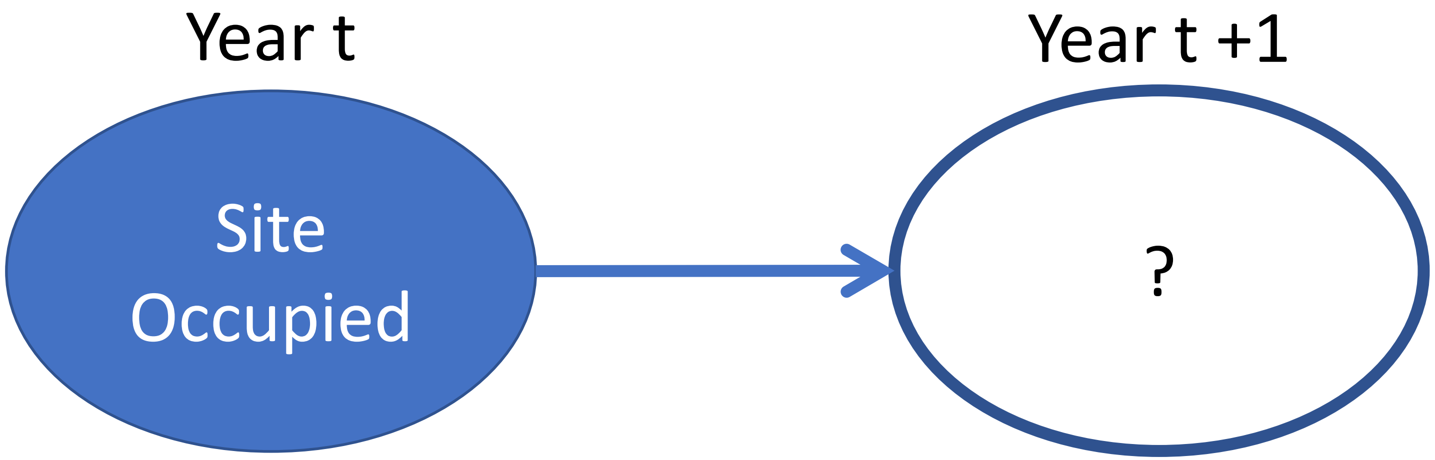
Occupancy and multi-state occupancy projection models

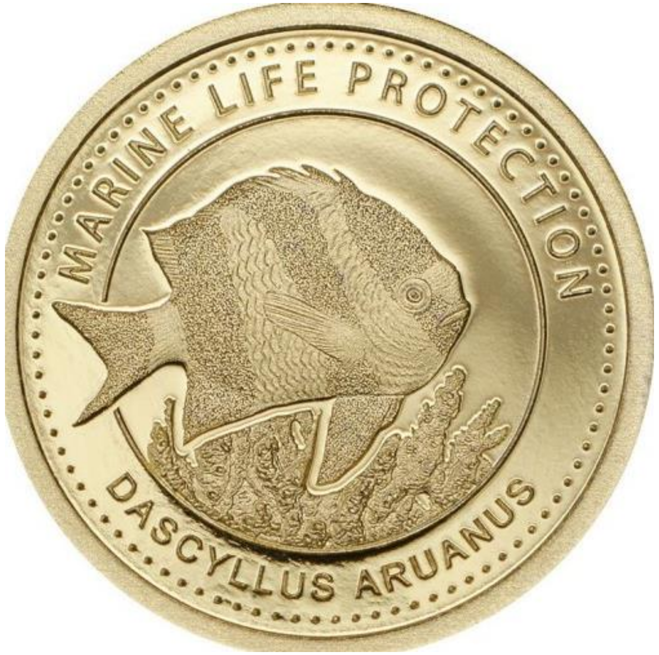
SSA 200

Site occupancy projection



Essentially a weighted coin flip

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



1 **0**

P can be a function of environmental factors

Year t

Year t +1

Site Occupied

?

Recolonize?

Natural persistence probability (*P*, near 1)

Invasive fish community affects *P*

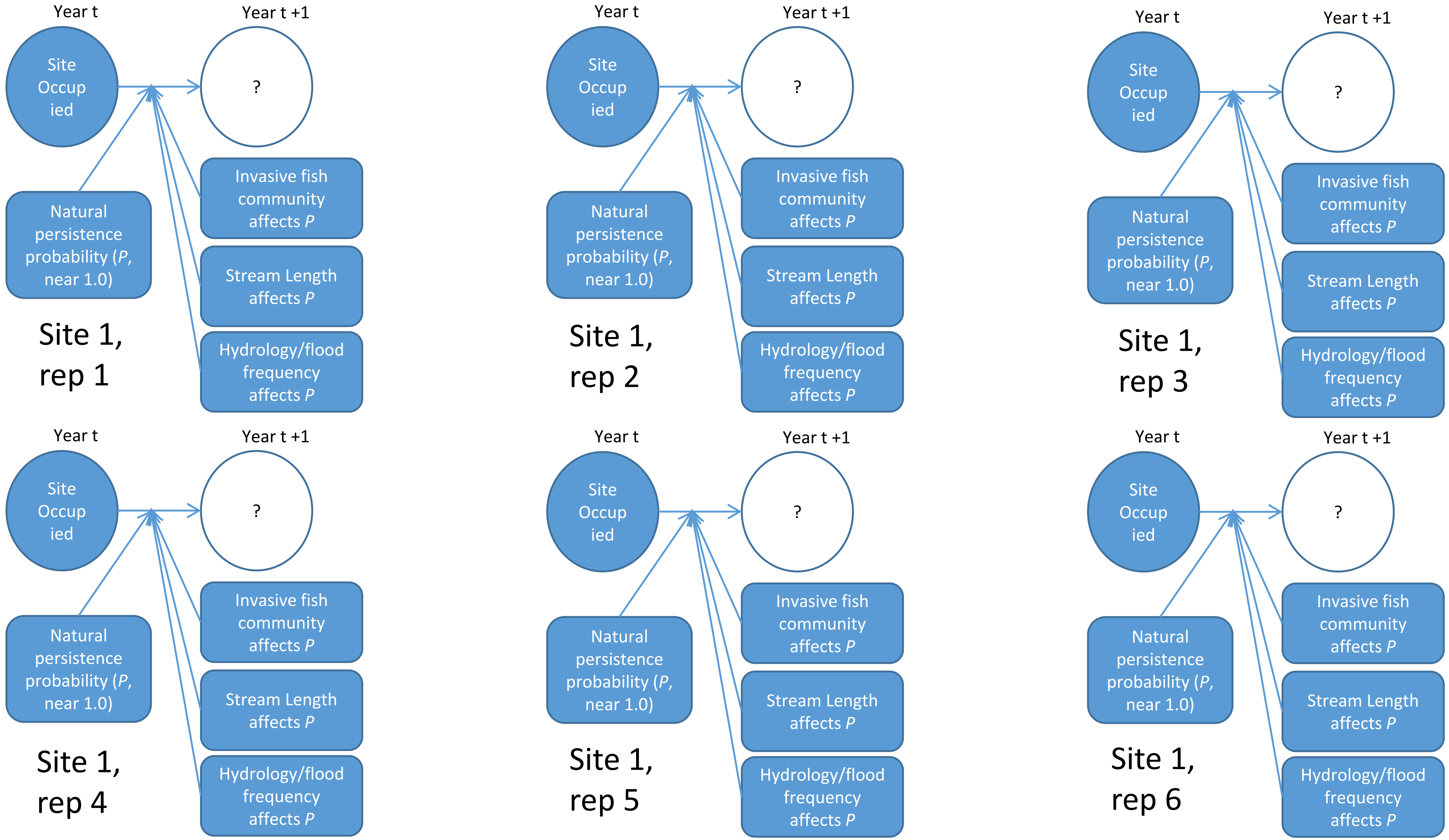
Stream Length affects *P*

Hydrology/flood frequency affects *P*

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

Multiple replicates



Spread sheet example

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

Sum of replicates that are occupied at year 10

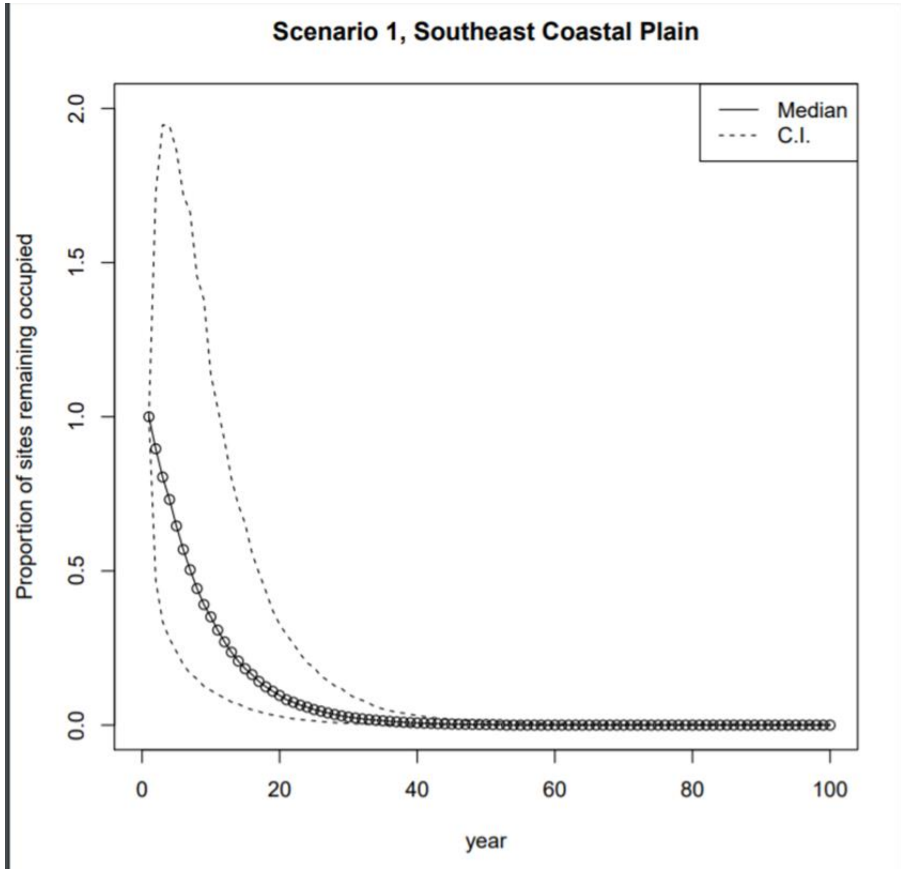
Occ	0.93										
reCol	0.1		10 yr occ	8							
	time										
rep	1	2	3	4				8	9	10	...
1	1	1	1	1				0	0	0	...
2	1	1	1	1				1	1	1	...
3	1	1	1	1				1	1	1	...
4	1	1	1	1	1	1	1	1	1	1	...
5	1	1	1	1	1	1	1	1	1	1	...
6	1	1	1	1	1	1	1	1	1	1	...
7	1	1	1	1	1	1	1	1	1	1	...
8	1	1	1	1	1	1	0	0	0	0	...
9	1	1	1	1	1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

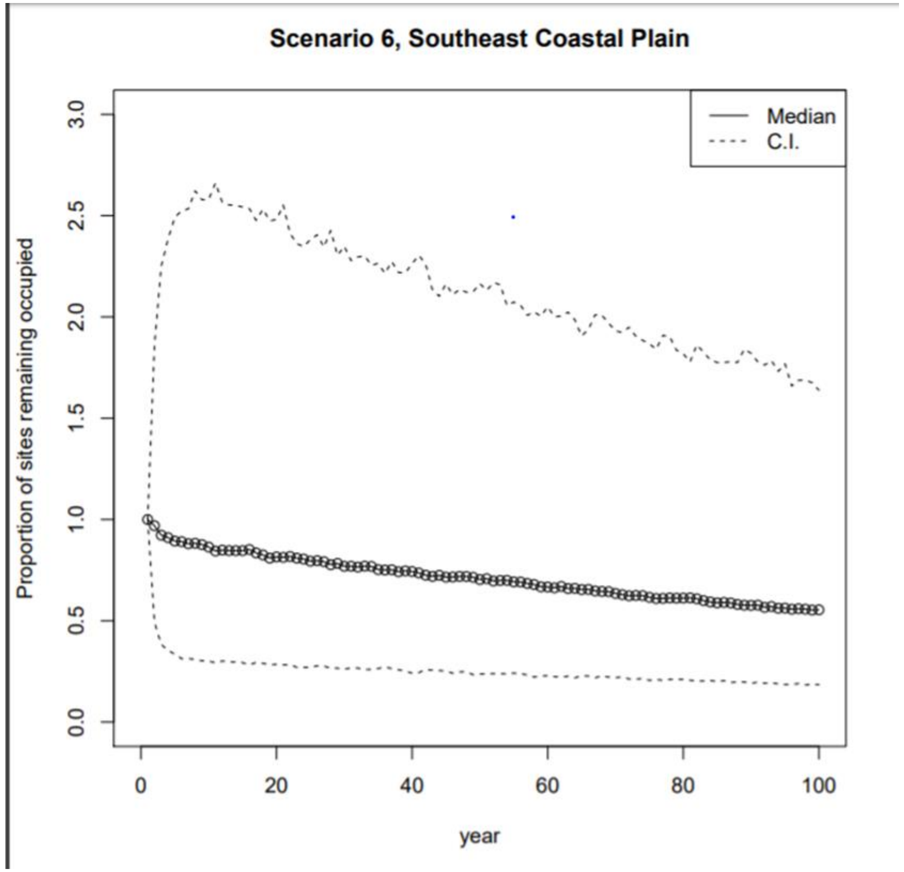
Eastern Black Rail species status assessment

Available occupancy data:

Site	State	2014			2015			2016			NLCD	Fire Ants	Y-precip
1	SC	0	0	1	0	0	0	0	0	0	22	0	27.2
2	SC	0	0	0	0	0	0	1	1	0	22	1	34.1
3	SC	0	0	0	0	0	0	0	0	0	95	1	19.7
4	SC	0	0	0	0	0	0	0	0	0	95	1	67
5	SC	0	0	0	0	0	0	0	0	0	22	0	22.2
6	SC	1	0	1	0	0	0	0	1	1	45	0	34.5
7	SC	1	0	0	0	0	0	0	0	1	22	1	17.9
8	SC	0	0	0	0	0	0	0	0	0	45	1	42.1
9	SC	0	0	0	1	0	0	0	1	0	45	0	28.6
...													

Eastern Black rail, proportion of sites occupied in the future





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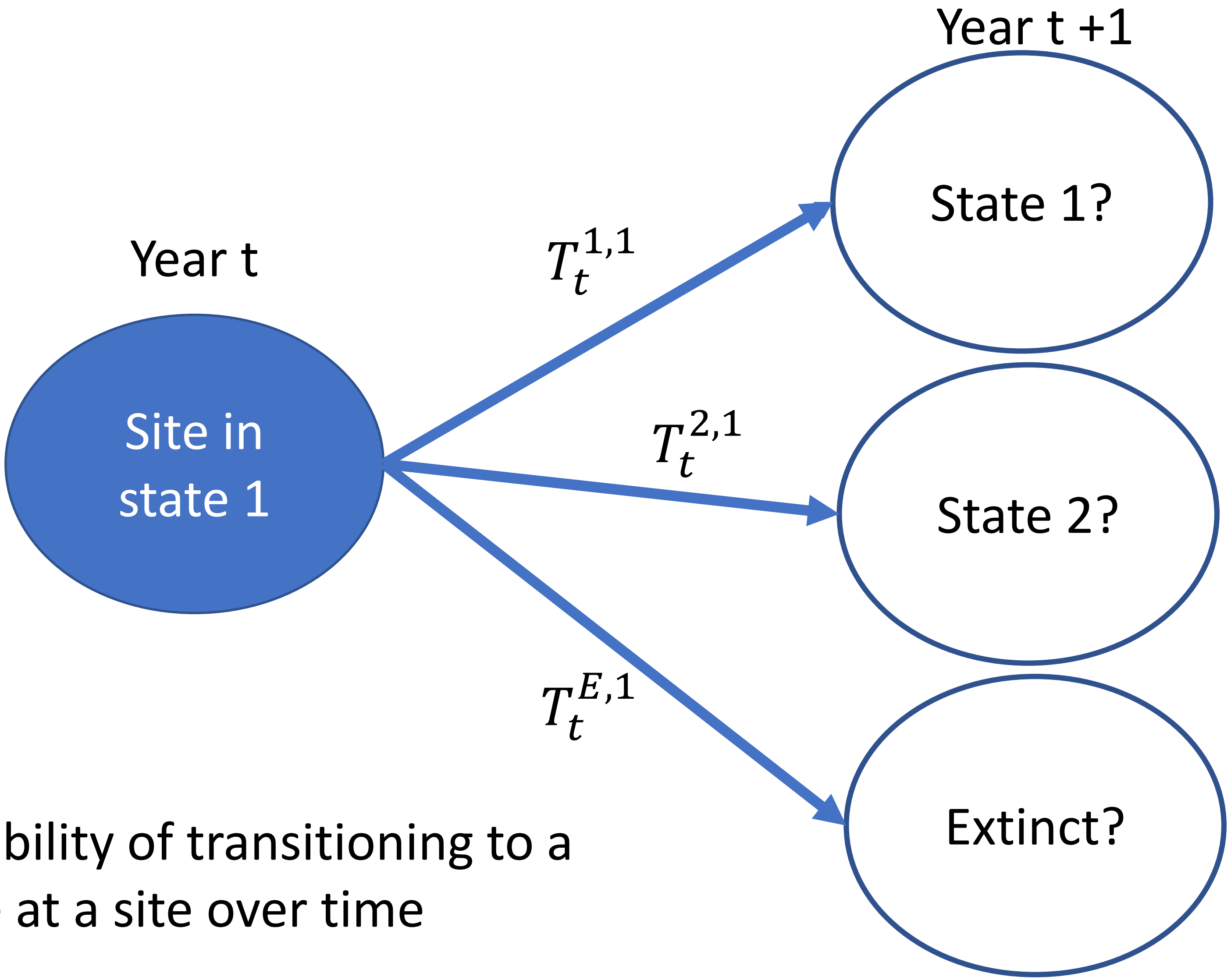
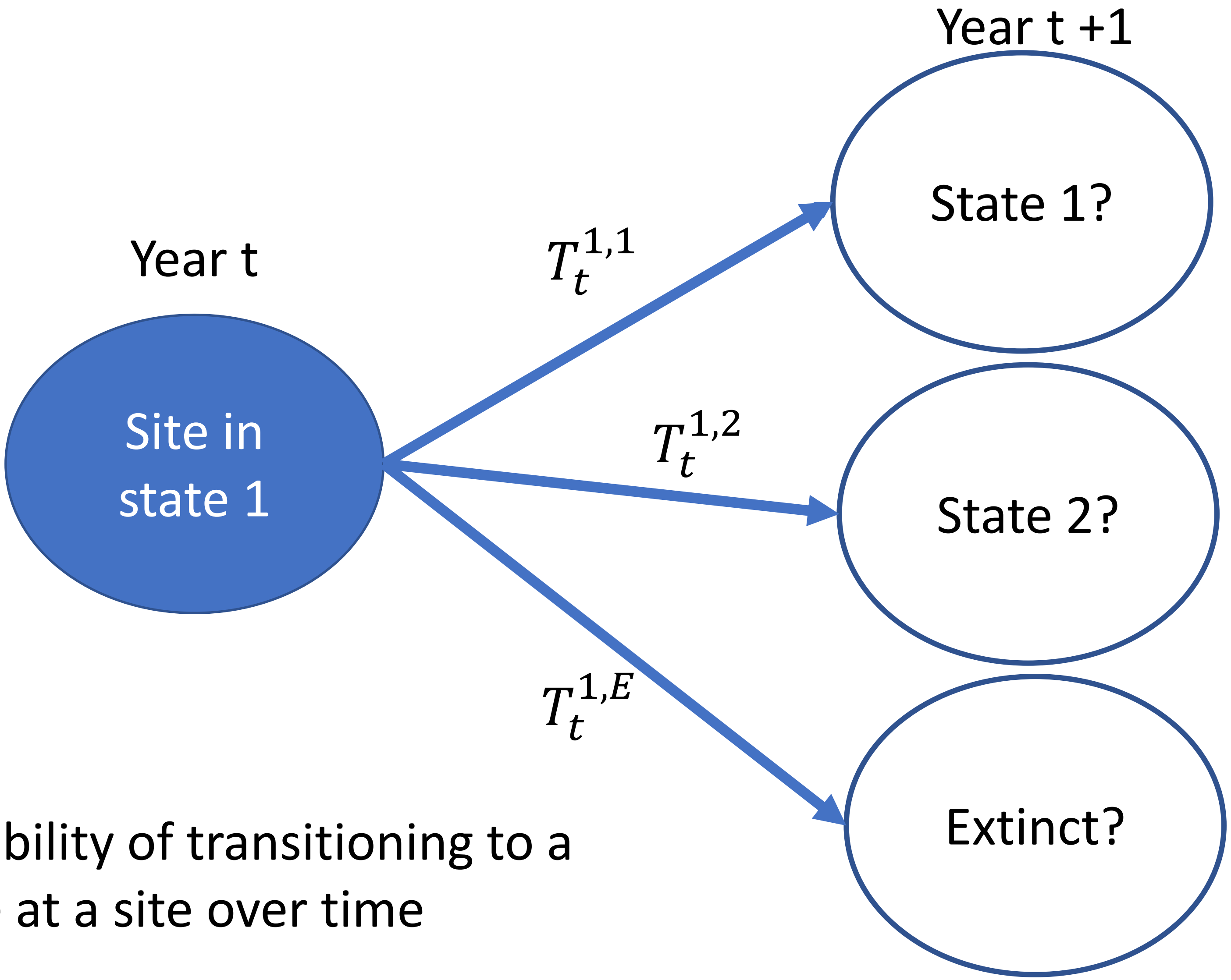
Multistate projection models



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

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

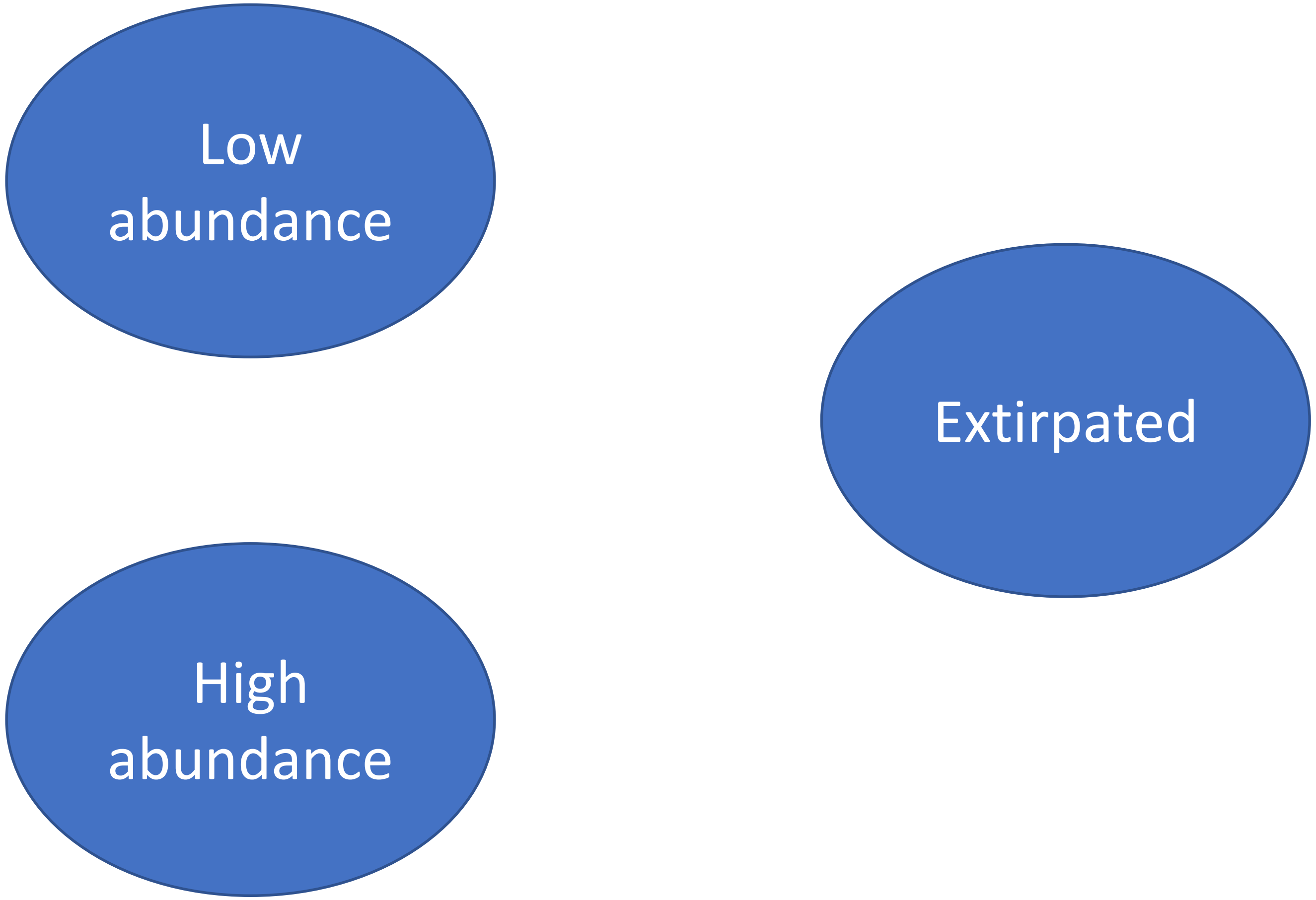
Multistate projection models



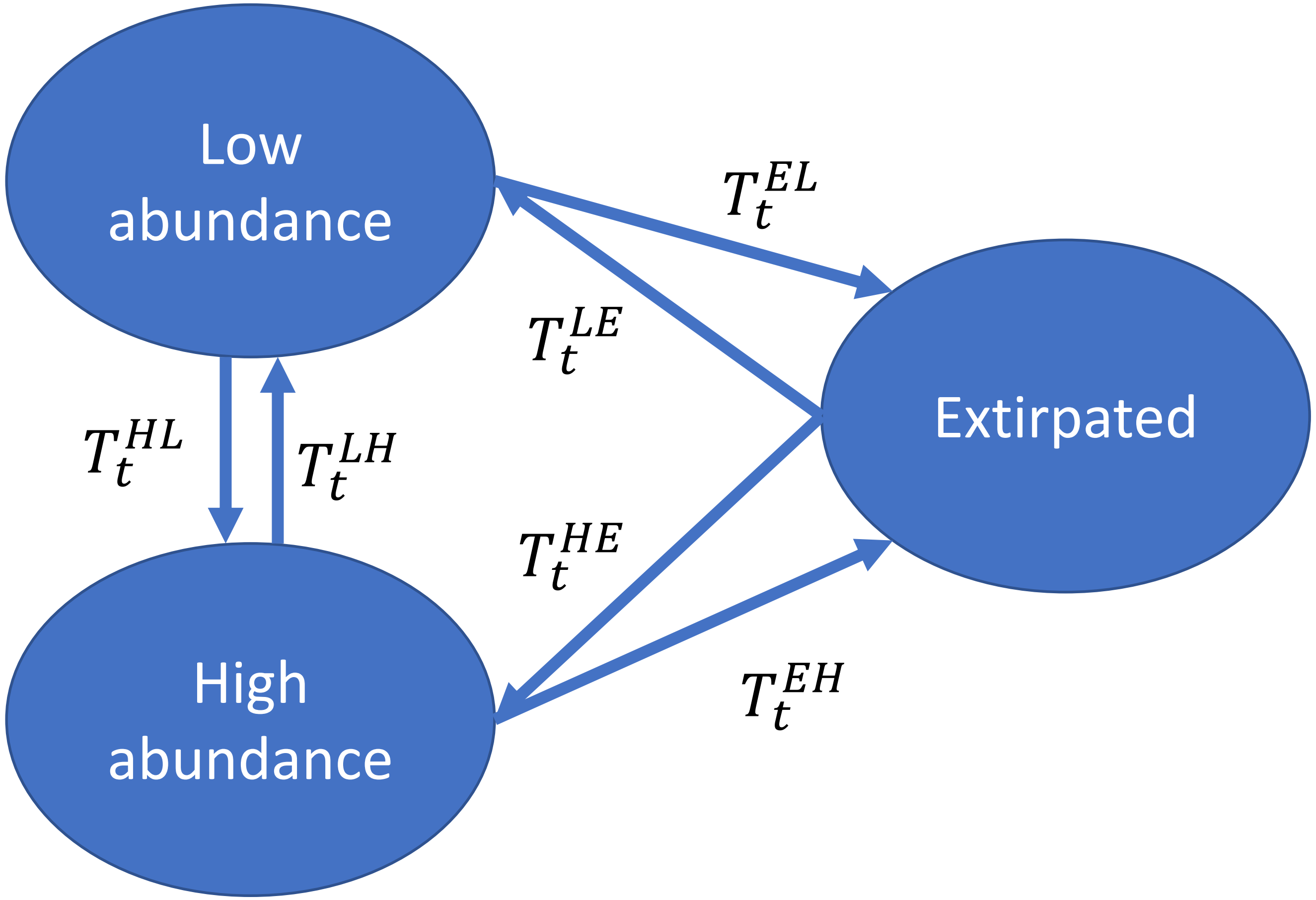
$$\sum T_t^{j,i} = 1$$

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

Multiple population states



Multiple population states



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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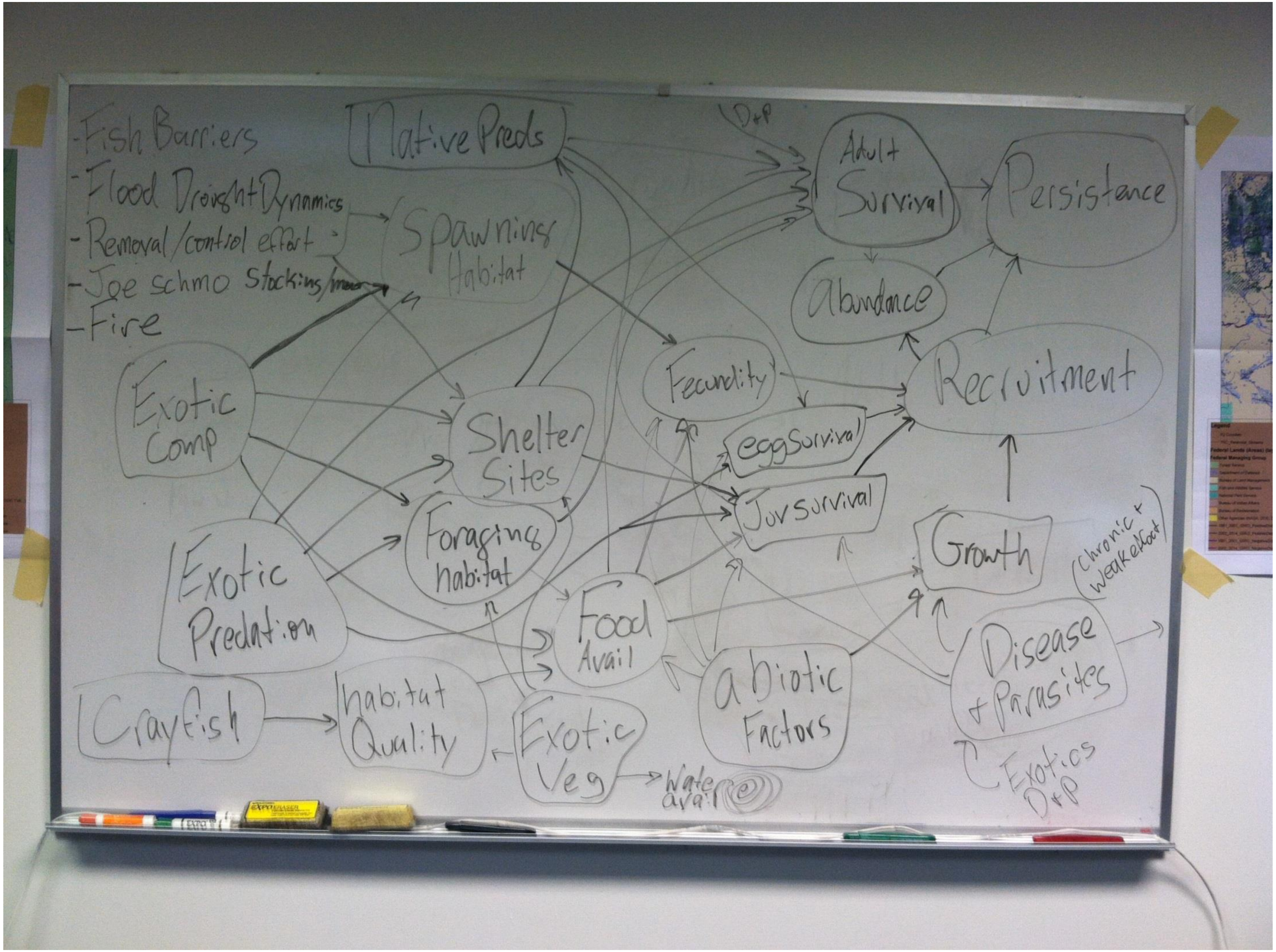
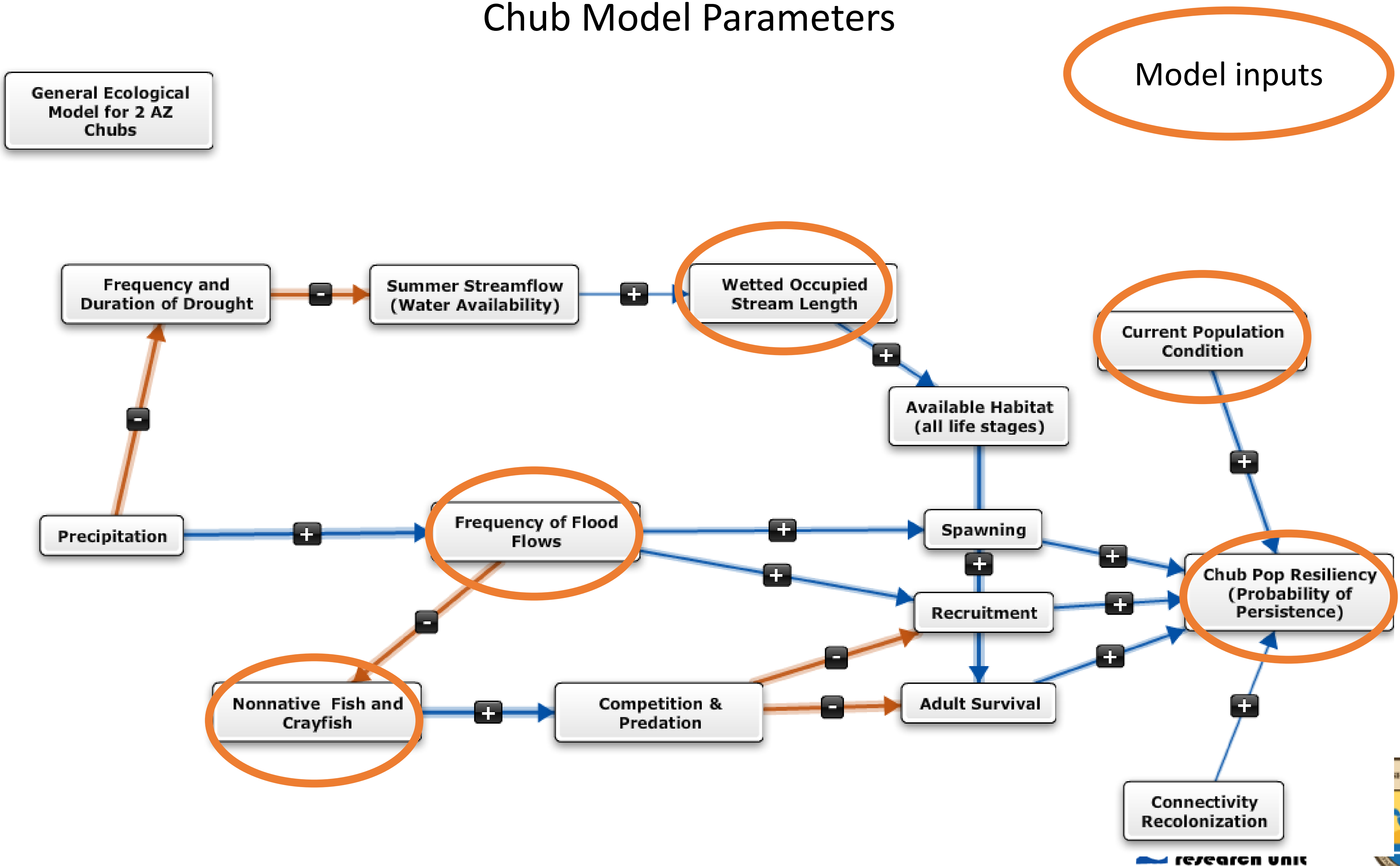
Example output

	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	...
...											

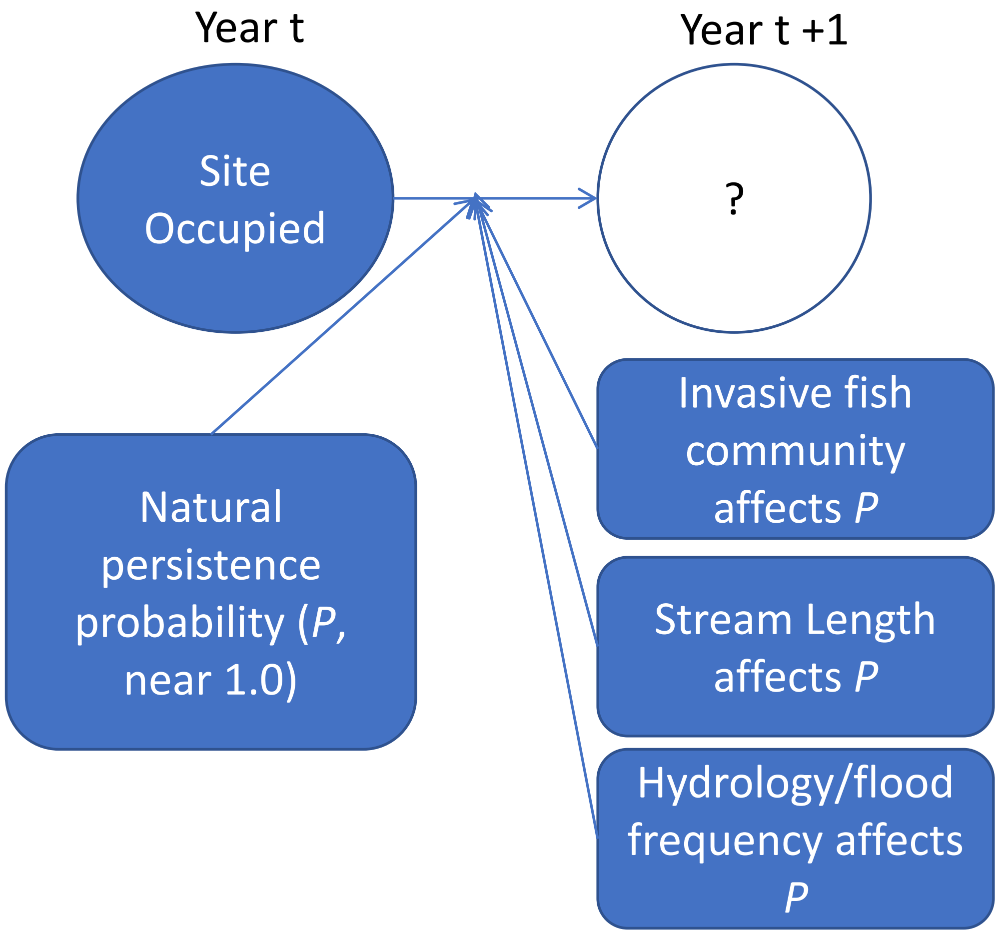
Modeling Headwater and Roundtail Chub resilience and redundancy


-Fish Barriers
-Flood Drought Dynamics
-Removal/control effort
-Joe schmo stocking
-Fire
Native Preds
D+P
Adult Survival
Persistence
Spawning Habitat
Abundance
Fecundity
Recruitment
Exotic Comp
Shelter Sites
egg Survival
Juv Survival
Foraging habitat
Growth
Exotic Predation
Food Avail
abiotic Factors
Disease + Parasites
Chronic + weak effect
Crayfish
habitat Quality
Exotic Veg
Water avail
Exotics D+P

Chub Model Parameters



Environmental effects on probabilities



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*"

"if exotic community is equal to 2, then persistence probability is 0.93; if exotic community is equal to 3 then persistence probability is…"

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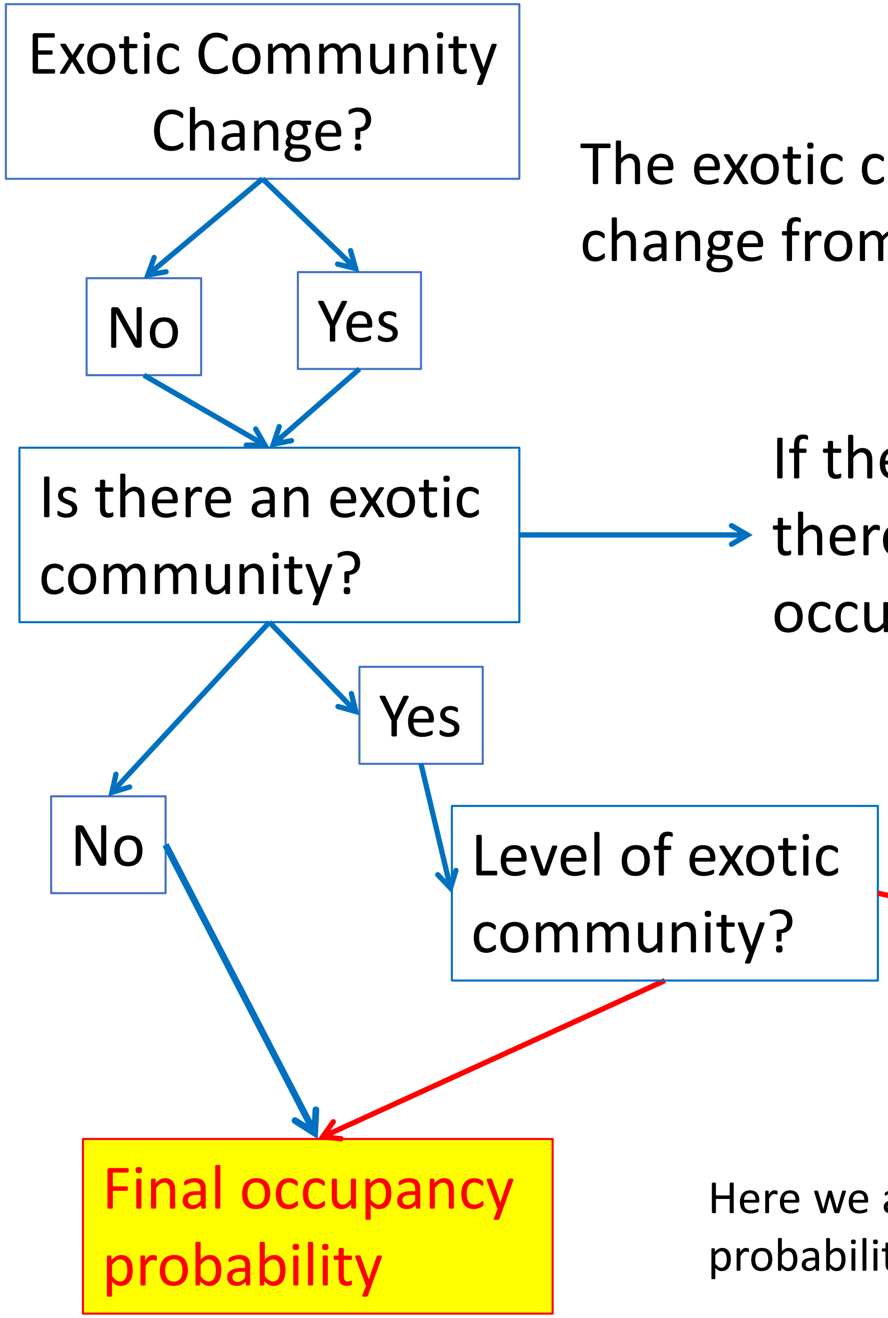


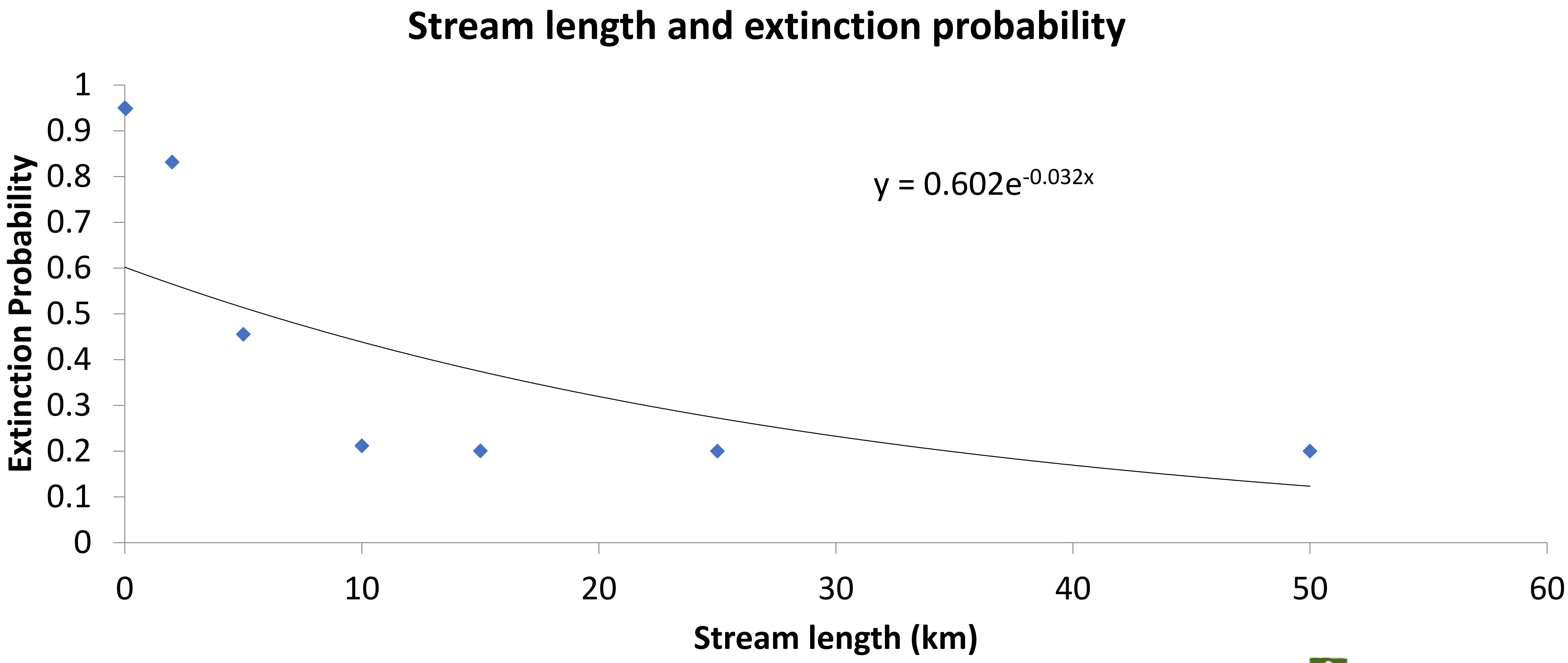
The exotic community may change from year to year

If there is no exotic community, there is no reduction in occupancy probability

Different exotic communities affect occupancy differently

Here we apply the last reduction to the probability of chubs occupying a stream.

Continuous functions



Stream Length Change?

A stream may change length over time

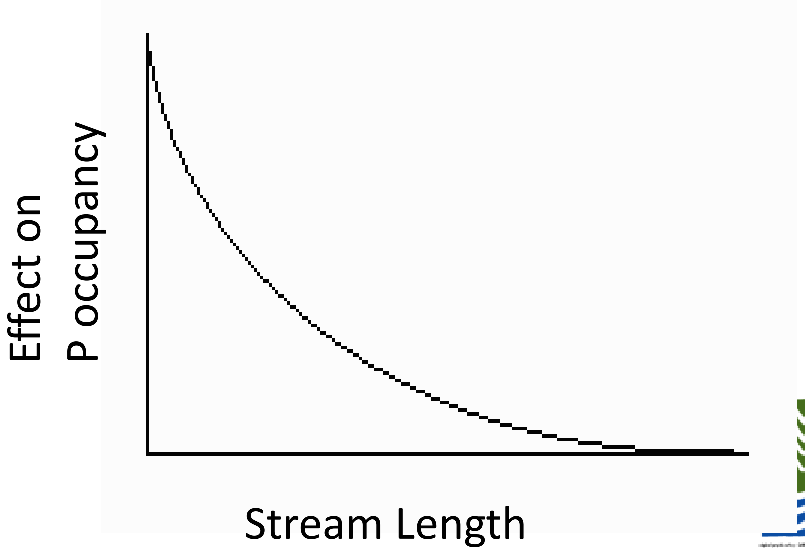
No

If the stream does not change length, there is no effect of this parameter on occupancy.

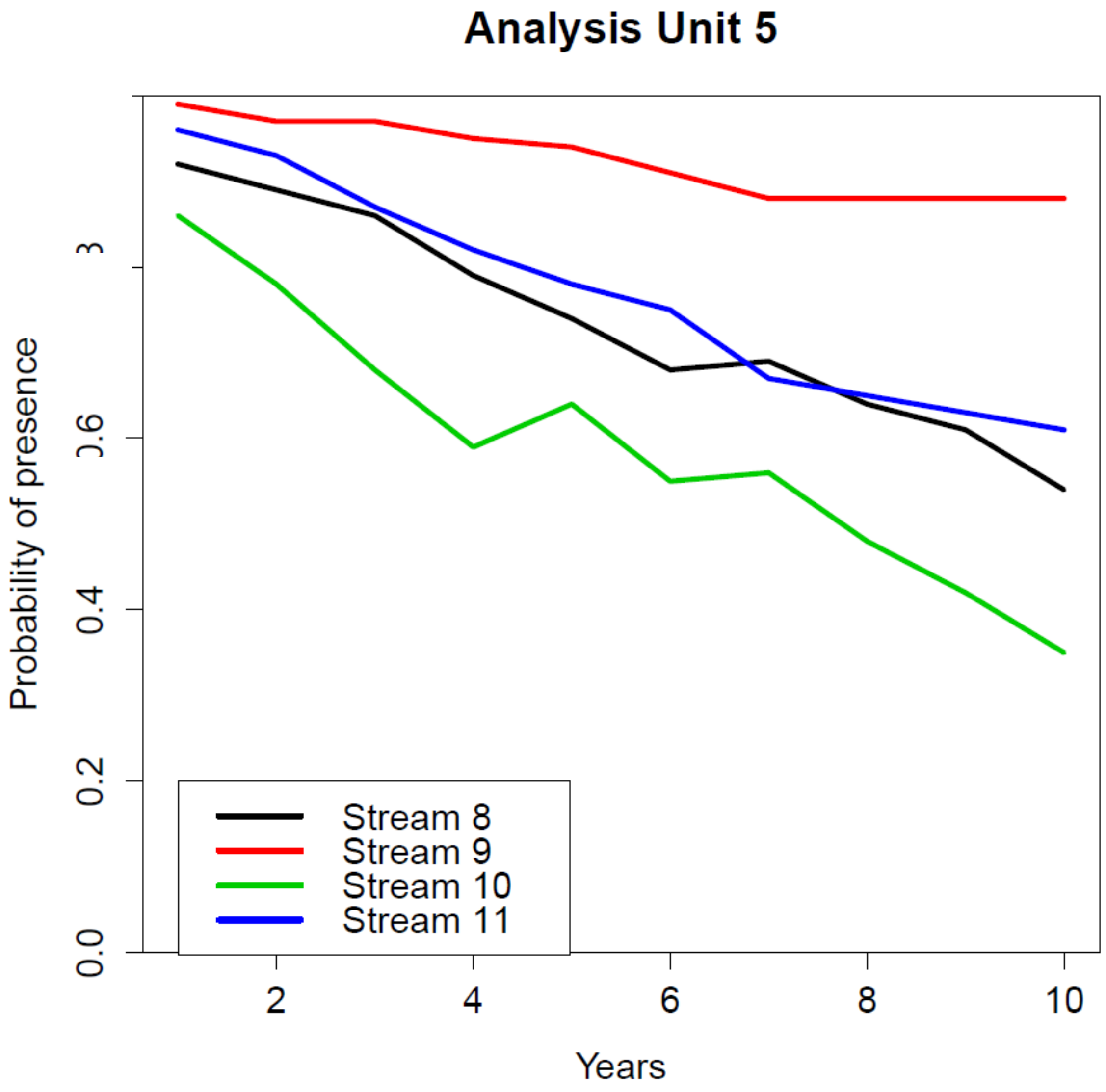
Yes

If the stream does change length, there will be an effect on the probability of occupancy.

The relationship between stream length and occupancy probability is curvilinear, a negative exponential relationship. The longer a stream is, the less it effects occupancy.



Model output



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Questions?