CSC 120 (R Section, L0201), Spring 2016 — Assignment #3

*Worth 10% of the course grade. Due by the start of class on April 8 (the course web page will have instructions for how to hand it in, using the **knitr** package and email). This assignment may be handed in late, with a 20% penalty, by noon on April 11. Assignments will not usually be accepted after that. Contact the instructor as soon as possible if you have a legitimate excuse (eg, documented illness) for handing in the assignment late (without penalty).*

This assignment is to be done by each student individually. You may discuss it in general terms with other students, but the work you hand in should be your own. In particular, you shouldn't leave a discussion with someone else with any written notes (either paper or electronic).

In this assignment, you will write an R program to simulate a cow wandering randomly in a field, eating grass that grows in random places. Simulations of this sort are widely used to model phenomena such as disease epidemics. Simulation is also used to test how well statistical methods work. Doing this assignment will also provide you with practice in how to organize a program into functions. In addition, you will learn how to use the `knitr` package, which runs an R script in a way that conveniently combines R commands, output, plots, and discussion.

Your program will simulate a cow that moves over a field that is represented by a grid of points, with `nr` rows and `nc` columns. At each grid point, there may or may not be some grass. Time is modeled as occurring in steps. At each time step, every grid point that does not already have grass has grass grow on it with probability `prgrow`, independently for each grid pint. The cow then moves randomly, choosing with equal probabilities (of 25%) to go up one row, down one row, left one column, or right one column, except that if the selected movement would take the cow out of the grid, the cow instead stays where it is. Finally, after the cow (possibly) moves, if the cow is then at a grid point where there is grass, the cow eats the grass, so there will not be grass at that grid point at the start of the next step.

You should start each simulation with no grass at any grid points, and with the cow in the lower-left corner, at row 1 and column 1. (Note that the coordinate system used should have rows on the y-axis and columns on the x-axis, with (1,1) in the lower-left corner.)

You should display the results of a simulation in several plots.

One type of plot will show the state of the world at one particular time step, as a plot of grid points, with grid points having grass shown as green circles, and the location of the cow shown as an X. Here is an example:
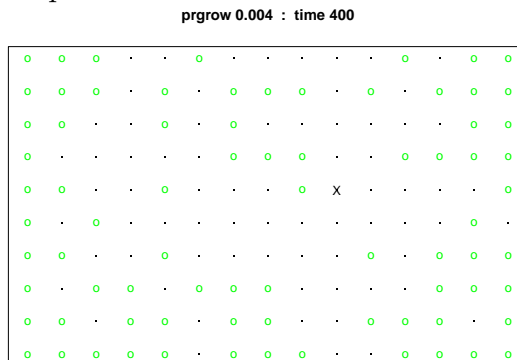
The title should identify the growth probability for the simulation, and which time step it shows.

Other plots should show the total amount of grass at each time step, and the row and column position of the cow at each time step. Here is an example, in which the last state at time 400 is the same as is shown in the plot above:
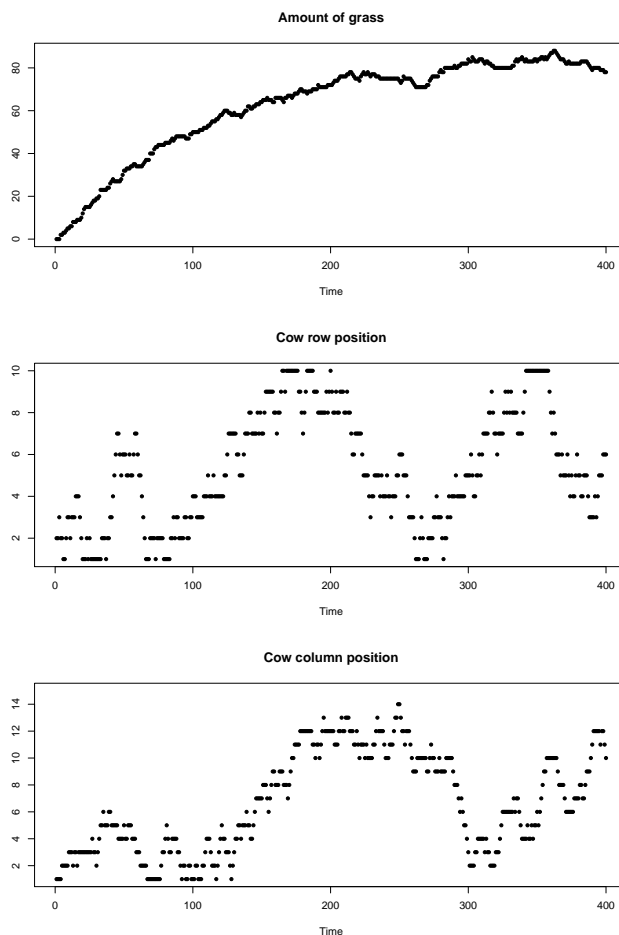
You can plot small dots using the `pch="."` option to `plot` or `points`, and somewhat bigger dots with `pch=20`. You can set the colour with, for example, `col="green"`.

You should hand in the results of doing three simulations, with parameters set as follows:

1. Grid has `nr=10` and `nc=15`. Growth probability is `prgrow=0.004`. Run for 400 time steps. Plots of the state of the world are produced at steps 100, 200, 300, and 400, in a 2x2 array, with `par(mfrow=c(2,2))`.

2. Like (1) above, except with `prgrow=0.007`.

3. Grid has `nr=20` and `nc=20`. Growth probability is `prgrow=0.002`. Run for 1000 time steps. Plots of the state of the world are produced at steps 100, 200, 500, and 1000, in a 2x2 array, with `par(mfrow=c(2,2))`.

For each of these simulations, you should also produce plots of the amount of grass and the row and column position of the cow (as a set of three, like above, using `par(mfrow=c(3,1))`).

Note that probably none of your plots will look exactly like the example plots above, since you will probably use a different random number seed.

For this assignment, you will have to decide for yourself what functions to define, and what their arguments are. You will also have to decide how to represent the state of the simulation (where grass is present, and where the cow is located). As for previous assignments, you should put the definitions of whatever functions you define for solving this problem in general in one script file, and in a separate script file you should put commands for doing the three simulation runs with the sets of parameters mentioned above. At the beginning of your script to run the simulations, you should set the random number seed to your student ID number.

You should hand in the assignment by email to `radford@cdf.utoronto.ca`, with two attachments: the R script file that defines the functions, and the output of the script for running the three simulations, as an HTML file produced using `knitr::spin`, with options set as described in the March 23 lab exercise (on the course web page).

Your program should be properly indented, with suitable comments. In particular, you should document what the functions you define do, including what arguments they take, and what value they return.