

Segunda ordem e lineares:

→ Plantas anuais:

parte das sementes que  $\bar{n}$  germina no verão seguinte sobrevive  $\oplus$  inverno e germina no 2º verão.

$f$  = n. média smts planta  $N^\circ$   
 $\sigma$  = sobrev.  
 $\alpha$  = germinar  $] [0, 1]$

Suponha  $p_{n-1}$  plantas no ano  $n-1$

$f p_{n-1}$  smts

$\sigma f p_{n-1}$

$\alpha \sigma f p_{n-1}$

$(1-\alpha) \sigma f p_{n-1}$

$\sigma (1-\alpha) \sigma f p_{n-1}$

$\alpha \sigma (1-\alpha) \sigma f p_{n-1}$

smts que sobrevivem 1 inv.

smts que germinam no tempo  $n$

" " sobreviveram mas ã germinaram

smts que sobrevivem 2 invernos

" " que germinam após 2 invernos

$$p_{n+1} = \alpha \sigma f p_n + \alpha (1-\alpha) \sigma^2 f p_{n-1}$$

$$f = 200 \quad \alpha = 0.5 \quad \sigma = 0.2$$

$$p_{n+1} = \alpha \sigma f p_n + \alpha (1-\alpha) \sigma^2 f p_{n-1}$$

$$p_{n+1} = \beta p_n - \gamma p_{n-1}$$

$$p_{n+1} = 20 p_n + 2 p_{n-1}$$

$$p_0 = 20$$

$$p_1 = 10$$

$$p_2 = 20 p_1 + 2 p_0$$

$$= 20 \cdot 10 + 2 \cdot 20 = \underline{240}$$

$$p_3 = 20 p_2 + 2 p_1$$

$$= 20 \cdot 240 + 2 \cdot 10 = \underline{4820}$$

$$\alpha \sigma f = \beta = 20$$

$$\alpha (1-\alpha) \sigma^2 f = -\gamma = 2$$

$$\gamma = -2$$

$$P_n = cR^n$$

check initial

$$P_{n+1} = \beta P_n - \gamma P_{n-1}$$

$$cR^{n+1} = \beta cR^n - \gamma cR^{n-1}$$

$$\frac{R^{n+1}}{R^{n-1}} = \beta \frac{R^n}{R^{n-1}} - \gamma \frac{R^{n-1}}{R^{n-1}}$$

$$R^2 = \beta R - \gamma$$

$$R^2 - \beta R + \gamma = 0$$

$$R_{\pm} = \frac{\beta \pm \sqrt{\beta^2 - 4\gamma}}{2}$$

$$P_n = CR^n$$

$$\left\{ \begin{array}{l} P_n = C_+ R_+^n + C_- R_-^n \end{array} \right.$$

$$P_0 = C_+ R_+^0 + C_- R_-^0 = C_+ + C_- \longrightarrow \underline{C_- = P_0 - C_+}$$

$$P_1 = C_+ R_+^1 + C_- R_-^1 = C_+ R_+ + C_- R_-$$

$$P_1 = C_+ R_+ + (P_0 - C_+) R_-$$

$$P_1 = \underline{C_+ R_+} + P_0 R_- - \underline{C_+ R_-}$$

$$P_1 = \underline{C_+ (R_+ - R_-)} + P_0 R_-$$

$$\begin{array}{l} \rightarrow C_+ (R_+ - R_-) = P_1 - P_0 R_- \\ \boxed{C_+ = \frac{P_1 - P_0 R_-}{R_+ - R_-}} \end{array}$$

$$C_- = P_0 - C_+$$

$$C_+ = \frac{p_1 - p_0 R_-}{R_+ - R_-}$$

$$C_- = P_0 - \left( \frac{p_1 - p_0 R_-}{R_+ - R_-} \right)$$

$$= \frac{p_0 (R_+ - R_-) - (p_1 - p_0 R_-)}{R_+ - R_-}$$

$$= \frac{p_0 R_+ - \cancel{p_0 R_-} - p_1 + \cancel{p_0 R_-}}{R_+ - R_-} = \frac{-p_1 + p_0 R_+}{R_+ - R_-}$$

$$p_{n+1} = \beta p_n - \gamma p_n$$

$$p_n = CR^n = C_+ R_+^n + C_- R_-^n$$

$$R_{\pm} = \frac{\beta \pm \sqrt{\beta^2 - 4\gamma}}{2}$$

$$p_0 \text{ e } p_1$$

$$p_n = \left( \frac{p_1 - p_0 R_-}{R_+ - R_-} \right) R_+^n + \left( \frac{-p_1 + p_0 R_+}{R_+ - R_-} \right) R_-^n$$

$$P_n = C_+ R_+^n + C_- R_-^n \quad 2^{\text{a}} \text{ order}$$

$$P_n = C_1 R_1^n + C_2 R_2^n + C_3 R_3^n \quad 3^{\text{a}} \text{ order}$$