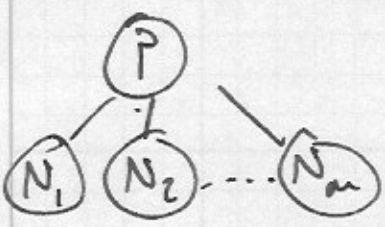
11.1 Adaptive/Optimal Foraging



- Choose foods that maximize return on investment / time

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

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

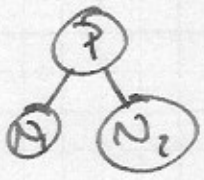
$\frac{dP}{dt} = \underbrace{eaNP}_{\text{energy gained/time @ population level}} - dP$

per-capita energy gained: eaN

two things in attack rate: $\frac{1}{[N][t]}$

- foraging efficiency $\frac{1}{[N][t]}$ (ϕ)
- foraging effort ($=1$) b/c no choices (proportion) (a)

Effort only makes sense in terms of >1 prey



$$\begin{cases} \frac{dN_i}{dt} = r_i N_i(1-\frac{N_i}{K_i}) - \underbrace{a_i}\phi_i N_i P \\ \frac{dP}{dt} = e a_1 \phi_1 N_1 P + e(1-a_1)\phi_2 N_2 P - mP \end{cases}$$

(*) $\sum_i a_i = 1$ so if $a_1 \uparrow$, then $(1-a_1) \downarrow$

Now... imagine that effort (a) on sp. i 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? Optimal Organisms make the best choice out of available options...
- Set Avg profitability at the threshold

Avg Profitability: $\sum_{\text{resources } x} a_{ef} X$ (current proportional contribution = weighted avg.)

Effort for cons i on resource j

$$\left\{ \frac{da_{ij}}{dt} = G_i a_{ij} \left(e_{ij} f_{ij} X_j - \sum_{k \in \text{Res.}} a_{ik} e_{ik} f_{ik} X_k \right) \right.$$

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

then effort on res. j ↑

Otherwise, effort on res j ↓

G ~ adaptive rate (fast or slow?)

Let's build a general food web model:

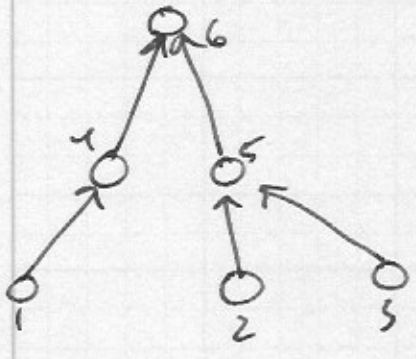
$$\frac{dX_i}{dt} = X_i\left(r_i - s_i X_i + \sum_{j=1}^{N} e_{ij} f_{ij} a_{ij} X_j - \sum_{j=1}^{N} f_{ji} a_{ji} X_j\right)$$

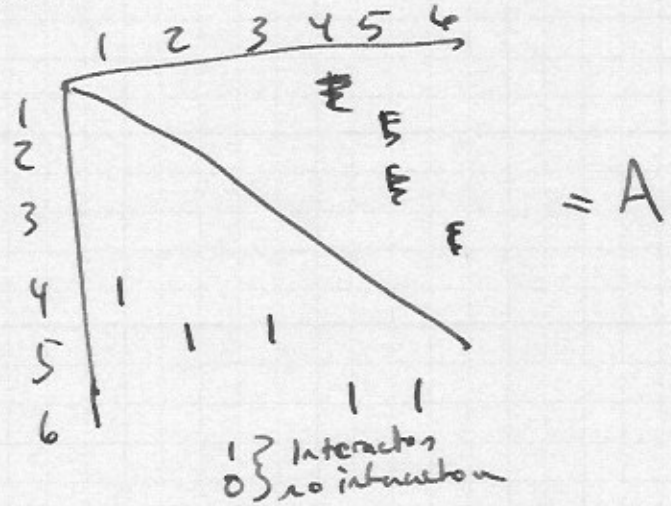
$$\frac{da_{ij}}{dt} = \sigma_i a_{ij}\left(e_{ij} f_{ij} X_j - \sum_{k=1}^{N} a_{ik} e_{ik} f_{ik} X_k\right)$$

Assumes everyone is connected to everyone!

How to build in an interaction network?

Include <u>Adjacency matrix</u> information to indicate link presence/absence.





$= A$

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

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

A_{ij}: 1 if int., 0 if no int.