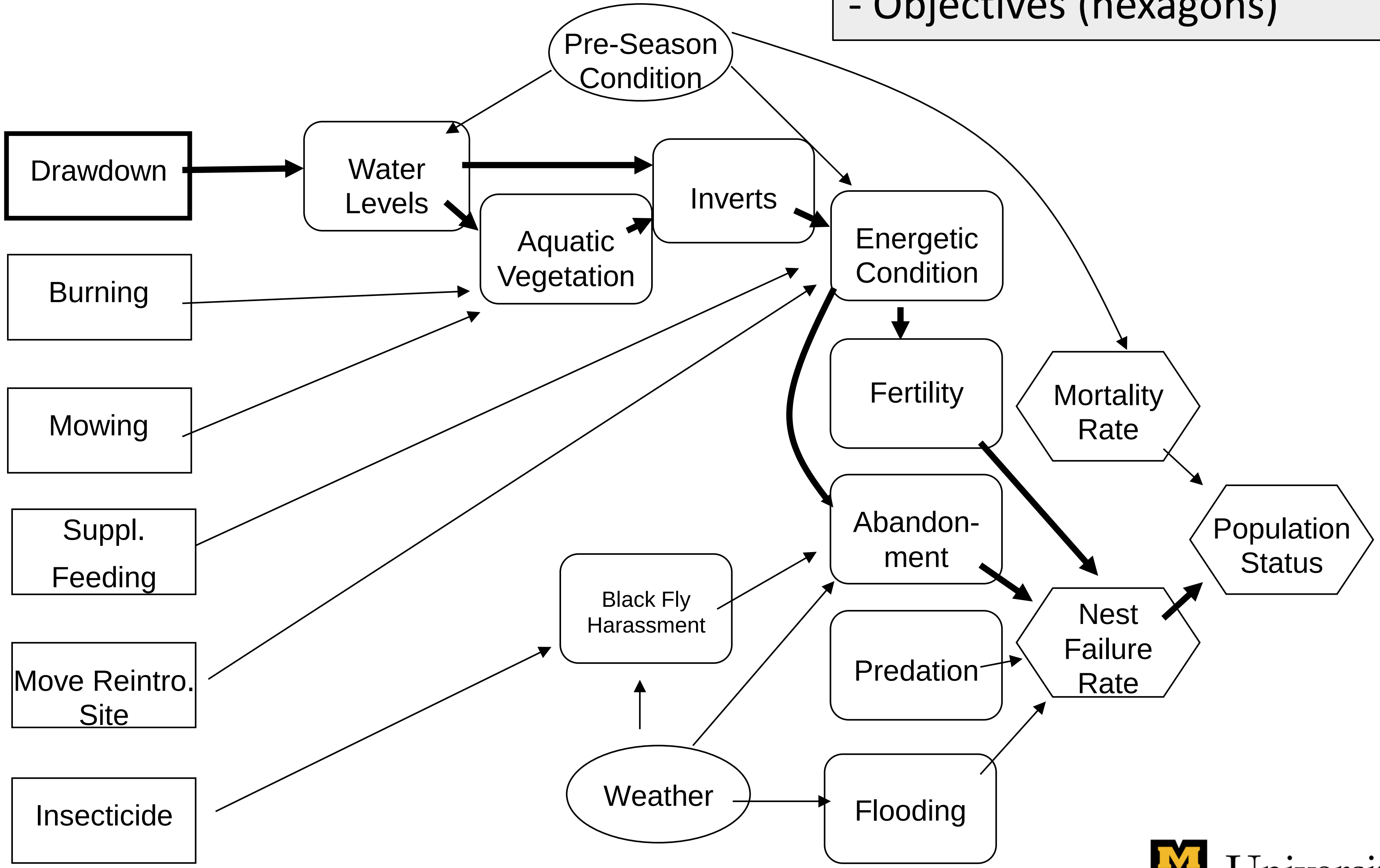
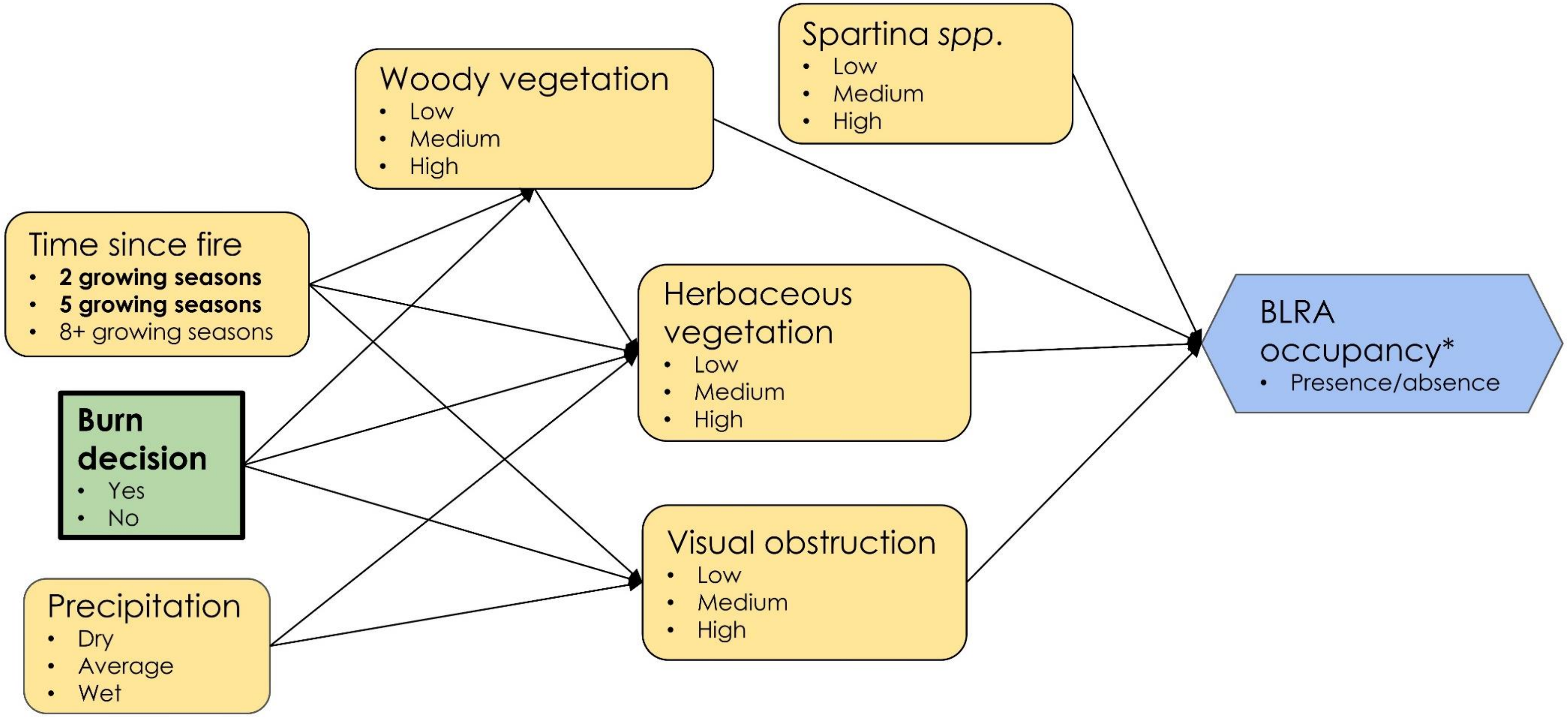
Example: Crane Nest Failure

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



Example: Black Rail



Stantial et al. *Unpublished manuscript*

See Stantial et al. 2023

*BLRA prototype

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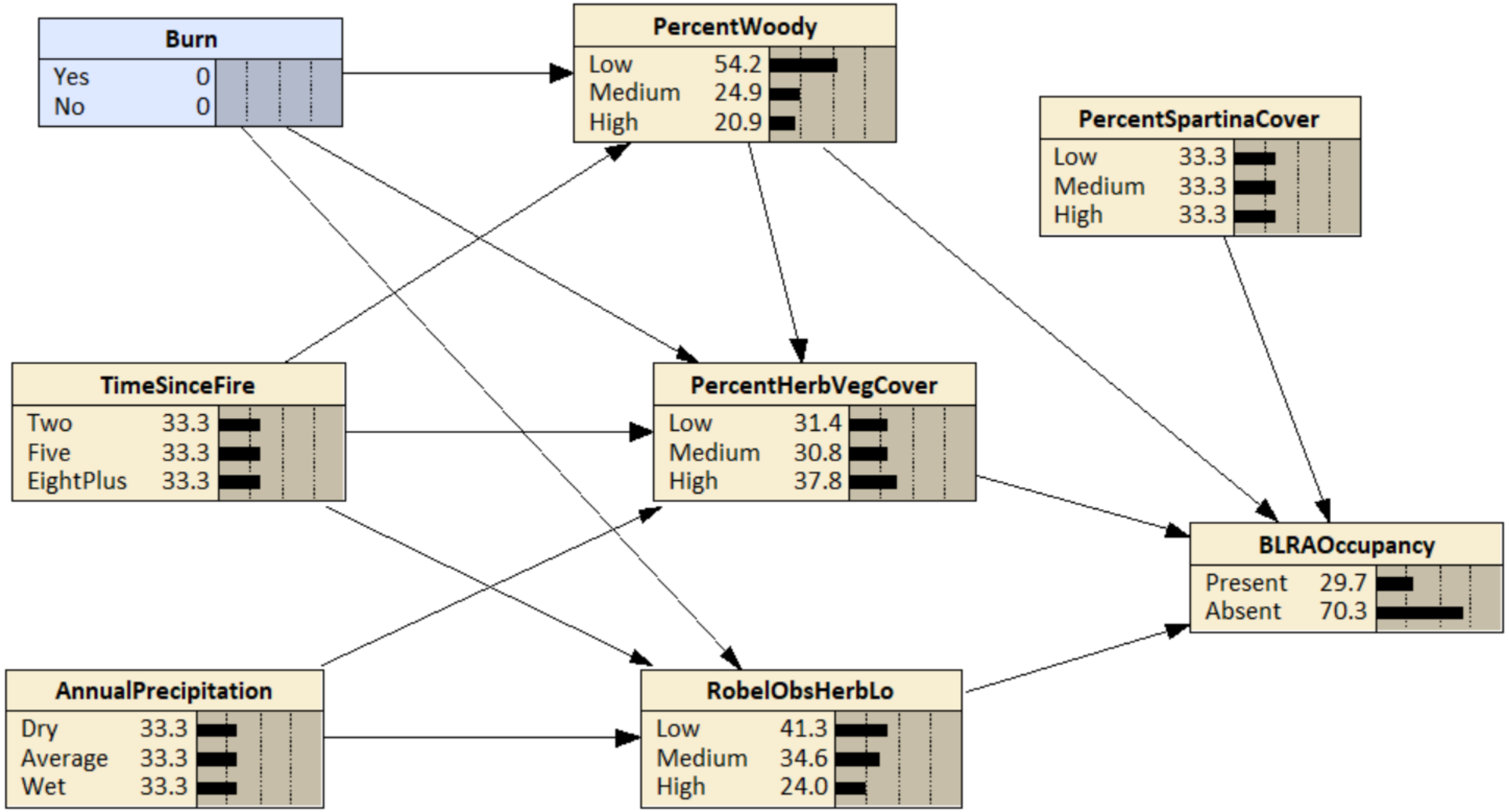
Example: Black Rail Bayesian Decision Network



Stantial et al. *Unpublished manuscript*

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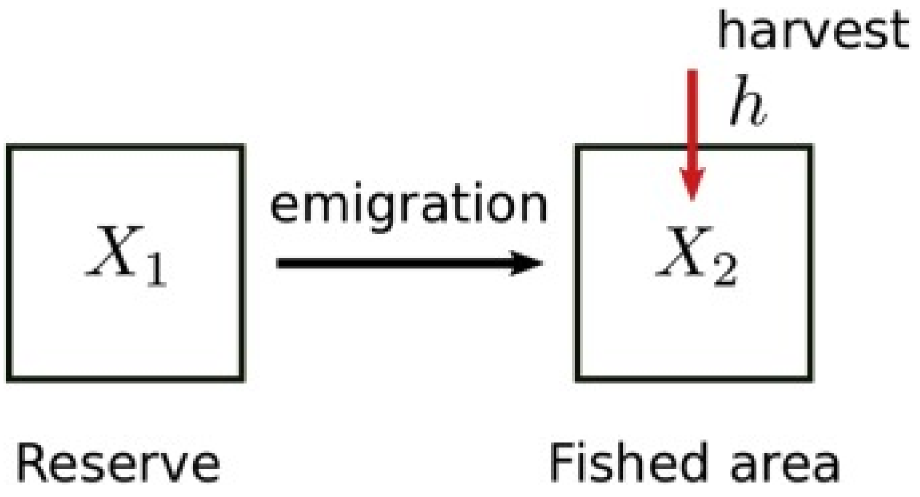
Modeling step

- 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!
  - Expert opinion/ expert elicitation



da Silveira Costa & dos Anjos 2019

- Conduct rapid prototyping: start simple, adjust, and build up

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Consequence table

- After obtaining results, we can organize the outcomes
- 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

	Alternative 1	**Alternative 2**	**…**	**Alternative n**
Objective 1	*prediction*	*prediction*		*prediction*
Objective 2	*prediction*	*prediction*		*prediction*
…				
Objective m	*prediction*	*prediction*		*prediction*

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

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Case study: (Runge et al. 2011)

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

Exercise: Consequences step

- Given the objectives you identified
- And given the alternatives generated
- Identify characteristics of the models we would want to build for this case study, including:
  - Inputs
  - Outputs
  - Model types
- Hint: Use an influence diagram
- Task: Create a consequence table (it is okay to make up answers!)

5 minute break!

CASE STUDY ACTUAL MODELS

- **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

Who should predict consequences?

CASE STUDY ACTUAL MODELS

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

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CASE STUDY ACTUAL MODELS

- **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

CASE STUDY ACTUAL MODELS

	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_2	LCR removal (lethal)	6.33	0.343	5003	3.17
C_3	LCR removal (mix)	6.33	0.341	5037	3.53
C_4	LCR removal (live, boat)	9.67	0.341	5003	3.38
C_5	LCR removal (live, heli)	9.67	0.341	5154	4.65
D_1	Removal curtain (lethal)	8.00	0.532	6824	3.47
D_2	Removal curtain (mix)	6.33	0.532	6824	3.98
D_3	Removal curtain (live)	9.67	0.532	6867	4.36
J_1	Kitchen Sink I	1.67	0.555	6753	3.43
J_1’	Kitchen Sink I w/ stock	1.67	0.536	6777	3.62
J_2	Kitchen Sink II	1.67	0.555	6793	4.08
J_2’	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.