WF4313/6413-Fisheries Management

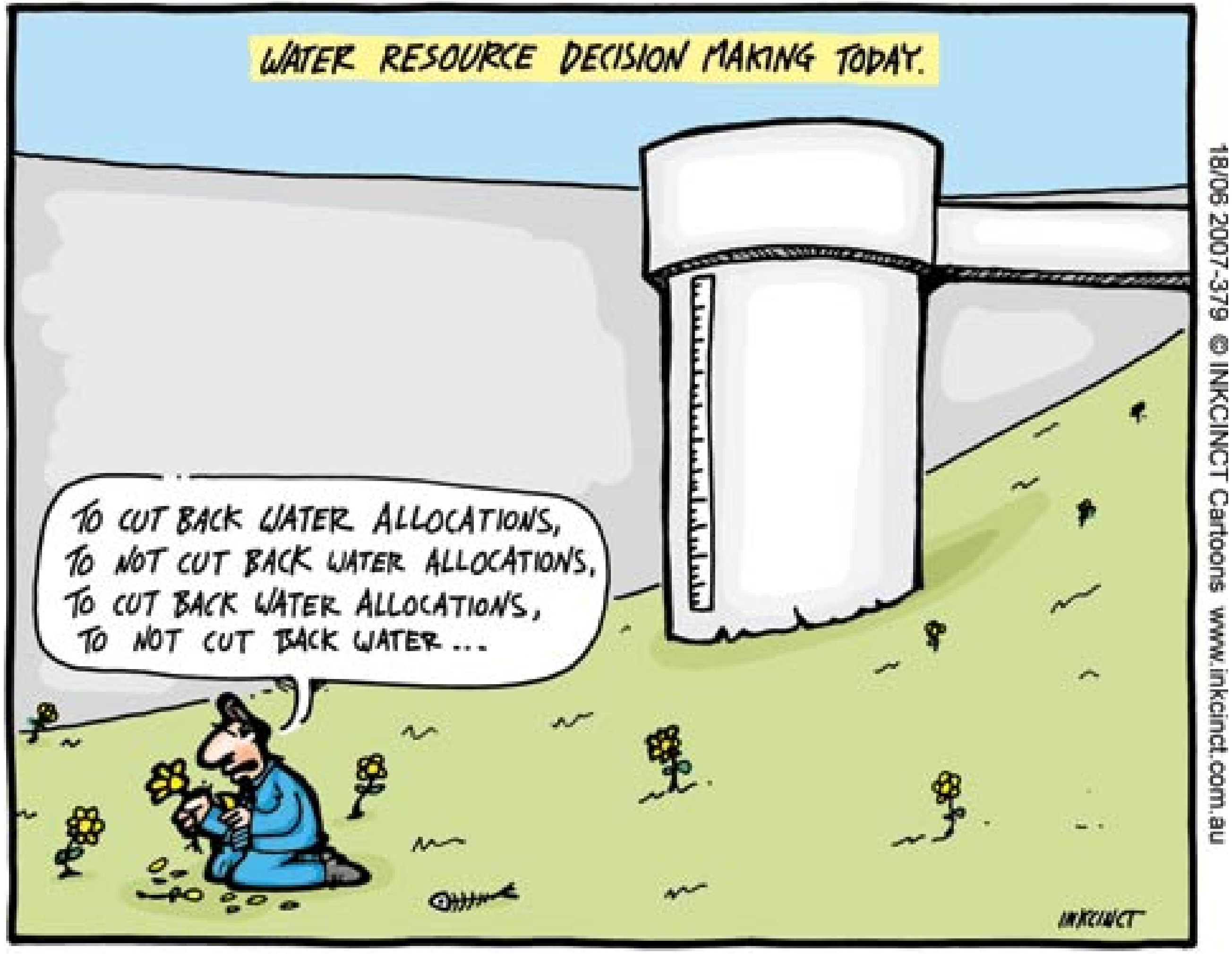
Class 24

Announcements

Revised Schedule

- ~~December 4th Brief presentations during lab.~~
- Grades are as stand in BB for presentations
- Final Exam 12/11 @ 8am
- Final Briefs due 12/11 @ 11am

WHERE WE LEFT OFF

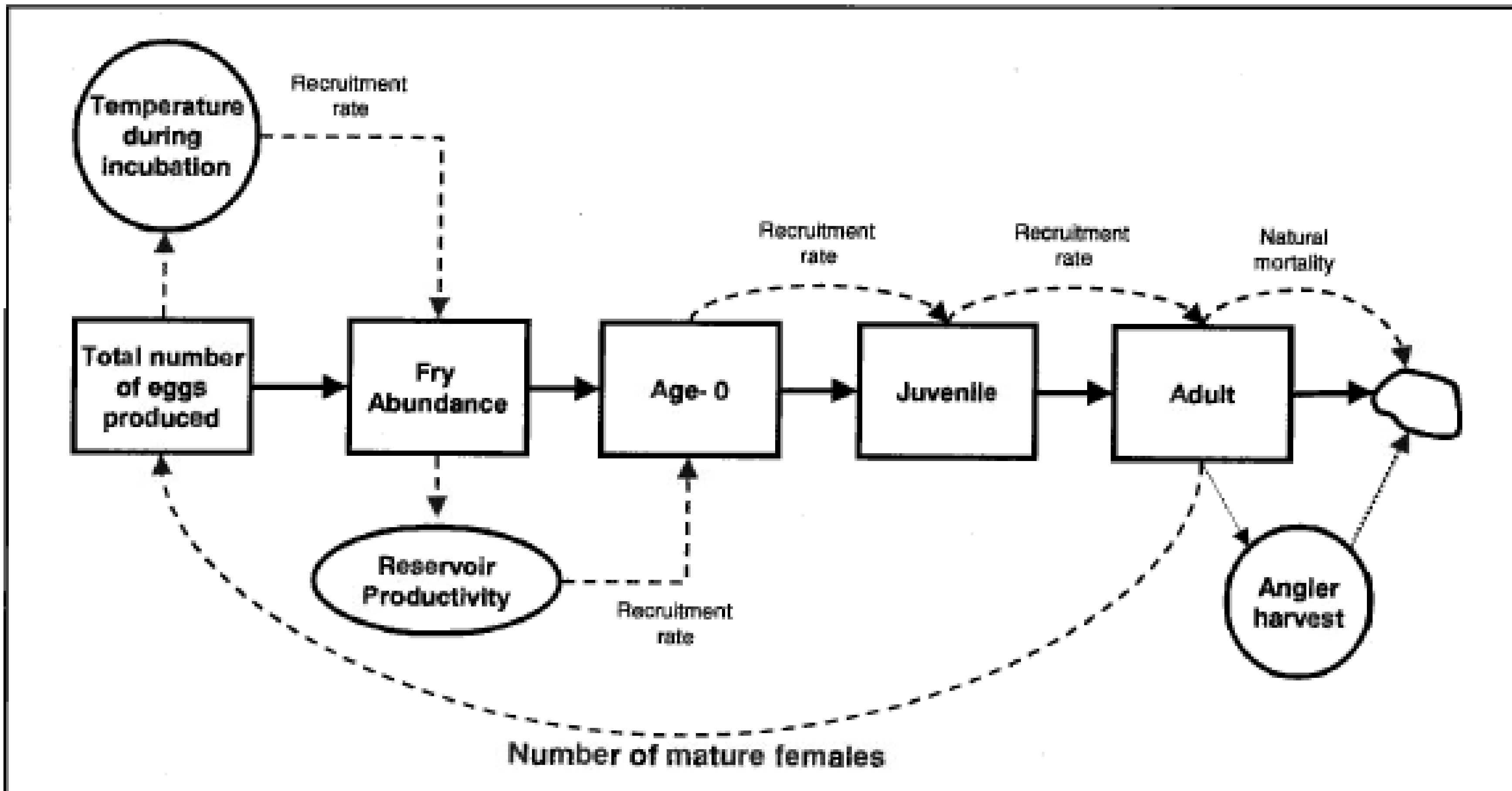


WHAT IS DECISION ANALYSIS?

A management decision is an irrevocable commitment of resources!

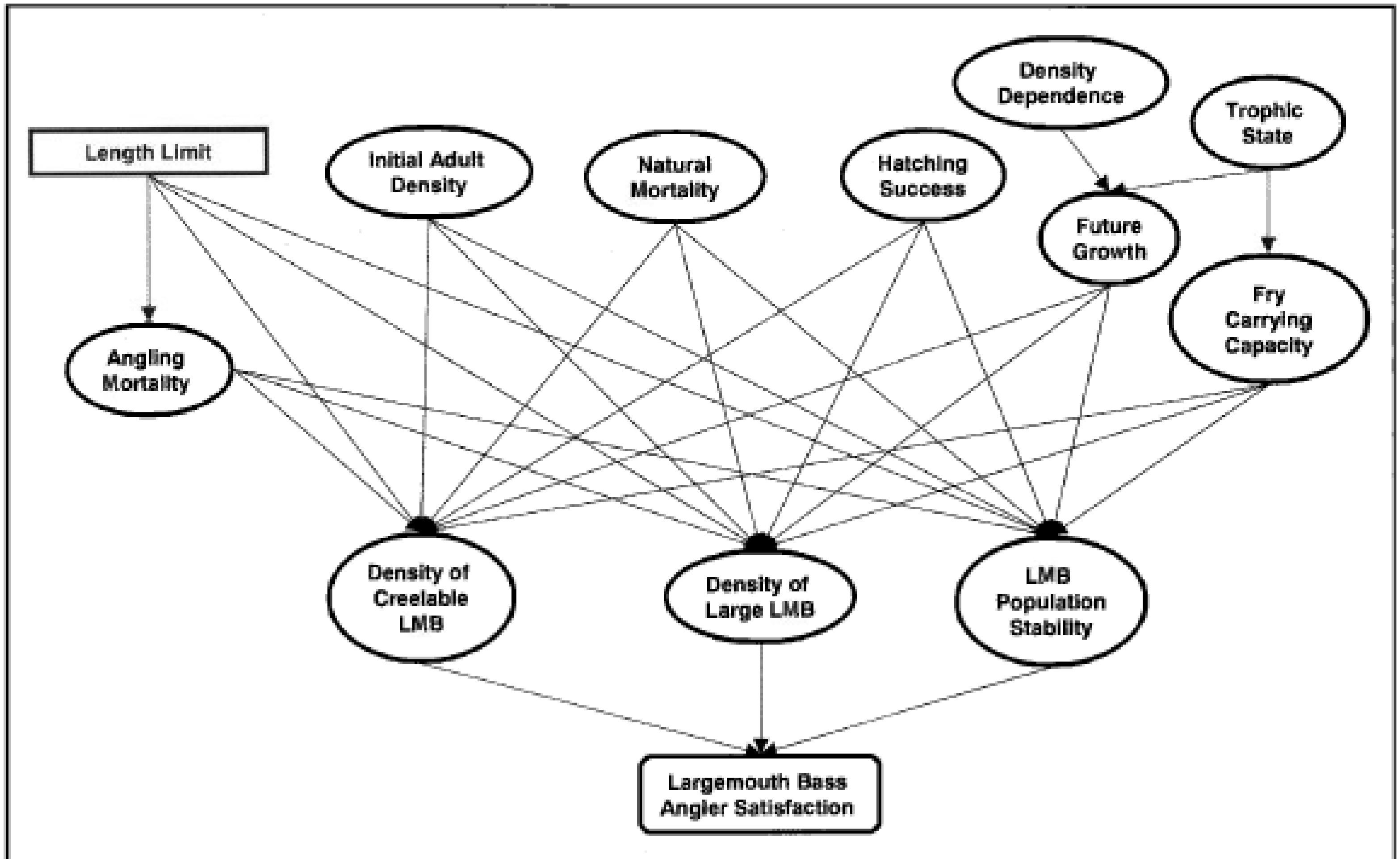
Model to predict outcomes

Figure 4. Flow chart of basic structural relationships of the largemouth bass population model using conventional symbols for rates, levels, sinks, and variables. Solid lines represent flow of material, and broken lines represent information links.

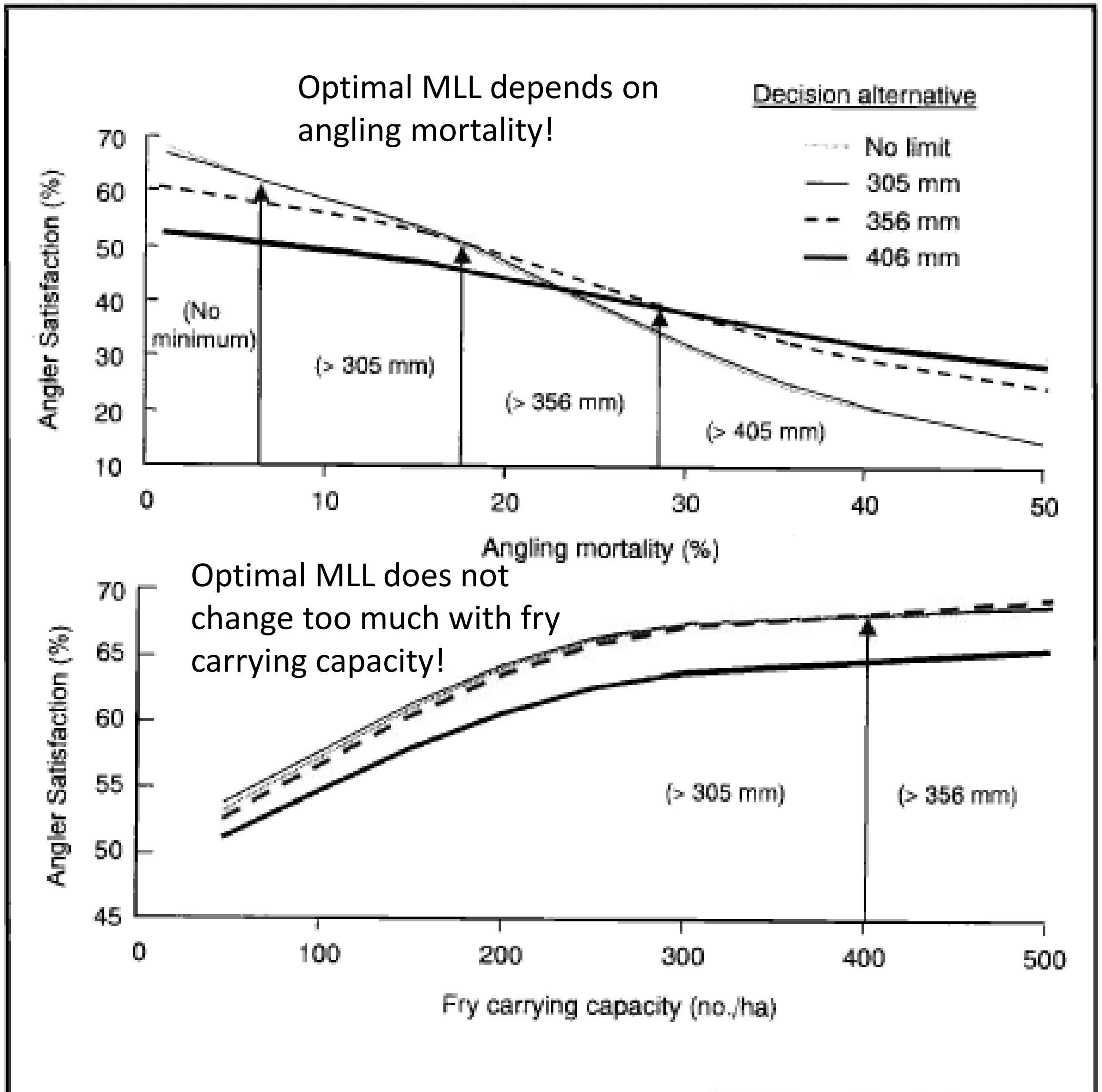


Influence of decision

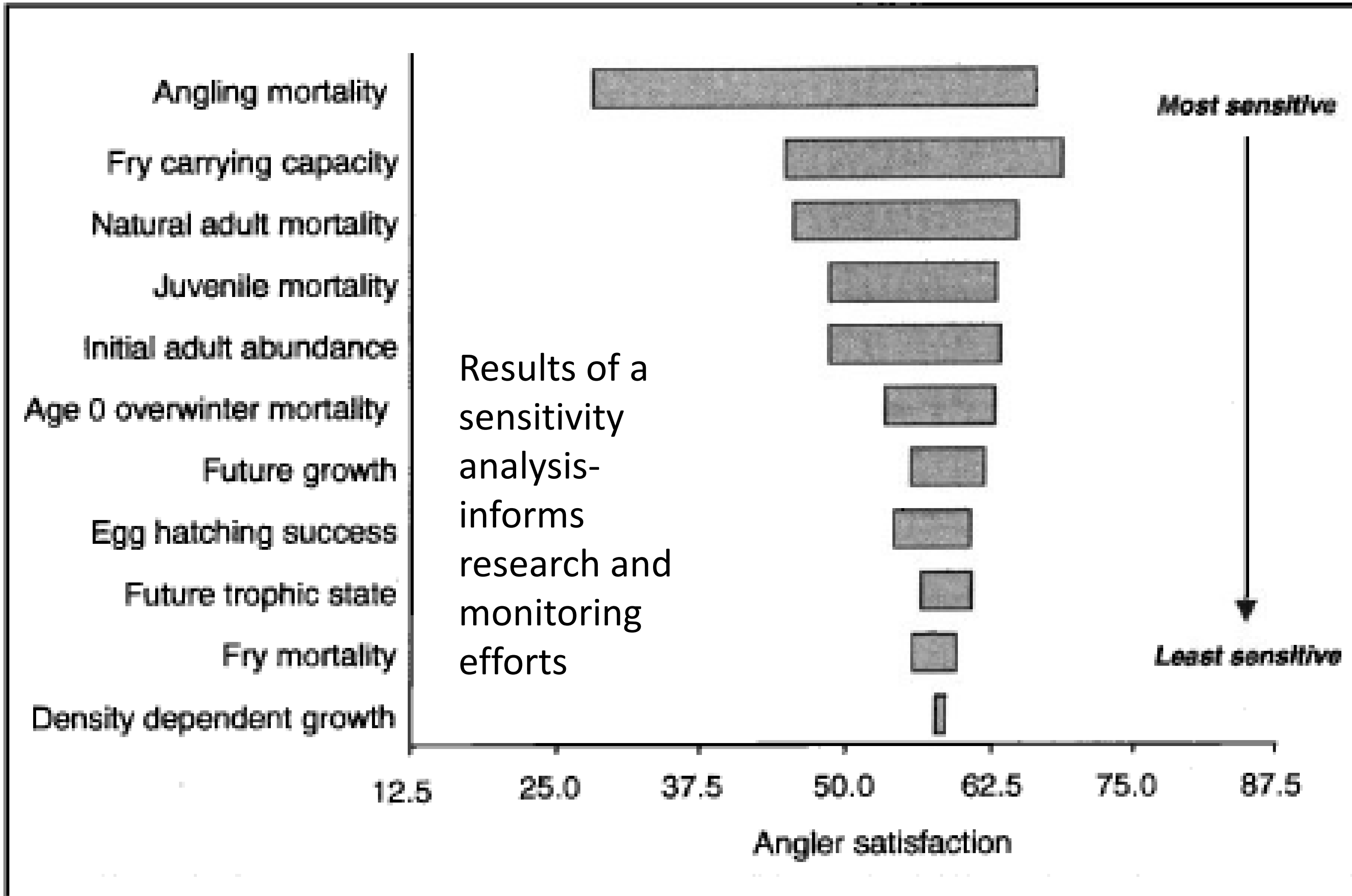
Figure 5. Influence diagram of West Point Reservoir largemouth bass length limit decision using the notation of Clemen (1996). The description of the model component states and their values are in Table 4. Natural mortality rates were modeled separately for fry, juvenile, and adult age classes but are represented as a single node for simplicity.



Decision uncertainty



What is important to know

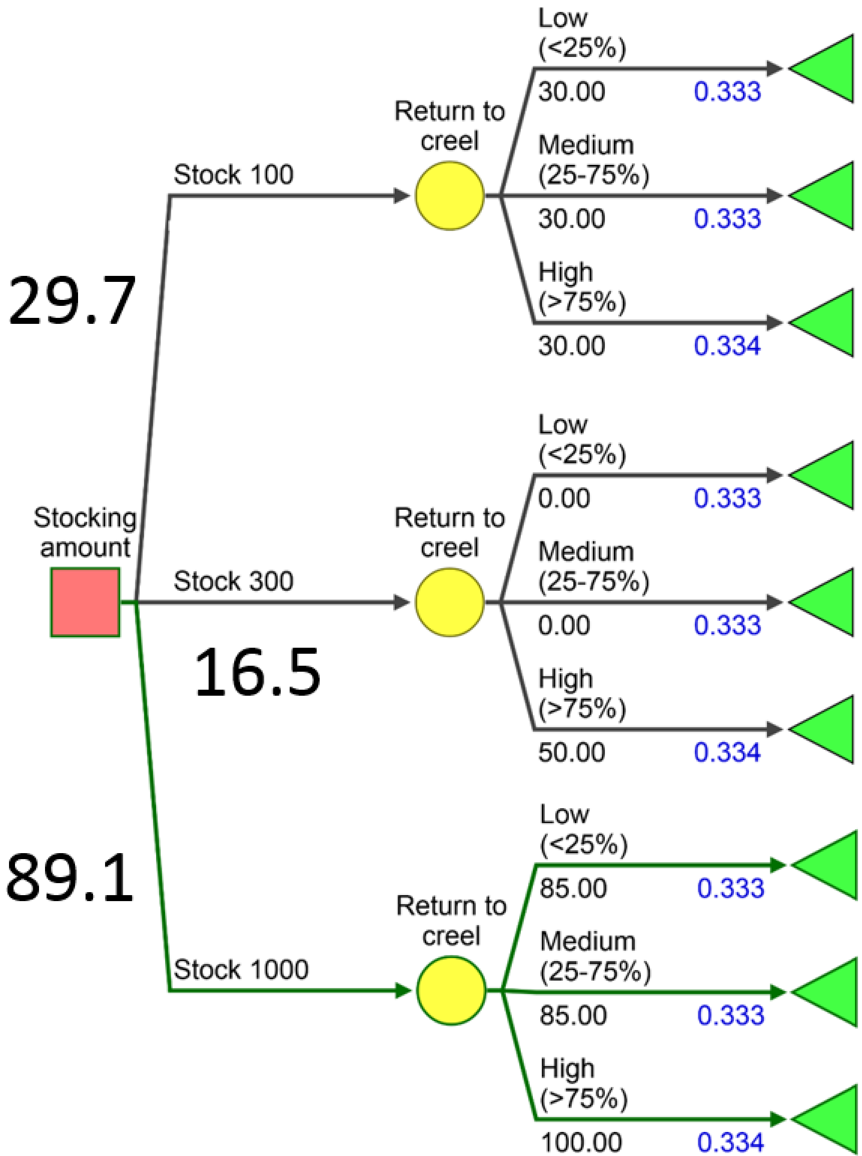


Results of a sensitivity analysis- informs research and monitoring efforts

Management objectives

1. Minimize predation of native amphibians
2. Maximize angler satisfaction

Visualizing the decision



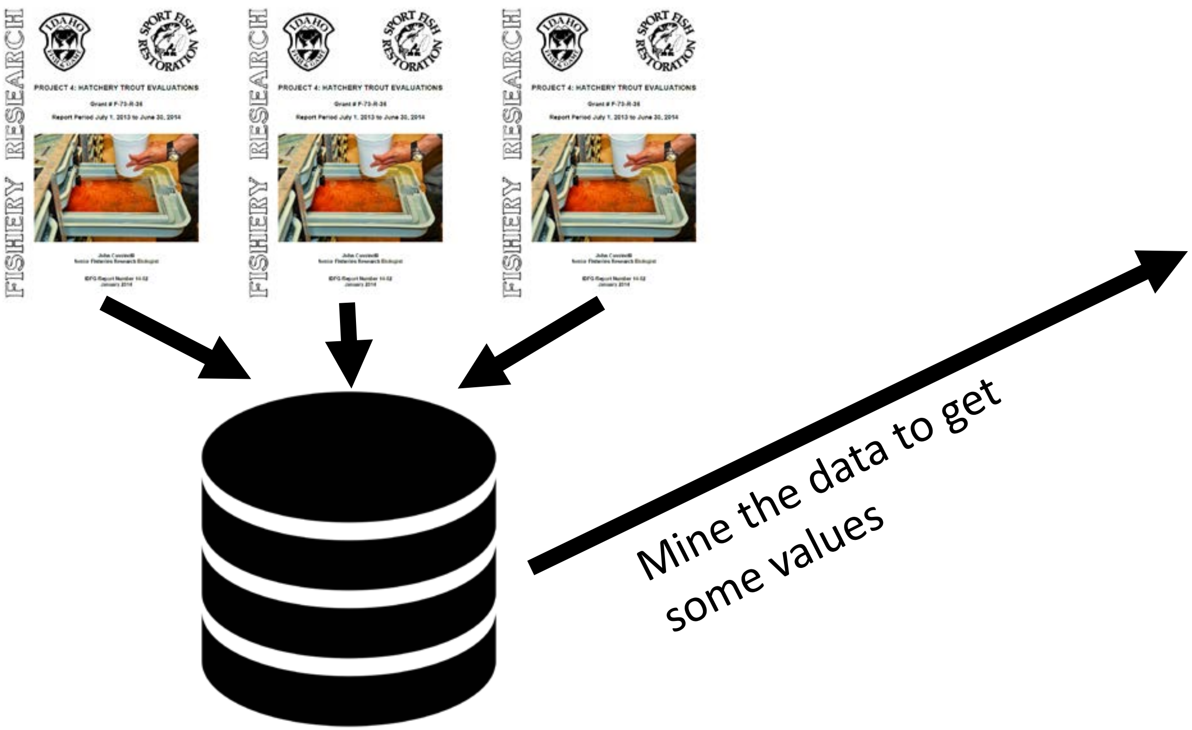
Outcome	Score	Expected value
1.	30	0.33*30=9.9
2.	30	0.33*30=9.9
3.	30	0.33*30=9.9
4.	0	0.33*0=0
5.	0	0.33*0=0
6.	50	0.33*50=16.5
7.	85	0.33*85=28.05
8.	85	0.33*85=28.05
9.	100	0.33*100=33

HOW DO WE MAKE A MANAGEMENT DECISION? CONTINUED…

What if some information is known about return to creel?

Using existing data

Suppose some return to creel studies have been done



Low: <0.25

Proportion of stocked fish harvested (all systems statewide)			
0.56	0.83	0.83	0.84
0	0.69	**0.07**	0.52
0.41	0.56	0.75	0.67
0.57	**0.13**	0.9	**0.17**
0.9	0.51	**0.01**	0.29
0.26	0.65	0.75	**0.22**
0.45	**0.03**	0.89	0.63
0.22	**0.08**	0.62	0.5
0.31	0.86	**0.09**	**0.15**
0.87	0.76	0.47	0.76
0.99	0.3	0.55	0.45
0.29	0.99	0.73	0.6
0.66	0.46	**0.1**	0.51
0.62	0.47	**0.08**	0.98
0.65	0.54	0.66	0.53
0.67	0.84	**0.1**	**0.05**
0.69	**0.05**	0.74	0.57
0.05	0.38	0.78	0.62
0.94	0.27	0.76	0.66

n=17

Probability=0.18

5

Med: 0.25 to 0.75

Proportion of stocked fish harvested (all systems statewide)			
0.56	0.83	0.83	0.84
0	**0.69**	0.07	**0.52**
0.41	**0.56**	**0.75**	**0.67**
0.57	0.13	0.9	0.17
0.9	**0.51**	0.01	**0.29**
0.26	**0.65**	**0.75**	0.22
0.45	0.03	0.89	**0.63**
0.22	0.08	**0.62**	**0.5**
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0.66	**0.46**	0.1	**0.51**
0.62	**0.47**	0.08	0.98
0.65	**0.54**	**0.66**	**0.53**
0.67	0.84	0.1	0.05
0.69	0.05	**0.74**	**0.57**
0.05	**0.38**	0.78	**0.62**
0.94	**0.27**	0.76	**0.66**

n=50

Probability=0.54

3

High: >0.75

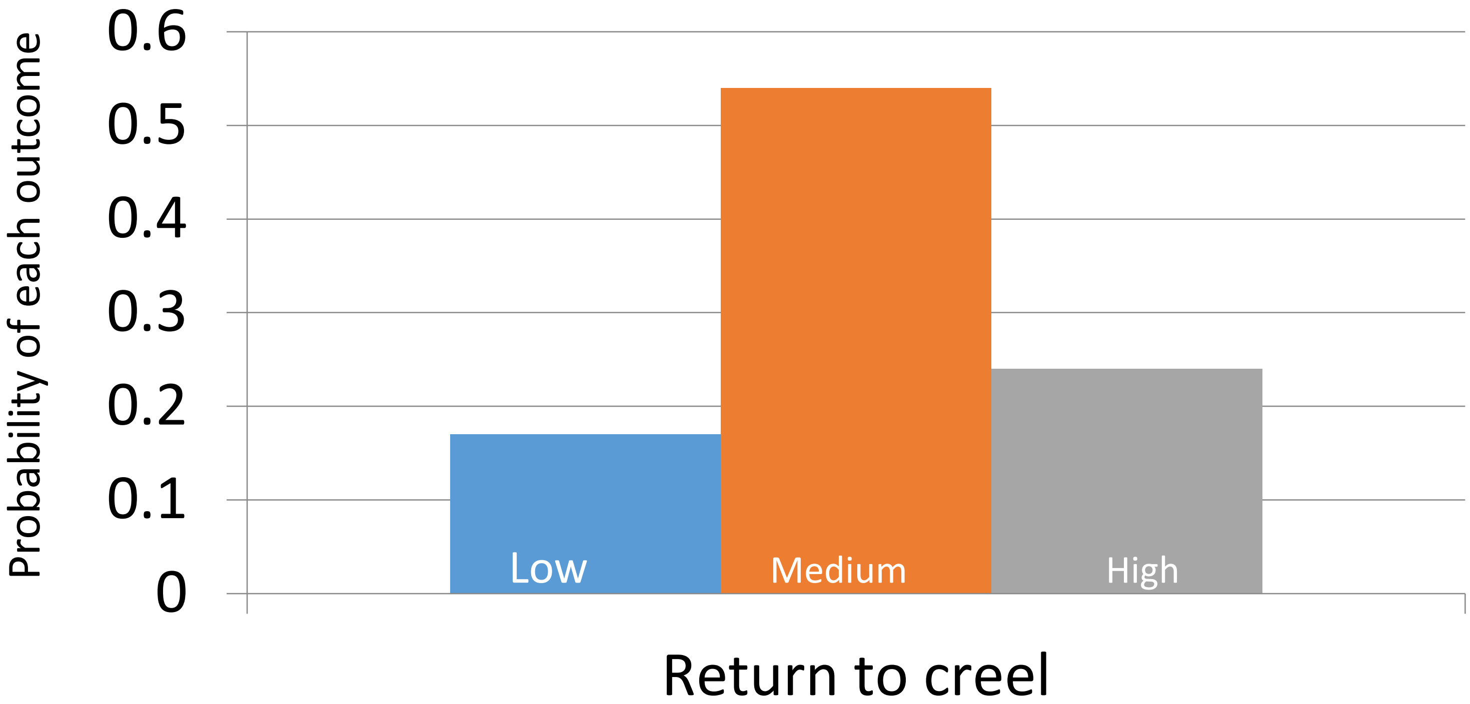
Proportion of stocked fish harvested (all systems statewide)			
0.56	**0.83**	**0.83**	**0.84**
0	0.69	0.07	0.52
0.41	0.56	**0.75**	0.67
0.57	0.13	**0.9**	0.17
0.9	0.51	0.01	0.29
0.26	0.65	**0.75**	0.22
0.45	0.03	**0.89**	0.63
0.22	0.08	0.62	0.5
0.31	**0.86**	0.09	0.15
0.87	**0.76**	0.47	**0.76**
0.99	0.3	0.55	0.45
0.29	**0.99**	0.73	0.6
0.66	0.46	0.1	0.51
0.62	0.47	0.08	**0.98**
0.65	0.54	0.66	0.53
0.67	**0.84**	0.1	0.05
0.69	0.05	0.74	0.57
0.05	0.38	**0.78**	0.62
0.94	0.27	**0.76**	0.66

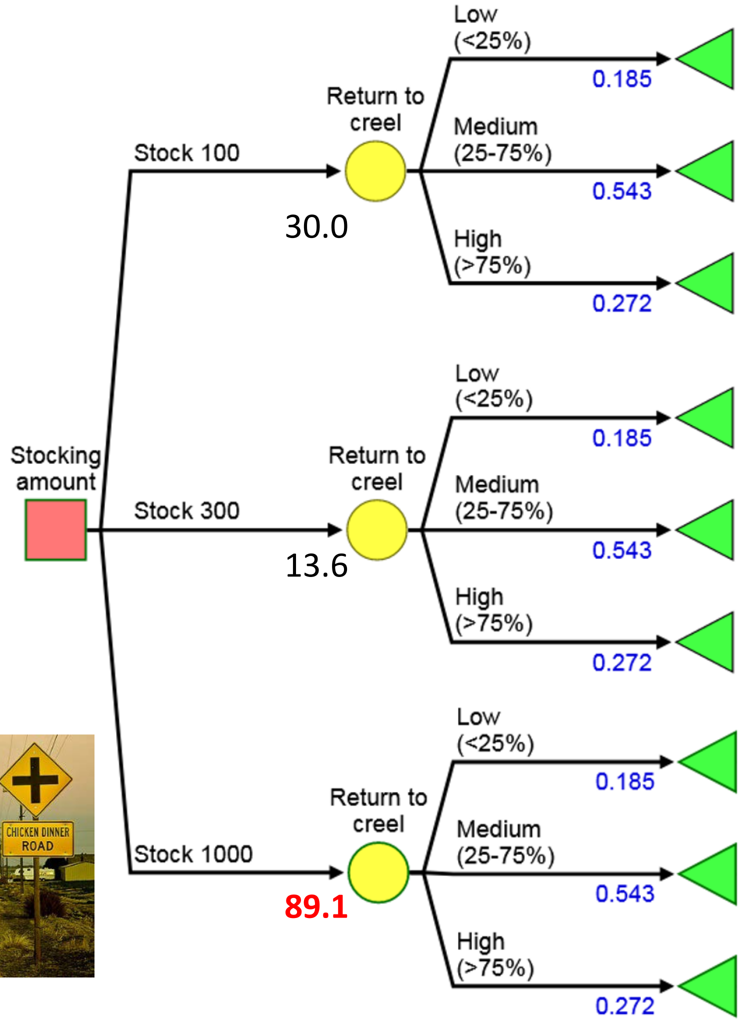
n=25

Probability=0.27

2

What if some information is known about return to creel?





Outcome	Score	Expected value	
1.	30	0.185*30=5.6	
2.	30	0.543*30=16.3	30.0
3.	30	0.272*30=8.2	
4.	0	0.185*0=0	
5.	0	0.543*0=0	13.6
6.	50	0.272*50=13.6	
7.	85	0.185*85=15.7	
8.	85	0.543*85=46.2	89.1
9.	100	0.272*100=27.2	

What if multiple lakes are stocked but frog presence is uncertain?

Adding more complexity & uncertainty to the decision model

Decision problem components

Decision

1. 100 rainbow trout stocked
2. 300 rainbow trout stocked
3. 1000 rainbow trout stocked

Return to creel

1. Low (<25%) — Probability=0.17
2. Medium (25-75%) — Probability=0.49
3. High (>75%) — Probability=0.21

Frog present?

1. Yes — Probability=0.5
2. No — Probability=0.5

Decision problem components

Decision

1. 100 rainbow trout stocked
2. 300 rainbow trout stocked
3. 1000 rainbow trout stocked

Return to creel

1. Low (<25%) Probability=0.17
2. Medium (25-75%) Probability=0.49
3. High (>75%) Probability=0.21

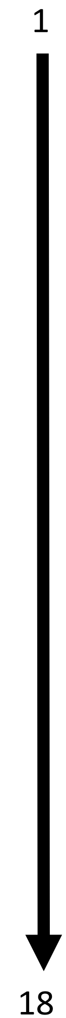
Frog present?

1. Yes Probability=0.5
2. No Probability=0.5

Completely uncertain… Don't know if frogs are occupying the lake to be stocked or not….

18 outcomes &
too many to rank…

Decision problems
can become big!



Decision Alternatives

1. Stock 100 Trout = $375
2. Stock 300 Trout = $625
3. Stock 1000 Trout = $1250

Predicted outcomes

Stocking	Frog present	Return to creel	id	Frog predation	Angler satisfaction	Maximize bag	Cost
100	Yes	Low	1	Medium	Low	Low	375
		Medium	2	Medium	Low	Medium	375
		High	3	Low	Medium	High	375
	No	Low	4	None	Low	Low	375
		Medium	5	None	Low	Medium	375
		High	6	None	Medium	High	375
300	Yes	Low	7	High	Low	Low	626
		Medium	8	Medium	Medium	Medium	626
		High	9	Low	Medium	High	626
	No	Low	10	None	Low	Low	626
		Medium	11	None	Medium	Medium	626
		High	12	None	Medium	High	626
1000	Yes	Low	13	High	Medium	Low	1250
		Medium	14	Medium	High	Medium	1250
		High	15	Low	High	High	1250
	No	Low	16	None	Medium	Low	1250
		Medium	17	None	High	Medium	1250
		High	18	None	High	High	1250

Linking outcomes to values

Stocking	Frog present	Return to creel	id	Minimize frog predation	Maximize angler satisfaction	Maximize bag	Cost
100	Yes	Low	1	Medium: 2	Low: 1	Low: 1	375
		Medium	2	Medium: 2	Low: 1	Medium: 2	375
		High	3	Low: 1	Medium: 2	High: 3	375
	No	Low	4	None: 0	Low: 1	Low: 1	375
		Medium	5	None: 0	Low: 1	Medium: 2	375
		High	6	None: 0	Medium: 2	High: 3	375
300	Yes	Low	7	High: 3	Low: 1	Low: 1	626
		Medium	8	Medium: 2	Medium: 2	Medium: 2	626
		High	9	Low: 1	Medium: 2	High: 3	626
	No	Low	10	None: 0	Low: 1	Low: 1	626
		Medium	11	None: 0	Medium: 2	Medium: 2	626
		High	12	None: 0	Medium: 2	High: 3	626
1000	Yes	Low	13	High: 3	Medium: 2	Low: 1	1250
		Medium	14	Medium: 2	High: 3	Medium: 2	1250
		High	15	Low: 1	High: 3	High: 3	1250
	No	Low	16	None: 0	Medium: 2	Low: 1	1250
		Medium	17	None: 0	High: 3	Medium: 2	1250
		High	18	None: 0	High: 3	High: 3	1250

Utilities-translate objectives to numbers

Stocking	Frog present	Return to creel	id	Minimize frog predation	Maximize angler satisfaction	Maximize bag	Weighted Utility	Cost	Overall
100	Yes	Low	1	0.33	0	0	0.11	375	0.0003
		Medium	2	0.33	0	0.5	0.275	375	0.0007
		High	3	0.67	0.5	1	0.715	375	0.0019
	No	Low	4	1.00	0	0	0.33	375	0.0009
		Medium	5	1.00	0	0.5	0.495	375	0.0013
		High	6	1.00	0.5	1	0.825	375	0.0022
300	Yes	Low	7	0.00	0	0	0	626	0
		Medium	8	0.33	0.5	0.5	0.44	626	0.0007
		High	9	0.67	0.5	1	0.715	626	0.0011
	No	Low	10	1.00	0	0	0.33	626	0.0005
		Medium	11	1.00	0.5	0.5	0.66	626	0.0011
		High	12	1.00	0.5	1	0.825	626	0.0013
1000	Yes	Low	13	0.00	0.5	0	0.165	1250	0.0001
		Medium	14	0.33	1	0.5	0.605	1250	0.0005
		High	15	0.67	1	1	0.88	1250	0.0007
	No	Low	16	1.00	0.5	0	0.495	1250	0.0004
		Medium	17	1.00	1	0.5	0.825	1250	0.0007
		High	18	1.00	1	1	0.99	1250	0.0008

Utilities

Stocking	Frog present	Return to creel	id	Minimize frog predation	Maximize angler satisfaction	Maximize bag	Weighted Utility	Cost	Overall
100	Yes	Low	1	0.33	0	0	0.11	375	0.0003
		Medium	2	0.33	0	0.5	0.275	375	0.0007
					0.5	1	0.715	375	0.0019
	No				0	0	0.33	375	0.0009
		l			0				0.0013
					0.5				0.0022
300	Yes				0				0
					0.5	0.5	0.44	626	0.0007
		High	9	0.67	0.5	1	0.715	626	0.0011
	No	Low	10	1.00	0	0	0.33	626	0.0005
		Medium	11	1.00	0.5	0.5	0.66	626	0.0011
		High	12	1.00			.825	626	0.0013
1000	Yes	Low	13	0.00			.165	1250	0.0001
		Medium	14	0.33			.605	1250	0.0005
		High	15	0.67				1250	0.0007
	No	Low	16	1.00			5	1250	0.0004
		Medium	17	1.00			5	1250	0.0007
		High	18	1.00	1	1	0.99	1250	0.0008

Scale values so low values get a 1

$$Utility = \frac{min(Value) - Value}{max(Value) - min(Value)}$$

Divide utility by cost for a marginal gain

Scale values so high values get a 1

$$Utility = \frac{Value - min(Value)}{max(Value) - min(Value)}$$

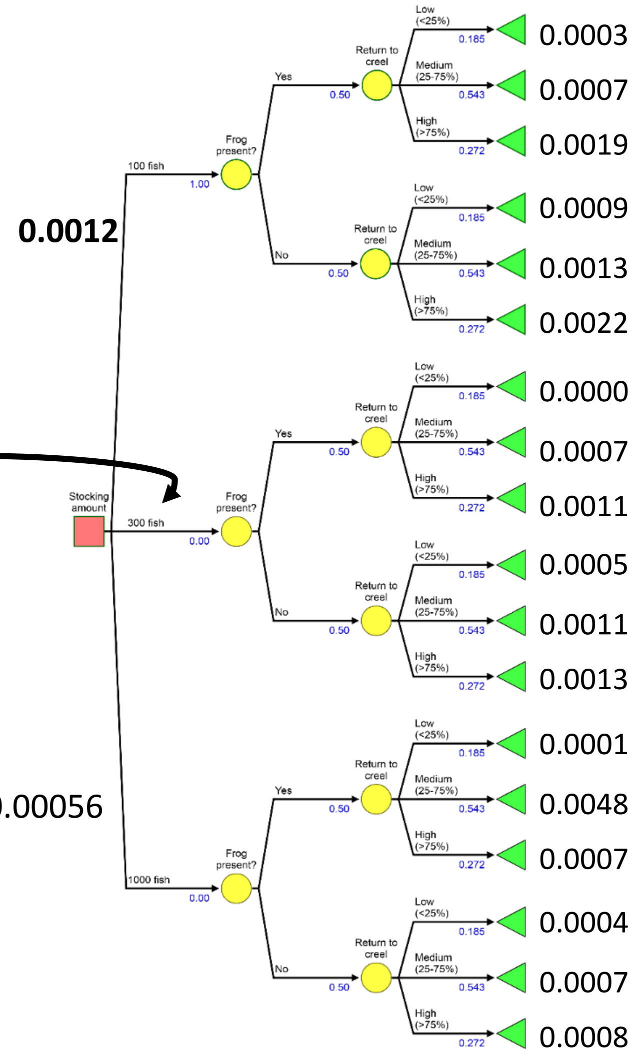
Unsure if frogs are present

Optimal decision

0.0012

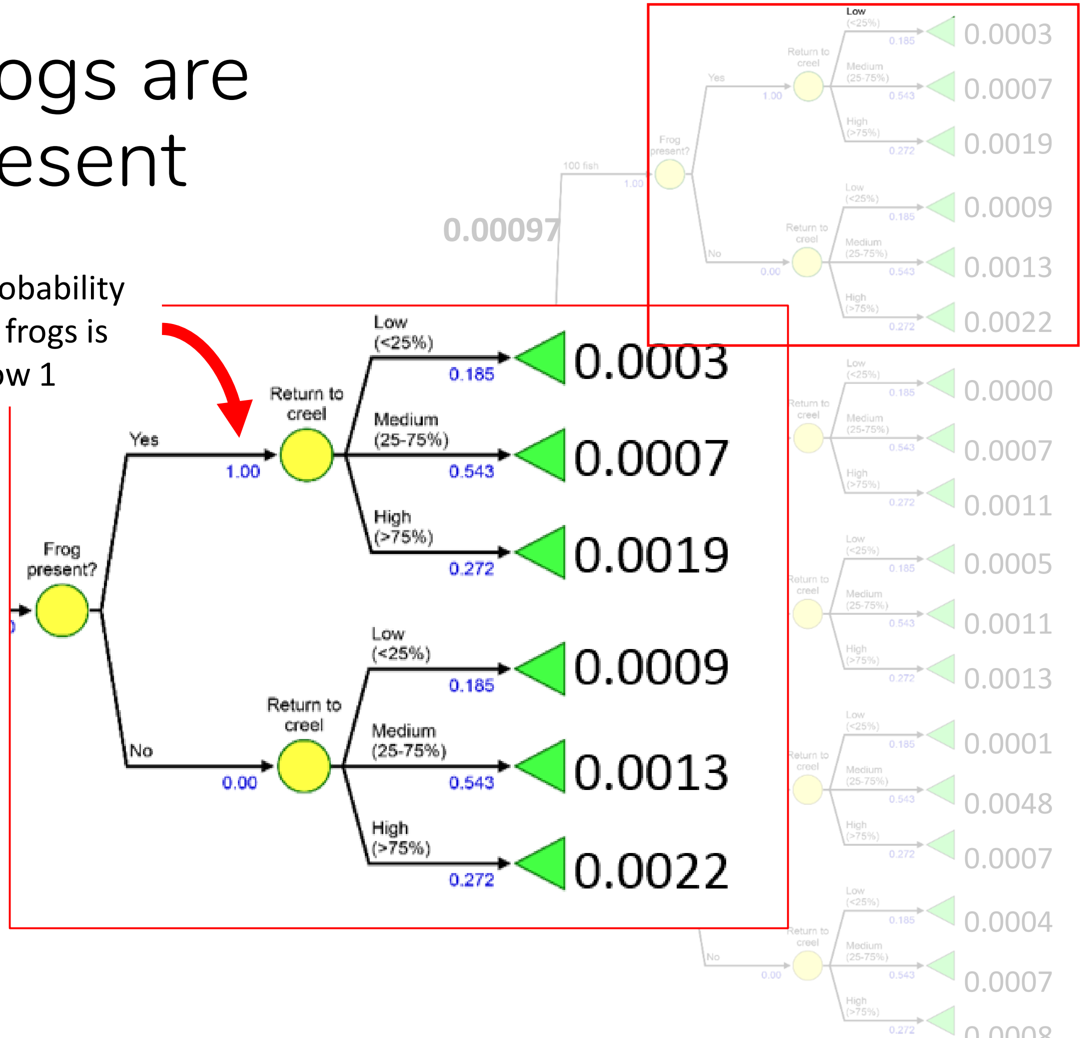
0.00086

0.00056

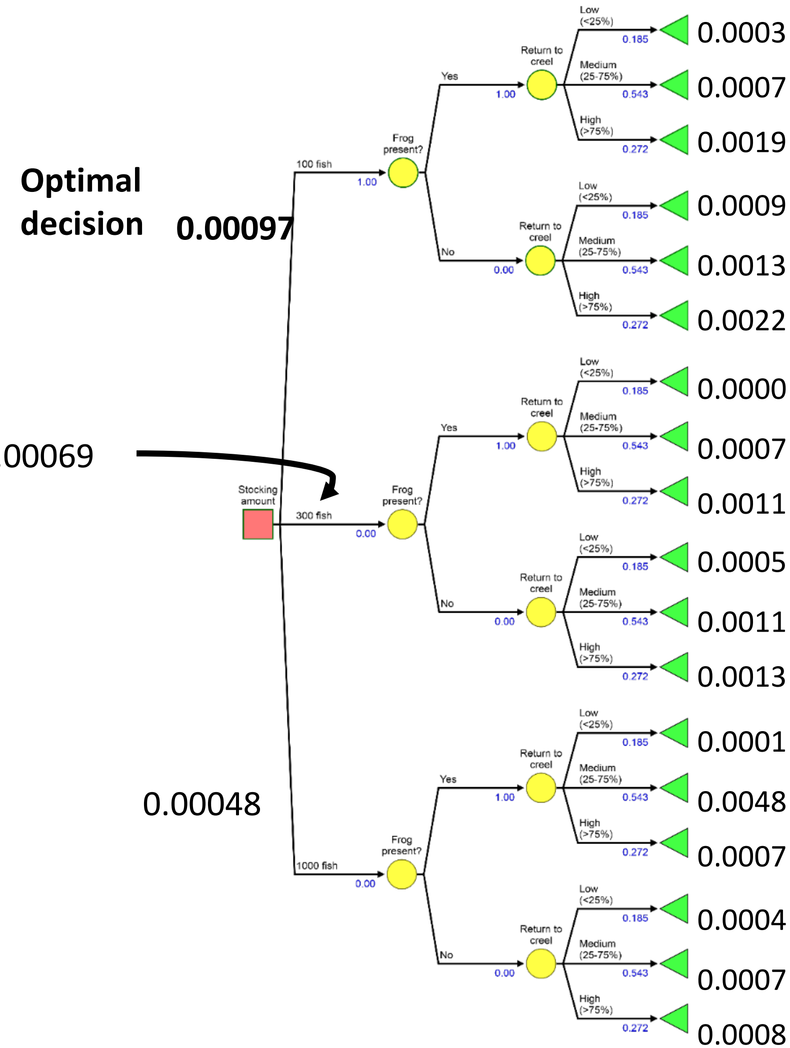


Frogs are present

Probability of frogs is now 1



Frogs are present



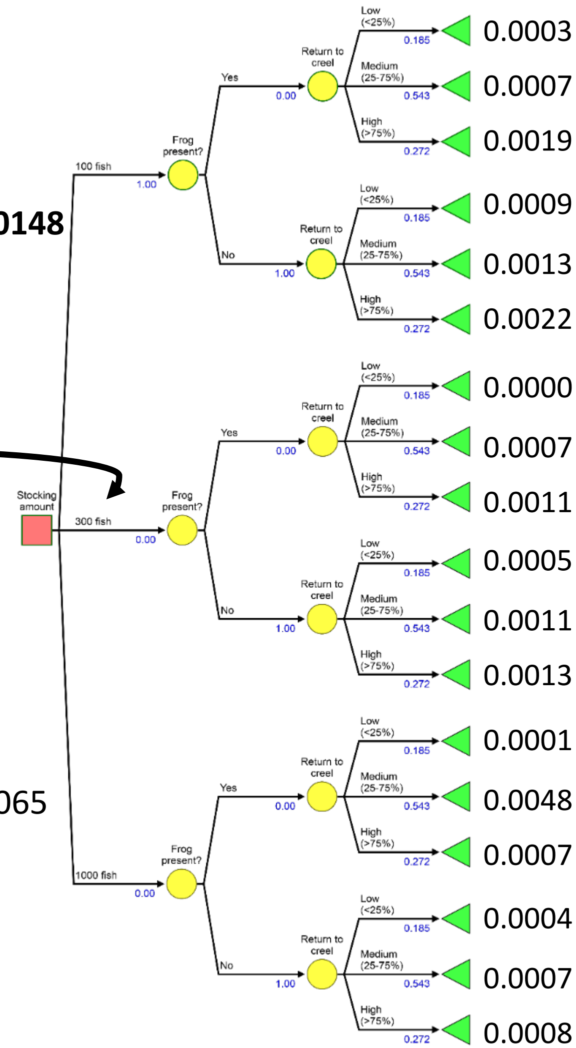
No frogs present

Optimal decision

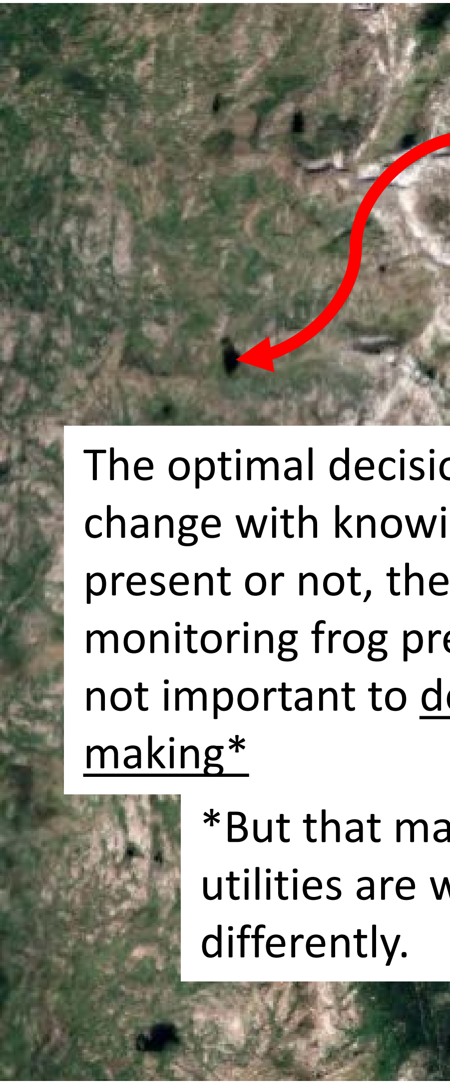
0.00148

0.00103

0.00065

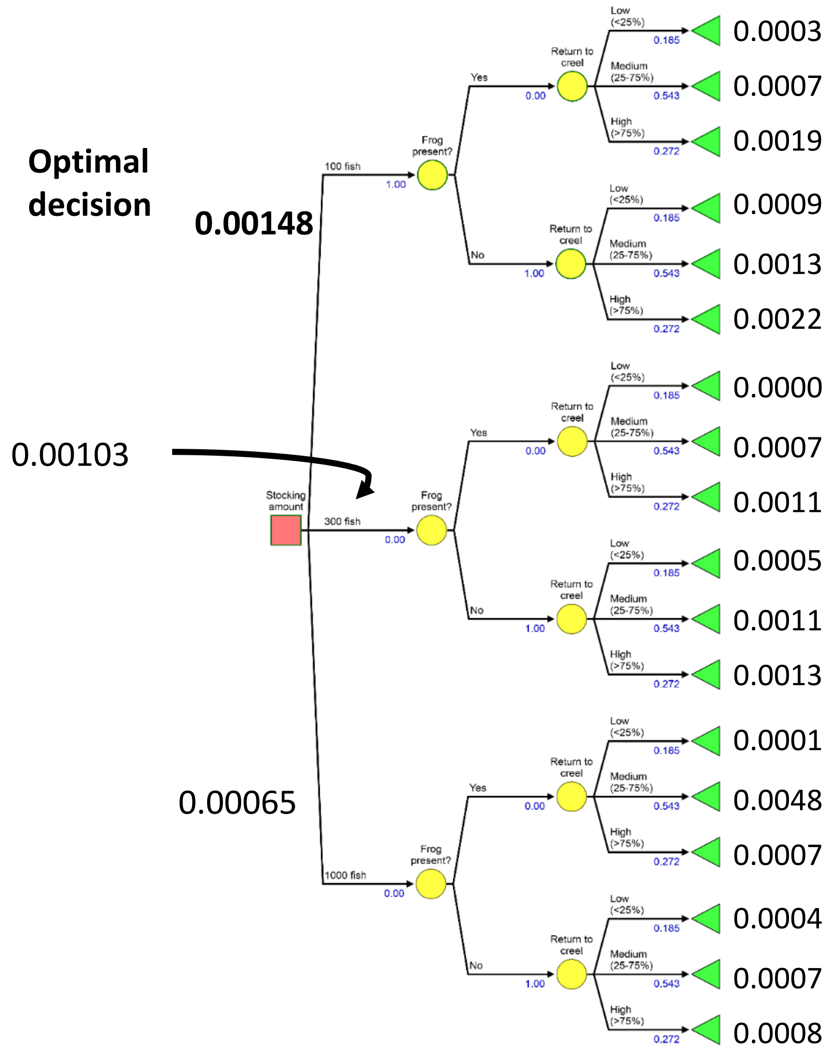


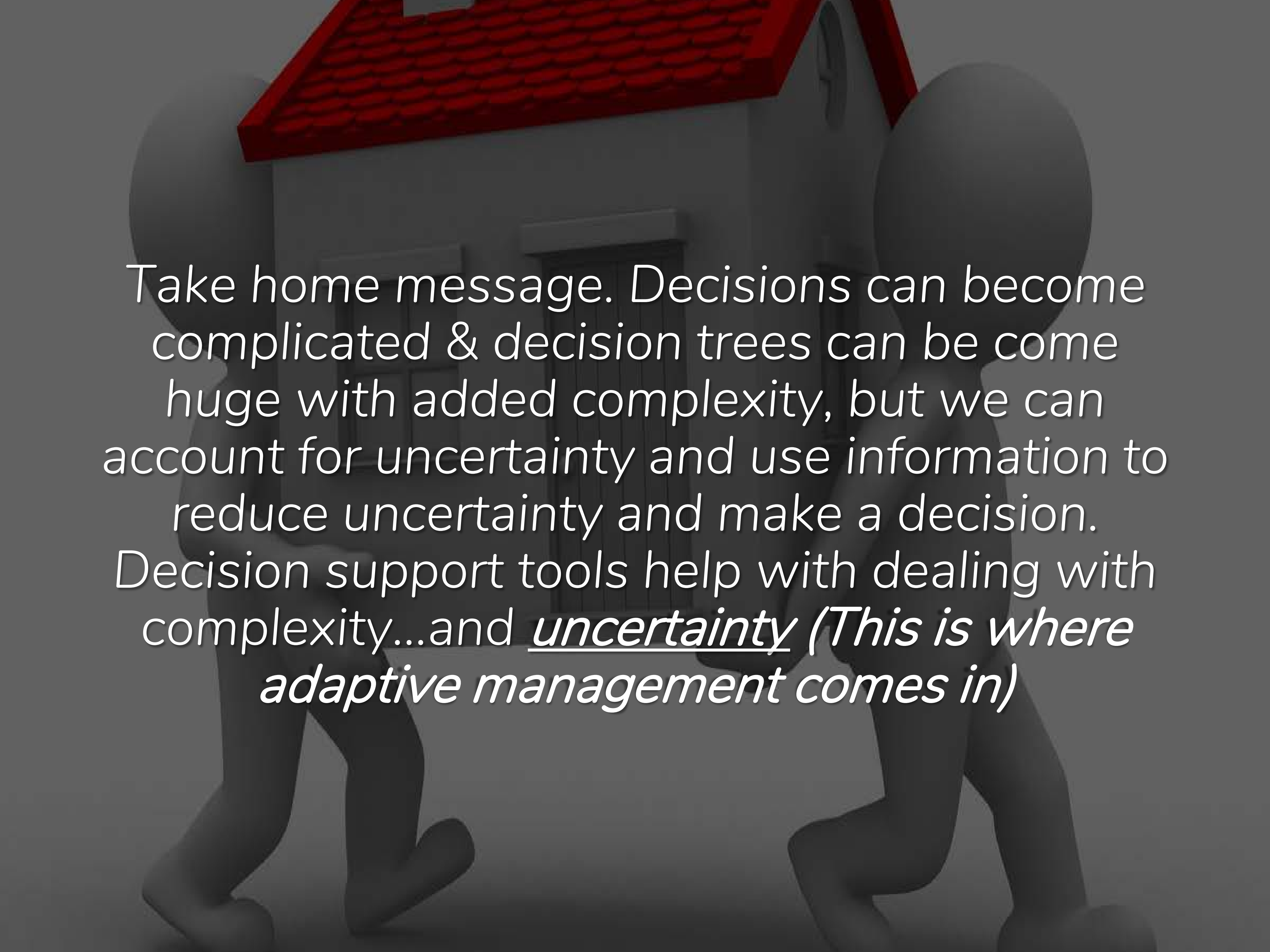
No frogs present



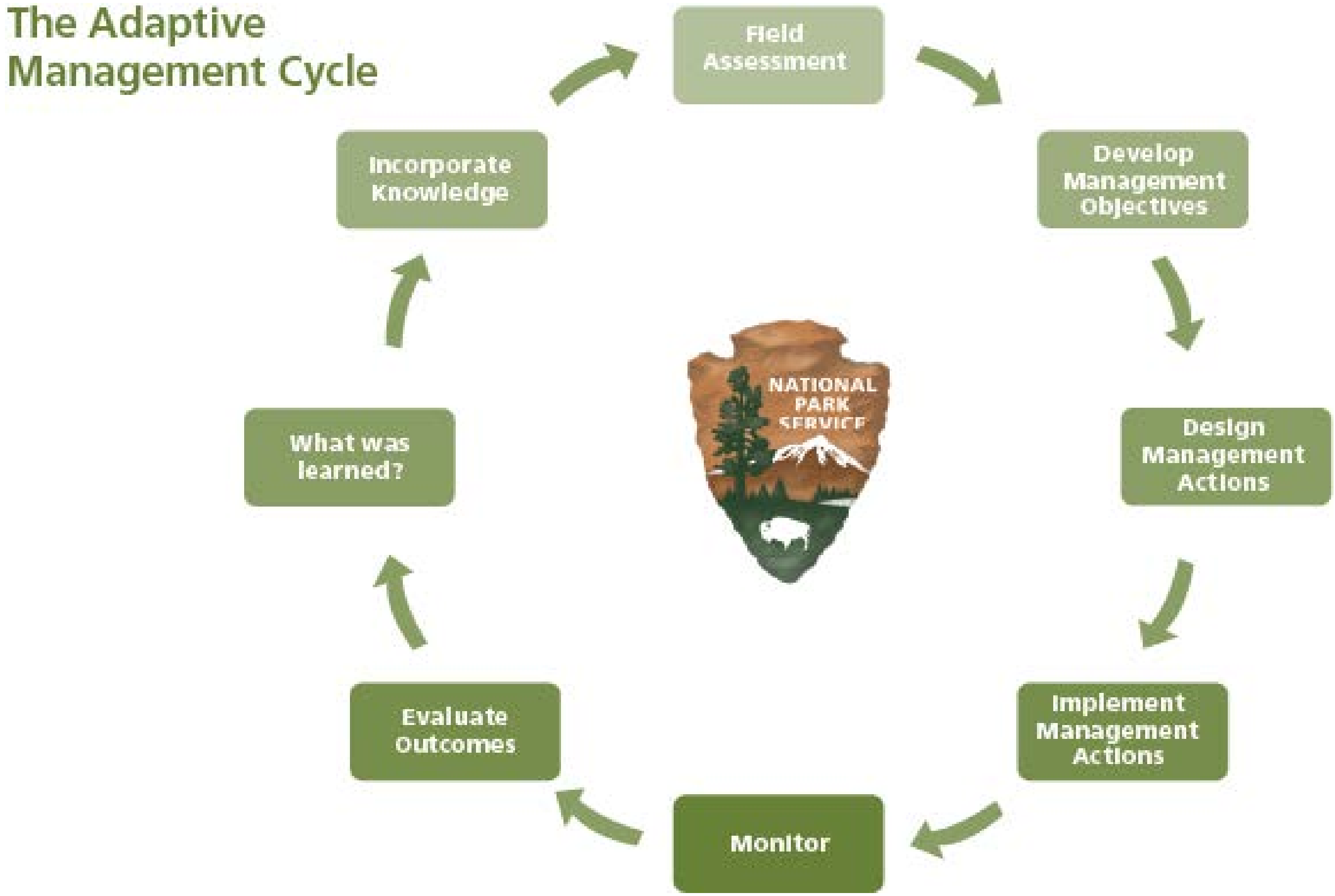
The optimal decision does not change with knowing frogs are present or not, therefore monitoring frog presence is not important to <u>decision making*</u>

*But that may change if utilities are weighted differently.





*Take home message. Decisions can become complicated & decision trees can be come huge with added complexity, but we can account for uncertainty and use information to reduce uncertainty and make a decision. Decision support tools help with dealing with complexity…and **uncertainty** (This is where adaptive management comes in)*



Management, uncertainty, & learning

What is adaptive management?

*“**Learning by doing**, and adapting based on what's learned"*

*“Management in the face of uncertainty, with a focus on the **reduction of that uncertainty**"*

*“Management that recognizes uncertainty in its consequences and seeks **to improve understanding**, so as to **improve decision making.**"*

A special case of SDM

Learning by doing…

…reduction of uncertainty…

…to improve understanding…

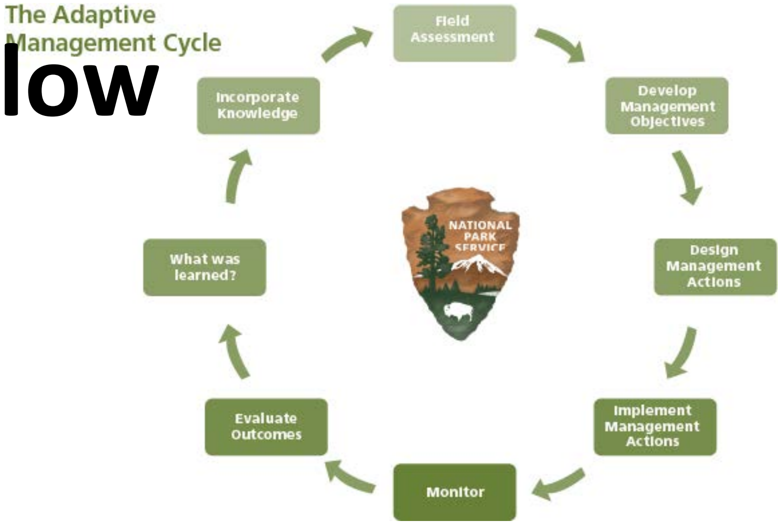
Need a **<u>recurrent</u>** application of management actions over time (or space) to:

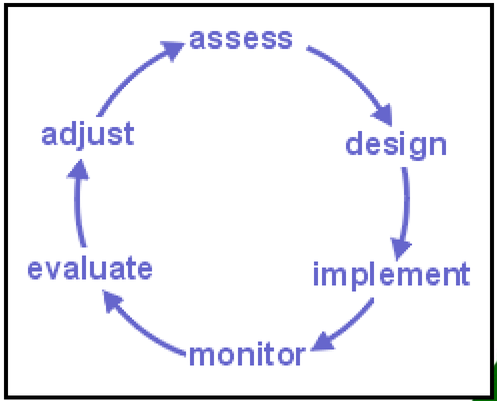
- Learn by doing,
- Improve understanding
- Reduce <u>uncertainty</u>

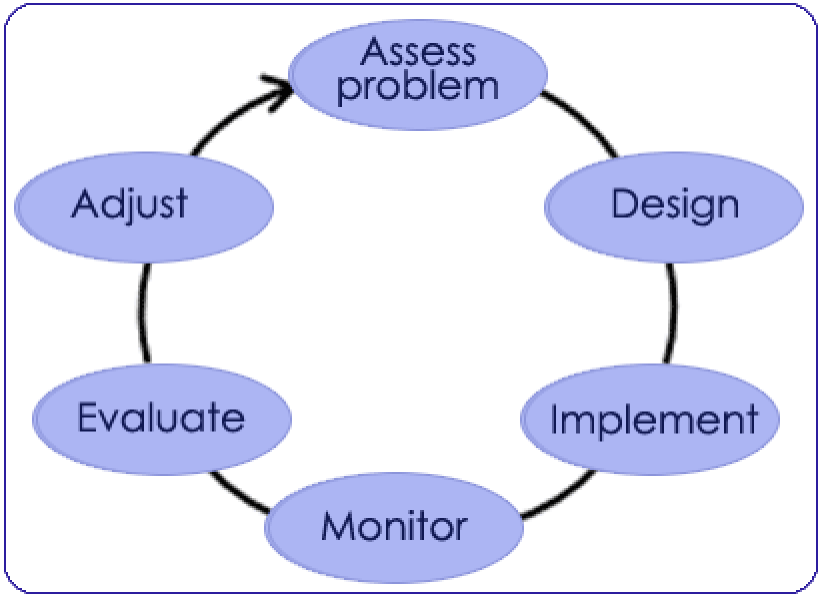
Uncertainty has to be high!

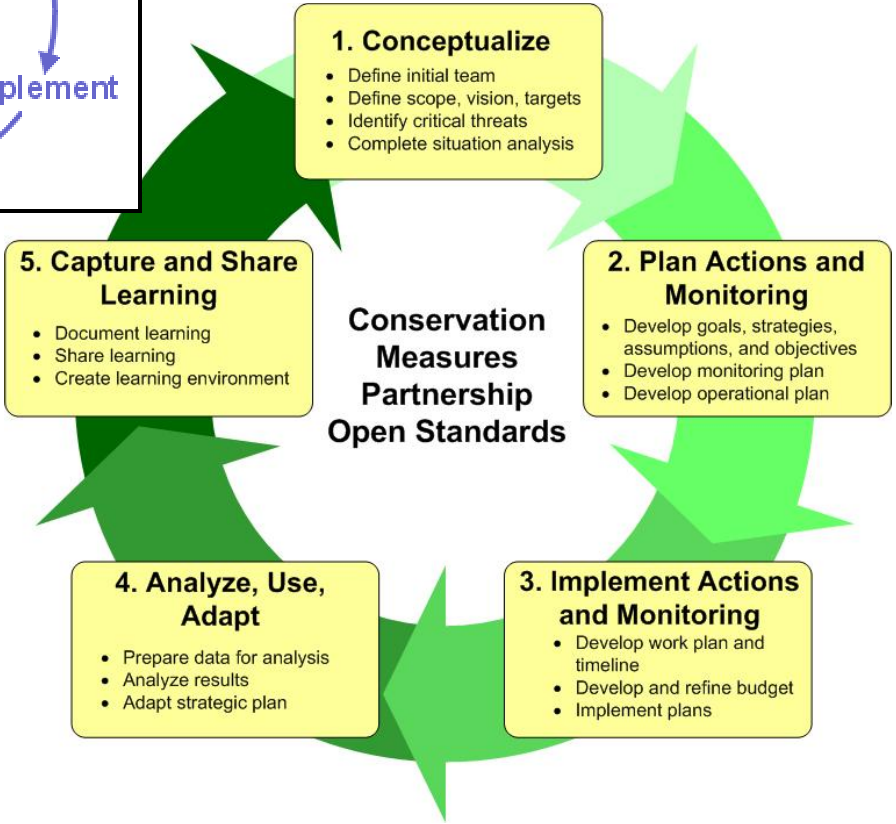
Without uncertainty we cannot learn

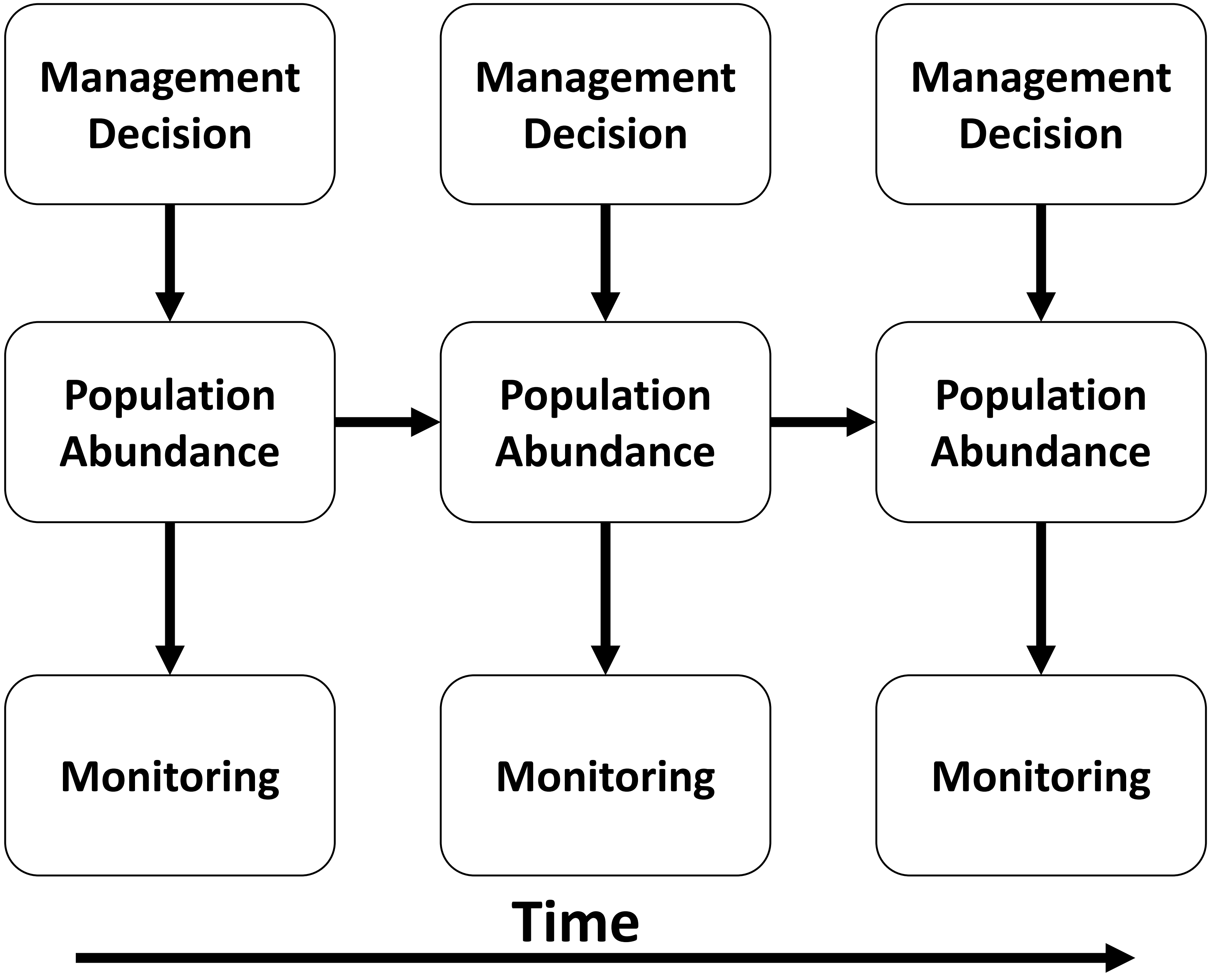
Just pretty flow charts?



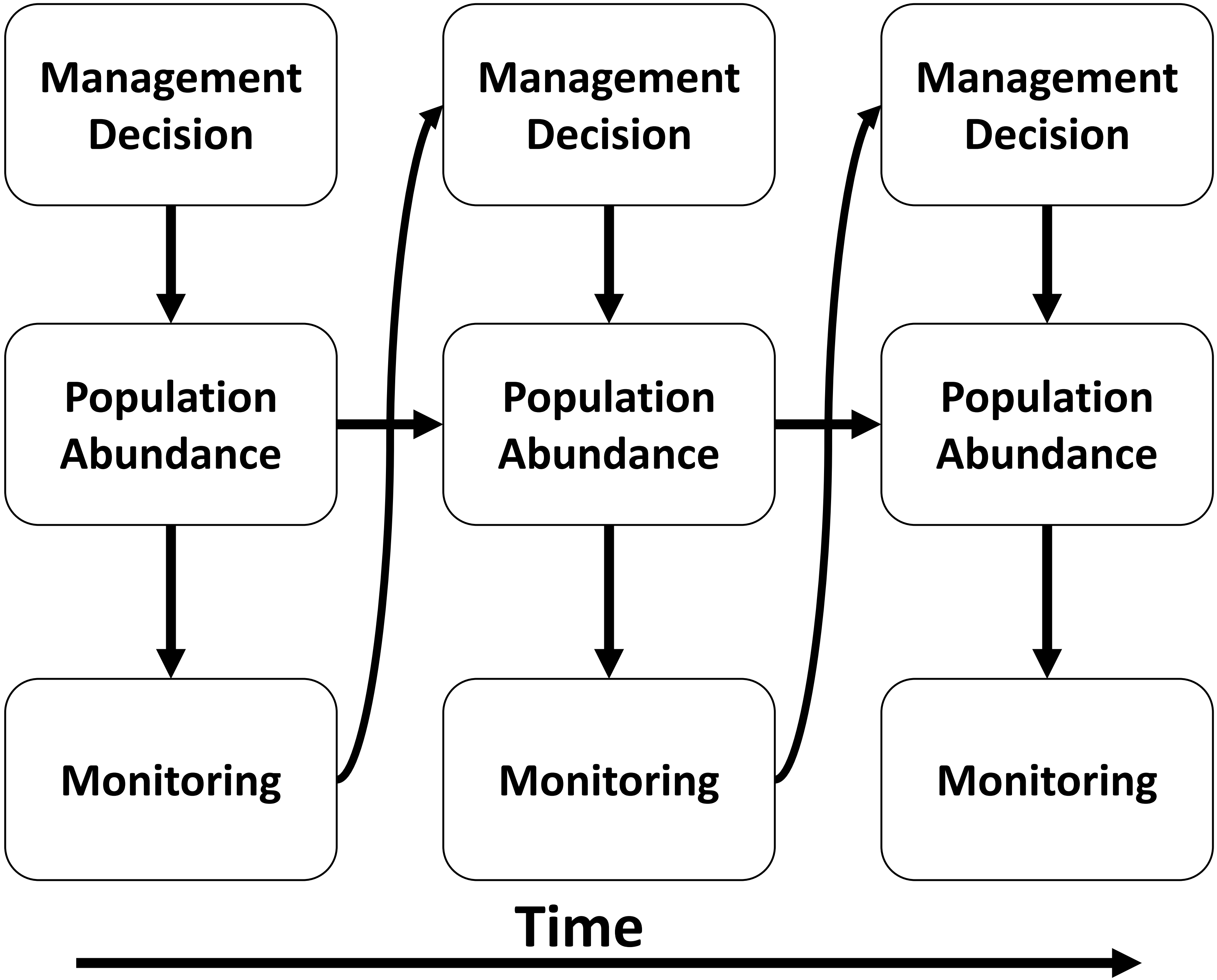








Management Decision
Management Decision
Management Decision
Population Abundance
Population Abundance
Population Abundance
Monitoring
Monitoring
Monitoring
Time


Management Decision
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Management Decision
Population Abundance
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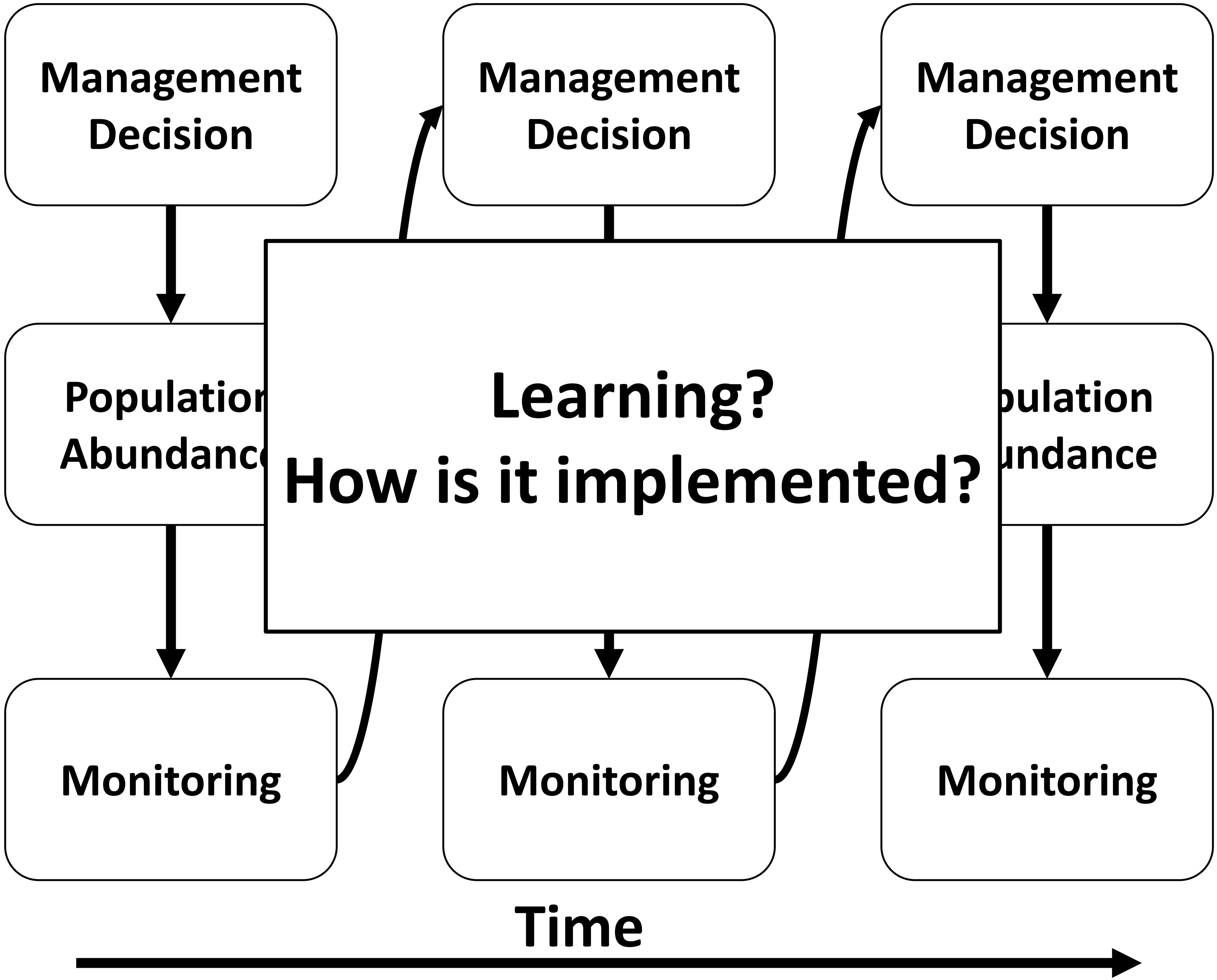
Monitoring
Monitoring
Monitoring
Time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Management Decision
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Population Abundanc
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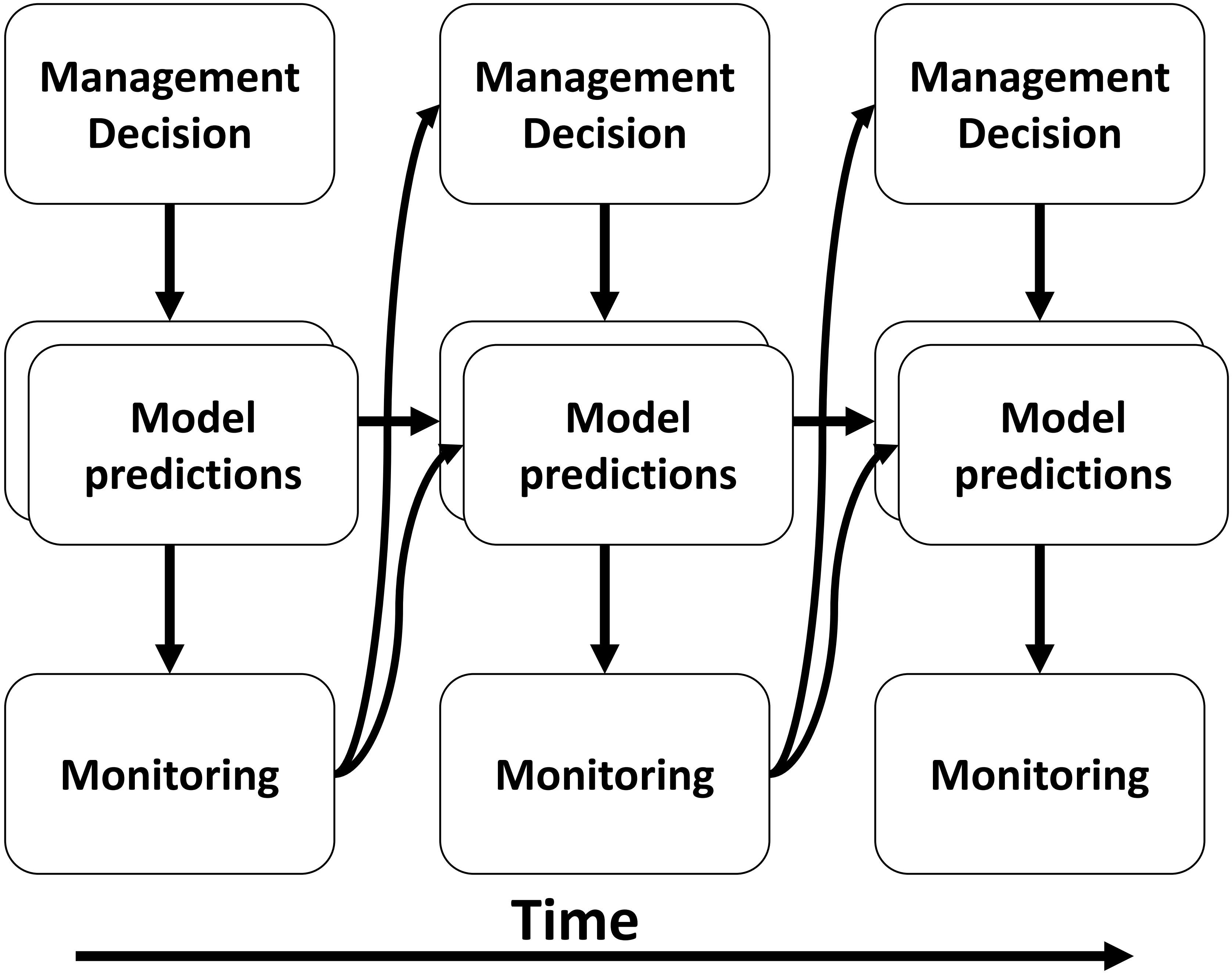
Learning?
How is it implemented?
Monitoring
Monitoring
Monitoring
Time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Management Decision
Management Decision
Model predictions
Model predictions
Model predictions
Monitoring
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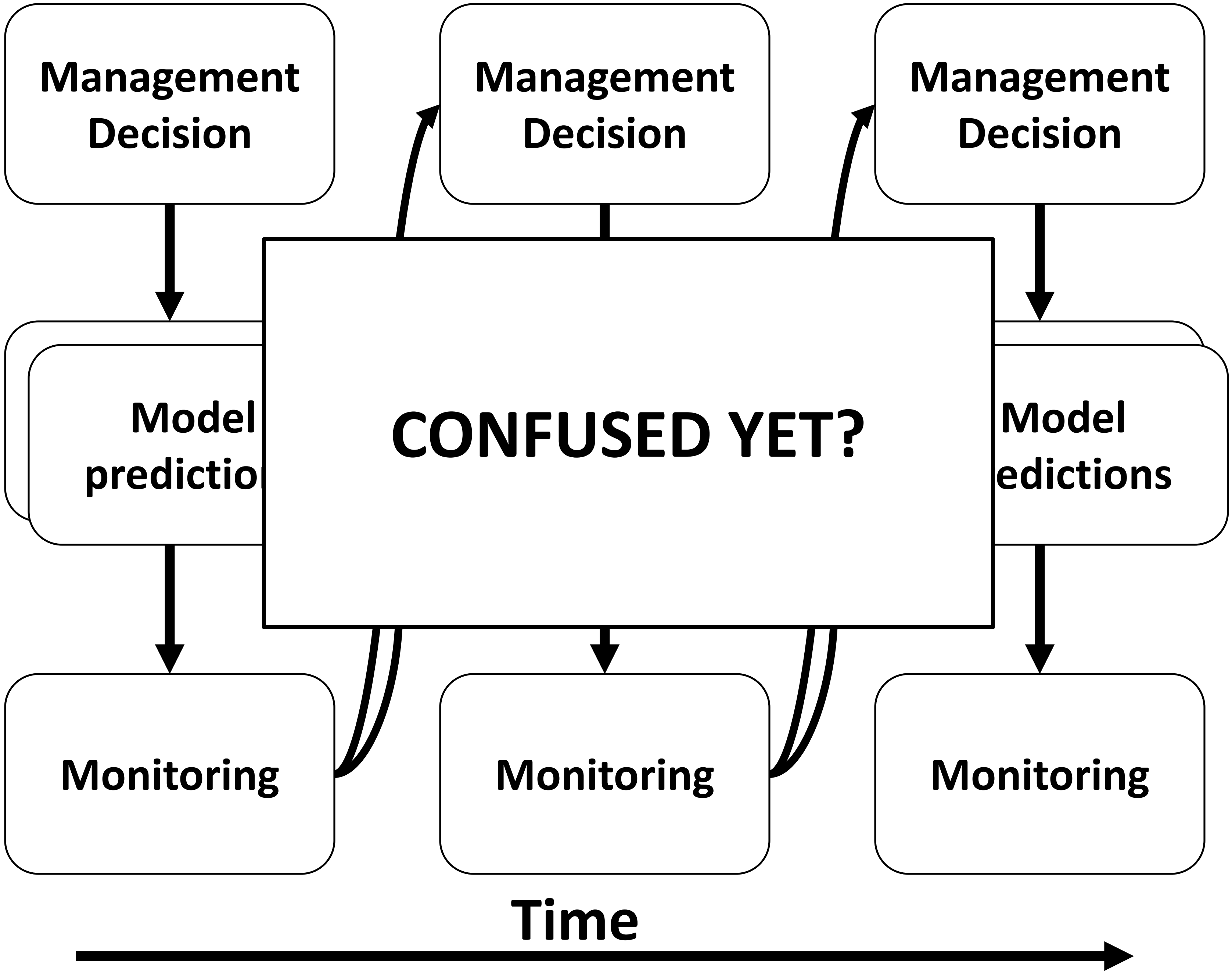
Monitoring
Time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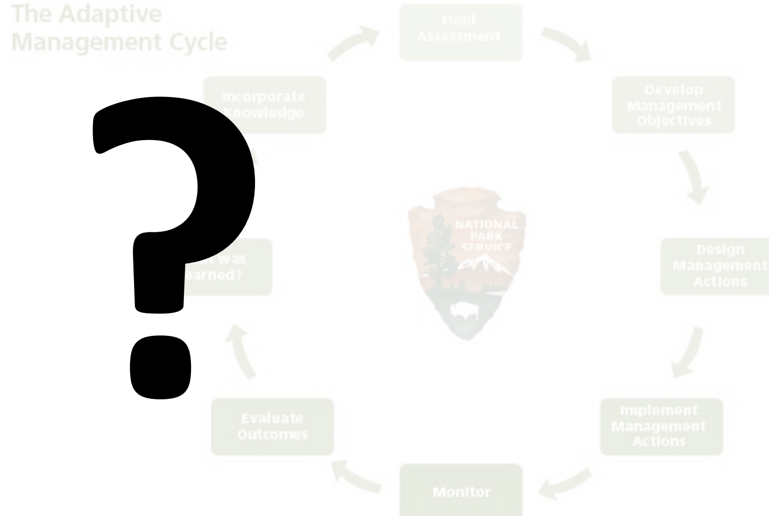
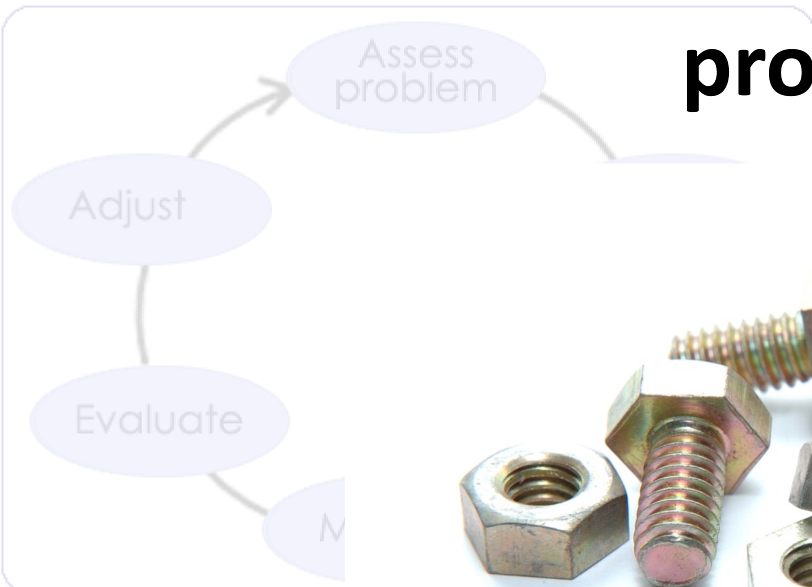
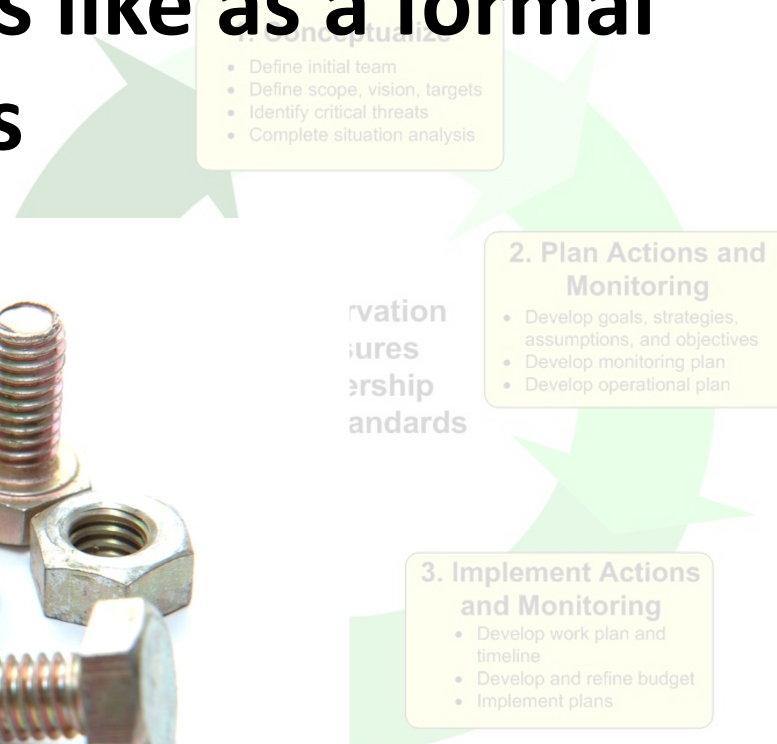


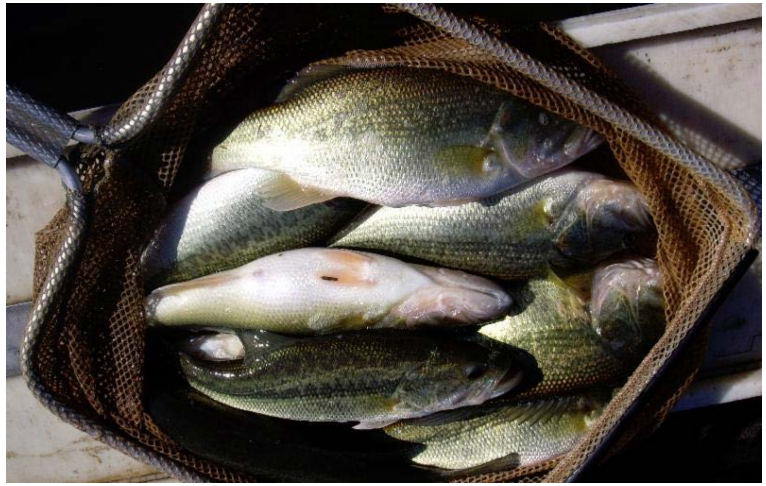
?

Lets see what this looks like as a formal process





Adaptive harvest management






A population of harvestable critters

500 to 2000 critters

Some preliminaries

- Harvest rate decisions

  0.1, 0.2, 0.3, & 0.4

Sustainable… evaluate over an **“infinite” time horizon

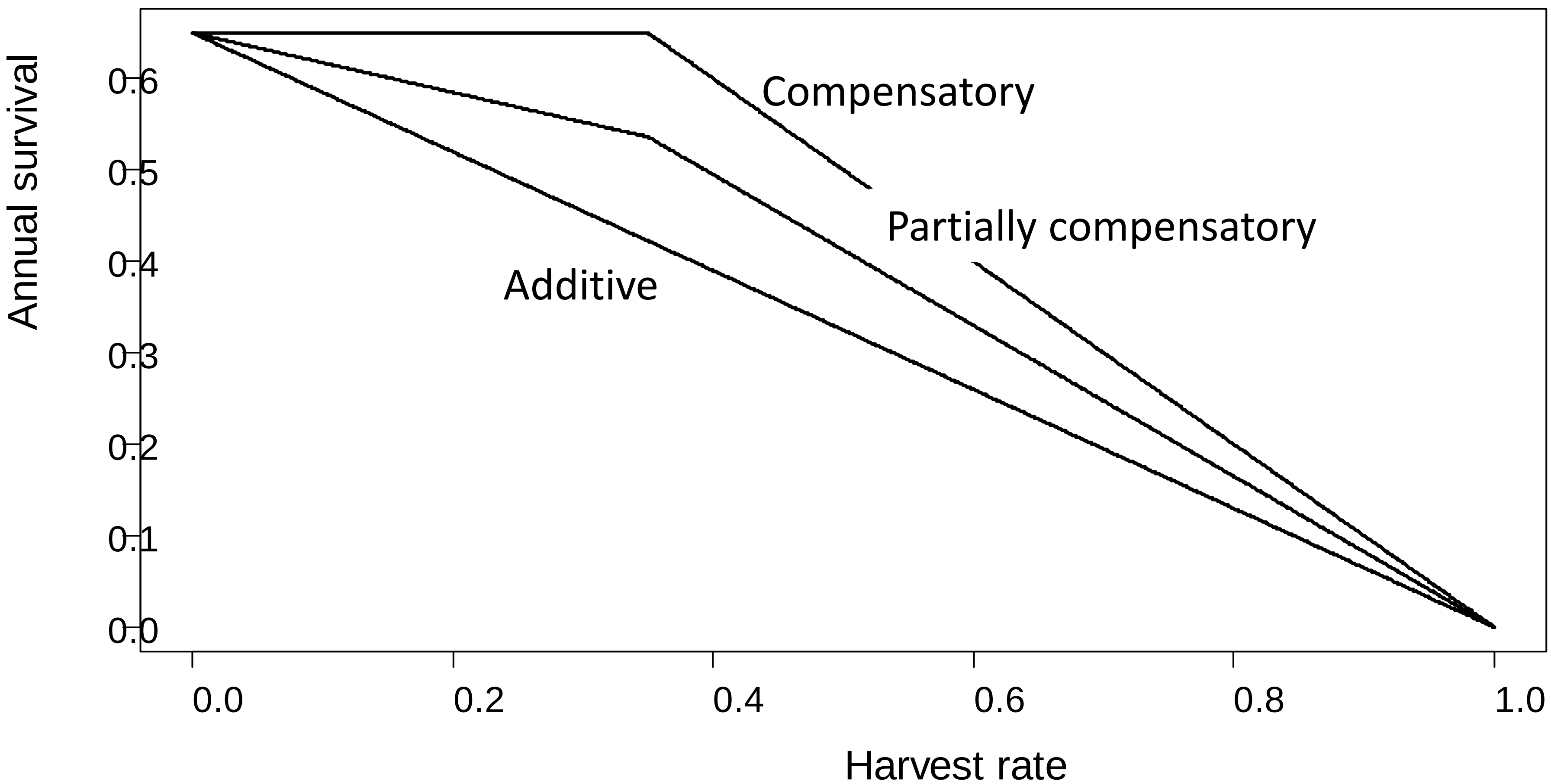
Abundance	Optimal** harvest rate
500-750	?
750-1000	?
1000-1250	?
1250-1500	?
1500-1750	?
1750-2000	?

Structural uncertainty

Where learning occurs

- *Effect of harvest: Additive, Compensatory, Partially compensatory (**3 competing Hypotheses**)*
- *Why is this important?*

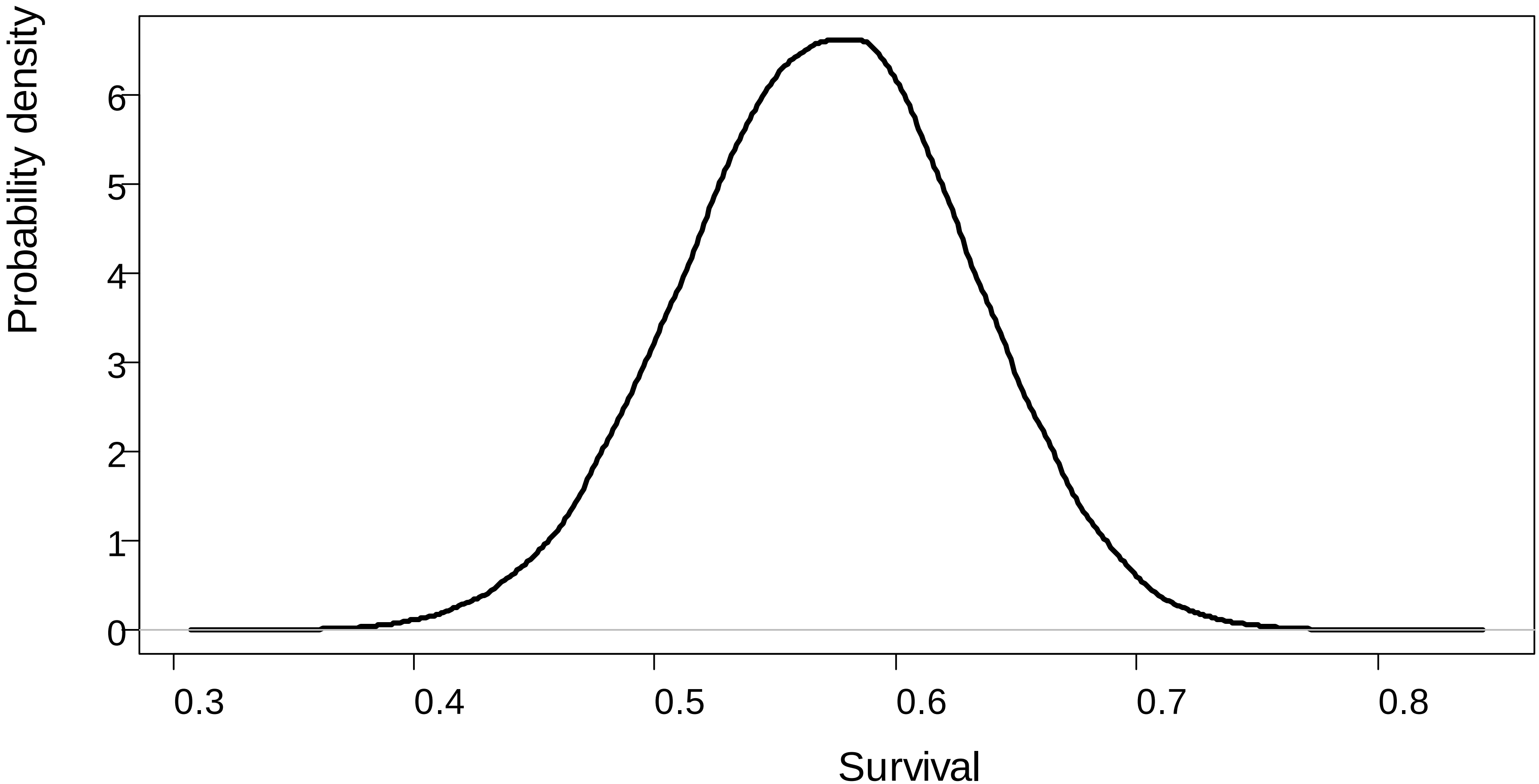
Learning: 3 hypotheses of the effect of harvest on a population



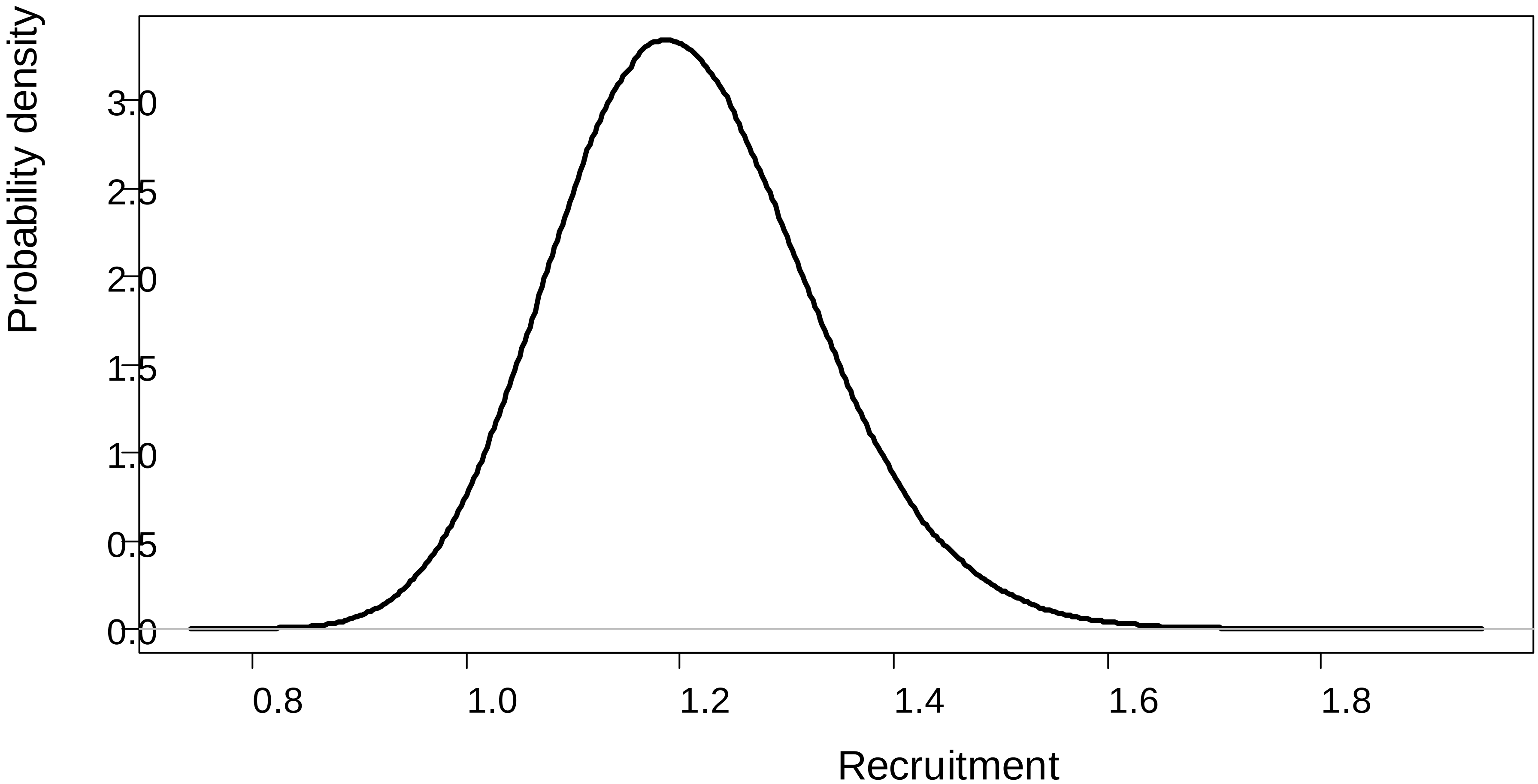
Parameter uncertainty

- *Survival*
- *Recruitment*
- *Current population abundance*

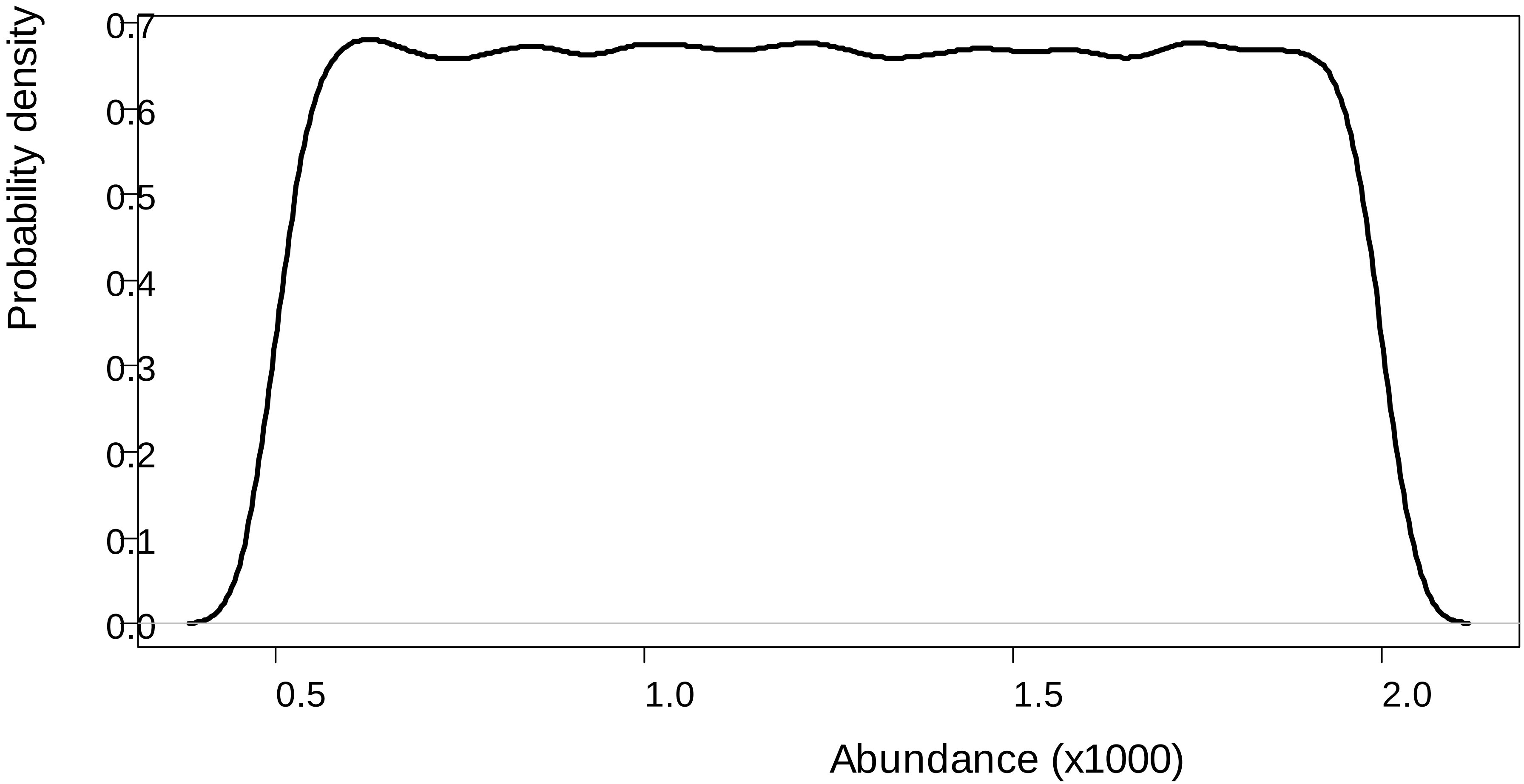
Survival uncertainty



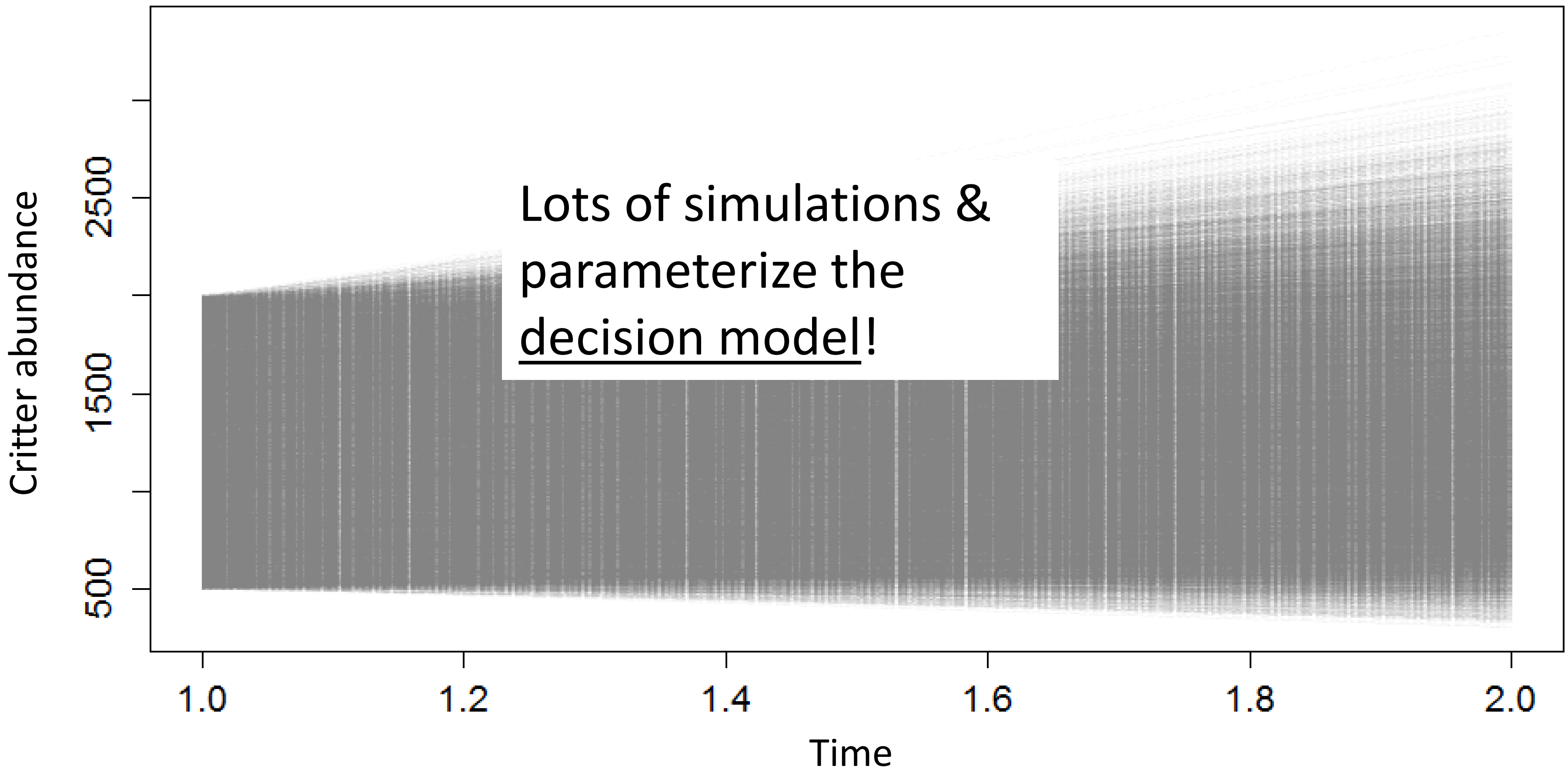
Recruitment uncertainty



Current population abundance



Optimal harvest policies given uncertainty



Optimal harvest policies

Abundance	Optimal harvest rate
500-750	0.1
750-1000	0.1
1000-1250	**0.1**
1250-1500	0.3
1500-1750	0.3
1750-2000	0.3

Optimal sustainable harvest rates given uncertainty from decision model

Implement decision, monitor, and compare

Monitoring data

Critter abundance	1200

Additive	0.33
P. Compensatory	0.33
Compensatory	0.33

Prior beliefs

Now implement harvest decision

Implement decision, monitor, and compare

Monitoring data

Critter abundance	1200	900

Additive	0.33	933	0.01
P. Compensatory	0.33	988	0.76
Compensatory	0.33	1037	0.24

Learning

Model predictions

Update optimal harvest policies given our learning

	Abundance	Optimal harvest rate	
	500-750	0.1	
Current state	**750-1000**	**0.1**	
	1000-1250	*0.2*	Learning
	1250-1500	0.3	
	1500-1750	0.3	
	1750-2000	0.3	

Can harvest more since there is evidence for partial compensation

Implement decision, monitor, and compare

Critter abundance	1200	1000	1183		

Additive	0.33	933	0.01	1001	0.00
P. Compensatory	0.33	988	0.76	1158	0.99
Compensatory	0.33	1037	0.24	1289	0.00

Update optimal harvest policies given our learning

Abundance	Optimal harvest rate
500-750	0.1
750-1000	*0.2*
1000-1250	***0.2***
1250-1500	0.3
1500-1750	0.3
1750-2000	*0.4*

Can harvest more since there is evidence for partial compensation

Implement optimal decision

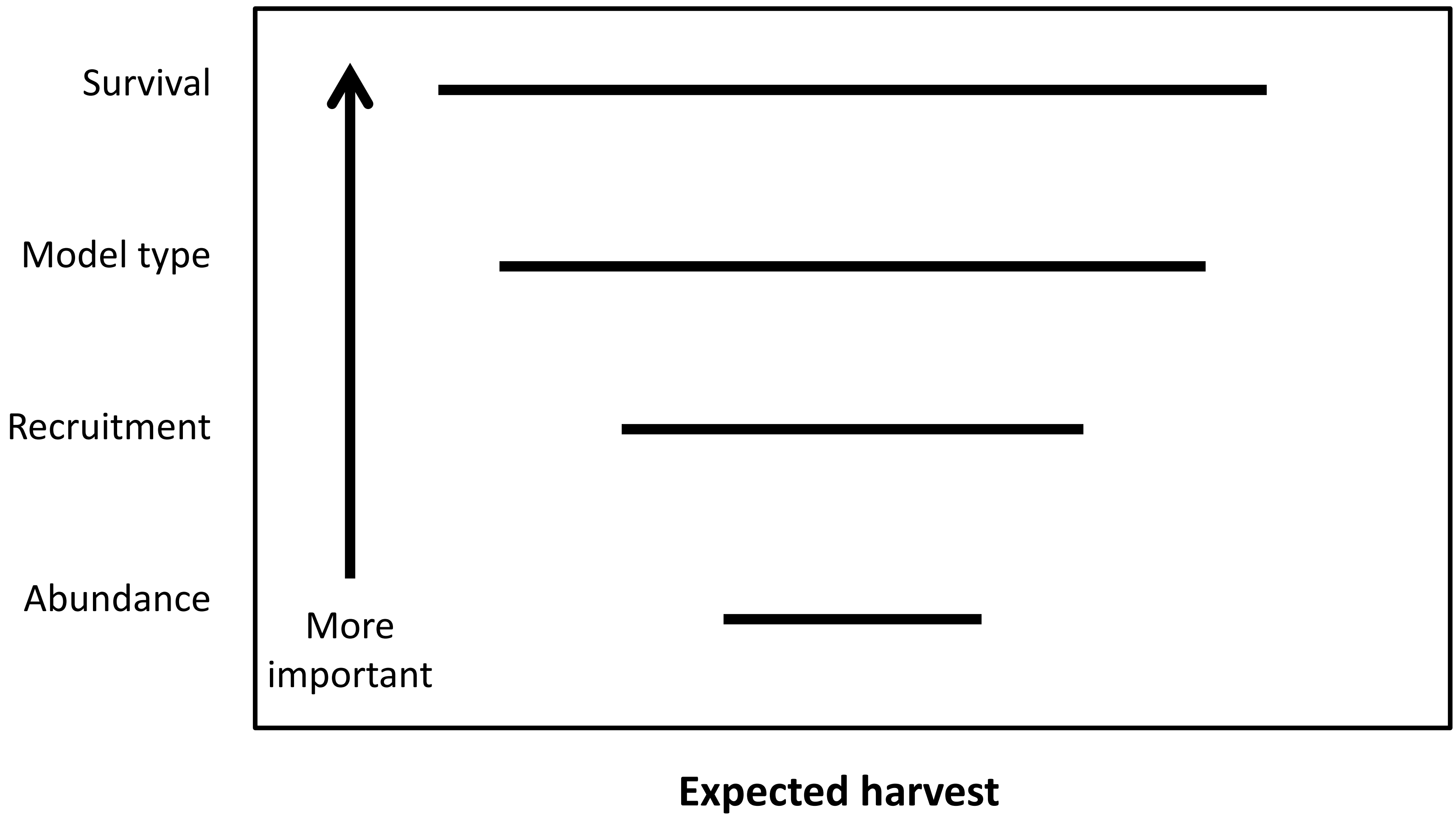
Critter abundance	1200	1000	1183		
Additive	0.33	933	0.01	1001	0.00
P. Compensatory	0.33	988	0.76	1158	0.99
Compensatory	0.33	1037	0.24	1289	0.00

Abundance	Optimal harvest rate
500-750	0.1
750-1000	**0.1**
1000-1250	0.2
1250-1500	0.3
1500-1750	0.3
1750-2000	0.3

Update learning and make better decisions

There we go, we are learning by doing!

Integrating research and monitoring: Sensitivity



Closing. The Process provides a means to

- Use management actions to learn
- Integrate monitoring data
- Inform research needs
- Improve decisions
- Include public participation & values

In the context of your decisions!