Occupancy and multi-state occupancy projection models

SSA 200

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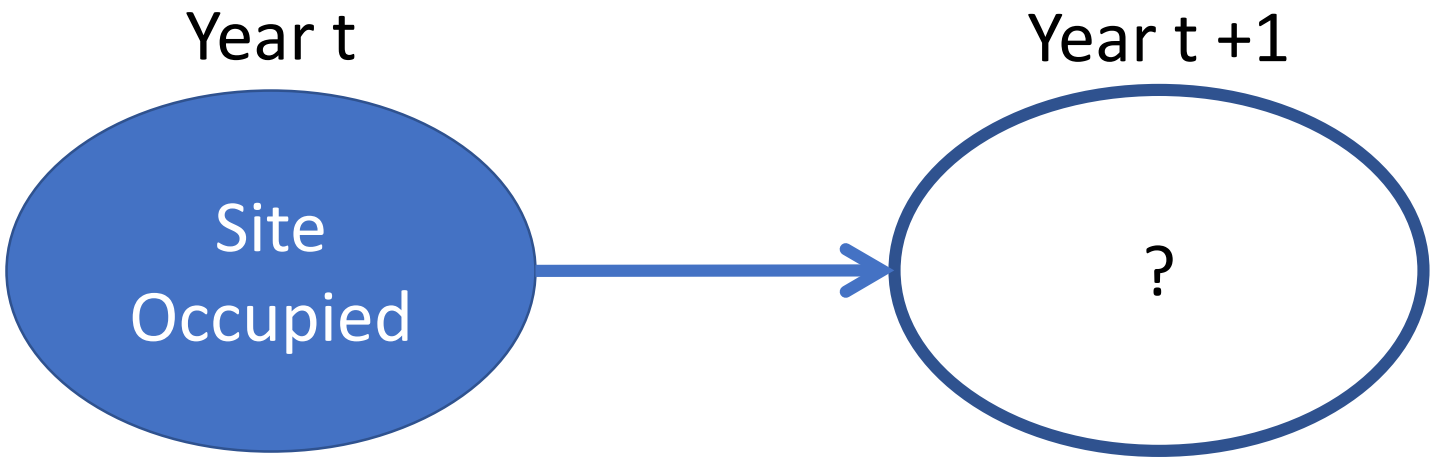
Site occupancy projection



Essentially a weighted coin flip

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Probability of heads (1) = Occupancy probability (P)

1

0

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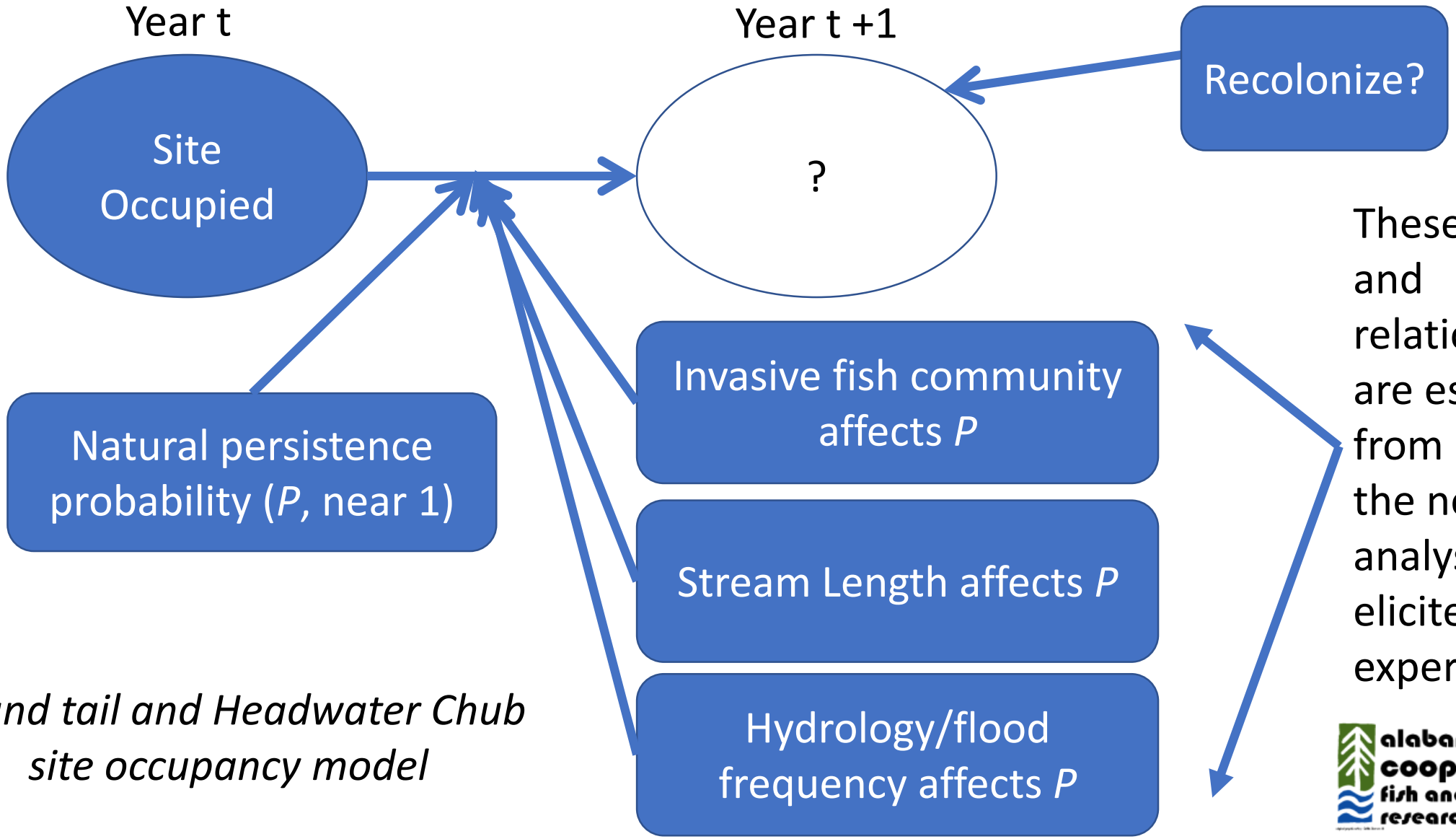
P can be a function of environmental factors



These effects and relationships are estimated from data (i.e., the needs analysis) or elicited from experts

Round tail and Headwater Chub site occupancy model

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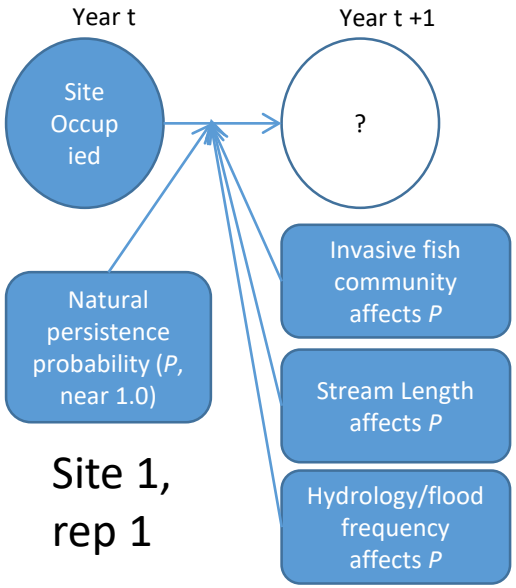
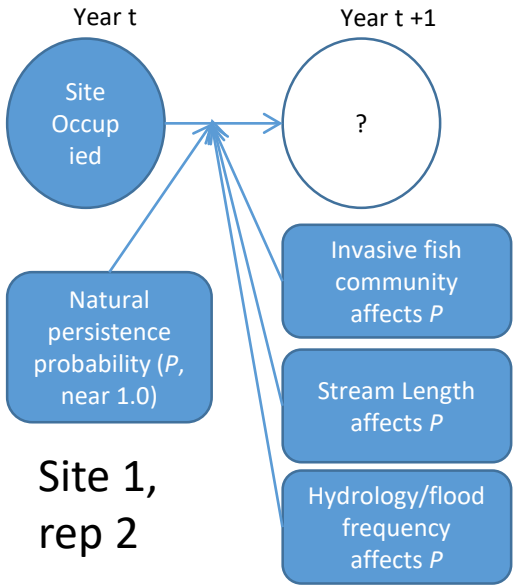
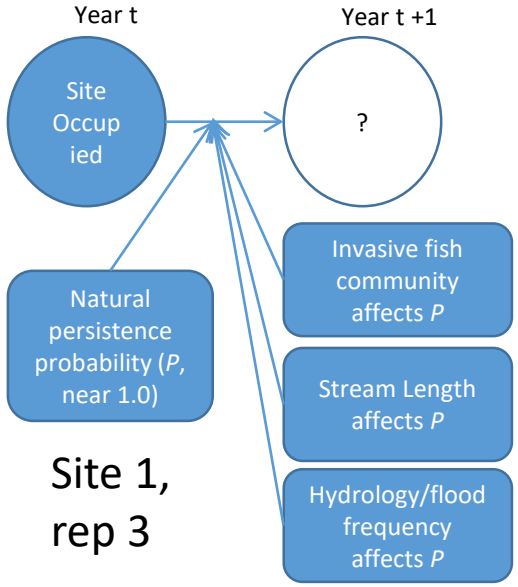
Multiple replicates



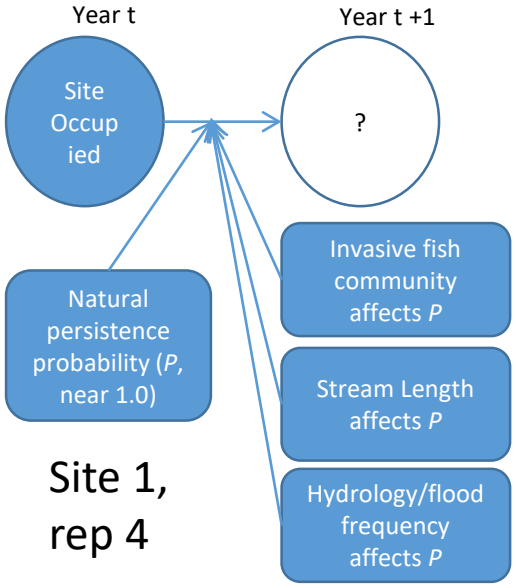
Site 1, rep 1



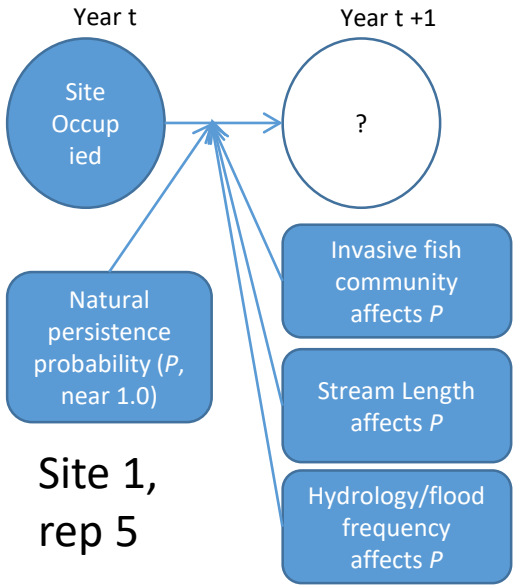
Site 1, rep 2



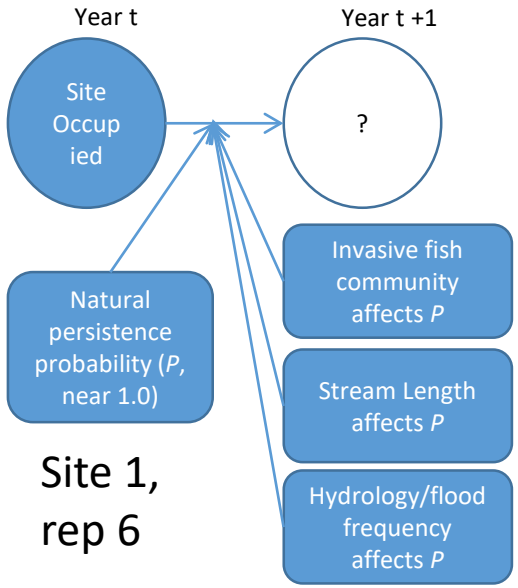
Site 1, rep 3



Site 1, rep 4



Site 1, rep 5



Site 1, rep 6

Spread sheet example

Persistence, near 1.0 – stream conditions (e.g., predators, length, etc.

Sum of replicates that are occupied at year 10

Occ	0.93										
reCol	0.1		10 yr occ	8							
	time										
rep	1	2	3	4				8	9	10	...
1	1	1	1	1				0	0	0	...
2	1	1	1	1				1	1	1	...
3	1	1	1	1				1	1	1	...
4	1	1	1	1	1	1	1	1	1	1	...
5	1	1	1	1	1	1	1	1	1	1	...
6	1	1	1	1	1	1	1	1	1	1	...
7	1	1	1	1	1	1	1	1	1	1	...
8	1	1	1	1	1	1	0	0	0	0	...
9	1	1	1	1	1	1	1	1	1	1	...
10	1	1	0	0	0	0	0	1	1	1	...
...											...

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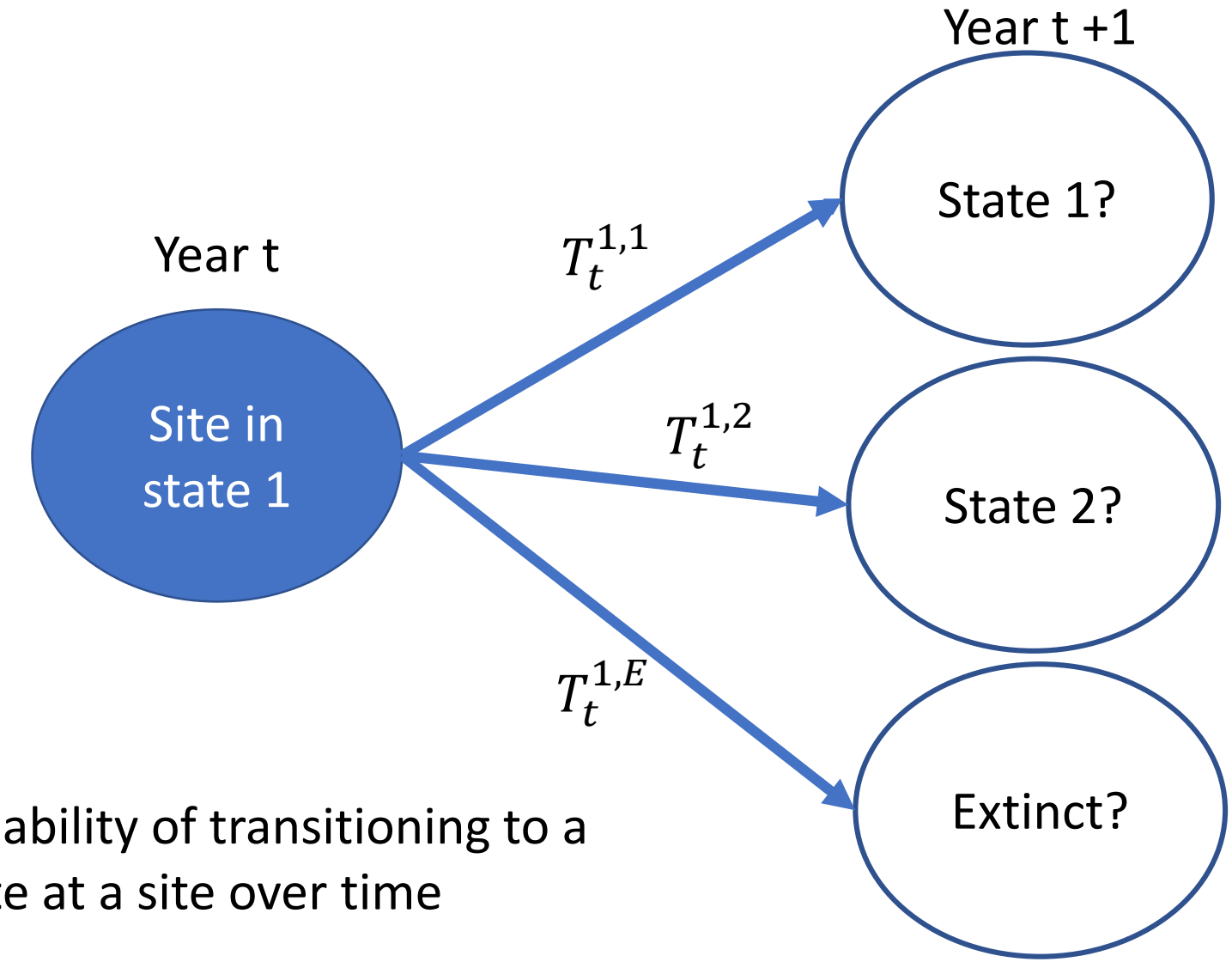
Multistate projection models



$$\sum T_t^{i,j} = 1$$

T = Probability of transitioning to a new state at a site over time

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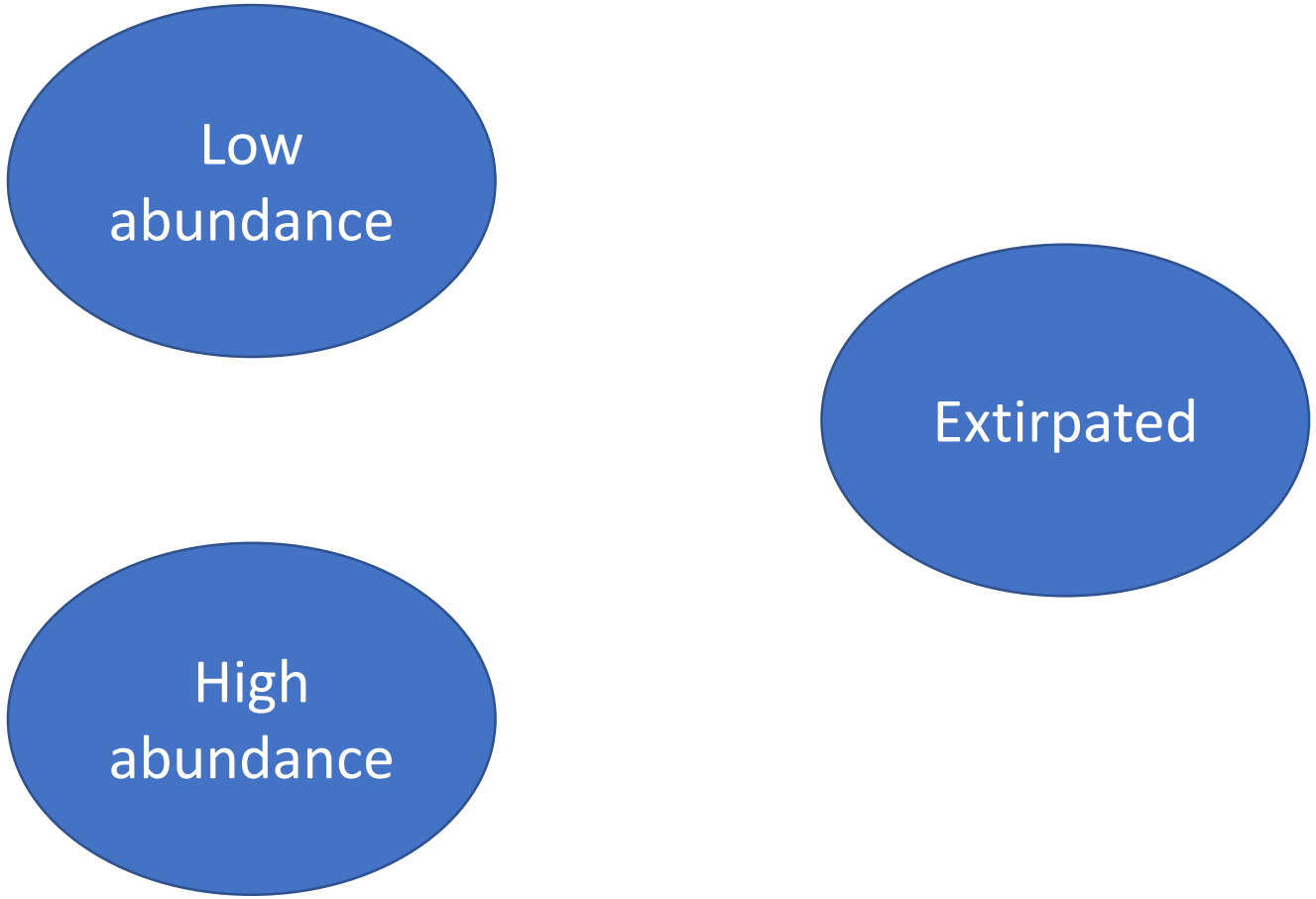
Multiple population states



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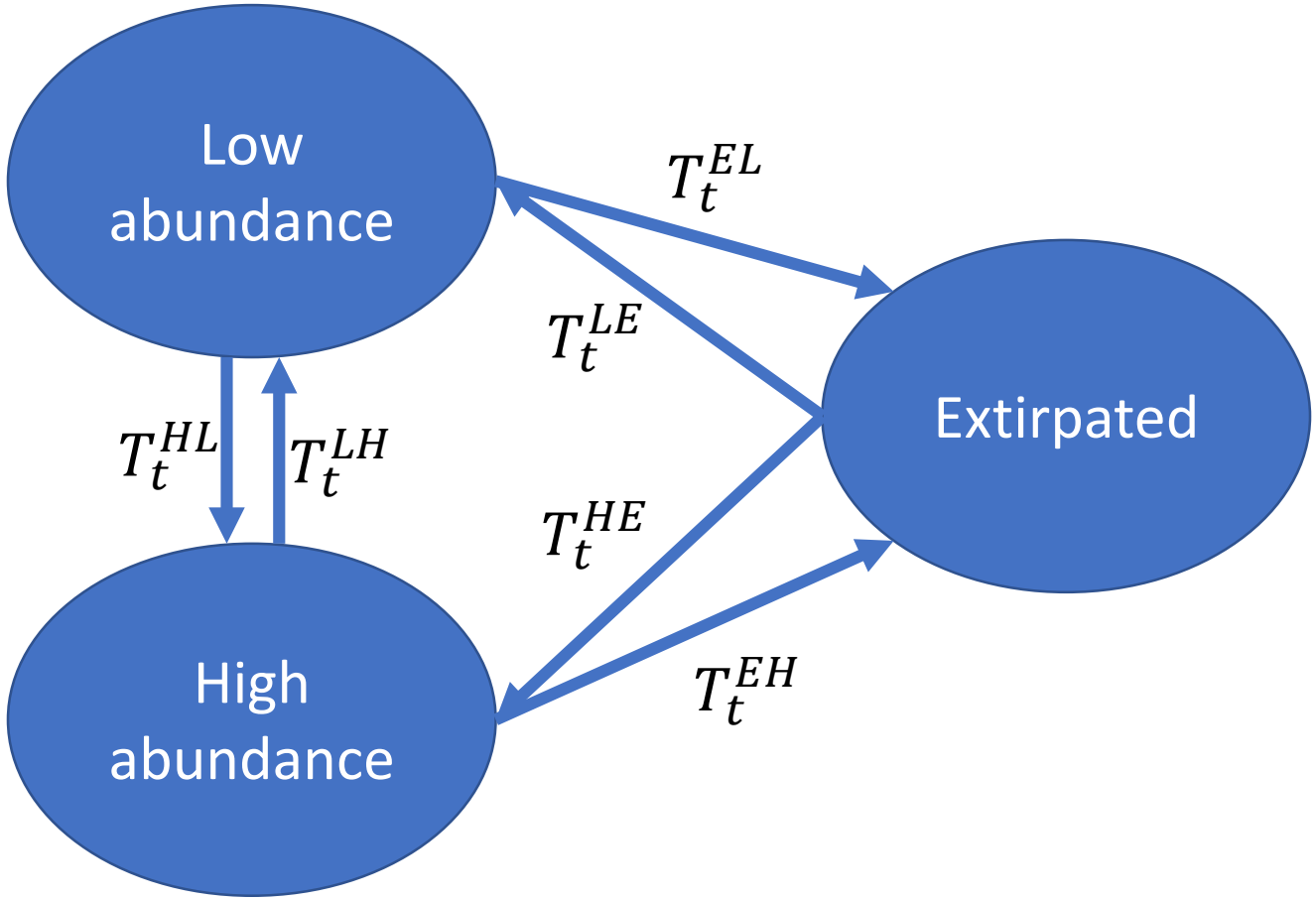
Multiple population states



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Matrix formulation

$$\begin{bmatrix} N_{t+1}^{e} \\ N_{t+1}^{L} \\ N_{t+1}^{H} \end{bmatrix} = \begin{bmatrix} T^{ee} & T^{eL} & T^{eH} \\ T^{Le} & T^{LL} & T^{LH} \\ T^{He} & T^{HL} & T^{HH} \end{bmatrix} \times \begin{bmatrix} N_{t}^{e} \\ N_{t}^{L} \\ N_{t}^{H} \end{bmatrix}$$

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Matrix formulation

$$\begin{bmatrix} N_{t+1}^{e} \\ N_{t+1}^{L} \\ N_{t+1}^{H} \end{bmatrix} = \begin{bmatrix} T^{ee} & T^{eL} & T^{eH} \\ T^{Le} & T^{LL} & T^{LH} \\ T^{He} & T^{HL} & T^{HH} \end{bmatrix} \times \begin{bmatrix} N_{t}^{e} \\ N_{t}^{L} \\ N_{t}^{H} \end{bmatrix}$$

$$N_{t+1}^{e} = N_{t}^{e}T^{ee} + N_{t}^{L}T^{eL} + N_{t}^{H}T^{eH}$$

$$N_{t+1}^{L} = N_{t}^{e}T^{Le} + N_{t}^{L}T^{LL} + N_{t}^{H}T^{LH}$$

$$N_{t+1}^{H} = N_{t}^{e}T^{He} + N_{t}^{L}T^{HL} + N_{t}^{H}T^{HH}$$

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Example output

	Time										
Replicate	1	2	3	4	5	6	7	8	9	10	...
1	2	2	2	2	1	1	2	2	1	1	...
2	2	1	1	1	0	0	0	0	0	0	...
3	2	2	2	2	2	2	2	2	2	2	...
4	2	2	2	2	2	1	1	2	2	2	...
5	2	0	0	0	0	0	0	0	0	0	...
6	2	2	2	2	2	2	2	2	2	2	...
7	2	1	2	2	2	2	2	2	2	2	...
8	2	2	2	2	2	2	2	2	2	2	...
9	2	2	2	2	2	1	1	1	1	1	...
10	2	1	1	1	2	2	2	1	1	1	...
...											

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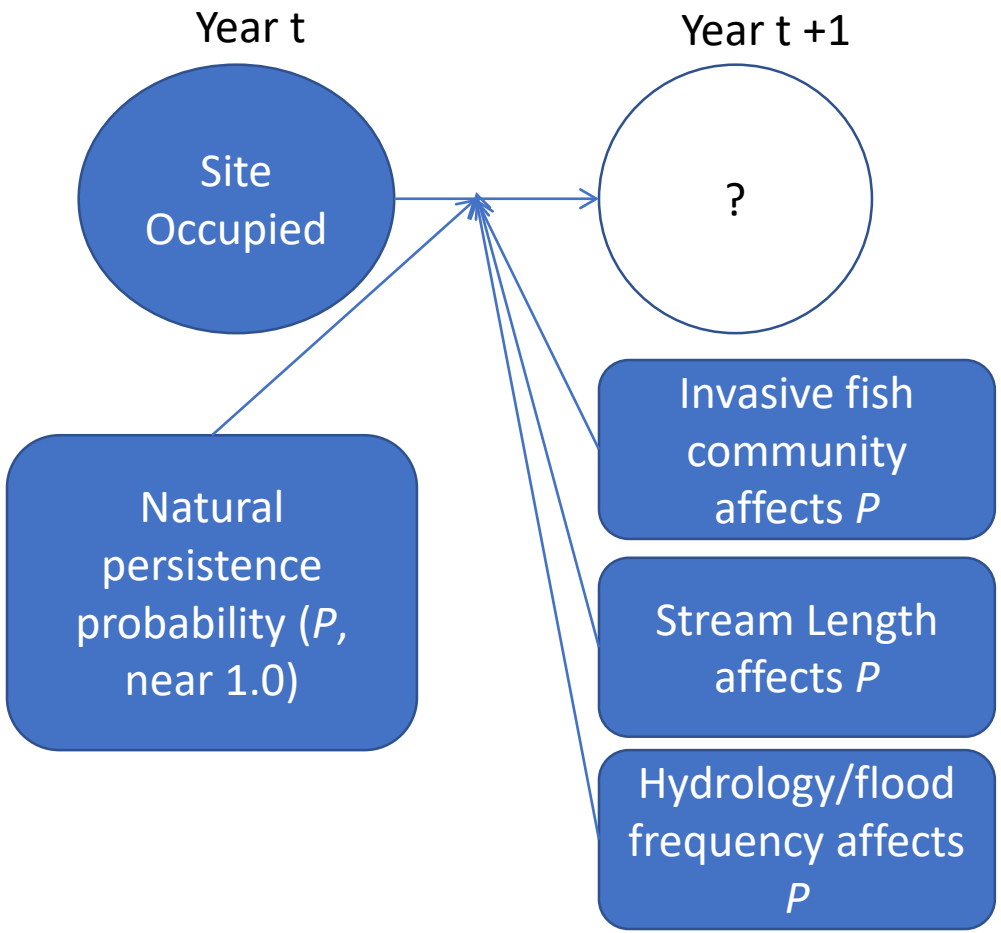
Environmental effects on probabilities



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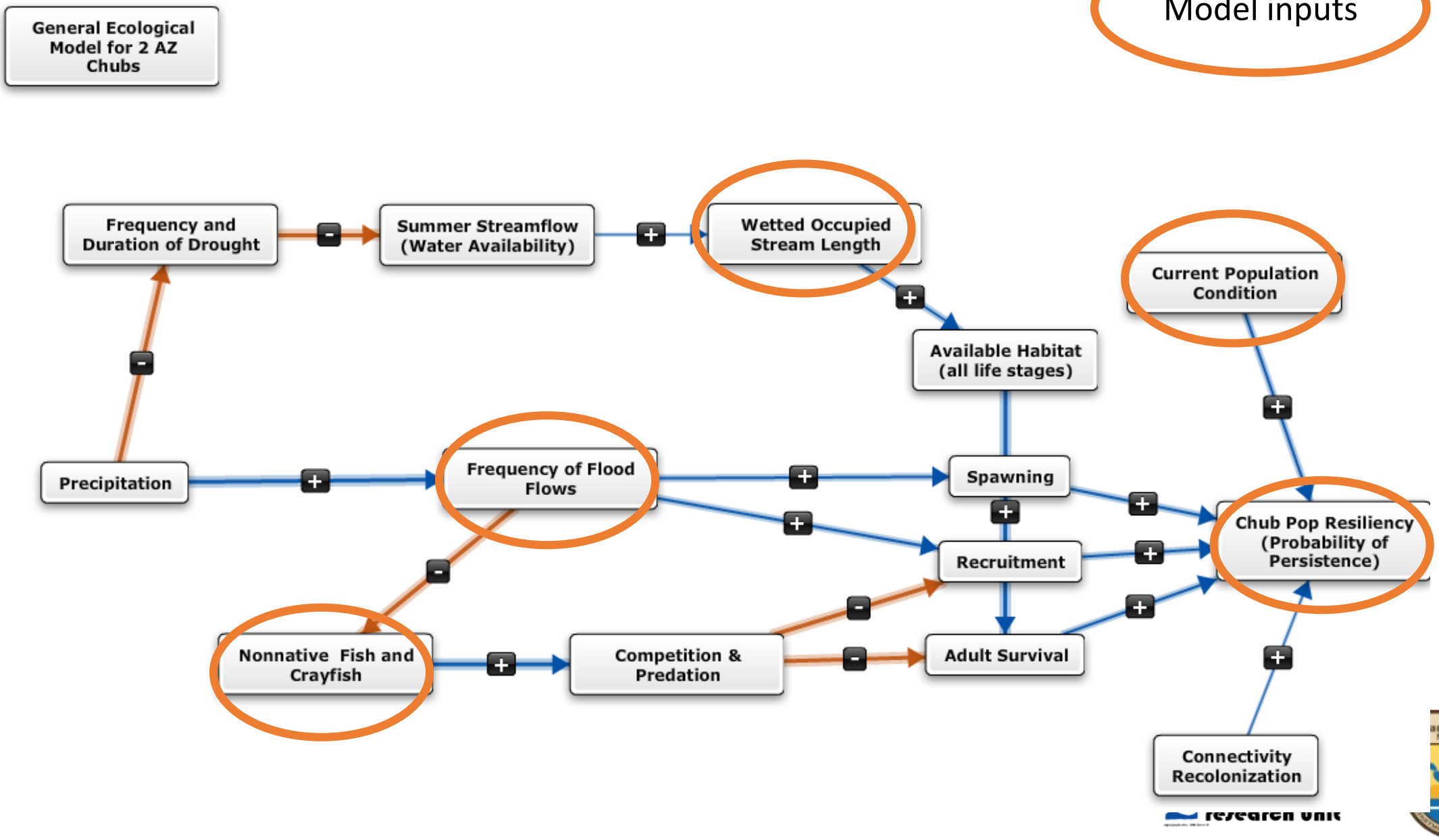
Chub Model Parameters

Model inputs



Conditional Logical functions

- Link population parameters to environmental conditions by discrete logic function

"**If** average rainfall is less than *x*, **then** occupancy probability is *y*"

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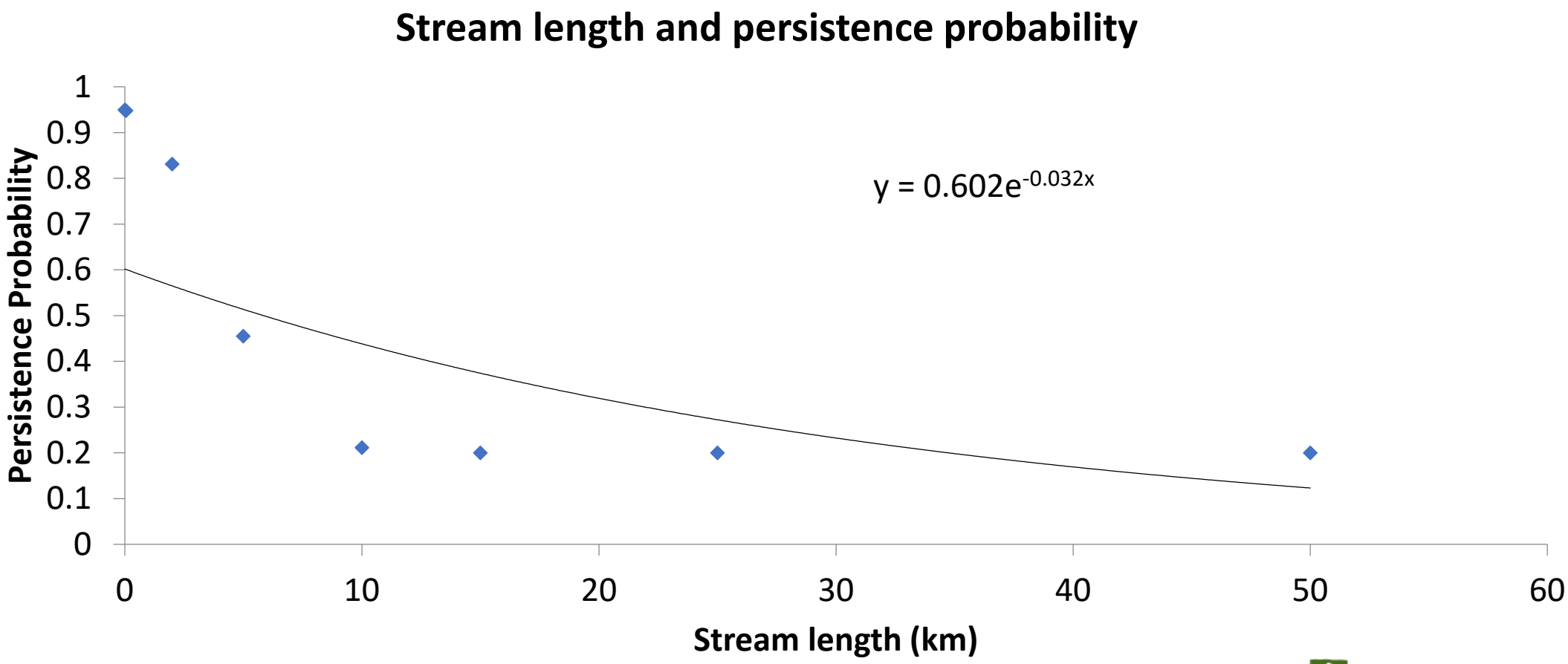
Continuous functions



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Measurement error

- Simulation data assume perfect knowledge of the system
  - i.e., no partial observability/observation error in monitoring data
- May be important to add observation error to output from the models
  - Recovery planning
  - Section 7 planning
  - Delisting decisions
- Observed system response will not match predictions
  - This is the case no matter, but account for all uncertainties might be important

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Modify model outputs

- Randomized adjustments to model output data

Spread sheet example

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Questions?

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