Conservation Biology

Lesson for High School Students

Description: Students will explore the ways that habitat loss due to human development impacts the population of the endangered Karner Blue butterfly (*Lycaeides melissa*)**.** Students will practice critical thinking, scientific literacy, and scientific investigation skills to interpret and evaluate experimental results with graphing. Students will explore these concepts in the context of their local environment.

This activity is adapted from the Conservation Biology lab in "Laboratory Biology" by Daniel W. Benjamin and Gilbert D. Starks, Central Michigan University.

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Materials Needed:

- Student worksheet
- Writing utensil, highlighter
- An electronic device (smart phone, tablet, and/or computer) with internet access to visit webpages

Learning Outcomes:

Students will be able to:

- List several of the threatened, endangered, and rare plant and animal species in New York State
- Predict the effects of a change in one or more components in a biological system based on data
- Demonstrate through simulation, the consequences of habitat loss on an animal population over time and use that data to evaluate a hypothesis
- Review and apply several terms used to describe the biology of a population
- Construct a graph and interpret population trends over several generations
- Appreciate that the Great Lakes support a broad diversity of life and ecosystems.

New York State P-12 Science Learning Standards (HS)

- HS-LS2 Interdependent Relationships in Ecosystems
- HS-ESS3 Human Sustainability

AP Biology Curriculum

- Unit 4 – Cell Communication and Cell Cycle (4.5 Feedback Mechanisms)
- Unit 8 – Ecology (8.3 Population Ecology, 8.6 Biodiversity, 8.7 Disruptions to Ecosystems)

Conservation Biology

Student Worksheet – Conservation Biology

Name _____ Date_____

Instructions: Gather the materials listed below and follow the instructions. Complete this lesson by reading the introductory passage, watching the video, and responding to all questions. Websites linked in the footnotes at the bottom of each page provide more information. If you are struggling to understand a concept or a question, click the link to read more about a topic. In this activity we will explore the ways that habitat loss due to human development impacts the population of the endangered Karner Blue butterfly (*Lycaeides melissa*)**.**

Materials Needed

- Writing utensil, highlighter
- An electronic device (smart phone, tablet, and/or computer) with internet access to visit webpages

Part A: Introduction to Conservation Biology: *Read the passage below. Highlight any terms you think are important. Take notes and define the key terms on the right-hand side of the page. Summarize the paragraph in three sentences or less.*

Investigation of the Impact of Habitat Destruction on the Endangered Species, the Karner Blue Butterfly (*Lycaeides melissa)* in New York State

Biodiversity (biological diversity) is a collective term used to describe the astounding variety of life on Earth. Biodiversity can be defined as the number of different species of plants, animals, and other living things found in an area. It is also a measure of variation at all levels - from genes within a species to ecosystems and plant and animal communities. The field of ***conservation biology*** combines the areas of ecology, geography, genetics, economics, and many other disciplines to work at conserving this biodiversity. The interactions between different plant, animal, and microbial species form the basis of what is known as the ***biosphere***. The removal of just one of these species can cause a chain reaction which effects all levels of the ***food web*** within an ***ecosystem***. Biodiversity is integral to ecosystem health and stability because the more biodiversity present in a system, the more likely that system is to maintain its health in the face of disruption.

When humans destroy or degrade the quality of a ***habitat***, the effect that it has on the species that inhabit that area can be devastating. The counties that make up the Niagara River Watershed (including Erie, Niagara, Genesee, Wyoming, Cattaraugus, and Chautauqua County)

Notes

added 14,727 acres of urbanized areas between 2000 and 2010, while at the same time losing 37,450 people.[1] When an area that was once natural becomes urbanized due to human development it inevitably loses habitat value and biodiversity.

The world is facing an interconnected crisis of rapid biodiversity loss and climate change. [2] The impacts of these issues are being felt right here in the Great Lakes Basin and Western New York. In New York State alone, there are over 90 species of threatened or endangered animals and hundreds of species of rare or vulnerable plants. Why does this matter? Douglas Tallamy, ecologist, and author of "Bringing Nature Home" put it best when he said:

> *"Biodiversity losses are a clear sign that our own life-support systems are failing. The ecosystems that support us – that determine the carrying capacity of the earth and our local spaces – are run by biodiversity. It is biodiversity that generates oxygen and cleans water, creates topsoil out of rock, buffers extreme weather events like droughts and floods, pollinates our crops, and recycles the mountains of garbage we create every day. And now, with human-induced climate change threatening the planet, it is biodiversity that, if given half a chance, will suck that carbon out of the air and sequester it in living plants.*
>
> *Humans cannot live as if they are the only species on this planet. Why? Because it is other species that create the ecosystem services that are so essential to us. Every time we force a species to extinction, we are encouraging our own demise. Despite the disdain with which we have treated it in the past, biodiversity is not optional."* [3]

An n ***ecosystem*** is the biological community of interacting organisms and their physical environment. An ***ecosystem service*** is the variety of benefits that a healthy, functioning ecosystem provides to humans.

In this activity we will use a simulation to demonstrate the impact of habitat degradation on the population of one endangered species in New York State, the Karner Blue butterfly (*Lycaeides melissa)*. We will experimentally manipulate environmental variables associated with the ***life***

Notes

[1] Niagara River Watershed Management Plan, Buffalo Niagara Waterkeeper website https://bnwaterkeeper.org/projects/healthyniagara/

[2] National Geographic article "Global Biodiversity is in Crisis" https://blog.nationalgeographic.org/2019/09/23/global-biodiversity-is-in-crisis-but-there-is-hope-for-recovery/

[3] American Forests article "A Call For Backyard Biodiversity" by Douglas Tallamy https://www.americanforests.org/magazine/article/backyard-biodiversity/

cycle of this species. You will graph population trends over time and make some predictions concerning the health of the butterfly population.

The New York State Department of Environmental Conservation (NYSDEC) describes the Karner Blue butterfly as an insect that, like all butterflies, has four stages in its life cycle - the egg, the larva (caterpillar), the pupa (chrysalis), and the adult (butterfly). There are two generations per year. The first-generation adults appear in late May to mid-June. Females lay eggs on the underside of a leaf or stem of the food plant, Blue Lupine (*Lupinus perrennis*). Forty to fifty percent of the eggs survive to the adult stage. The resulting second brood adults, emerging in mid-July to early August, lay their eggs singly in dried lupine seed pods or near the ground on the stems. Eggs of the second brood overwinter, to hatch the next May. Karner Blue butterfly adults are nectar-feeders, aiding in the pollination of a variety of wildflowers. The larvae, however, are highly specialized, feeding exclusively on the wild Blue Lupine leaves. Without blue lupine, the Karner Blue butterfly would not survive.

Figure 1: *Karner Blue butterfly and its larval food plant, Blue Lupine.*

The Karner Blue butterfly is experiencing a population decline primarily due to human activities such as agriculture, urbanization and fire suppression. The sandy habitat essential to the Blue Lupine, and therefore the Karner Blue, occurs mostly along river valleys and outwash plains. Because of the location and topography of such areas, they have been heavily favored as settlement sites. Extinctions of entire populations of the Karner Blue have occurred around large urban centers such as Chicago and New York City. Other populations, such as those in the Albany Pine Bush, have been reduced both by habitat destruction from urbanization and by loss of lupine through natural succession resulting from fire suppression. [4]

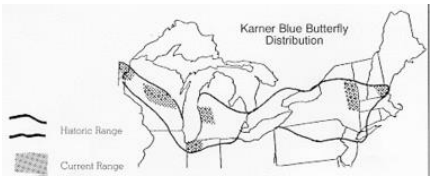

Figure 2: *Karner Blue butterfly distribution in the Great Lakes region* [5]

Notes

Summary

[4] The Karner Blue butterfly and Blue Lupine photographs are from the New York State Department of Environmental Conservation and the United States Fish and Wildlife Service website, respectively.

[5] The information in the passage above and the map are from the New York State Department of Environmental Conservation Karner Blue Butterfly Fact Sheet

1. What specific plant does the Karner Blue butterfly require? _____

2. In what type of habitat is this plant found? _____

3. Hypothesize three possible reasons that the Karner Blue butterfly is at risk of extinction:
   a. _____
   b. _____
   c. _____

Watch "Feedback loops: How nature gets its rhythms", narrated by Anje-Margriet Neutel on the Ted-ed YouTube channel (https://www.youtube.com/watch?v=inVZoI1AkC8).[6]

4. Define positive feedback. Give an ecological example.
   _____
   _____
   _____

5. Define negative feedback. Give an ecological example.
   _____
   _____
   _____

6. ***Environmental justice issues*** occur when communities of Black, Indigenous and People of Color as well as poor and working-class communities are ***disproportionately*** harmed by environmental burdens like pollution. Explain how the disruption of ecological feedback loops, and ecosystem services, could also present an ***environmental burden*** that negatively impacts those communities.

   Hint: Consider the ecosystem services a healthy, functioning wetland ecosystem provides to a community in the Niagara River Watershed [7]
   _____
   _____
   _____
   _____
   _____
   _____
   _____
   _____

[6] "Feedback loops: How nature gets its rhythms", narrated by Anje-Margriet Neutel on the Ted-ed YouTube channel https://www.youtube.com/watch?v=inVZoI1AkC8

[7] Fact sheet from the United States Environmental Protection Agency (USEPA) on the Function and Values of Wetlands https://nepis.epa.gov/Exe/ZyPDF.cgi/200053Q1.PDF?Dockey=200053Q1.PDF

Part B: Ideal Population Growth (Exponential Growth) *This portion of the experiment will represent the ideal growth of a population in a habitat without any human disturbance.*

1. For this experiment, assume that you have an equal number of males and female Karner Blue butterflies in all of the populations. Begin with an initial population size of 12 individuals. Therefore, you have 6 breeding pairs of butterflies.
2. Using the random number generation wheel https://pickerwheel.com/tools/random-number-generator/ set the maximum number to 36 and spin the wheel one time for each breeding pair. This spin represents the reproductive success for the pair of butterflies. The numbers in the left-hand column of your data chart will correspond to each of the pairs. With each spin, record the number in the column marked *number spun* on the data sheet below.
3. **If you spin an even number**, this means that the patch of land that your butterfly pair landed in is of poor quality; therefore, they only have the potential to produce 2 offspring. Record this number (2) in the column marked *offspring* in your data sheet below.
4. **If you spin an odd number**, this means that the patch of land that your butterfly pair landed in is of good quality; therefore, they will produce 3 offspring. Record this number (3) in the column marked *offspring* in your data sheet below.
5. **If you spin 0**, this means no reproduction due to predation.
6. Continue this process for each of the 6 breeding pairs in generation # 1.
7. When you are finished with this generation, sum the numbers in the *offspring* column. This is the number of individuals that will be reproductive in generation # 2. **Use this number to determine how many pairs reproduce in the next generation.**
8. Follow this protocol for each of the next four generations. Continue as you just did for each of these new generations.

Generation # 1			Generation # 2			Generation # 3			Generation # 4			Generation # 5		
Pair	Number Spun	Offspring	Pair	Number Spun	Offspring	Pair	Number Spun	Offspring	Pair	Number Spun	Offspring	Pair	Number Spun	Offspring
1			1			1			1			1		
2			2			2			2			2		
3			3			3			3			3		
4			4			4			4			4		
5			5			5			5			5		
6			6			6			6			6		
			7			7			7			7		
			8			8			8			8		
			9			9			9			9		
			10			10			10			10		
			11			11			11			11		
			12			12			12			12		
			13			13			13			13		
			14			14			14			14		
			15			15			15			15		
			16			16			16			16		
			17			17			17			17		
			18			18			18			18		
			19			19			19			19		
			20			20			20			20		
			21			21			21			21		
			22			22			22			22		
			23			23			23			23		
			24			24			24			24		
			25			25			25			25		

Total # of Butterfly Offspring: Generation #1: Generation #2: Generation #3: Generation #4: Generation #5:

9. Graph the data! Plot the data that you just recorded on the graph on the last page of this lesson packet.

10. If the ideal growth (exponential growth) of this population continues and the habitat for the Karner Blue butterfly remains undisturbed, what is your hypothesis for further growth of the population? Will it continue to increase, decrease, or stay the same? Explain.

    _____
    _____
    _____
    _____

11. What factors do you think might influence the growth of a population? List at least three factors and describe what their influence would be on the growth of a population.

    a. _____
       _____
       _____
    b. _____
       _____
       _____
    c. _____
       _____
       _____

12. The next portion of our experiment will include the destruction of 25% of the Karner Blue butterfly habitat. Will the population continue its exponential growth after that? Explain why or why not.

    _____
    _____
    _____
    _____

Part C: Habitat Destruction *While population growth could continue indefinitely without decline, habitat changes can drastically alter this picture. This portion of the experiment will look at the result of habitat destruction, a 25% reduction, on the size of our breeding population.*

1. Select 9 squares to represent the areas will houses will be built in this ecosystem. Place an X across those squares.

1	2	3	4	5	6
7	8	9	10	11	12
13	14	15	16	17	18
19	20	21	22	23	24
25	26	27	28	29	30
31	32	33	34	35	36

2. Transfer the number of pairs from the fifth generation onto the new data sheet below.
3. Repeat the procedure of the experiment in Part B for five generations.
    a. This time, if you spin one of the numbers selected for housing development, record an offspring number of 0 for that pair.
    b. If the number is something other than one selected for housing development, follow the procedures as described in Part B (odd numbers represent 3 offspring, even number represent 2 offspring)

Generation # 6			**Generation # 7**			**Generation # 8**			**Generation # 9**			**Generation # 10**		
Pair	Number Spun	Offspring	Pair	Number Spun	Offspring	Pair	Number Spun	Offspring	Pair	Number Spun	Offspring	Pair	Number Spun	Offspring
1			1			1			1			1		
2			2			2			2			2		
3			3			3			3			3		
4			4			4			4			4		
5			5			5			5			5		
6			6			6			6			6		
7			7			7			7			7		
8			8			8			8			8		
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21			21			21			21			21		
22			22			22			22			22		
23			23			23			23			23		
24			24			24			24			24		
25			25			25			25			25		

Total # of Butterfly Offspring: Generation #6: _____ Generation #7: _____Generation #8: _____ Generation #9: _____Generation #10: _____

4. Graph the data! Plot the data that you just recorded in your data sheet on the graph on the last page of this lesson packet.

5. How did the population respond to the removal of 25% of its habitat?

_____
_____
_____

6. Is this what you hypothesized? Explain why or why not.

_____
_____
_____

7. What trends have you observed in the population over time?

_____
_____
_____
_____

Part D: Will increased habitat loss lead to population problems? *This portion of the experiment will simulate an additional 25% destruction of the existing habitat. We will examine the impact this additional change will have on the size of our butterfly population.*

1. Mark the same 9 squares as you did in Part C. Select 9 additional squares to remove as a result of housing development. Remember, if a breeding pair of butterflies selects any of the now 18 squares selected, they will be reproductively unsuccessful and will not produce any offspring.

1	2	3	4	5	6
7	8	9	10	11	12
13	14	15	16	17	18
19	20	21	22	23	24
25	26	27	28	29	30
31	32	33	34	35	36

2. Remember to start this part of the experiment with the number of offspring left at the end of the tenth generation from Part C.
3. In this part of the experiment, continue as you did for parts B and C expect that id a butterfly lands on one of the additional squares, the pair will produce 0 offspring. Continue for at least 5 more generations.

Generation # 11			Generation # 12			Generation # 13			Generation # 14			Generation # 15		
Pair	Number Spun	Offspring	Pair	Number Spun	Offspring	Pair	Number Spun	Offspring	Pair	Number Spun	Offspring	Pair	Number Spun	Offspring
1			1			1			1			1		
2			2			2			2			2		
3			3			3			3			3		
4			4			4			4			4		
5			5			5			5			5		
6			6			6			6			6		
7			7			7			7			7		
8			8			8			8			8		
9			9			9			9			9		
10			10			10			10			10		
11			11			11			11			11		
12			12			12			12			12		
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15			15			15			15			15		
16			16			16			16			16		
17			17			17			17			17		
18			18			18			18			18		
19			19			19			19			19		
20			20			20			20			20		
21			21			21			21			21		
22			22			22			22			22		
23			23			23			23			23		
24			24			24			24			24		
25			25			25			25			25		

Total # of Butterfly Offspring: Generation #11: Generation #12: Generation #13: Generation #14: Generation #15:

4. Graph the data! Plot the data that you just recorded in your data sheet on the graph on the last page of this lesson packet.

5. After what you have just seen with this simulation, does it surprise you to learn that climate change, along with habitat destruction and degradation, is the number one threat to biodiversity throughout the world? [8]

   Circle YES or NO

6. Have you noticed increasing or decreasing biodiversity (the number of different species of plants, animals, and other living things) in your community? If you can, give an example of a specific plant or animal whose population you have noticed changing.

   _____
   _____
   _____
   _____
   _____
   _____

7. Do you think the changes in the population of that plant or animal will impact other species? The ecosystem as a whole? Explain. [9]

   _____
   _____
   _____
   _____
   _____
   _____
   _____
   _____

[8] "Climate Change Is Becoming a Top Threat to Biodiversity" by Chelsea Harvey, Scientific American https://www.scientificamerican.com/article/climate-change-is-becoming-a-top-threat-to-biodiversity/

[9] Check out this list of endangered species in New York State https://www.newyorkupstate.com/outdoors/2017/10/endangered_threatened_species_new_york_state_animals.html

Part E: Applying the concepts to the Niagara River Watershed

The Great Lakes support a broad diversity of life.[10] The Niagara River corridor is recognized as a RAMSAR Wetland of International Importance because its unique coastal fish and wildlife habitat supports numerous rare and threatened ecological communities and is an incredibly important overwintering site for waterbirds. [11]

The map below was created using the New York State Department of Environmental Conservation Natural Resource Mapper tool. The pink color represents significant natural communities, such as the Calcareous talus slope woodland community located along the Niagara Gorge.[12] The orange color represents rare plants or animals, such as the threatened fish species that lives in the Niagara River called the Lake Sturgeon.[13]

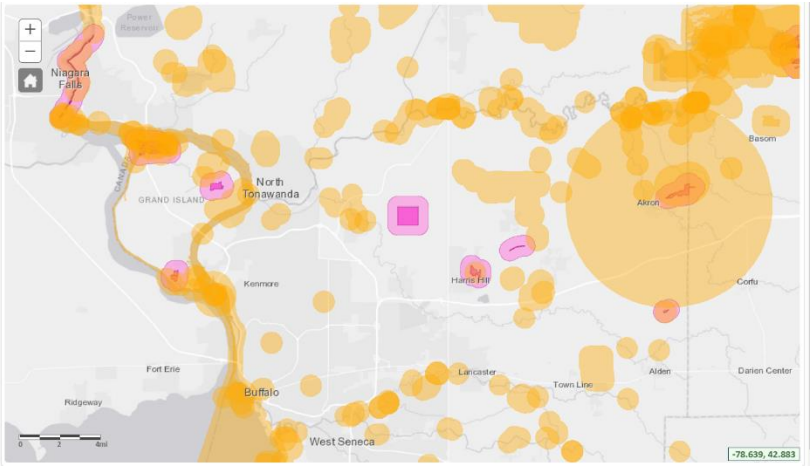

Figure 3: *Significant Natural Communities and Rare Plants or Animals in Western New York* [14]

1. Do you live in Western New York? If you can, mark your home on the map above.

2. Do you live near a significant natural community and/or rare plants or animals (within the colored boundaries)?

   Circle YES or NO

3. Did you know that Western New York was home to so many significant natural communities?

   Circle YES or NO

[10] Center for Great Lakes Literacy https://www.cgll.org/for-educators/great-lakes-literacy-principles/principle-5/
[11] Ramsar Convention on Wetlands of International Importance webpage for the Niagara River Corridor site https://rsis.ramsar.org/ris/2402
[12] New York Natural Heritage Program guide to Calcareous Talus Slope Woodland community https://guides.nynhp.org/calcareous-talus-slope-woodland/.
[13] New York State Department of Conservation Lake Sturgeon webpage https://www.dec.ny.gov/animals/26035.html
[14] New York State Department of Conservation Environmental Resource Mapper https://gisservices.dec.ny.gov/gis/erm/

4. Read and respond to the prompt below.

   In this hypothetical scenario, there is an area of land proposed for development near the Niagara River. A company is planning to build its storage facilities on forested and wetland ecosystems. Building these facilities would require thousands of trees to be cut down, miles of road to be built, and the area near the river that had resisted development for many years would dramatically change. Take into consideration the fact that the forest, wetland, and the river provide valuable habitat for fish and wildlife.

   Specifically, this habitat is home to threatened, endangered, or rare species like the Bald Eagle (*Haliaeetus leucocephalus*), Sky Blue Aster (*Symphyotrichum oolentangiense*), and the Red-headed Woodpecker (*Melanerpes erythrocephalus*). Write a letter to the local planning board, which is an elected or appointed group that makes decisions about the growth and development in a community or municipality, as a concerned community member. Could this development co-exist with the environmental concerns?



Figure 4: *Bald Eagle, Sky Blue Aster (Kimberly J. Smith)[15], and Red-headed Woodpecker*

[15] New York State Natural Heritage Guide Sky Blue Aster https://guides.nynhp.org/sky-blue-aster/

Graph – *Impact of Habitat Destruction on Karner Blue butterfly population*