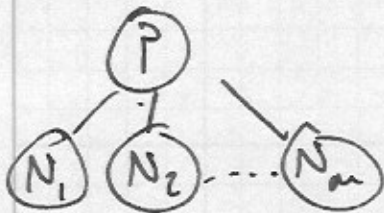


Adaptive
Optimal Foraging

- Choose foods that maximize return on investment / time

$$\text{Profitability} = \frac{\text{Energy gained} - E_{\text{out}}}{\text{time}}$$

From L-V: $\frac{dN}{dt} = rN(1 - \frac{N}{K}) - aNP$

$$\frac{dP}{dt} = \underbrace{eaNP} - dP$$

energy gained/time @ population level

per-capita energy gained:

$$eaN$$

↳ 2 things in attack rate $\frac{1}{[N][E]}$

foraging efficiency

$$\frac{1}{[N][E]}$$

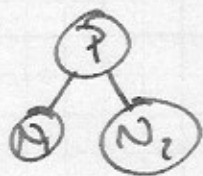
(b)

foraging effort (= 1)

b/c no choices (proportion)

(a)

Effort only makes sense when $\phi > 1$ prey



$$\frac{dN_i}{dt} = r_i N_i \left(1 - \frac{N_i}{K_i}\right) - a_i \beta_i N_i P$$

$$\frac{dP}{dt} = ea_1 \beta_1 N_1 P + e(1-a_1) \beta_2 N_2 P - mP$$

$$\star \sum_i a_i = 1 \quad \text{so if } a_1 \uparrow, \text{ then } (1-a_1) \downarrow$$

Now... imagine that effort a_{ij} can change over time... what should it change in response to?

- Effort on prey i should increase if prey i becomes more profitable
- Effort on prey i should decrease if prey i becomes LESS profitable
- Less profitable than what? If the Organisms make the best choice out of available options...
- Set Avg profitability at the threshold

Avg Profitability:

$$\sum_{\text{resources } k} a_{ik} e_{ik} f_{ik} X_k$$

current proportional contribution weighted avg.

Effort for cons i on resource j

$$\frac{da_{ij}}{dt} = G_i a_{ij} \left(\underbrace{e_{ij} b_{ij} X_j}_{\text{energy gain per unit effort on res. } j} - \underbrace{\sum_{k \in \text{res.}} a_{ik} e_{ik} f_{ik} X_k}_{\text{Avg profitability that consumer is currently forming}} \right)$$

When energy gain per unit effort on res. j > Avg profitability that consumer is currently forming

then effort on res. j ↑

otherwise, effort on res. j ↓

$G \sim$ adaptive rate (fast or slow?)

Let's build a general food web model:

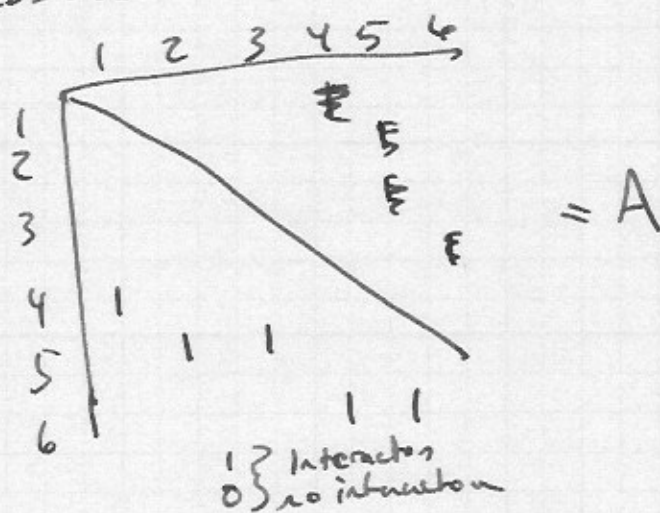
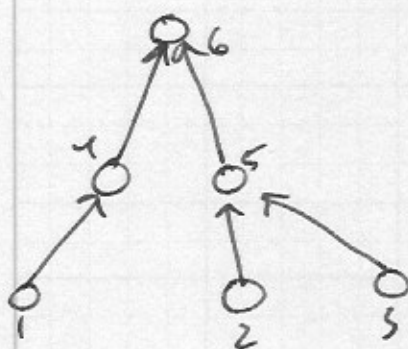
$$\frac{dX_i}{dt} = X_i \left(r_i - s_i X_i + \sum_{j=1}^N e_{ij} f_{ij} a_{ij} X_j - \sum_{j=1}^N f_{ji} a_{ji} X_j \right)$$

$$\frac{da_{ij}}{dt} = G_i a_{ij} \left(e_{ij} f_{ij} X_j - \sum_{k=1}^N a_{ik} e_{ik} f_{ik} X_k \right)$$

Assume everyone is connected to everyone!

How to build in an interaction network?

Include Adjacency matrix information to indicate link presence/absence.



$$\frac{dX_i}{dt} = X_i \left(r_i - s_i X_i + \sum_{j=1}^N A_{(ij)} e_{ij} f_{ij} a_{ij} X_j - \sum_{j=1}^N A_{(ji)} f_{ji} a_{ji} X_j \right)$$

$$\frac{da_{ij}}{dt} = A_{ij} G_i a_{ij} \left(e_{ij} f_{ij} X_j \right) - \sum_{k=1}^N a_{ik} e_{ik} f_{ik} X_k$$

ω
1 if int.
0 if no int.