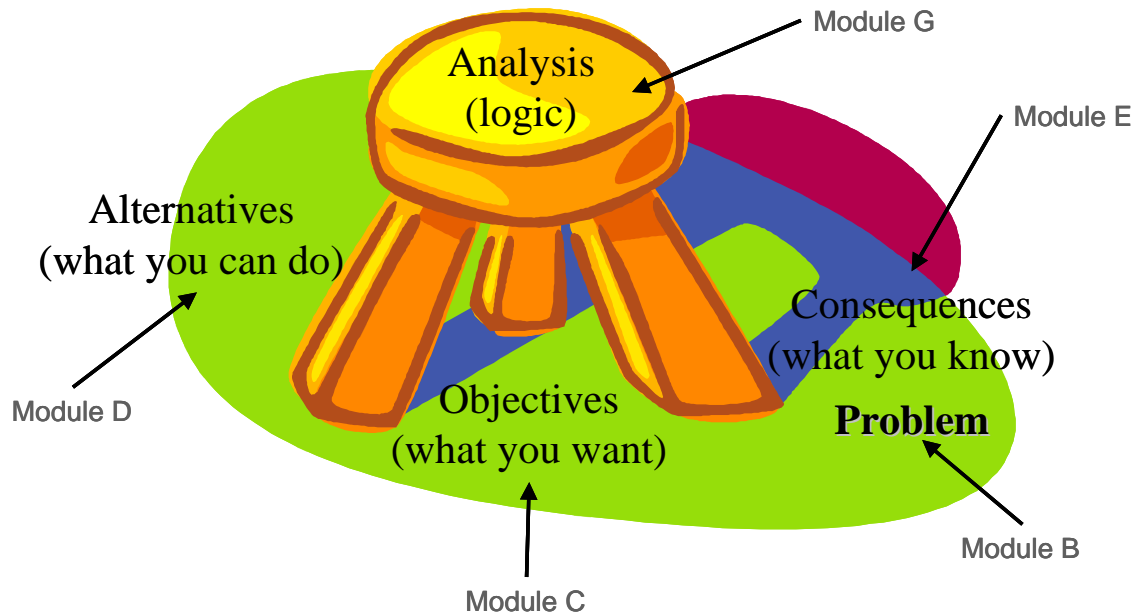


Module E — Consequences

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Where does predicting consequences fit?



Recall PrOACT

- We now need to understand the Consequences of different Actions in terms of our Objectives
 - Consequences link Objectives and Actions
- 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?

Consequences
An Overview of Structured Decision Making

A Simple SDM example

Consequences

An Overview of Structured Decision Making

Predicting Consequences

Consequence table:

- Highly useful
- Puts a lot of information in a concise and orderly format
- Easy to compare alternatives, objective by objective
- Initial framework for assessing tradeoffs

Predictions and models:

- Requires projection into the future
- Uses common scale within each objective
- Includes 'hard data' (e.g., total cost) and subjective assessment (e.g., friendliness)
- Makes the most of available information, including 'expert opinion'
- Reports appropriate level of precision
- Incorporates uncertainty

Cultus Lake Sockeye

(Gregory R, 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 Re building	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 \$000	\$ 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

Consequences
An Overview of Structured Decision Making

Role of Modeling in SDM

- Models
 - Range from simple to complex
 - May or may not be quantitative
 - Involve little or great uncertainty
- The characteristics of the model are case-dependent
 - That is, model structure depends upon
 - the specific role of the model
 - the other components of the decision framework
 - Inputs are based on actions
 - Outputs are measureable attributes

Through modeling we:

1. Structure the analytical problem
2. Lend transparency to the analysis
3. Develop predictions of consequences

Let's explore these three benefits models offer:

1. Structuring the Analysis

- Often determining the consequences of alternatives involves complex and multiple analytical steps
- Models are useful for thinking through these problems
 - by graphically displaying the problem, the key elements and the relationships among them are more easily discerned
 - by decomposing the problem, the analytical steps are more readily apparent

2. Transparency

Every decision maker uses some kind of model to predict the consequences of alternative actions

- In SDM, we want to make these models explicit and available to everyone involved
- During model development we:
 - Illustrate key elements of the problem and relationships among them
 - capture complex information

3. Predicting Outcomes

And finally...

- In order to compare and contrast alternatives, we must predict the future outcomes of each
 - and specifically, in terms that are relevant to our objectives

Consequences
An Overview of Structured Decision Making

Quick exercise:

- A USFWS Refuge manager has to decide which of 3 areas adjacent to the Refuge to acquire. Each of the areas contains current or potential habitat for an endangered butterfly.
- She would like to minimize the probability that the butterfly will go extinct, while minimizing costs.
- She wants you to build one or more models to help her make this decision

Answer the following:

- What will the model(s) need to be able to predict?
- What are benefits of building explicit predictive models in this case?

Examples of Models

Conceptual models

- Influence diagram
- Systems diagram

Predictive models

- Population model
- Habitat model
- Bayesian Belief Network

Consequences
An Overview of Structured Decision Making

Model Choice

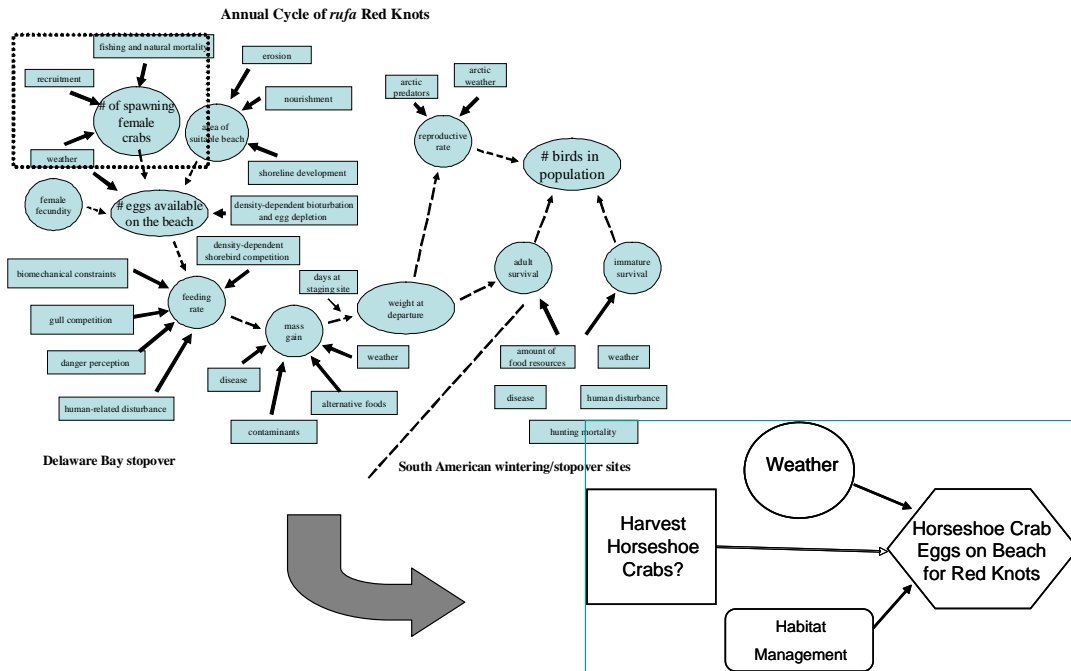
In building (or selecting) a model, the important questions to ask are...

- "What will help me make better predictions?"
 - Ecological understanding is *not* the focus unless it improves prediction

- "What are the pertinent model variables?"
 - Model inputs are essentially the alternatives
 - e.g., feral cat control affects juvenile survival
 - Model outputs are essentially the objectives
 - e.g., maximize N at year 20

- "What uncertainty needs to be included?"
 - Incorporate that uncertainty that affects the decision

How much complexity is useful?



Influence Diagrams

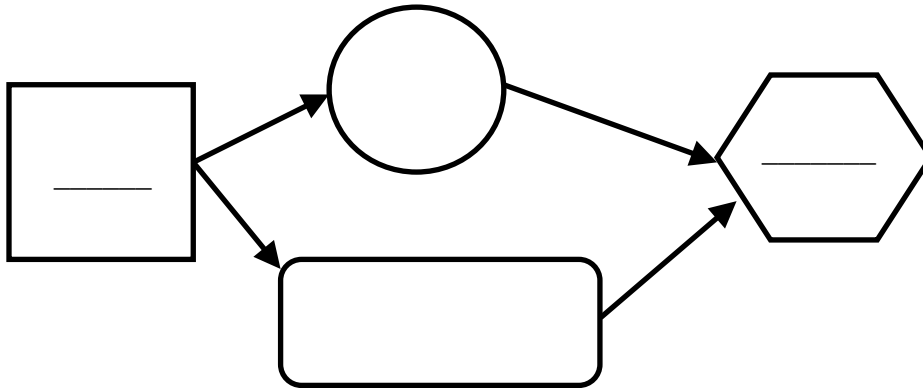
Conceptually link the actions to objectives

Distinguish between relationships that can and cannot be controlled

- “Nodes” for
 - decisions
 - chance events
 - outcomes
 - calculations

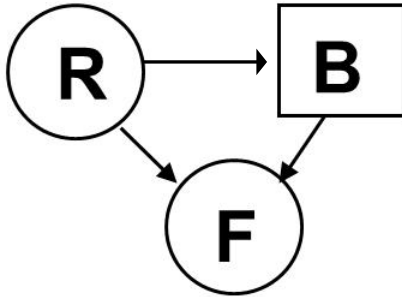
Different Shapes for Different Elements

- Rectangles: decision node
- Oval: chance node
- Hexagon: outcome node
- Rounded rectangle: calculation or constant



Representing relationships in influence diagrams

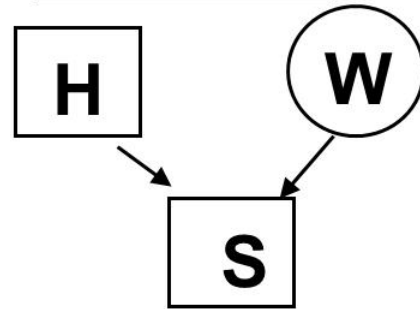
Relevance



Chance associated with node R & decision in node B are *relevant* to assessing chance events in node F.

R = rain fall
B = controlled burn
F = wild fire

Sequence



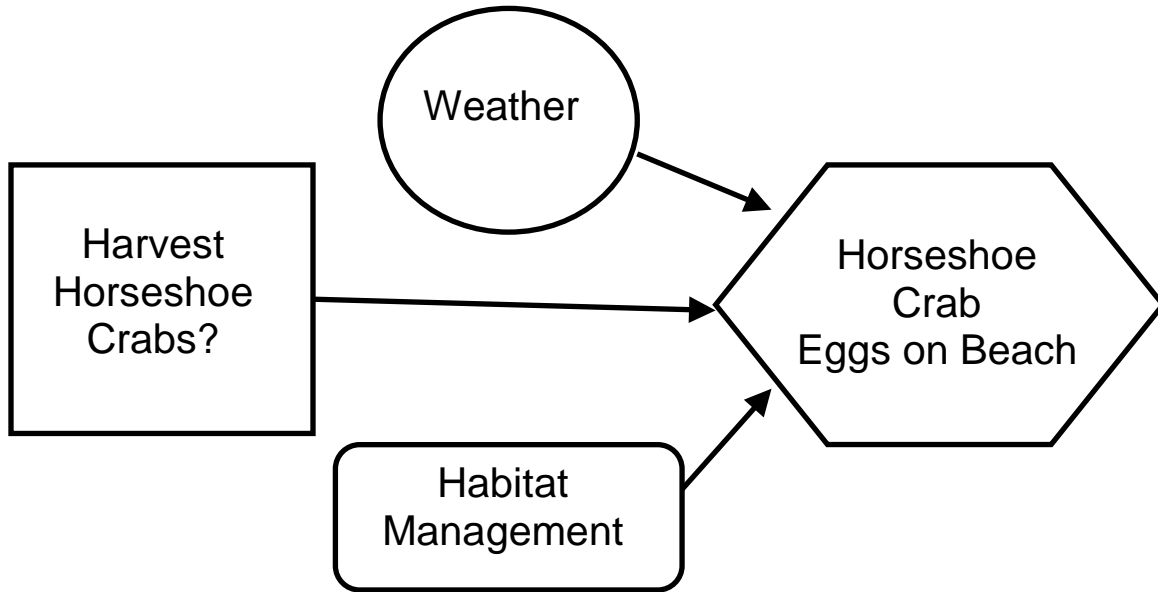
Decision in node S is made *after* decision in node H & *after* knowing the chance event in W.

H = completes homework
W = weather
S = play soccer

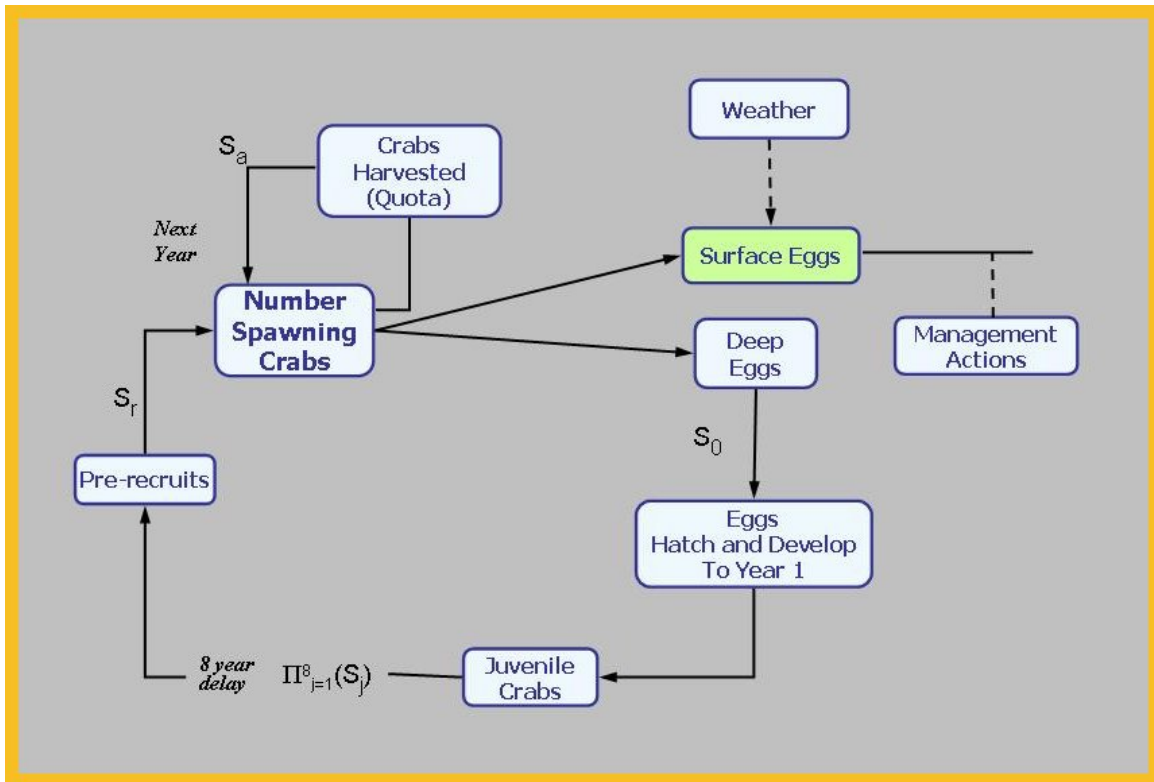
Influence Diagram vs. System Model

- In influence diagrams
 - Nodes and arrows represent belief or knowledge about how values of variables affect the values or probability distributions of other variables
- In system models
 - Nodes represent stocks, sources, and sinks of conserved quantities.
 - Arrows represent flow of materials, e.g., births, deaths, migrations, etc.

Horseshoe Crabs and Shorebirds Influence Diagram



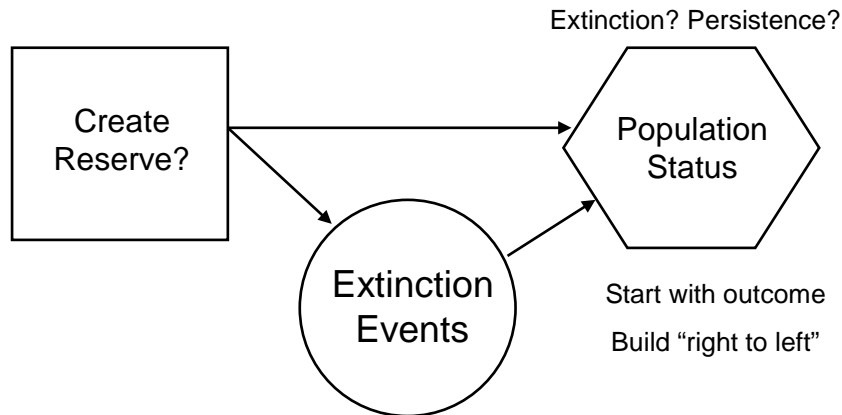
Horseshoe Crab System Model



Consequences
An Overview of Structured Decision Making

Establish a reserve?

- Consider an endangered species that may benefit from a new reserve
- Decision: Establish a reserve or not?
- Objective: Species persistence



Alternatives
Reserve
No Reserve

<u>Choice</u>	<u>Outcome</u>
Reserve	Extinct Persist
No Reserve	Extinct Persist

Summary

- Models
 - Link objectives to actions
 1. structure the analytical problem
 2. lend transparency to analysis
 3. predict the consequences of alternatives
 - May be quite complex or very simple...
 1. It depends on the decision problem and the necessary precision
- Influence diagrams
 - Useful to develop a shared understanding of system behavior
 - Concisely convey complex information