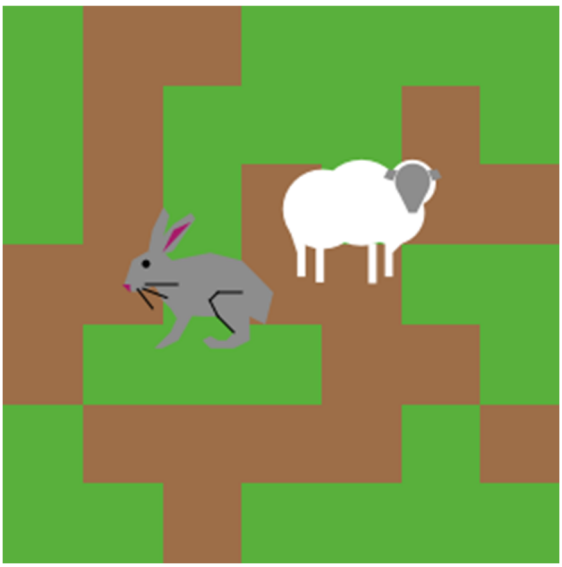
**COMPETITION**

Competition occurs when more than one organism is competing for the same resources. This could occur between animals of the same species (*intraspecific competition*) or between animals of different species (*interspecific competition*). All other things being equal, when two animals compete for the same environmental resources, one will eventually be driven into extinction. Different adaptations, such as the ability of the animal to move longer distances or the rate that an animal reproduces, can affect an animal's success in such competitions.

**The Model**

Like the Carrying Capacity model, this model has an environment with food, but that food is now being consumed by two species: hares and sheep. Both animals require the same food from their environment, so they are in direct competition for that resource. Animals that have food in their immediate environment (green squares) survive, but those that do not (brown squares) will die.



Surviving animals can move to a surrounding food source that has no other animals on it. Each species has a set distance it can travel for food, allowing it to move up to 1, 2, or 3 squares away to collect food:

*hares-move* = 1 *hares-move* = 2 *hares-move* = 3

If one of the sources within that distance has food, the animal will choose to move there; otherwise, it will move to any free source in its search area. If there are no free sources in that area, the animal will stay put.

After all the surviving hares have moved, a percentage of the existing each species will reproduce. For example, if the population of sheep is 100 and the growth rate is 2%, then the next time step the sheep population is 100 + (100 x 0.02) = 102. The new animals will then move to any free food source within their search distance with food available. If there are no free sources with food in a new animals' search area, then environment cannot sustain the new animal and the reproduction fails.

**How the Model Works**

The Competition model can be used to experiment with the effects of food availability and species-level adaptation on population. To set up an experiment, you will need to

1) Set the starting number of hares and sheep using the *start-hare-population* and *start-sheep-population* sliders (default is 10, max is 100)
2) Set the amount of time it takes for food to regrow with the *food-regrowth-time* slider (default is 2 days, max is 10 days)
3) Set the population growth rate for hares and sheep using the *hare-growth-rate* and *sheep-growth-rate* sliders; this increases the population each time step by a percentage of the current population.
4) Set the distance animals can search for food using the *hares-move* and *sheep-move* sliders (either 100, 200, or 300 meters).
5) Press the *Setup* button to initialize the model, and then press *Go* to let the model run
6) While the model is running, you can control the speed of the model with the slider at top
7) Press the *Go* button again to stop the model

Like in the Carrying Capacity model, the animals will interact with their environment as described in the section above, repeating these actions each day. A graph on the right side of the model tracks the total population for both animals over time.

**Questions**

1. What happens the animals have the same starting population, growth rate, and movement distance, and food take four days to regrow?

   *Answer: Variable (e.g. populations go up and down, rabbits or sheep eventually die out)*

2. What happens when you run the model again using those same parameters? Do you get a similar outcome or something different?

   *Answer: Variable (e.g. could be similar, could be different)*

3. What kind of effect does changing the starting population of sheep to 50 have?

   *Answer: Sheep start out a higher population, and either a) hares die out, or b) hares overtake sheep and sheep die out*

4. What happens when the start populations are set to 10 for each species and the hare population growth rate is increased to 3%? Why do you think this happened?

   *Answer: Hare population grows to carrying capacity while sheep die out. Hare population grows faster and outcompete the sheep for accessible food.*

5. What happens when the sheep and hare start populations are both set to 10, the hare population is set to 3%, and the sheep movement distance is set to 200 meters? Why do you think this is?

   *Answer: Hare populations are initially higher, but are then overtaken by the sheep population.*

**Make a prediction**

If the model is set up using the following settings:

- both start populations are set to 10
- hare population growth is set to 7%
- sheep movement distance is set to 200 meters
- food regrowth time is set to 2 days

What do you think will happen to the hare and sheep populations? Write down you prediction here:

Now run the model using these parameter settings. What happened to the two populations? Were any of your predictions correct?

**About the model**

This model is built using the NetLogo modeling platform. You can see the code that's used in the model by opening the *Code* tab at the bottom of the screen. Comments in the code (lines that begin with a ; semicolon) describe how each part of the code works in the model. If you want to learn more about NetLogo and modeling, visit: https://ccl.northwestern.edu/netlogo/index.shtml