BIOU9PC: Population and Community Ecology
Lab Practical week 4: Meta-populations
6 October 2016

Objective

The aims of this week's lab practical is to use and understand simple meta-population models and to strengthen your abilities in reading and manipulating R code.

1. We will start with the meta-population model by Levins (1969):

$$P_{t+1} = P_t + cP_t(1 - P_t) - eP_t$$

where *P* is the fraction of occupied patches, *c* is the colonization rate and *e* is the extinction rate. We code this mathematical function in *R* using a for() loop, and use this to project the sub-population sizes into the future.

a) Vary the colonization rate between 0 and 1 while keeping the extinction rate constant (e.g. 0.5). Then, vary the extinction rate between 0 and 1 while keeping the colonization rate constant (e.g. 0.5). Plot the fraction of occupied patches (*P)* for different combinations of rates, and describe the patterns you observe. What determines the equilibrium fraction of patches occupied?
b) Compare the mathematical solution of equilibrium of $P^*=1-e/c$ to your results from question 1a) by calculating *P* for the combinations of *e* and *c* you tested. Make a table of *P, e* and *c* and describe the results in comparison to 1a).
c) Set $e > c$. What value does P* take when you do so? How can this be biologically interpreted?

2. Levin's model assumes that the interlinked sub-populations grow logistically, but it elides the details of their population sizes, focusing only on the colonization and extinction of patches. Here, we examine the population dynamics of a set of logistically-growing populations that are linked by migration. The main aim of this part of the practical is to understand the effects of emigration and immigration and nature of source-sink dynamics. The second aim is to understand and use complex code that someone else has written.

a) There is no migration at time 0. At what time-step does migration start?
b) What are the migration rates among the populations? What governs the rates of migration? Describe the rate of migration from each sub-population to the others.
c) What are the population sizes of the different populations before and after migration?
d) Do the sub-populations converge upon their respective carrying capacities in the presence of migration? Why or why not?
e) Create sink sub-populations by giving some sub-populations slightly negative intrinsic population growth rates. Try growth rates of -0.01, 0.01, 0.01. What is the population trend before and after migration starts? What biological scenario does this mimic?
f) Change the growth rates of the populations to trigger extinction in a sub-population. Under which circumstances in e) can a sub-population go extinct? What happens to the population size after migration starts?

g) Change the carrying capacity to 50 for one population and 1000 for the others. What happens to the population trend of the sub-populations? Can the sub-population with low carrying capacity persist? If so, at which population size?
h) Explain the conservation applications of the source-sink dynamics you modelled in f) and in g). Use real-world examples.