



Density dependence in structured populations - Tutorial in Spreadsheets

The [basic model of transition matrices](#) does not include any kind of restriction on the increase of the natural population. Therefore, this model assumes that the resources are unlimited and that the population grows (or decreases) at a constant rate. We know, however, that populations are limited by many mechanisms (eg interaction with populations of other species, resource constraints, dispersion limitation). One way in which populations are limited is related to their own density. These regulatory mechanisms associated with the density of the population are denominated dense dependence: changes in the vital rates of the populations associated to the variations of its own density.

Density dependence in a cacti population

In this exercise we will relax the premise of indefinite growth including a dense-dependence effect on one of the transition probabilities: transition in the cactus seedlings *Escobaria robbinsorum* (example in chapter 5 of Gurevitch et al 2009, a matrix of 3 stages of life).

Let us use the brake expression of the known [logistic growth model](#), which will act on the probability of permanence of the seedlings (element $a_{2,1}$ of the matrix). For this, this probability of transiting in time $t + 1$ becomes the function

$$a_{2,1} = a_{\max} \left(1 - \frac{N_t}{K} \right)$$

1)

Where a_{\max} is the maximum value of the transition probability from state 1 to 2, N_t the population size in time t , and K the population carrying capacity. The closer the population size is to K , the younger the seedling transition probability, the higher the mortality rate.

Inserting dense-dependency into spreadsheet

- **1.** Open the DenDep spreadsheet of the [file](#) de dados do cactus *Escobaria robbinsorum* (Gurevitch et al 2009). of cactus data *Escobaria robbinsorum* (Gurevitch et al 2009). In cells B4 and B5 we have the dense-dependency parameters:
 - $a_{\max} = 0,33$
 - $K = 50$
- **2. Calculate the size of the population in time t :** to do that, include in the cell G15 the formula =SUM(G12:G14) .
- **3.** In cell B6 include the formula for calculating the density dependent transition probability: =B4*(1-G15/B5).

- **4.** include in the cell B7 a condition using the IF function so that the probability of permanence does not fall below zero: $=SE(B6<0;0;B6)$.
- **5.** Direct the result of cell B7 to the transition matrix. For this, include in the cell "C13" the formula $"=B7"$.

Your spreadsheet should look like this one:

Arquivo Editar Exibir Inserir Formatar Ferramentas Dados R00o Janela Ajuda									
B6 $=B4*(1-G15/B5)$									
	A	B	C	D	E	F	G	H	
1	<i>Coryphantha robbinsorum</i> com denso-dependencia sobre permanencia de juvenis								
2									
3	Parametros Denso-Dependentes								
4	amax	0.33							
5	K	50							
6	a21	-0.231							
7	a21	0							
8									
9	Matriz de Transição								
10				tempo t					
11			plântula	juvenil	adulto		t	t+1	
12	tempo	plântula	0.43	0	0.56		50		
13	t+1	juvenil	0	0.61	0		25		
14		adulto	0	0.3	0.96		10		
15							85		
16	Projeção da população								
17		t1	t2	t3	t4	t5	t6	t7	t8
18	plântula	50							
19	juvenil	25							
20	adulto	10							

If you want to check, see the worksheet with the formulas [here](#).

Projecting population sizes

Now you must perform, in H12:H14 cells, the multiplication of the transition matrix (cells \$C\$12:\$E\$14) by the time abundance vector \$t\$ (cells G12:G14), following the same orientations of the script [en:ecovirt:roteiro:pop_str:pstr_mtexcel| basic model of transition matrices]]. This will result in the vector of abundances in time \$t+1\$. Now, just reiterate these calculations as follows:

- **1.** Copy (using “copy special” wiht only “values”. Do not copy the formulas!!) the values of H12:H14 on G12:G14.
- **2.** Copy the same values that were placed in the cells G12:G14 also for the column \$t2\$ (cells C18:C20).
- **3.** Note that by replacing the numbers in the G12:G14 cells, the formulas in the H12:H14 cells will update their values and then you have projected the population one more step of time. Repeat steps 1 and 2 above and, with each substitution, go past the values obtained in the following columns (t3, t4, t5, t6, etc) of the cells “D18:D20”. Proceed until the lambda value (which is being automatically calculated on line 23) stabilizes.
- **4.** Graph the number of individuals at each stage of life and in total as a function of time.

Exercício: Palmito sustentável

In our exercise [about palmito extraction without dense dependence](#), we used a simple model to evaluate the sustainability of the extraction.

However, the results may be unrealistic. For example, in the original model: (1) there was no limitation to the growth of the palm heart population, (2) the transition rates do not vary from year to year; (3) management has no impact on transition rates.

The challenge here is to create a more realistic model, including density dependency. Use the transition matrix for a palmito population (*Euterpe edulis* Mart.) In the Santa Genebra Reserve, Campinas (Frenckleton et al., 2002), which is in the worksheet [palmitos2011.xls](#). Using the same procedure of the previous exercise with the cactus:

- Choose one of the transition rates to model the dense-dependence in the heart of palm population and justify the choice;
- Produce dense-dependency extraction scenarios for the palm heart population;
- Make projections and suggestions for the sustainable management of palm heart.

To learn more

Gotelli, N. J. 2007. Ecologia. Cap.2 - Crescimento Logistico de Populações. Pp. 26-48. Ed. Planta.

Gurevitch, J, Scheiner, S.M, Fox, G.A. 2009. Ecologia Vegetal. Cap. 5 - Ed. Artmed, São Paulo.

Silva Matos, D.M. et al. 1999. THE ROLE OF DENSITY DEPENDENCE IN THE POPULATION DYNAMICS OF A TROPICAL PALM. Ecology, 80(8), 1999, pp. 2635-2650

[planilha](#), [uma população](#), [população estruturada](#), [exercício](#)

1)

if you have trouble viewing math expressions on this wiki, look for some plugin or extension that has ASCIIMath in the name for {a} {a} { your browser. **Chrome** the extension is named *MathML-2-CSS* Firefox recognizes the formulas by default, other browsers have not been tested.

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