**Modelling with MATLAB: Assignment 2, 2016.**

This assignment is based on the following papers (available on Moodle), and extends some of the ideas (random matrices, random parameter values and Monte Carlo integration) from the practicals into an applied “complex systems” context.

Stability criteria for complex ecosystems, Allesina and Tang, Nature, 2012. (*This paper extends some of the issues of complexity and stability raised in the classic May papers in the 1960s and 1970s, as discussed in lectures*. *Footballs squash into rugby balls, beautiful.*)

“Disentangling nestedness from models of ecological complexity”, James, Pitchford & Plank, Nature, 2012. (*This paper concentrates on dynamic models of mutualistic interactions, in a range of applications, using methods based on generalised Lotka-Volterra dynamical systems*.)

“Constructing Random Matrices to Represent Real Ecosystems”, James et al., American Naturalist, 2015. (*In the context of this assignment, we ask whether May’s original assumption of equal elements on the diagonal of the Jacobian matrix is important in our assessment of the system-level behaviour. We would argue that it is.*)

“The ecology of the microbiome: Networks, competition, and stability”, Coyte, Schluter and Foster, Science, 2015. (*A recent and elegant extension of some of the ideas developed in some of the preceding papers. Among other things, the notion of “linearly stable equilibrium point” is challenged using more general ideas which need not concern us here.*)

**YOU DO NOT NEED TO READ AND UNDERSTAND EVERY PART OF THESE PAPERS IN ORDER TO DO THIS ASSIGNMENT. THE MAIN RESULTS FROM ALLESINA AND TANG FIGURE 1 (AS DISCUSSED IN LECTURES) AND THE ROLE OF DIAGONAL VARIABILITY (AS DISCUSSED IN LECTURES) ARE THE KEY ELEMENTS.**

**EACH QUESTION CARRIES AN EQUAL NUMBER OF MARKS.**

**CREDIT WILL BE GIVEN FOR THE CLARITY AND LOGIC IN YOUR ANSWERS, AND FOR PROVIDING CLEARLY WRITTEN AND WELL COMMENTED CODE AS APPROPRIATE.**

**QUESTION 4 IS MORE CHALLENGING AND OPEN-ENDED, AND HAS A ONE-PAGE MAXIMUM LENGTH (YOU MAY ATTACH ADDITIONAL SUPPORTING MATLAB CODE IF NECESSARY).**

1. Using the May-like random matrices developed in Week 5 Practical, and incorporating the sign structure used in the Allesina and Tang interpretation of predator-prey and mutualistic interactions, verify numerically the key result of Allesina and Tang (2012) i.e. show that under the assumptions of Allesina and Tang (2012), predator-prey interactions are stabilising, and mutualistic interactions are destabilising. (Simplest method: recreate the top panel of Allesina and Tang’s Figure 1.)

2. Suppose that an unstructured random matrix of the form considered by Allesina and Tang (i.e. a matrix leading to the circular eigenvalue spectrum in Figure 1a) is modified by having the elements of each row multiplied by a factor Ri , where Ri is a uniform U[0,2] random variable chosen independently for each row. Evaluate the consequences of this modification for stability (in the sense of Allesina and Tang), in comparison to the roles of mutualism and predator-prey interactions.

(N.B. You may be able to see the relevance of this modification in the context of May’s original 1972 model and the James et al. 2015 paper; they both attempt to account for underlying Lotka-Volterra dynamics, but they arrive at different conclusions.)

3. Consider the Thebault and Fontaine model of obligate mutualism used in James et al. (2012), as detailed in the Supplementary Information. The authors claim that (SI, p. 12):

“*Moreover, simple simulations on systems with only a single plant species and single animal species show that an isolated mutualistic pair of species, each with no other partners, has an extinction probability of over 99%*.”

Solve the system numerically to check whether this claim is true.

4. Explain briefly why the models considered by Coyte et al. (2015) (as detailed in Section Method 1a of the Supplementary Material, pages 4 and 5) are vulnerable to the criticisms about diagonal elements in the Jacobian as outlined in James et al. 2015. Do the main conclusions of Coyte et al. (2015) change qualitatively when diagonal variability is added? Explain your answer with the support of appropriate numerical outputs.

N.B. Your answer to this question **must not exceed one printed page**, and **should not** consider features such as permanence, IBMs, or analysis of real data.