Population dynamics is the study of how populations change over time, including population size, which is the number of individuals in a population. For example, we could ask how many white-tailed deer live in Pullman, Washington. Biologists sometimes track population sizes and try to figure out causes for increases or decreases in populations. In fact, some biologists might track the population sizes of many different species in the same place – this collection of species is called a community. Today we will be looking at how the population size of one species can influence the population sizes of other species that it eats or is eaten by.

Part 1: set up the activity.

Confirm that you have the following materials:

- Four cup labels with drawings of animals (from "printable_materials.pdf")
- Three arrows (from "printable_materials.pdf")
- A sheet with four graphs (from "printable_materials.pdf")
- Four clear cups
- One color of food dye (optional)

To set up the activity:

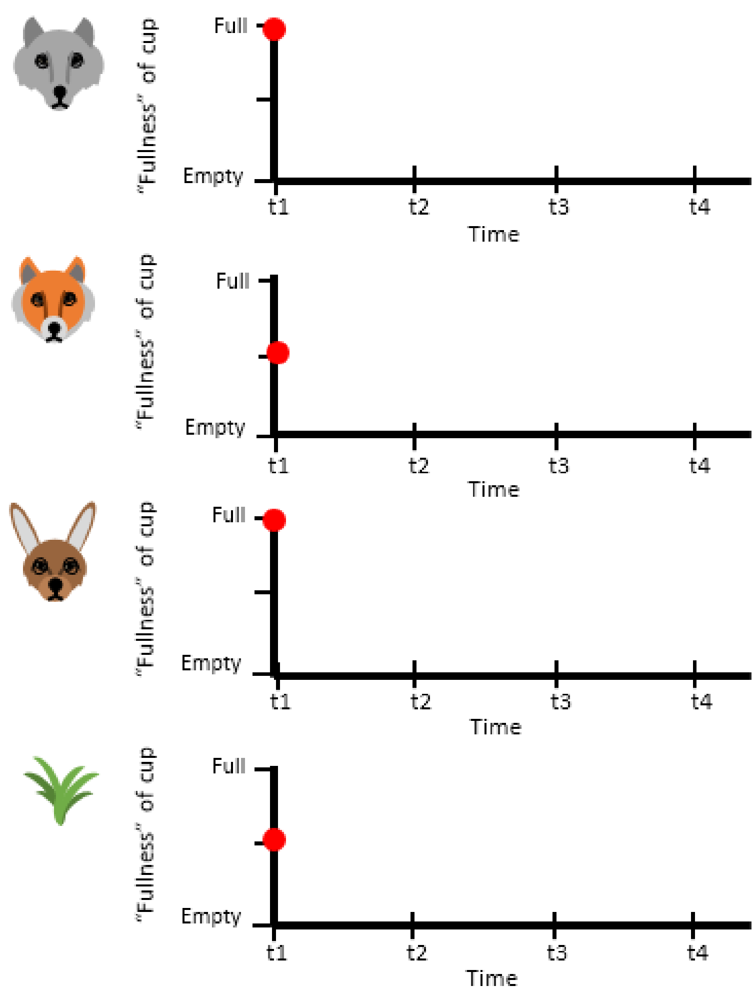
1. Cut out the four drawings under the "cup labels" part of. You should have a wolf, a fox, a rabbit, and a plant. Tape these to the cups using the tabs.
2. Put the cups in the order plant, rabbit, fox, and wolf.
3. Cut out the three arrows. Place an arrow on the table pointing from the plant to the rabbit, from the rabbit to the fox, and from the fox to the wolf. These arrows show that the plant is eaten by the rabbit, and so on.
4. Fill the plant cup half way. Fill the rabbit cup to the top. Fill the fox cup half way. Fill the wolf cup to the top. Confirm with the picture below that your materials are set up properly:

Part 2: carrying out the activity.
We can see here that the cups look a little bit unbalanced. You may be wondering how there can be so many wolves when there are not very many foxes, which the wolves rely on for food. You're on the right track. We are looking at only one point in time – a time point we will call time point 1.

We are going to graph how full each cup is over time (how big the population size for each species is) on the graph sheet. The y-axis of each graph (the vertical line) represents the fullness of the cup (which ranges from empty to full). The x-axis represents time, with labels indicating what time point we are on. We are on time point 1, written as t1.

Fill in the time point t1 for all of the species.

After graphing time point 1 for all four species, your graphs should look like this:



The wolf population size is too large to be supported by its food source, the foxes. The wolf population size will decrease, which we can model as wolves dying, decomposing, and leading to an increase in the plant population size. Poor about half of the wolf cup of water into the plant cup of water, and place the wolf cup back where it was. The wolf cup should now be about half full, and the plant cup should be completely full. Confirm with the picture below that your cups look correct:

Foxes now have fewer predators (wolves), so they will be eaten less often. They also have a lot of food – the rabbit cup is full (meaning its population size is high). Foxes will consume many rabbits, and the fox population size will grow. Pour half of the rabbit cup into the fox cup. Confirm with the picture below that your cups look correct:

This is time point 2 (t2). Just like before, **plot a point on each graph for t2**.

Moving on from time point 2, let's start with the wolves. They have a lot of food now (there are many foxes). The wolves will eat many foxes, and the wolf population size will increase. Represent this by pouring half of the fox cup into the wolf cup. Check the picture below to confirm:

Rabbits also have a lot of food, and now that many foxes are being eaten by wolves, the rabbits also do not have many predators and are eaten less often. The rabbit population size will increase. You guessed it – pour half of the plant cup into the rabbit cup. Check the picture below to confirm:

This is time point 3 (t3). Just like before, **plot a point on each graph for t3**.

Let’s move on from time point 3. The fullness of the cups may look familiar. This is exactly how the cups were at the start of this activity – we have come full circle! Take a look at your graphs and see if there are any patterns. Try to predict what the next time point (t4) will look like.

Just like at the start, there are too many wolves compared to foxes. The wolf population size will decrease – that is, wolves will start to die off, and this will contribute to plant growth. Pour half of the wolf cup into the plant cup. Check the picture below to confirm:

Foxes once again have fewer predators (wolves), so they will be eaten less often. They also have a lot of food – the rabbit cup is full (meaning its population size is high). Foxes will consume many rabbits, and the fox population size will grow. Pour half of the rabbit cup into the fox cup. Confirm with the picture below that your cups look correct:

This is time point 4 (t4), our last time point. Just like before**, plot a point on each graph for t4.**

Congratulations! We have completed the data collection part of our activity. We now have graphs showing population sizes for four species at four time points! You can check your graphs against the answer key on the next page. As scientists, we also interpret our data (including our graphs) and think about why it might be important. Let's think about the patterns found in our graphs.

Between time point 1 and time point 2, the population size of the wolf decreases. This means that less foxes are eaten, and their population size increases. Now that the fox population size is increasing, more rabbits are being eaten, and the rabbit population size decreases. With fewer rabbits, less plants are eaten, and the plant population size increases.
At time point 2, there are many foxes and few wolves. Wolves now have an excess of food, and their population size will increase between now and the next time point. Similar to before, the change in population size in the wolf trickles down the food chain. This pattern could continue for a long time!

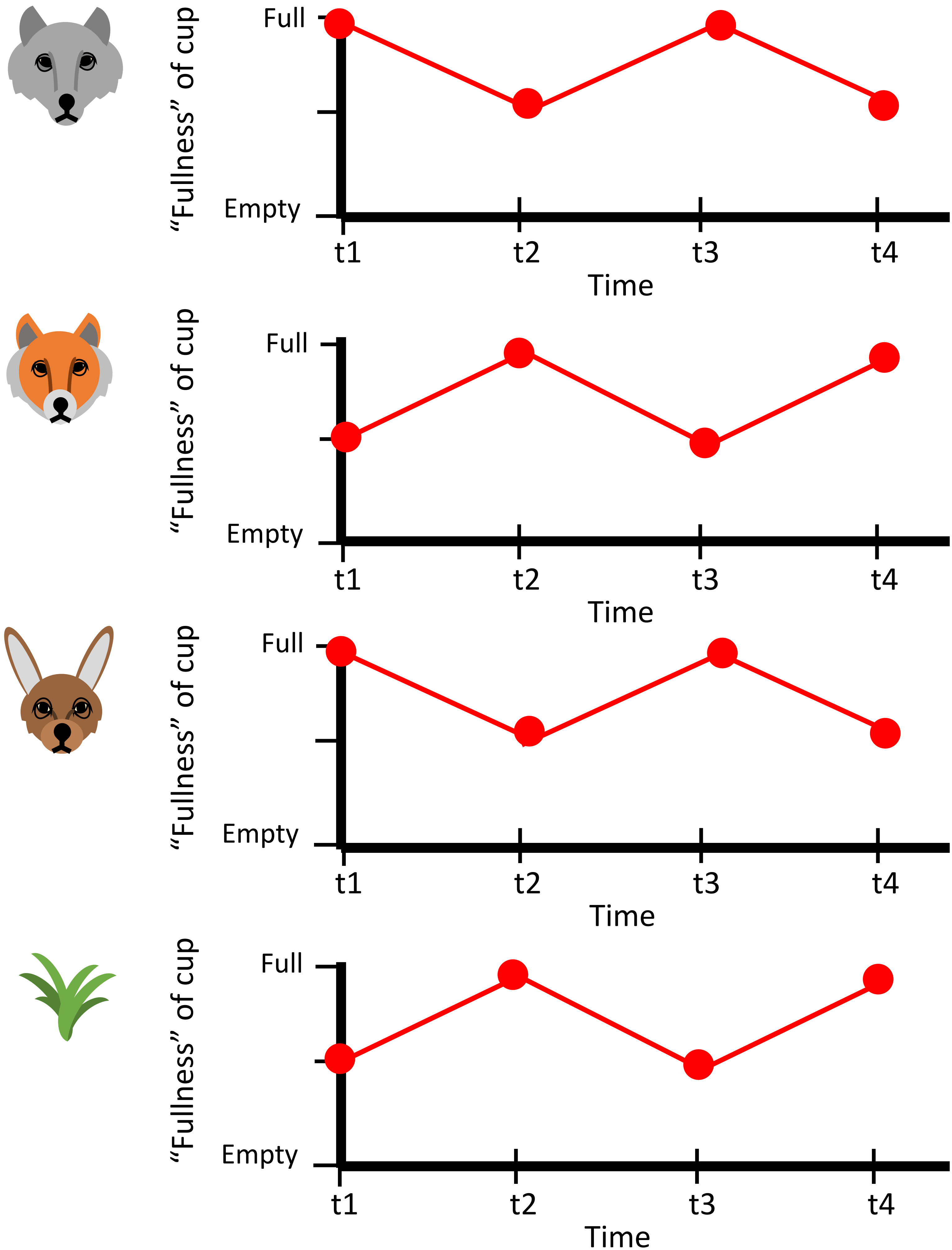
Now, think about the following questions:

- What do you think would happen if different species went extinct (the cup was completely emptied)?
    - What about the species at the top of the food chain?
    - What about the species at the bottom of the food chain?

- Are there other things besides eating/being eaten that influence population sizes? How might they affect the patterns in the graphs?

- What about more complicated communities? If you have more cups, you can try to extend this activity to 5, 6, or more species!

Let's think about an example of a real ecological community that has experienced big changes in population dynamics because of humans. In coastal waters in some parts of the world, sea otters play an important role in the food web. Otters eat sea urchins, and sea urchins in kelp. You might be able to predict what would happen to the population sizes of sea urchins and kelp if otters were removed. Humans have valued sea otters for their fur pelts. Due to overhunting, the sea otter population size decreased rapidly to the point of near-extinction. As a result, sea urchins increased in abundance and decimated the kelp forests, which negatively impacted other species, such as fish and crabs. Thankfully, hunting of sea otters has decreased and their populations are recovering. Can you think of other species and communities that have been impacted by humans? How can we use our knowledge of population dynamics to help prevent species from going extinct?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