Exercise 3 – Neutral Theory and emergent pattern in Ecology.

Deadline: May 13/2019. **Send email with object: Exercise 3**: A presentation of the project in .pdf (no more than 4 pages) and the source code. The files name should be surname_name_ex3.pdf and surname_name_code3.XX

If the project has been developed by a group (max 3 persons), please indicate the name of the other authors in the presentation of the project.

The Dataset: Barro Colorado Forest Census Plot Data (Version 2012) (file: bci05.csv) - the same you used in Exercise 1.

Tasks:

1. Divide the 50-hectar plots in N=800 subplots of equal area. We will assume that these are independent and we can do the statistics on these plots. Calculate: a) the vector of the abundances for all the species ($x_1,...,x_S$) for each subplot; In this way you have a N*S matrix, where each row represent the statistics of abundances in one subplot. b) Transform the matrix in one big vector of N*S component and remove all the 0s in the vector. The resulting vector – let us call it **X** contains all information about "present" species in our statistics.

2. Build the empirical cumulative distribution function from **X**, i.e. calculate the probability that picking a species at random it has an abundance equal or greater than x, i.e. $P_>(x)$. Of course $P_>(1)=1$. This is the cumulative of the Relative Specie Abundance (RSA).

3. Compare the stationary solution of the birth and death ME with birth rate $b_n=b*n$ and death rate $d_n=d*n$ and immigration $b_0=m$ with the cumulative RSA, knowing that experimentally the immigration rate has been measured and it is m=0.05. *Notes:* 1) you need to use the cumulative distribution of the solution; 2) You need normalize the solution of the birth and death ME from 1 to ∞ (not from 0).

4. *OPTIONAL:* Build the empirical Species Area relationship in the BCI

forest, i.e. calculate the different number of species for increasing area building the curve <S(j*a/A)> where a=area of the subplot, A = total area and j=1,…N). Of course you need to perform averages. Compare the empirical curve with the prediction from Neutral Theory in a well-mixed ecosystem that I have presented in class (doing the best fit for the free parameter m).

5. *Logistic Growth.* Another widespread model for population dynamics used in ecology is the so called logistic model, where species abundance initially grows exponentially but then reaches a carrying capacity K. There are several microscopic derivations that give the same logistic behavior. In particular consider the reactions:

   1) Birth: A --> A+A with probability *b* (per unit time and per particle);

   2) Migration: 0 --> A with probability *m* (x unit time and x particle);

   3) Death: A --> 0 with prob. *d*(A)=b A / K (x unit time and x particle).

   Write the transition rate W^+(A)=W(A-->A+1) (summing both 1+2) and W^-(A)=W(A-->A-1) (using 3) for the population dynamics of 1 species. Write the corresponding Birth and death Master equation a as function of the stationary state. Plot it for m=0.1, b=1 and K=10 (P(0) can be calculated numerically).