

Population Viability Analysis

Módulo 14

Population Viability Analysis (PVA)

Lato sensu:

Conjunto de métodos que utilizam modelos estocásticos (= probabilísticos) para projectar o futuro da população e, ...

Stricto sensu:

... em particular, a probabilidade da população persistir (ou extinguir-se) num dado período de tempo.

Shaffer, ML. 1981. Minimum population sizes for species conservation. *Bioscience* **31**:131-134.

Soulé, M. (Ed.) 1986. *Conservation Biology. The Science of Scarcity and Diversity*. Sinauer.

O caminho para a extinção

Uma via usual ...

1º Processos determinísticos unidireccionais conduzem a fragmentação em populações menores e isoladas (exploração comercial, deflorestação, monoculturas agrícolas, introdução de espécies exóticas ...).

2º As pequenas populações ficam vulneráveis a processos aleatórios que as conduzem à extinção.

(estocasticidade demográfica, deriva genética, depressão por consanguinidade)

Ciclo de vida: Sucessão de processos estocásticos

Considere-se 1 indivíduo particular e o seu CV:

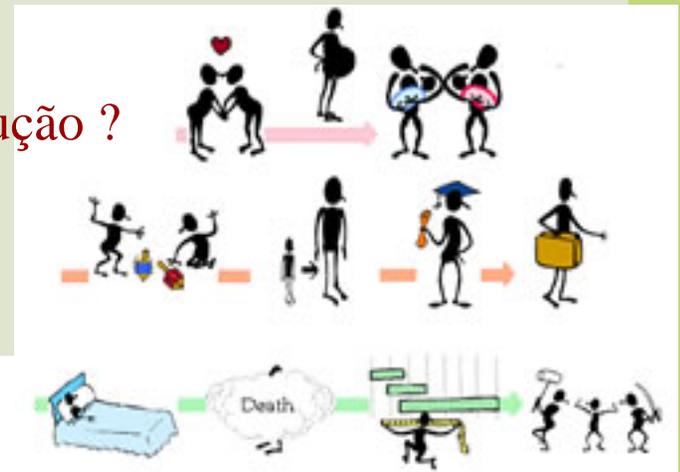
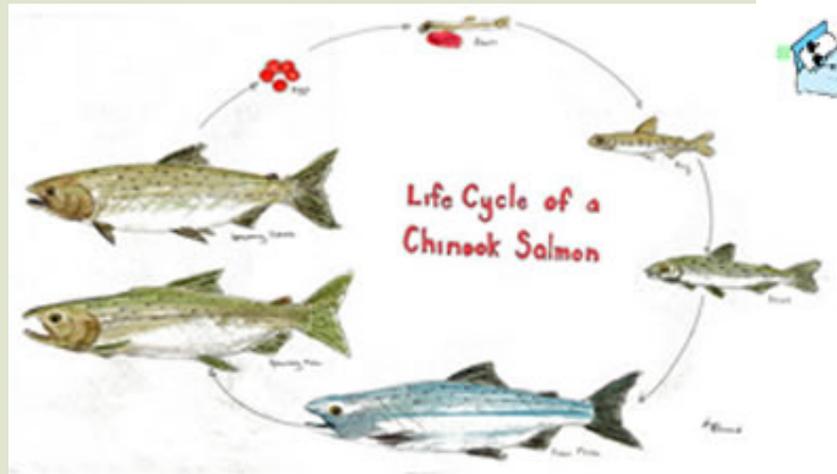
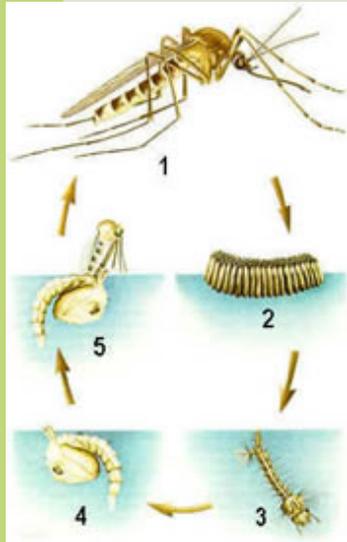
Sobrevive aos 1^os anos de vida ?

Encontra parceira para acasalar ?

As condições ambientais são favoráveis à reprodução ?

Qual o tamanho da sua 1^a ninhada ?

Quantos recém-nascidos sobrevivem ao 1^o ano ?



Grandes populações: probabilidades médias funcionam bem



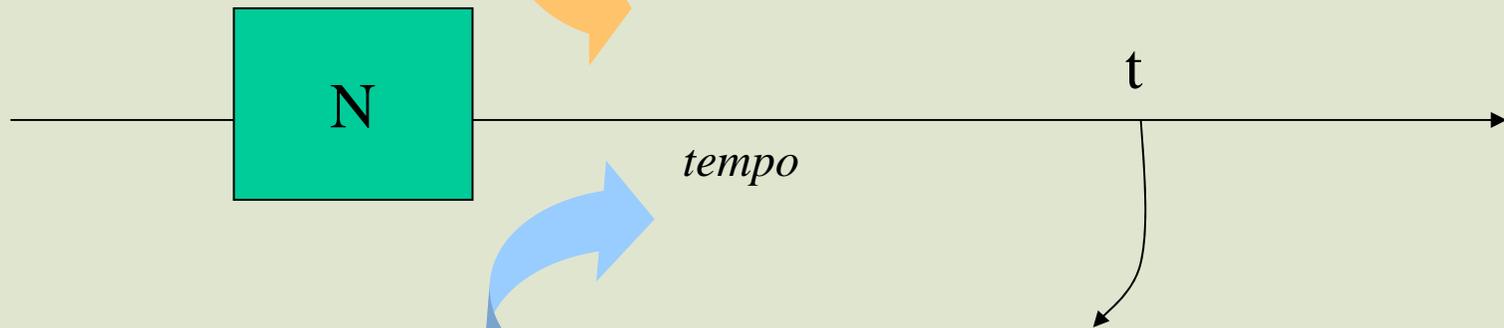
Numa grande população:

Atribuimos probabilidades médias a cada passo do CV
- uma grande população não se ressent de “desvios”
locais a essas médias.



PVA (strictu sensu)

Factores determinísticos



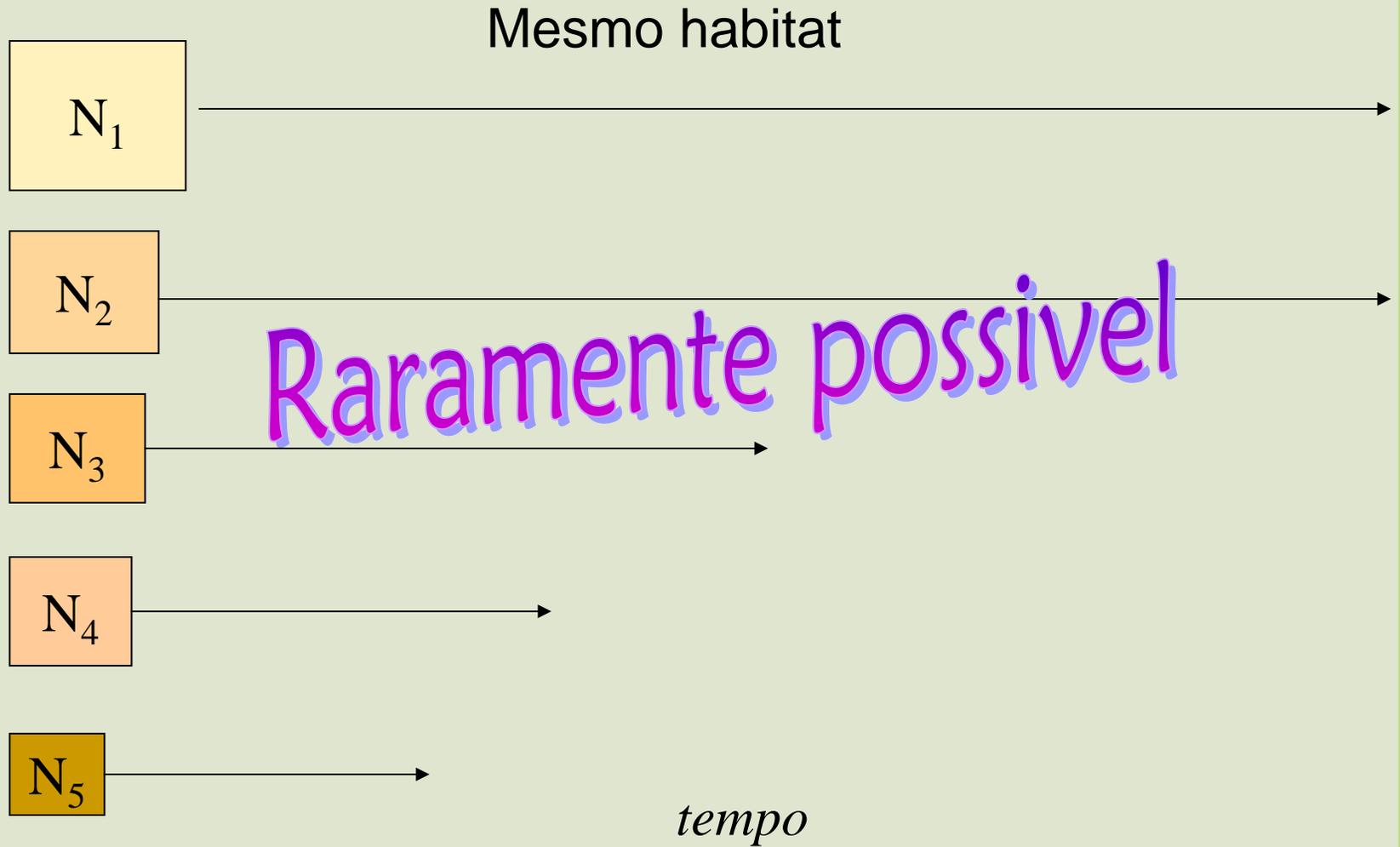
Factores aleatórios

Probabilidade de ainda persistir aqui ?

Raízes históricas no termo **MVP = Mimimum Viable Population**

Sinónimos: Population Viability Assessement; Population Vulnerability Analysis

A PVA ideal

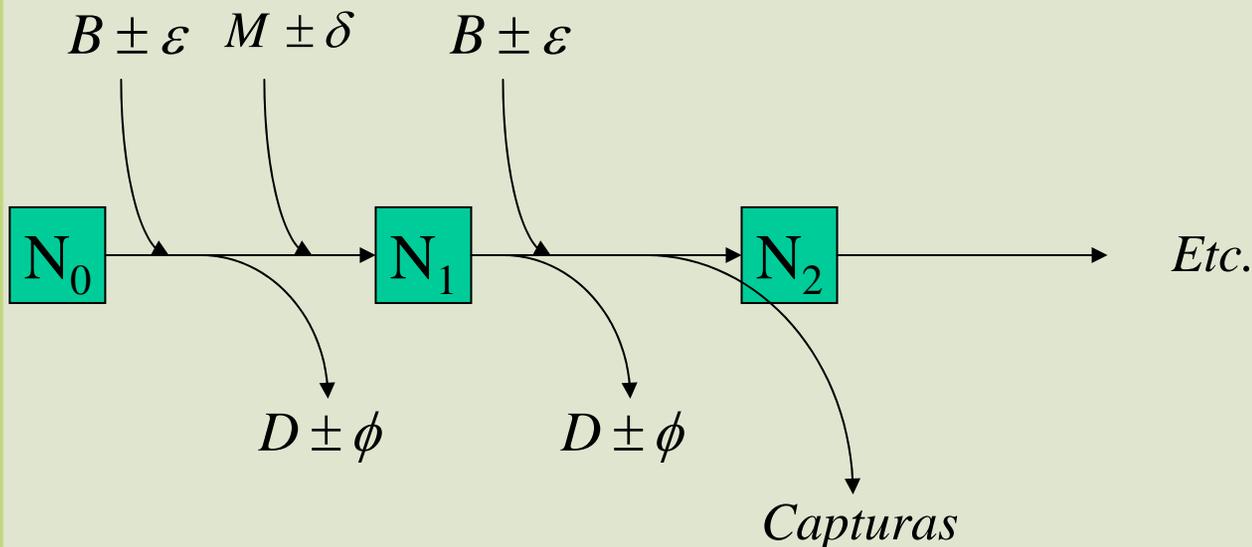


A alternativa habitual: mod. simulativos

Modelos simulativos em computador (algoritmos simulativos)

Algoritmo = sequência de instruções (regras) que são aplicadas sucessivamente, em passos de tempo discretos ($t, t+1, t+2, \dots$)

Um algoritmo visa em geral resolver um problema ou imitar um fenômeno real



“Individual-based models”

Perguntas individuais



Sobreviveu ?
Migrou ?
Disponível para reprodução ?
Acasalou ?



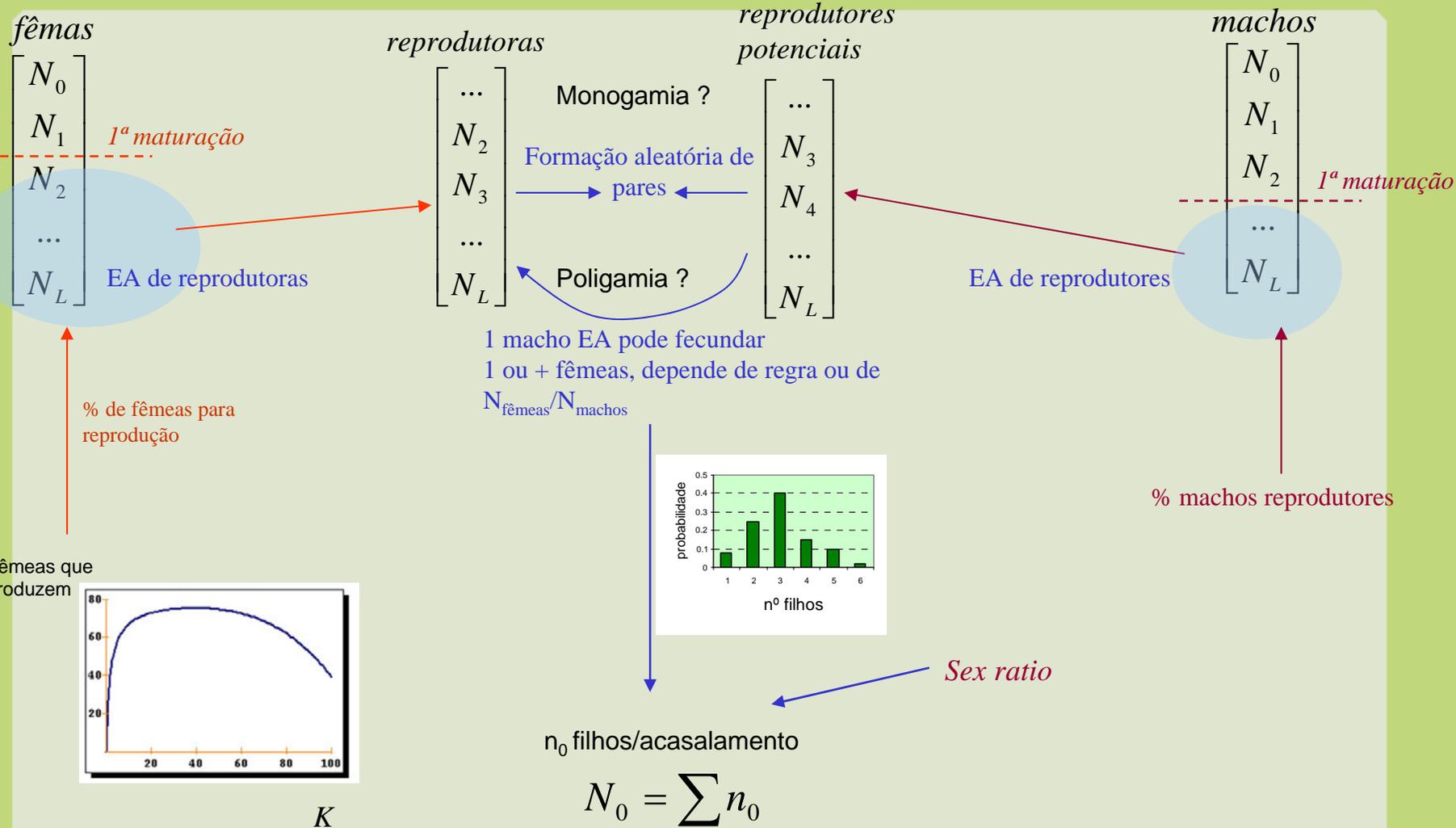
Envelhece 1 unid tempo



t

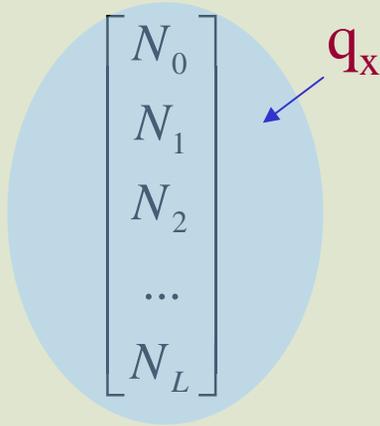
$t+1$

Algoritmo do Vortex – reprodução em (t, t+1)



Algoritmo do Vortex – sobrevivência em (t, t+1)

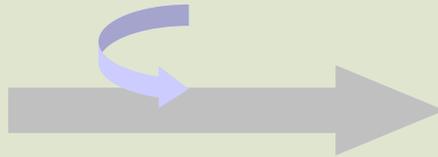
População em t
pós-reprodução



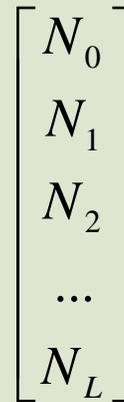
EA de sobreviventes por idade

Ajustar até $N=K$
Probabilidade de
qualquer indivíduo morrer
 $= (N-K)/N$

Catástrofe no ano t ?



População em t+1
pós-reprodução, pós-mortalidade



$$N = \sum N_x$$

Excede K ?

Sim !

Não !
→ (t+1, t+2)

Réplicas e Sensibilidade

1) Réplicas

1ª corrida (todos os indivíduos)
2ª corrida (todos os indivíduos)
3ª corrida (todos os indivíduos)
[...]
N corridas

Probabilidade de extinção em T anos:

$$\frac{\text{número de corridas em que ocorreu extinção}}{\text{número total de corridas}}$$

2) Sensibilidade

Alterar os valores dos parâmetros mais incertos de forma sistemática e estudar a sensibilidade dos resultados a estas alterações

Informações (em geral) necessárias

Determinísticas:

- Taxas médias de sobrevivência e fertilidade por idade
- 1ª e última idades reprodutoras
- Monogamia ou poligamia ?
- Tamanho médio da ninhada
- % média de fêmeas e machos disponíveis p/ reprodução em cada época
- Carrying capacity (K) da população e mecanismos de dependência da densidade
- Capturas comerciais

Aleatórias:

- Variabilidade das taxas de sobrevivência e fertilidade
- Variabilidade na % de fêmeas e machos reprodutores
- Catástrofes e respectiva probabilidade
- Variabilidade em K

VORTEX



Vortex - An individual-based model for Population Viability Analysis

Individual-based model

Populações ou
meta-populações (até 50 sub-pops)

Vortex models population dynamics as discrete, sequential events (births, deaths, catastrophes...) that occur according to defined probabilities. These probabilities are constants or random variables that follow specified distributions.

Since the dynamics of a simulated population is strongly influenced by random events, separate “runs” with the same parameters will produce different results. Consequently the model should be run many times with the same parameters in order to reveal the distribution of fates that the population might experience.

In: User's Manual, 2003

<http://pweb.netcom.com/~rlacy/vortex.html>

Vortex interface – Scenario Settings

Project1 - not previously saved

Project Settings | **Simulation Input** | Text Output | Graphs and Tables | Project Report

[Add Scenario](#) | [Delete Scenario](#) | < Scenario 1 > | [Reorder](#) | Scenario 1

Scenario Settings

Scenario Name: Scenario 1

Number of Iterations: 100

Number of Years: 100

Extinction Definition:
 Only 1 Sex Remains
 Total N < Critical Size: 30000

Number of Populations: 2

Copy input values from:
Population 1
This Section
to subsequent populations.
[Copy Input Values](#)

+

Vortex interface – Reproductive system

Project1 - not previously saved

Project Settings | Simulation Input | Text Output | Graphs and Tables | Project Report

Add Scenario | Delete Scenario | Scenario 1 | Reorder | Scenario 1

Scenario Settings

- Species Description
- Labels and State Vars.
- Dispersal
- Reproductive System**
- Reproductive Rates
- Mortality Rates
- Catastrophes
- Mate Monopolization
- Initial Population Size
- Carrying Capacity
- Harvest
- Supplementation

Reproductive System

Monogamous Polygamous Hermaphroditic
 Long Term Monogamy Long Term Polygamy

Age of First Offspring for Females:
Age of First Offspring for Males:
Maximum Age of Reproduction:
Maximum Number of Progeny per Year:
Sex Ratio at Birth - in % Males:

Clickar para ter "density-dependent reproduction"

	Population 1	Population 2
Density Dependent Reproduction	<input type="checkbox"/>	<input type="checkbox"/>
% Breeding at Low Density, P(0)		
% Breeding at Carrying Capacity, P(K)		
Allee Parameter A		
Steepness Parameter B		

Copy input values from:

to subsequent populations.
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Density-dependence das fêmeas reprodutoras

1º Explo: sem efeito de Allee: $A=0$ e com $B = 4$, $P(0)= 80\%$ $P(K)= 40\%$

The screenshot shows a software interface for population modeling. The main window is titled "Project1 - not previously saved" and has tabs for "Project Settings", "Simulation Input", "Text Output", "Graphs and Tables", and "Project Report". The "Simulation Input" tab is active, showing a "Scenario 1" configuration. On the left, there is a sidebar with various settings categories: Scenario Settings, Species Description, Labels and State Vars., Dispersal, Reproductive System, Reproductive Rates, Mortality Rates, Catastrophes, Mate Monopolization, Initial Population Size, Carrying Capacity, Harvest, and Supplementation. The "Reproductive System" section is expanded, showing parameters for "Population 1":

Parameter	Value
Age of First Offspring for Females	2
Age of First Offspring for Males	2
Maximum Age of Reproduction	10
Maximum Number of Progeny per Year	2
Sex Ratio at Birth - in % Males	50
Density Dependent Reproduction	<input checked="" type="checkbox"/>
% Breeding at Low Density, $P(0)$	80
% Breeding at Carrying Capacity, $P(K)$	40
Allee Parameter A	0
Steepness Parameter B	4

Below the table, there is a "View function for" dropdown set to "Population 1". A red circle highlights the "Density Dependent Reproduction" checkbox and the $P(0)$ and $P(K)$ values. An overlaid "Function Preview" window shows a graph of the function $f(N)$ versus population size N . The x-axis ranges from 0 to 100, and the y-axis ranges from 0 to 80. The curve starts at $(0, 80)$ and decreases to $(100, 40)$. A red arrow points from the $P(0)=80\%$ value in the settings to the starting point of the curve. A green arrow points from the $P(K)=40\%$ value in the settings to the ending point of the curve. The function preview window also displays the mathematical formula: $[80 - ((80 - 40) * ((N / K)^4))] * (N / (0 + N))$.

Efeito de Allee

2º Explo: efeito de Allee: $A=2$ e com $B = 4$, $P(0)= 80\%$ $P(K)= 40\%$

Project Settings | Simulation Input | Text Output | Graphs and Tables | Project Report

[Add Scenario](#) [Delete Scenario](#) < Scenario 1 > [Reorder](#)

Reproductive System

Monogamous Polygamous Long Term Monogamy Long Term Po

Age of First Offspring for Females: 2
Age of First Offspring for Males: 2
Maximum Age of Reproduction: 10
Maximum Number of Progeny per Year: 2
Sex Ratio at Birth - in % Males: 50

	Population 1
Density Dependent Reproduction	<input checked="" type="checkbox"/>
% Breeding at Low Density, $P(0)$	80
% Breeding at Carrying Capacity, $P(K)$	40
Allee Parameter A	2
Steepness Parameter B	4

Copy input values from:
Population 1
This Section
to subsequent populations.
[Copy Input Values](#)

Function Preview

From 0 To 100 Incr 1

Help Update Graph Close

$[80 - ((80 - 40) * ((N/K)^4))] * (N / (2 + N))$

N

Vortex interface – Reproductive rates

Save the current project **ously saved**

Project Settings | Simulation Input | Text Output | Graphs and Tables | Project Report

[Add Scenario](#) [Delete Scenario](#) < Scenario 1 > [Reorder](#) Scenario 1

Scenario Settings

- Species Description
- Labels and State Vars.
- Dispersal
- Reproductive System
- Reproductive Rates**
- Mortality Rates
- Catastrophes
- Mate Monopolization
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- Supplementation

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Population 1
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Reproductive Rates

	Population 1	Population 2
% Adult Females Breeding		
EV in % Breeding		

Specify the distribution of number of offspring per female per year.

Use Normal distribution approximation Specify exact distribution

Normal Distribution

	Population 1	Population 2
Mean		
Standard Deviation		

Data

	Population 1	Population 2
1 Offspring		
2 Offspring		

Vortex interface - Mortality

Project Settings | Simulation Input | Text Output | Graphs and Tables | Project Report

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Scenario Settings
[Species Description](#)
[Labels and State Vars.](#)
[Dispersal](#)
[Reproductive System](#)
[Reproductive Rates](#)
[Mortality Rates](#)
[Catastrophes](#)
[Mate Monopolization](#)
[Initial Population Size](#)
[Carrying Capacity](#)
[Harvest](#)
[Supplementation](#)

Copy input values from:
Population 1
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to subsequent populations.
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Mortality

Mortality of Females as %

	Population 1	Population 2
Mortality From Age 0 to 1		
SD in 0 to 1 Mortality Due to EV		
Mortality From Age 1 to 2		
SD in 1 to 2 Mortality Due to EV		
Annual Mortality After Age 2		
SD in Mortality After Age 2		

Mortality of Males as % [Copy from Females](#)

	Population 1	Population 2
Mortality From Age 0 to 1		
SD in 0 to 1 Mortality Due to EV		
Mortality From Age 1 to 2		
SD in 1 to 2 Mortality Due to EV		

+ 

Vortex interface - Catastrophes

Project Settings | Simulation Input | Text Output | Graphs and Tables | Project Report

[Add Scenario](#) [Delete Scenario](#) < Scenario 1 > [Reorder](#) Scenario 1

Scenario Settings
[Species Description](#)
[Labels and State Vars.](#)
[Dispersal](#)
[Reproductive System](#)
[Reproductive Rates](#)
[Mortality Rates](#)
Catastrophes
[Mate Monopolization](#)
[Initial Population Size](#)
[Carrying Capacity](#)
[Harvest](#)
[Supplementation](#)

Copy input values from:
Population 1
This Section
to subsequent populations.
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Catastrophes

Catastrophe1 Catastrophe2

	Population 1	Population 2
Global/Local	Global	Global
Frequency %		

Severity (proportion of normal values)

	Population 1	Population 2
Reproduction		
Survival		

+

Vortex interface - K

Project Settings | Simulation Input | Text Output | Graphs and Tables | Project Report

[Add Scenario](#) | [Delete Scenario](#) | Scenario 1 | [Reorder](#) | Scenario 1

Scenario Settings

- Species Description
- Labels and State Vars.
- Dispersal
- Reproductive System
- Reproductive Rates
- Mortality Rates
- Catastrophes
- Mate Monopolization
- Initial Population Size
- Carrying Capacity**
- Harvest
- Supplementation

Copy input values from:
Population 1
This Section
to subsequent populations.
[Copy Input Values](#)

Carrying Capacity

	Population 1	Population 2
Carrying Capacity (K)		
SD in K Due to EV		

	Population 1	Population 2
Future change in K?	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Over how many years?		
% annual increase decrease?		

+

Vortex interface - Harvest

Project Settings | Simulation Input | Text Output | Graphs and Tables | Project Report

[Add Scenario](#) [Delete Scenario](#) < Scenario 1 > [Reorder](#) Scenario 1

Scenario Settings
[Species Description](#)
[Labels and State Vars.](#)
[Dispersal](#)
[Reproductive System](#)
[Reproductive Rates](#)
[Mortality Rates](#)
[Catastrophes](#)
[Mate Monopolization](#)
[Initial Population Size](#)
[Carrying Capacity](#)
Harvest
[Supplementation](#)

Copy input values from:
Population 1
This Section
to subsequent populations.
[Copy Input Values](#)

Harvest

	Population 1	Population 2
Population Harvested?	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
First Year of Harvest		
Last Year of Harvest		
Interval Between Harvests		
Optional Threshold for Harvest		

Number of Females of each age to be Harvested

	Population 1	Population 2
Age 1 Harvested		
Adults Harvested		

Number of Males of each age to be Harvested

	Population 1	Population 2
Age 1 Harvested		
Adults Harvested		

+

Iniciar as simulações

