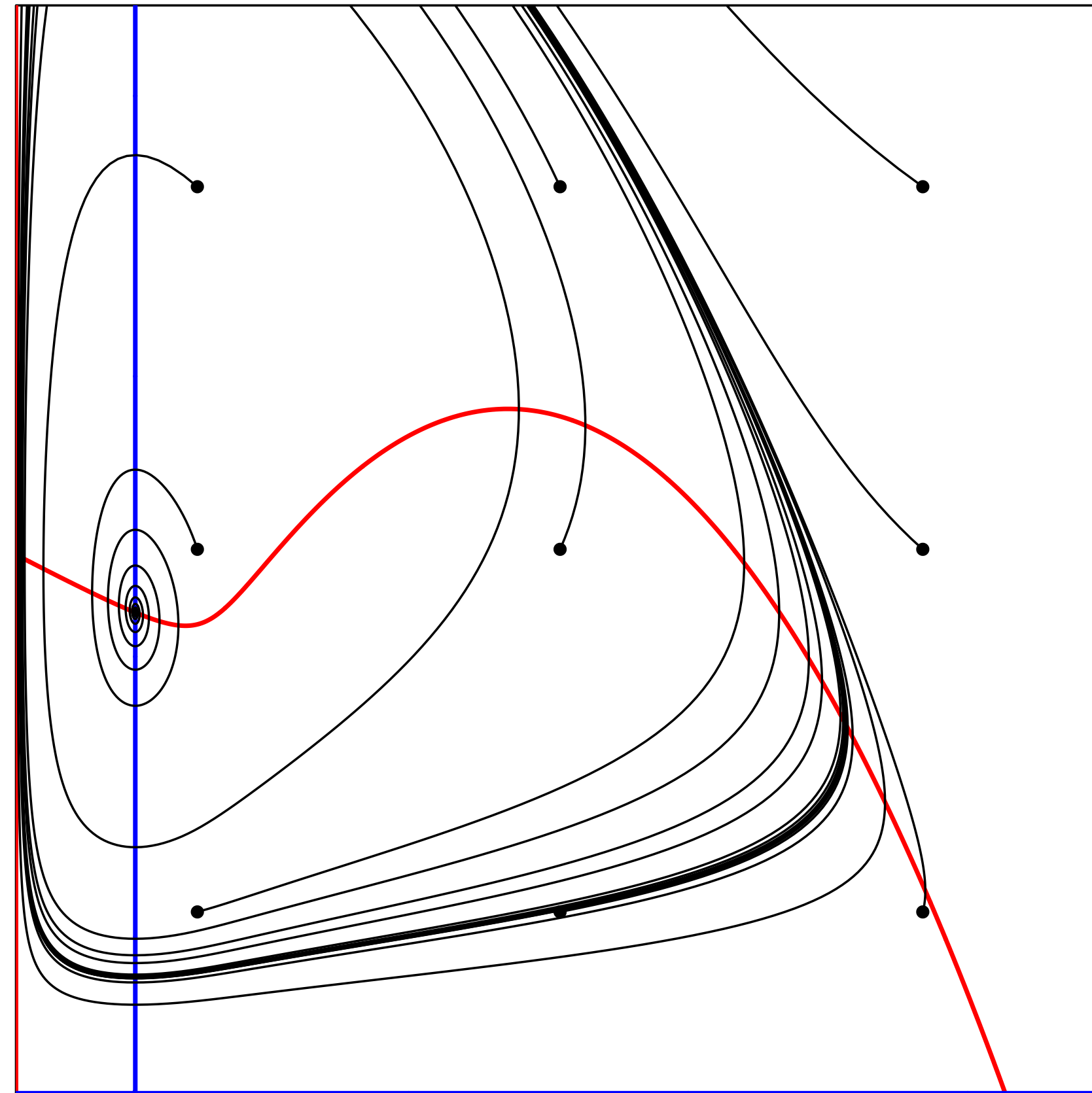


Biological Modeling of Population Dynamics 2023



Rob J de Boer, Theoretical Biology & Bioinformatics

Aim of this course

Learn to use mathematical models as a tool for investigating biological questions

Learn to develop and analyze models (second hour)

Phase planes, steady states, stability, bifurcations, numerical integration.

Both on paper and with a computer (R).

Learn to rigorously interpret results from a mathematical model

Focus on populations (cells, prey & predators, bacteria, viruses, molecules)

Not on neurobiology, space, transduction networks,

Structure of this course

First 6 weeks Math-reader and the BM-book
Last lecture and practical on Thursday Dec 21.

Exam in week 7 (on Thursday January 11).
Open book for math-reader only.
After the exam the master students leave us

Week 8-10 bachelor students work on a project and attend seminars.
Week 10: open book exam and presentation of project (in English)

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✕

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Please read this general information and mark it as completed afterwards.

[Have a look around and introduce yourself](#)



Week 1: Making models and doing math

This week we will alternate between modeling (the BM book) and math (the math book).



Monday 13 Nov Lecture 13:15-15h in Ruppert-Blauw: Introduction



Practical 15:15-17h in BBG 001: Questions & tutorials



Lecture recording & Clips



Tutorial: Nullclines and phase plane analysis

General program

Mondays

13:15-15:00 Lecture and 15:00-17:00 Practical

Tuesdays & Thursdays

9:00-11:00 Lecture, 11:00-15:00 Practical, 15:00-17:00 Self Study time

Read the book beforehand. Watch afterwards if necessary

Practicals

Make exercises in small groups. Ask for help from TAs!

Math and Tutorials

Crash course into eigenvectors and eigenvalues required for stability analysis
Understanding concepts more important than math skills

Several tutorials to refresh your math skills (videos with **script**):

Sketching functions with free parameters

Solving equations composed of variables and free parameters

Sketching nullclines and vector fields in phase spaces

Grind: R-script to solve and fit ODEs and to perform phase plane analysis

You are all supposed to know some R:

A (very) short introduction to R

Paul Torfs & Claudia Brauer

Install R and RStudio on your own device

Read the first pages of the Grind tutorial (read it again while doing a project)

Install the 3 required libraries (once). Source grind.R before you start (each time).

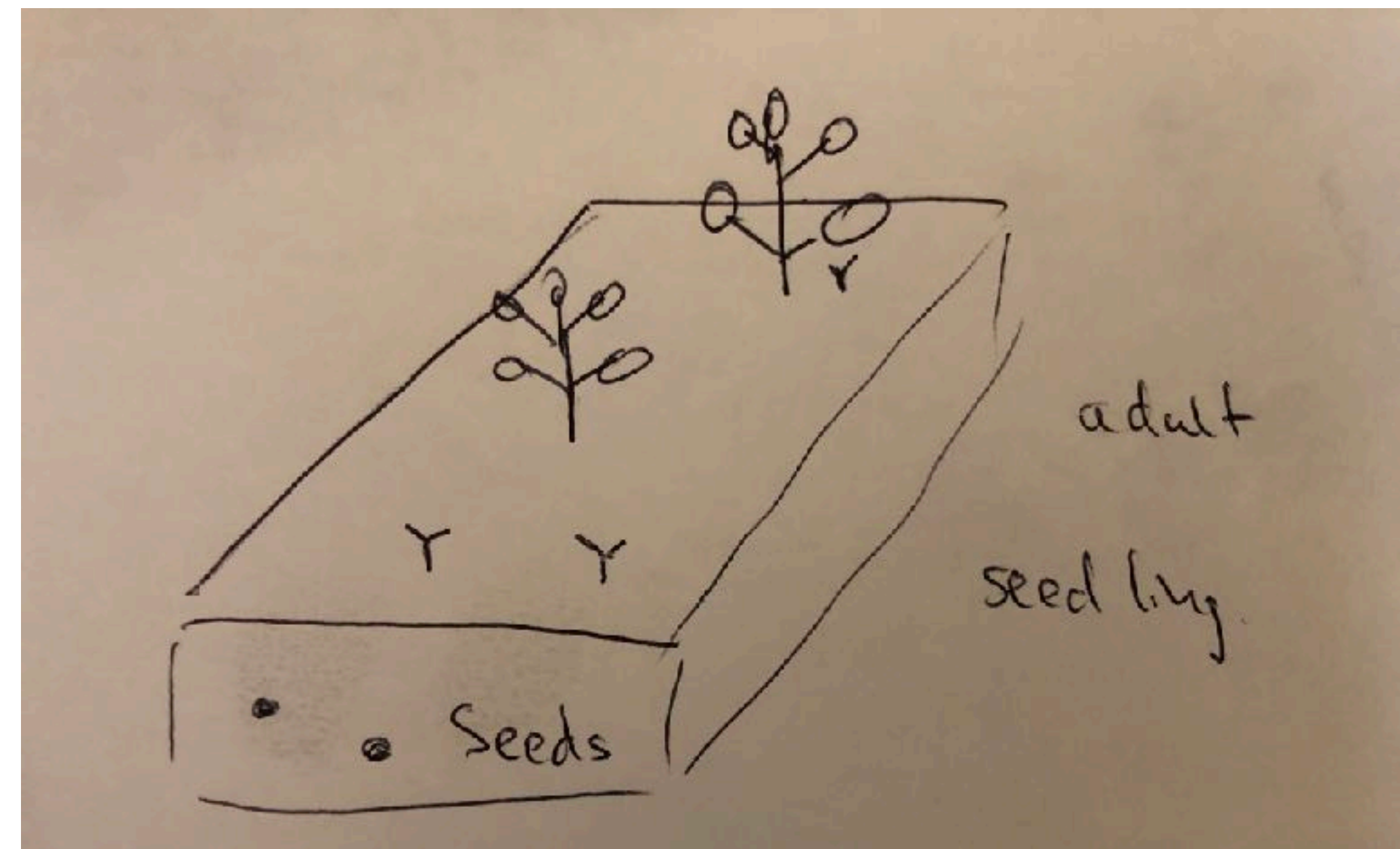
We do provide a **Mathematica** notebook on analyzing the Lotka Volterra model (Wolfram alpha).

Make a model

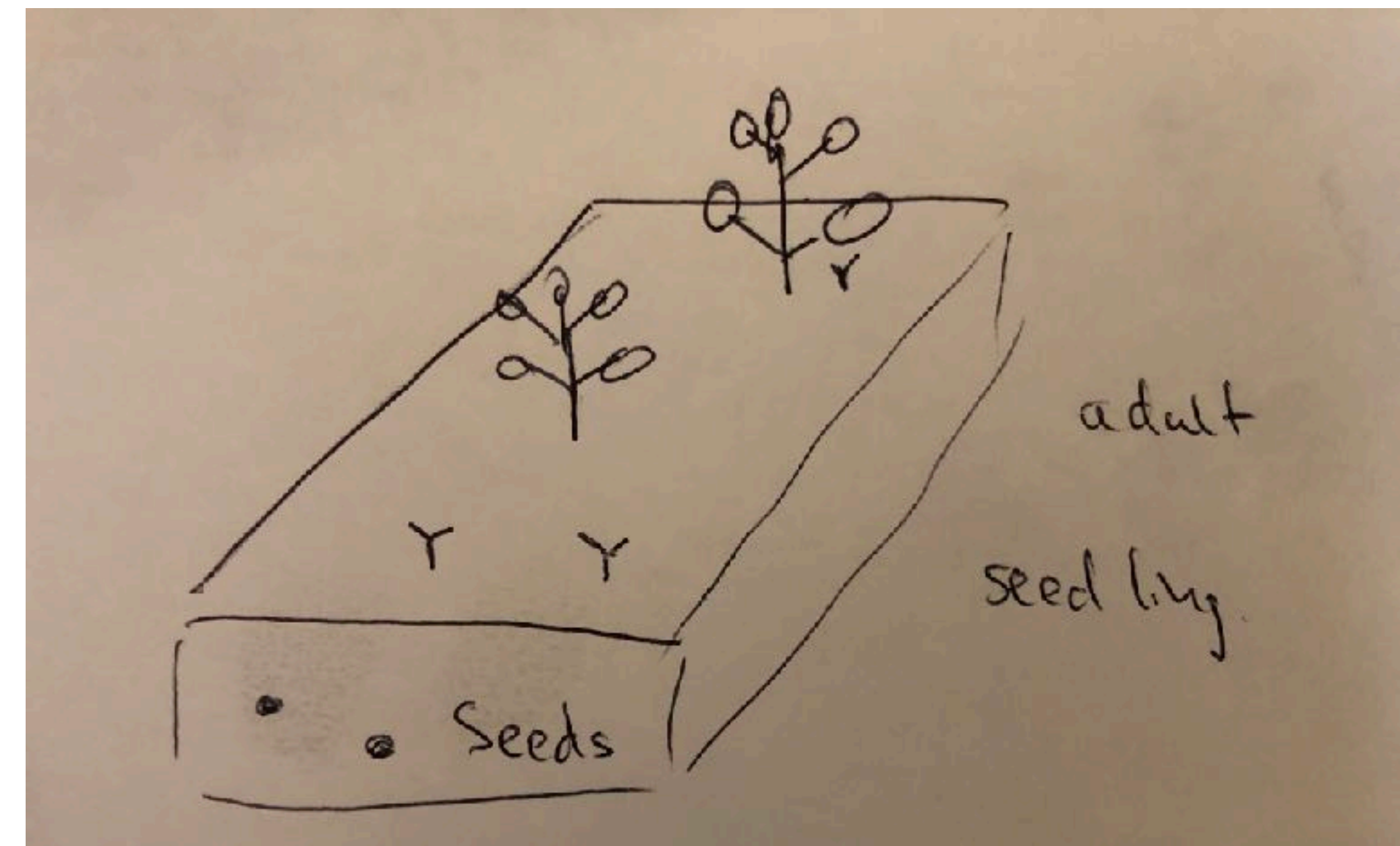
Question 13.1. Seedlings over-shadowed by adult plants

Consider a field in which the seeds of one particular plant species are sprouting from a large slow seed bank. The seeds in the seed bank are so long lived that the production of novel seeds by the current population hardly matters. On a daily basis a few seeds sprout from the soil to form a small seedling that either dies or matures to become an adult plant (we ignore seasonality). Adult plants die (and produce seeds), and have to be replaced by novel seedlings that successfully mature. Since adult plants are larger than the small seedlings, seedlings growing under the cover of adult plants will receive less sunlight, and hence mature slower than those that are directly exposed to the sun. Make a natural model for the number of seedlings and adult plants in the field.

First define variables, processes, and then interaction functions

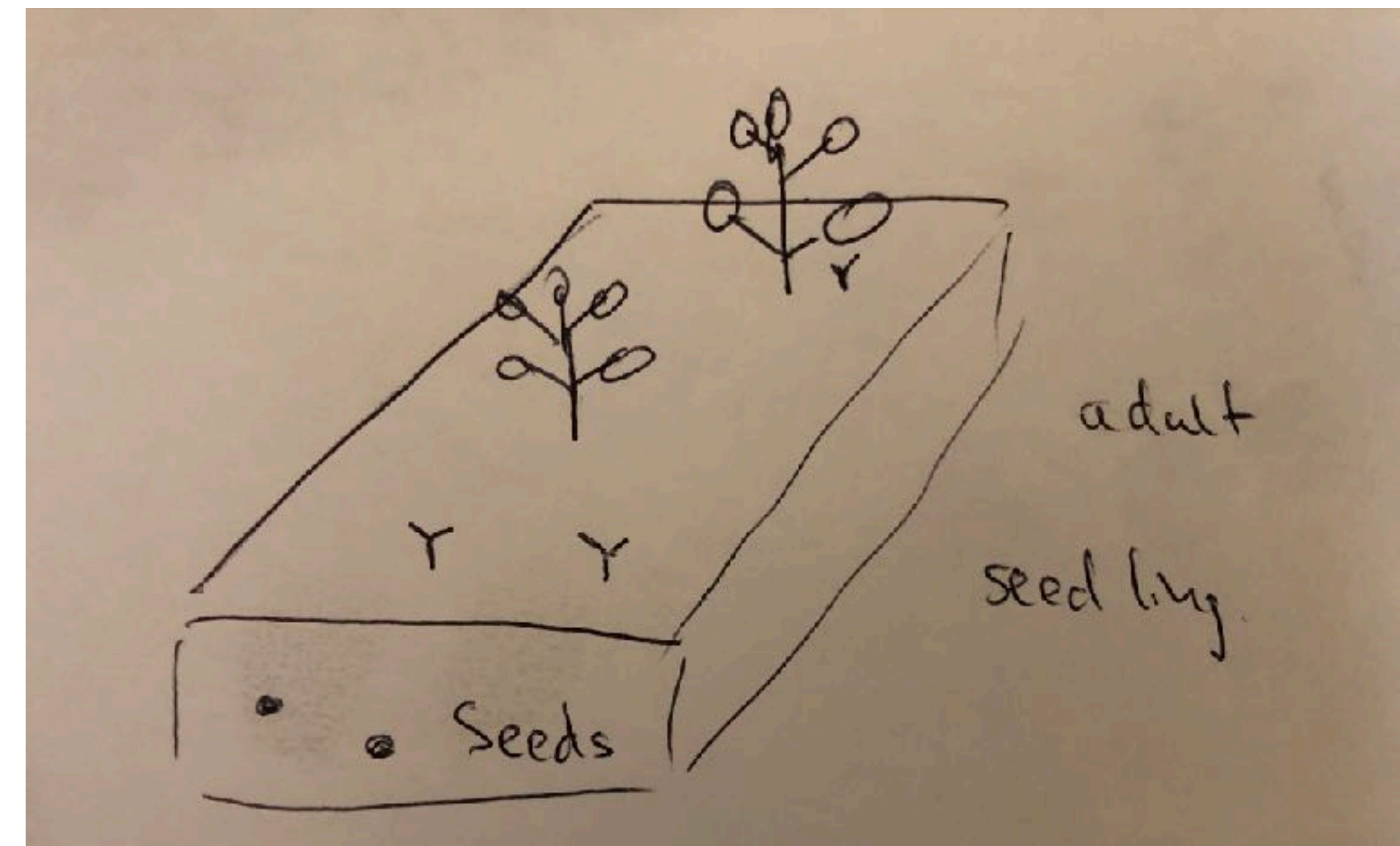
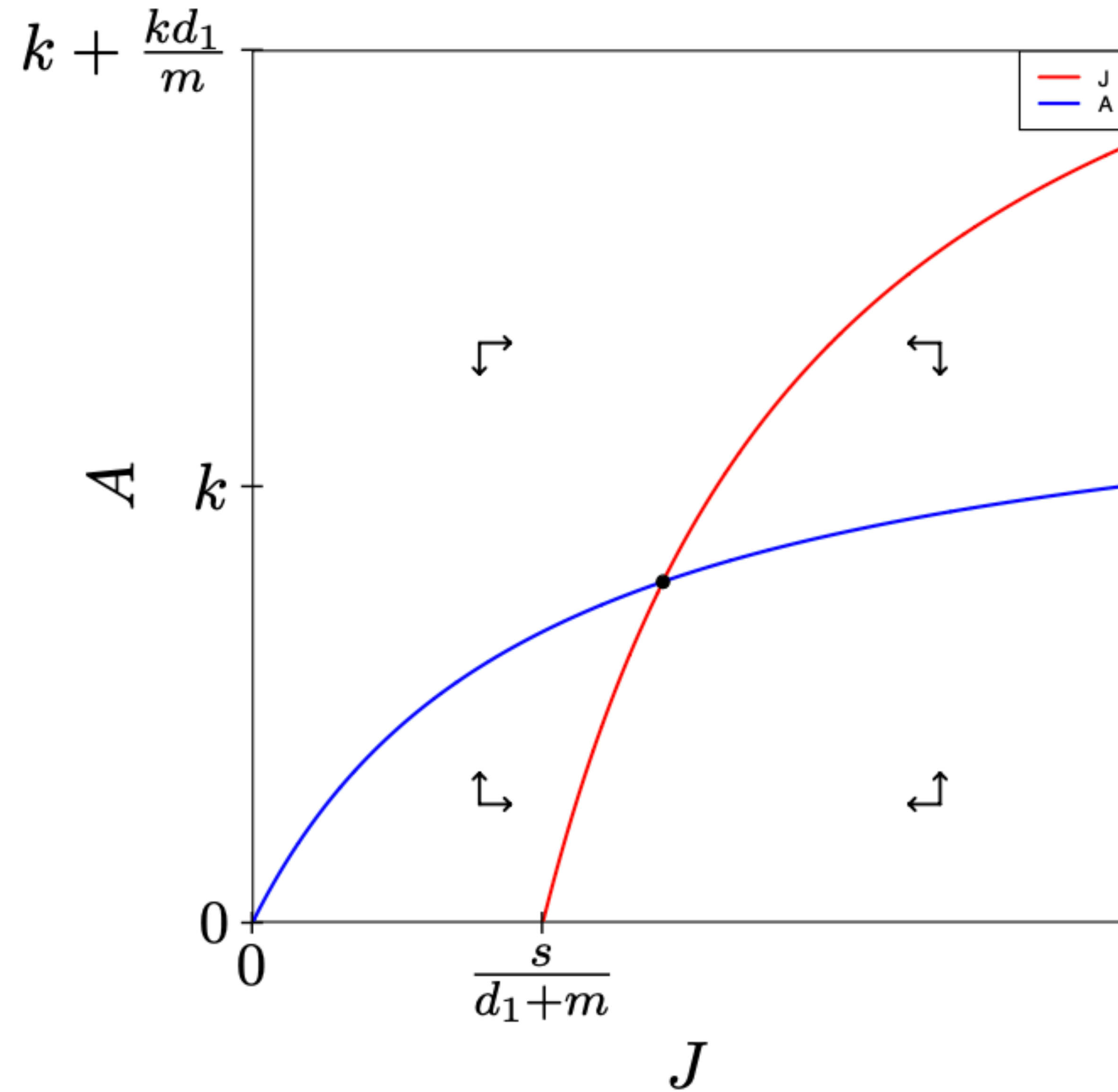


First define variables, processes, and then interaction functions



Question 3.12. Seedlings over-shadowed by adult plants

Figure made with the model seedling.R:



Similar models?

Progenitors of red blood cells (RBC) in the bone marrow.

Release of RBC into the circulation depends on oxygen levels (EPO),
i.e., on the concentration of circulating RBC.

Thus high RBC (adults) levels repress formation of adults from progenitors
(seedlings)

Progenitor T cells maturing in the thymus, and emigrate into periphery.
Successful entry into peripheral pool depends on the pool size.

‘Ecological’ models or thinking applying to populations of cells (and molecules)