Ecological Dynamics
Assignment 2

Instructions

1. Download the `R markdown` assignment template from Blackboard or the web
2. Open the file `dynamics-assnTemplate.Rmd` in RStudio
3. Insert the relevant information (i.e., assignment number, student name)
4. Save the file as `assnNUMBER-yourLastName.Rmd` and replace `NUMBER` with the assignment number
5. For each question, your answer should consist of (1) the `R` code used to generate the results and (2) the interpretation of the results
6. Generate a PDF of the `R Markdown` document by clicking on the **"`Knit PDF`"** icon in RStudio
7. Email a PDF and `R Markdown` version of your completed assignment to the instructor
8. The assignment is due on Monday April 06

Problem 1: Effective biocontrol agents (30 points)

You are tasked with finding a good candidate species to serve as a biocontrol agent for an invasive pest that is causing significant damange to US crops in the midwest. You travel to the native range of the invasive pest to look for natural predators that may be serve as effective biocontrol agents. You identify three different natural predators, each characterized by a different functional response. Specifically, predator species 1 has a type I functional response, species 2 a type II and species 3 and type III.

1. To determine the effectiveness of each species, conduct an *in silico* experiment whereby you will simulate the dynamics of a Rosenzweig-MacArthur predator-prey model for a total of $t = 3000$ timesteps and for a range of handling times h (i) with vs. (ii) without the predator. For each simulation, compute the mean log response ratio of the prey over the last 500 time steps (i.e, the log of the ratio of the equilibrium abundance of the prey without vs. with the predator). Assume that the prey's intrinsic rate of growth and carrying capacity are respectively $r = 3$ and $K = 10$. Furthermore, assume that the predator's attack rate, efficiency, mortality rate are respectively $a = 2$, $b = 1$ and $m = 1.5$. Finally, perform this simulation for h varying from 0 to 1 in 20 linearly-spaced values and initial abundance set to 0.1 (**10 points**)
2. Plot the log response ratio as a function of the handling time for each predator. Based on this result, rank the three species in terms of their efficiency as potential biocontrol agents and justify your answer (**5 points**)
3. To determine whether the introduction of each of the three potential biocontrol agents might destabilize the system, you decide to run an enrichment experiment whereby you determine the stability of the predator-prey system for carrying capacities K ranging from 2 to 14 in 20 linearly-spaced values. For each value of K, measure the local min/max of the prey abundance over the last 500 time steps of the simulation. Assume that handling time $h = 0.5$ and that all other parameters are identical (**10 points**)

4. Plot the local min/max of the prey abundance as a function of carrying capacity K for each of the three species. Does this figure make your reconsider you ranking of the species in the previous question? Justify your answer (**5 points**)

Problem 2: Intraguild predation (20 points)

Intraguild predation (IGP) is a common phenomenon in nature and occurs when species engage in both exploitative competition and predation. To determine whether IGP alters the conditions under which species can coexist, we will analyze the equilibrium behavior of two IGP models.

1. Begin by assuming that species N_1 and N_2 engage in explicit exploitative competition for resource R and that N_2 also consumes N_1. Assume that N_1 and N_2 consume resource R according to function $f_1(R)$ and $f_2(R)$ respectively, that N_1 is consumed by N_2 according to function $y(N_1)$ and converted to N_2 abundance according to function $g(y(N_1))$. Derive and interpret the coexistence conditions in the presence of intraguild predation (**5 points**)
2. Now derive and interpret the coexistence conditions in the absence of intraguild predation. Is IGP likely to promote or reduce coexistence? (**5 points**)
3. Now derive the coexistence conditions in the presence of IGP for an explicit model where $f_i(R) = a_i R - m_i$, $y(N_1) = b$, $g(y(N_1)) = cbN_1$. Furthermore, assume that the resource grows at rate r and leaves the system at rate δ (**5 points**)
4. Derive the coexistence conditions in the absence of IGP and compare them to those obtained in the presence of IGP (**5 points**)