Predator-Prey Interactions (SD)

This tutorial describes how to construct a model of the interactions between a predator species (wolves) and a prey species (moose). Before starting the tutorial, make sure you have familiarized yourself with how to create primitives and run models.

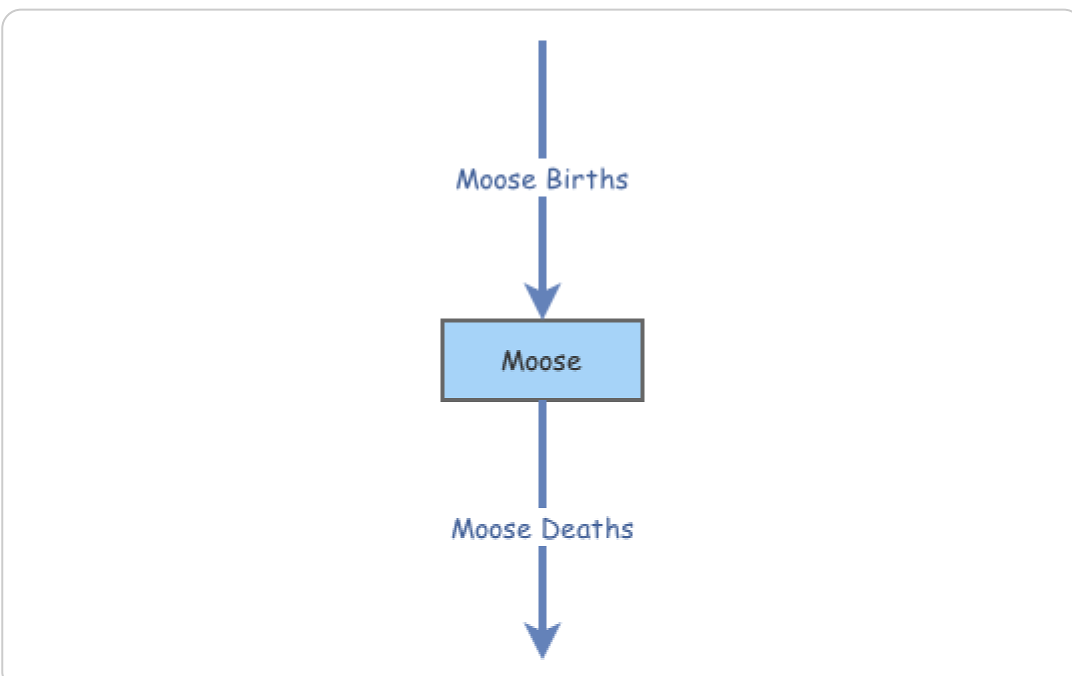
> First, let's create the structure to model a small population of moose.

1 Create a new **Stock** named **Moose** .

2 Create a new **Flow** going from empty space to the primitive **Moose** . Name that flow **Moose Births** .

3 Create a new **Flow** going from the primitive **Moose** to empty space. Name that flow **Moose Deaths** .

4 The model diagram should now look something like this:



> Now that the structure has been defined, let's enter the equations to define how our moose population behaves. We'll assume 150 moose to start and constant birth- and death-rates.

5 Change the **Initial Value** property of the primitive **Moose** to **150** .

6 Change the **Flow Rate** property of the primitive **Moose Births** to **0.16*[Moose]** .

7 Change the **Flow Rate** property of the primitive **Moose Deaths** to **0.10*[Moose]** .

8 Run the model. Here are sample results:

> We see an exponential growth pattern to this model. That because the birth-rate is higher than the death-rate. If the reverse had been true, we would have seen a population decline over time.
>
> Now let's create a population of wolves.

9 Create a new **Stock** named **Wolves** .

10 Create a new **Flow** going from empty space to the primitive **Wolves** . Name that flow **Wolf Births** .

11 Create a new **Flow** going from the primitive **Wolves** to empty space. Name that flow **Wolf Deaths** .

12 The model diagram should now look something like this:

> Now we can enter equations to define the behavior of the wolf population.

13 Change the **Initial Value** property of the primitive **Wolves** to **100** .

14 Change the **Flow Rate** property of the primitive **Wolf Births** to **0.2*[Wolves]** .

15 Change the **Flow Rate** property of the primitive **Wolf Deaths** to **0.12*[Wolves]** .

16 Run the model. Here are sample results:

> So far, so good.
>
> Before we have the two populations interact, let's make our model more modular by putting all the rate constants into separate variable primitives. This will make the model easier to mantain.

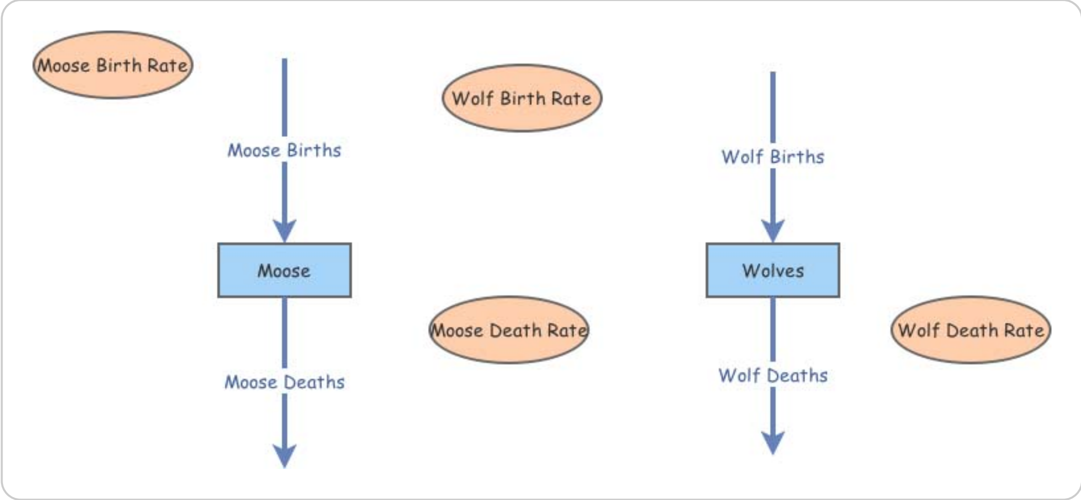
17 Create a new **Variable** named **Moose Birth Rate** .

18 Create a new **Variable** named **Wolf Birth Rate** .

19 Create a new **Variable** named **Moose Death Rate** .

20 Create a new **Variable** named **Wolf Death Rate** .

21 The model diagram should now look something like this:



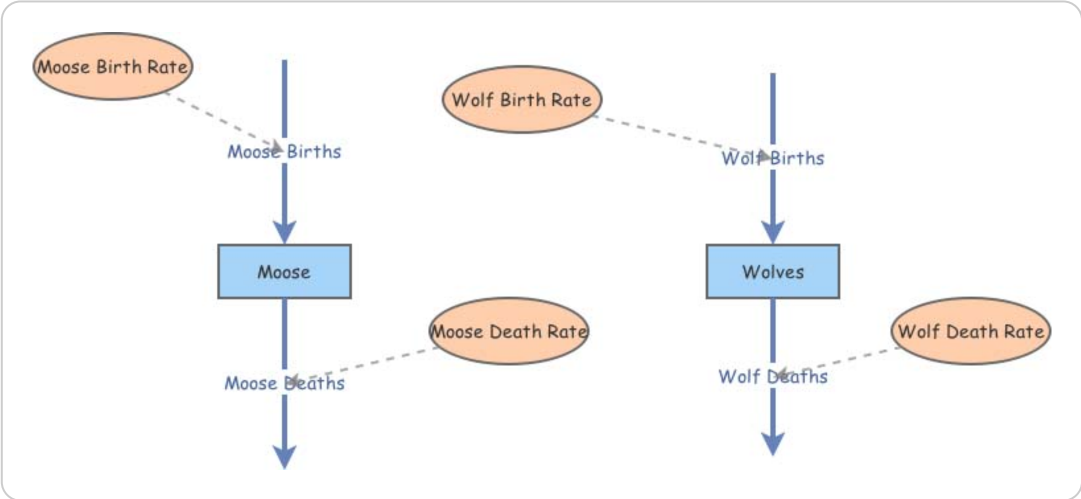
22 Create a new **Link** going from the primitive **Moose Birth Rate** to the primitive **Moose Births** .

23 Create a new **Link** going from the primitive **Wolf Birth Rate** to the primitive **Wolf Births** .

24 Create a new **Link** going from the primitive **Moose Death Rate** to the primitive **Moose Deaths** .

25 Create a new **Link** going from the primitive **Wolf Death Rate** to the primitive **Wolf Deaths** .

26 The model diagram should now look something like this:



> Let's add the equations for the new cariables to complete this modularization.

27 Change the **Flow Rate** property of the primitive **Moose Births** to **[Moose Birth Rate]*[Moose]** .

28 Change the **Equation** property of the primitive **Moose Birth Rate** to **0.16** .

29 Change the **Flow Rate** property of the primitive **Moose Deaths** to **[Moose Death Rate]*[Moose]** .

30 Change the **Equation** property of the primitive **Moose Death Rate** to **0.10** .

31 Change the **Flow Rate** property of the primitive **Wolf Births** to **[Wolf Birth Rate]*[Wolves]** .

32 Change the **Equation** property of the primitive **Wolf Birth Rate** to **0.2** .

33 Change the **Flow Rate** property of the primitive **Wolf Deaths** to **[Wolf Death Rate]*[Wolves]** .

34 Change the **Equation** property of the primitive **Wolf Death Rate** to **0.12** .

> That's it! Let's check to make sure we get the same results as before.

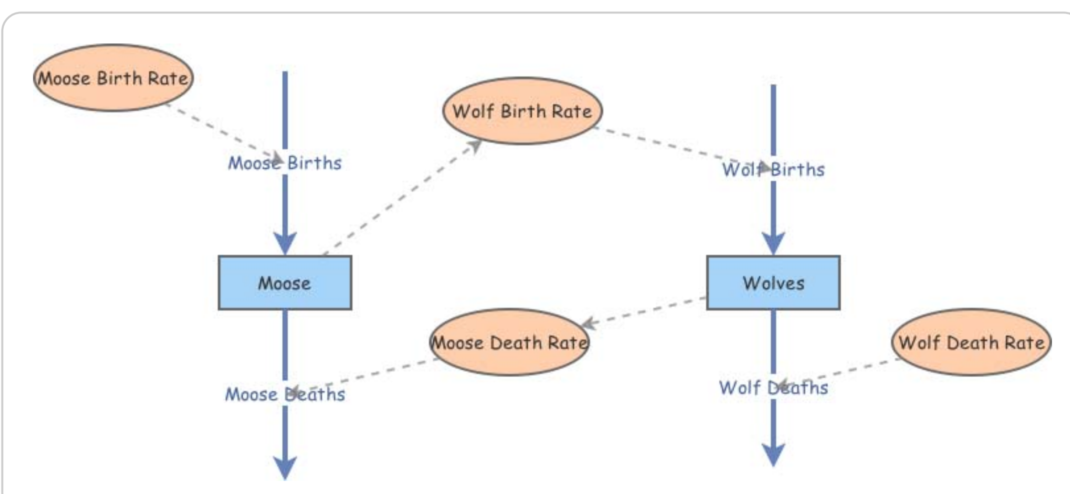
35 Run the model. Here are sample results:

> Now it's time to make the wolf and moose populations interact. In this model extension, wolves will chase and consume the moose. The more moose they catch, the faster the wolves reproduce, and the faster the moose population declines. We'll make the moose death-rate dependent on the number of wolves, and the wolf birth-rate dependent on the number of moose.

36 Create a new **Link** going from the primitive **Moose** to the primitive **Wolf Birth Rate** .

37 Create a new **Link** going from the primitive **Wolves** to the primitive **Moose Death Rate** .

38 The model diagram should now look something like this:



39 Change the **Equation** property of the primitive **Wolf Birth Rate** to **0.001*[Moose]** .

40 Change the **Equation** property of the primitive **Moose Death Rate** to **0.0008*[Wolves]** .

41 Run the model. Here are sample results:

> That's getting interesting! Let's increase the length and accuracy of our simulation.

42 Change the **Analysis Algorithm** property of the Time Settings to **RK4** .

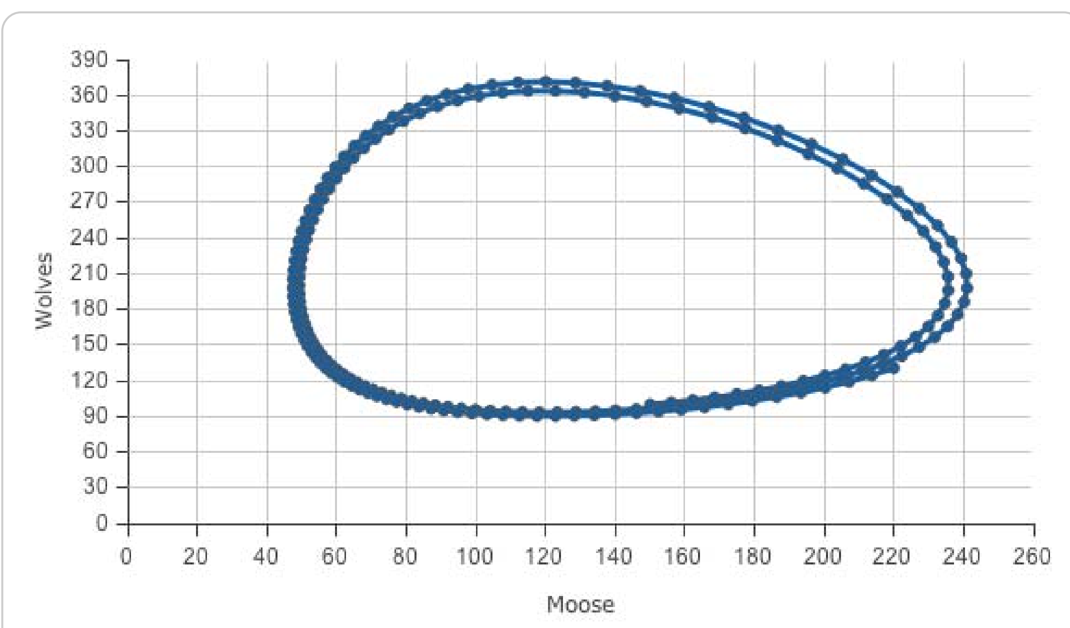
43 Change the **Simulation Time Step** property of the Time Settings to **0.5** .

44 Change the **Simulation Length** property of the Time Settings to **100** .

45 Run the model. Here are sample results:

> Great! The oscillatory behavior we see is typical of some predator-prey systems. The wolves kill many of the moose, but then the wolves have nothing to eat. This leads the wolf population to drop, allowing the moose population to recovery. This repeats in an ongoing cycle.
>
> We can also configure the display to use a scatter-plot instead of a time-series to show the phase-plane oscillatory behavior clearly.

46 Run the model. Here are sample results:



> There are many parameters in this model you can experiment with. This form of model what is known as the **Lotka-Volterra Model** in the modeling community.