**The Mathematics Behind Biological Invasions**
**Computer exploration I**

Our team of programmers has created a set of MATLAB programs to investigate spread. They should be waiting for you in your main directory, and you should be able to run them by name, open them in the editor and modify them. Our goal is to use these programs as templates for further investigation. The main programs are:

| File | What it does |
|---|---|
| IBM1d.m | Individual based simulation of spread in one dimension |
| IBM2d.m | Individual based simulation of spread in two dimensions |
| IDE1d.m | Numerical solution of integro-difference equation (1D) |
| RD.m | Numerical solution of reaction-diffusion equation (1D) |
| ide.m | Competing solver of integro-difference equations (1D) |

# 1 Background exercises

First, work through Exercises 1-9 in the handout **Spatio-Temporal Models in Ecology** by James Powell. Make sure you have some understanding of the portion on the FFT.

# 2 Exploration and comparison with theory

**Exercise 1: Exploring the shape of the dispersal kernel in one dimension** The programs `IBM1d.m` and `IDE1d.m` both study an integro-difference model, the first by simulating the behavior of individuals and the second by using `fft` to solve the equations. Each includes a variety of dispersal kernels. To choose among them, comment out (put % at the beginning) the lines describing the ones you don't want, and remove the comments for the one you do. For the normal, Laplace, and Cauchy distributions, match the parameters in the two programs, and compare the speed of the numerical wave front with the simulation. Find the theoretical speed of the wave front and compare. The programs also show the distribution of individuals behind the wave. How well do they match?

**Exercise 2: Adding a new dispersal kernel to `IBM1d.m`** The program `IDE1d.m` includes the "Finite Moment Kernel". Figure out what is special about it, add some lines to the program `IBM1d.m` to include, and see what happens to the wave. Does the theory help make sense of this?

**Exercise 3: Comparing the integro-difference model with a reaction-diffusion model** The program `RD.m` numerically solves for the spread of species governed by a reaction-diffusion equation. Experiment with the wave speed in this case by changing the diffusion constant. Does it behave according the theory? What is $r$ in the program?

**Exercise 4: Comparing different methods for detecting the front of the simulated wave** The program `IBM1d.m` includes three methods for finding the front of the wave. Compare their results (by commenting out the one you don't want and removing the % from the one you do). Are they more different for dispersal kernels with fat tails? Can you think of and implement another plausible method?

**Exercise 5: Comparing different growth functions** The program `IDE1d.m` includes three different models of growth, which can be selected as usual by commenting (which you will need to do in two different places). Compare their results. As you might know, the Ricker model can produce unstable dynamics when $R$ is sufficiently large. Make $R$ larger and larger until something wild happens.