

Activity 2.2.2 Population Model**Purpose**

Ecosystems contain a complex mix of biotic and abiotic components that are interconnected. Scientists use models to simplify an ecosystem, explain how they work, and solve environmental problems.

Conceptual models are diagrams or pictures representing a system. Food chains and food webs are examples of conceptual models explaining how an environment is connected. Mathematical equations are models as well. Scientists use equations to represent patterns they observe in an environment, such as the population's growth.

The birth rate of an animal species is an example of a mathematical model. If 50% of the deer population are adult females and the deer population in the ecosystem is 300 deer, we can predict the number of deer born in a year, as seen in Figure 1.

Environments cannot support the continual growth of a population. Besides the birth rate, a population model must consider a death rate. Limiting factors, such as food, space, predators, and environmental conditions, affect a population's death rate in an ecosystem, limiting population growth.

Steps	Calculations
1. Births are equal to the total population times the percentage of animals giving birth.	Births = population $\times$ female %
2. Fifty percent of 300 deer is equal to 150 births.	150 deer = 300 deer $\times$ 0.50
3. Assuming no deaths occur, the new population will grow from 300 deer to 450 deer.	300 deer + 150 deer = 450 deer

Figure 1. Birth Rate Calculations

How are mathematical and conceptual models used to predict a population of a species in an ecosystem? What problems can these models solve?

Materials**Per pair of students:**

- Computer with internet access
- Stella® Online account
- *Deer Herd Model*

Per student:

- Pen
- *ESI Notebook*

Procedure

Work with your partner to model the population of deer in an ecosystem.

Part One – Modeling Birth Rate

1. Log into Stella® Online at <https://exchange.iseesystems.com/login> using the username and password provided by your teacher.
2. Under **Options**, select *Add New Content* and then *Create New Model*.
3. Under **Name**, type *DeerHerd_YourInitials* and select **Add Model**.

4. Select **Upload an existing model**.
5. Choose the *Deer Herd* file as directed by your teacher and click **Open**.
6. Review the following titles in the model and what they represent.
7. Copy the conceptual model of the deer herd population on the student data sheet.
8. Double click on the **Births** icon and record the equation on the student data sheet. Repeat for the **Deaths** icon.
9. Double click on the icons listed below and record the values for each.
 - **Birth Rate**
 - **Death Rate**
 - **Deer Herd**

Table 1. Model Titles

Title	Representations
Deer Herd	The total population of the deer herd
Births	Number of deer born in a year
Deaths	Number of deer deaths in a year
Birth Rate	Percentage of deer giving birth in a single year
Death Rate	Percentage of deer dying in a single year

10. Answer the Part One prediction questions on the student data sheet.
11. Click on **Run Specs** ► in the lower-left corner of the screen.
12. The graph represents the first row of data. Use the graph to find the deer population in 25-year increments.
13. Record the populations in Table 2.
14. Double click on **Birth Rate**.
15. Change the birth rate to a number lower than the death rate and click on the green checkmark. See Figure 2.
16. Click on **Run Specs** ►.
17. Record the populations in Table 2.
18. Repeat Steps 14–17 with a birth rate higher than the death rate.
19. Enter other birth rates into the model and complete your table.
20. Answer the Part One analysis questions.

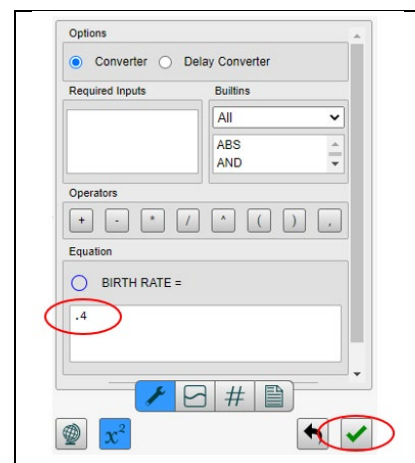


Figure 2. Birth Rate Entry

Part Two – Modeling Birth Rate and Death Rate

1. Enter the first row of data from Table 3 into the model.
2. Click on **Run Specs** ►.
3. Record the populations in Table 3.
4. Repeat Steps 1–3 with the next two rows of data.
5. Repeat Steps 1–3 trying different numbers for the birth and death rate until you complete five runs.
6. Answer the Part Two analysis questions.

Conclusion

1. What are the differences between a conceptual and mathematical model?
2. How can conceptual and mathematical models be used to manage an ecosystem?
3. Which factors should you include in a mathematical model to manage an ecosystem?

Activity 2.2.3 Student Data

Figure 3. Conceptual Model of the Deer Herd Population

Equations

- Births =
- Deaths =

Values

- Birth Rate =
- Death Rate =
- Deer Herd =

Part One Prediction

q1 Is this model conceptual, mathematical, or both? What makes it so?

q2 What do the equations represent?

q3 Why should the birth rate be no higher than 0.5?

q4 What does the death rate of 0.45 mean?

Table 2. Birth Rate

Birth Rate	Death Rate	25-year Population	50-year Population	75-year Population	100-year Population
0.5	0.45				
	0.45				
	0.45				
	0.45				
	0.45				

Part One Analysis

Q5 What is the relationship between birth rate, death rate, and total population?

Q6 If the entire population were female, and each deer had twins, what equation would represent the birth rate?

Table 3. Birth and Death Rate

Birth Rate	Death Rate	25-year Population	50-year Population	75-year Population	100-year Population
0.5	0.45				
0.45	0.45				
0.40	0.45				

Part Two Analysis

Q7 What happens when the death rate of a population is greater than the birth rate?

Q8 Which birth and death rates would stabilize the population, so no growth or decline in population will occur?

Q9 What makes this model unrealistic?

Q10 Which other factors could be added to the birth rate and death rate side to make the model more accurate?