

Activity 2.2.3 Productivity Prediction**Purpose**

During *Activity 2.2.2 Population Model*, you learned how to model population growth using birth and death rates. What can be added to the model to make more realistic population predictions?

The productivity of an ecosystem is dependent upon many limiting factors. Limiting factors affect the population of a species in an ecosystem. The population of a species an ecosystem can hold is called the carrying capacity. Factors such as the available space, food, shelter, and water all affect an ecosystem's carrying capacity. Plants provide the ecosystem service of food to support populations of primary consumers. The ecosystem services available affect the carrying capacity of different species.

A productive ecosystem has a variety of species dependent upon each other. Since one species' productivity affects others within an ecosystem, limiting factors of one species will determine another's productivity. For example, if the available food for a primary consumer, such as a rabbit, decreases due to a change in weather patterns, the population of predators preying on rabbits will be affected. The rabbit provides the ecosystem service of food to the predators. As the rabbit population declines, the ecosystem service of food for predators declines as well.

How can limiting factors be added to a model to predict the productivity of an ecosystem?

Materials**Per pair of students:**

- Device with internet access
- Stella® Online account
- *Carrying Capacity* and *Lynx and Hare* models

Per student:

- Pen
- *ESI Notebook*

Procedure

Model the effects of available space and predators on a population of deer in an ecosystem.

Part One – Carrying Capacity

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 *CarryingCapacity_YourInitials* and select **Add Model**.
4. Select **Upload an existing model**.
5. Choose the *Carrying Capacity* file as directed by your teacher and click **Open**.
6. Copy the conceptual model of the deer herd population into the student data sheet.
7. Review the titles in the model, listed at right, and what they represent.

Table 1. Model Titles

Title	Representations
Deer Herd	The total population of the deer herd
Births	Number of deer born in a year

8. Double-click on each of the following titled icons and record equations for each on the student data sheet.	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
	Area	Total area where the deer population lives in square miles
	Animal per Area	The density of the deer population, number of deer per square mile
	Dapa	Delay: adjusts population growth based upon the maturity of deer (deer need to be two years of age before giving birth)

9. Double-click on each of the following titled icons and record the values for each.

- **Deer Herd**
- **Area**

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 populations with an area of 200 square miles. Use the graph to find the deer population for the years listed in your table.

13. Record the births, deaths, and populations in Table 2 on the student data sheet.

14. Double click on **Area**.

15. Change the **Area** to 150, as seen in Table 2, and click on the green checkmark.

16. Click on **Run Specs** ►.

17. Record the births, deaths, and populations in your table.

18. Repeat Steps 14–17 for the remaining areas listed in Table 2.

19. Answer the Part One analysis questions.

20. Click **My Activity** to save and close the model.

Part Two – Predator and Prey

1. Under **Options**, select *Add New Content* and then *Create New Model*.

2. Under **Name**, type *Predator_Prey_YourInitials* and select **Add Model**.

3. Select **Upload an existing model**.

4. Choose the *Lynx_Hare* file as directed by your teacher and click **Open**.

5. Copy the conceptual model of the lynx and hare population into your *Laboratory Notebook*.

6. Double click on each of the following titled icons and record equations for each.

- **Hares per area**
- **Hares killed by lynx**

7. Double click on each of the following titled icons and record the values for each.

- **Lynx**
- **Area**
- **Hares**

8. Answer the Part Two prediction questions.

9. Click on **Run Specs** ►.

10. The graph represents the first row of data. Use the graph to find the populations in 10-year increments and record the data in Table 3.

11. Sketch the graph on the student data sheet.
12. Answer the analysis questions about the population graph.
13. Double-click on **Hare**.
14. Change the hare population to 40,000, as seen in Table 3, and click on the green checkmark.
15. Double-click on **Lynx**.
16. Check the lynx population to be sure it is 2,500.
17. Click on **Run Specs ►**.
18. Record the lynx and hare populations in Table 3.
19. Repeat Steps 13–18 for the remaining lynx and hare populations listed in Table 3.
20. Answer the Part Two analysis questions.

Conclusion

1. Which limiting factors affect the productivity of an organism in an ecosystem?
2. Which ecosystem services do predator-prey relationships include?
3. How do species populations in an ecosystem affect each species' productivity?
4. How does diversity in an ecosystem affect its productivity?

Activity 2.2.3 Student Data

Figure 1. Conceptual Model of the Deer Herd Population

Equations

- Animal per area =
- Dapa =

Values

- Deer Herd =
- Area =

Part One Prediction

- q1 Which parts of the model are related to animals per area?
- q2 Which factors could cause an increase in the area available for deer?
- q3 What effect will an increase in the area have on the deer population? Why?
- q4 Which factors could cause a decrease in the area available for deer?
- q5 What effect will a decrease in the area have on the deer population? Why?

Table 2. Area

Area (mi ²)	6 Years			12.5 Years			25 Years		
	Births	Deaths	Pop	Births	Deaths	Pop	Births	Deaths	Pop
200									
150									
100									
250									
300									

Part One Analysis

Q6 How does habitat area affect the number of births and deaths per year?

Q7 If a disease destroys half the available trees and plants, what will happen to the deer herd's productivity? Why?

Q8 What other information about the habitat could you add to the model?

Figure 2. Conceptual Model of the Lynx and Hare Populations

Equations

- Hares per area =
- Hares killed by lynx =

Values

- Lynx =
- Area =
- Hares =

Part Two Prediction

Q9 Which factors determine the lynx population?

Q10 What is the relationship between the lynx population and the hare population?

Table 3. Lynx and Hare Populations

Initial Population		10 Year Population		20 Year Population		30 Year Population	
Hares	Lynx	Hares	Lynx	Hares	Lynx	Hares	Lynx
50,000	2,500						
40,000	2,500						
30,000	2,500						
50,000	1,250						
40,000	1,250						
30,000	1,250						
10,000	0						
2,500	2,500						

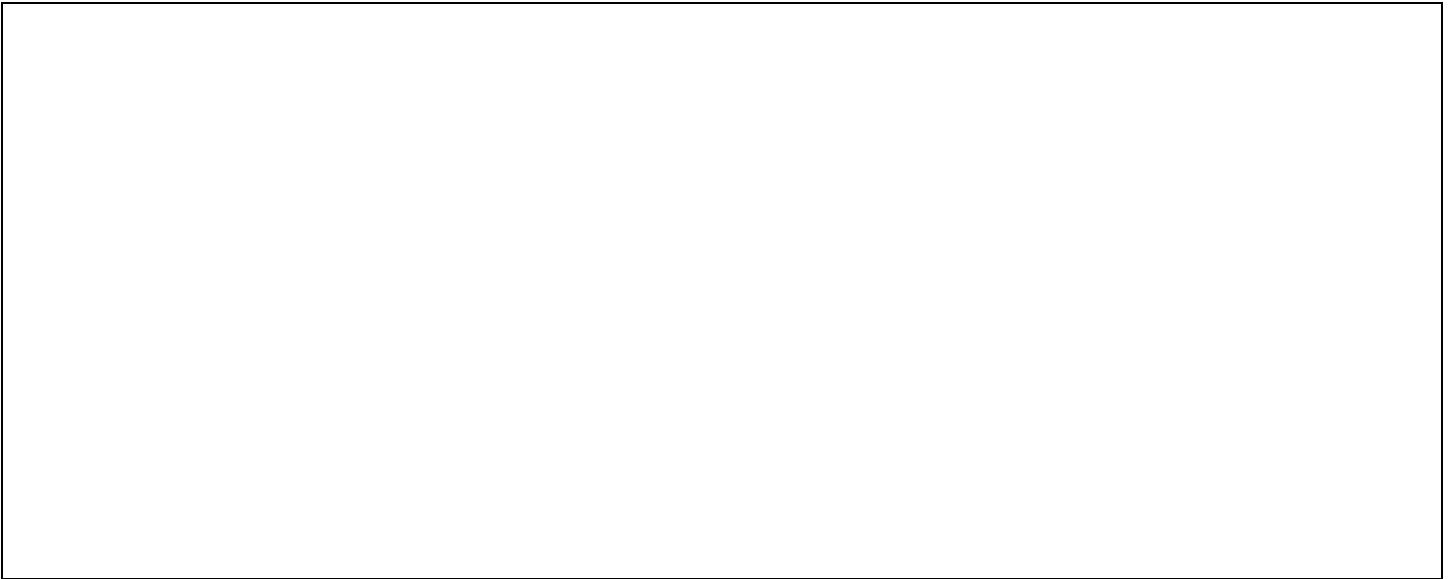


Figure 3. 10-year Population Graph

Population Graph Analysis

Q11 What happens to the lynx population during the first 20 years?

Q12 What happens to the hare population during the first 20 years?

Q13 Which population increases first, lynx or hare? Why?

Part Two Analysis

Q1 What is the carrying capacity of the area for the lynx and hare? How do you know?

Q2 Can the lynx survive without the hare? Why or why not?

Q3 Can the hare survive without the lynx? Why or why not?

Q4 How does eliminating the lynx population affect the carrying capacity of the ecosystem?

Q5 How does changing the initial populations affect the stability of the population?