Biology Instruction Segment: Stability & Change in Ecosystems—Part 1 of 2

This 5E model for instruction may be useful for connecting the concept of adapting to different ecosystems and human impact on the environment.

Student Science Performance

Grade: 9-12 Biology	**Title:**
Topic: Human Population Growth and Carrying Capacity	We Are the World

Performance Expectation for GSE:

SB5. Obtain, evaluate, and communicate information to assess the interdependence of all organisms on one another and their environment.

a. Plan and carry out investigations and analyze data to support explanations about factors affecting biodiversity and populations in ecosystems.
(*Clarification statement:* Factors include population size, carrying capacity, response to limiting factors, and keystone species.)

c. Construct an argument to predict the impact of environmental change on the stability of an ecosystem.

d. Design a solution to reduce the impact of a human activity on the environment.
(*Clarification statement*: Human activities may include chemical use, natural resources consumption, introduction of non-native species, greenhouse gas production.)

SB2. Obtain, evaluate, and communicate information to analyze how genetic information is expressed in cells.

c. Ask questions to gather and communicate information about the use and ethical considerations of biotechnology in forensics, medicine, and agriculture.
(*Clarification statement:* The element is intended to include advancements in technology relating to economics and society such as advancements may include Genetically Modified Organisms.)

Standard notes: The focus of this lesson is on the population size and carrying capacity of one species; however, implicit connections between populations may arise. Keystone species are not addressed in this lesson.

Performance Expectations for Instruction:

Investigate how population growth responds to the availability of resources needed for survival.

Group Performance: (Engage and Explore)

- Obtain information about the status of human population on earth.
- Ask questions to develop a model and construct an explanation for the factors that caused the-patterns seen in the historical data of human population.
- Carry out investigations (the carrying capacity exploration activity) to obtain data for evidence.
- Analyze and interpret the data to refine your model and explanation constructed for the cause of patterns in populations in response to resource availability.

Individual Performance: (Explore)

- Write an argument for your explanation supported by evidence from the investigation.

Group Discussion: (Explore and Explain)

- Use the evidence and explanations shared from others to refine or confirm your model and argument.

Teacher Reflection: (Explain)

- Reflect on students' ability to develop an argument where the explanation is supported by evidence.
- Reflect on students' ability to conclude that population size is impacted by resource availability and is supported by evidence in the activity.

Group Performance: (Elaborate)

- Obtain information regarding agricultural land use and genetically modified crops.
- Ask questions to develop models and construct an explanation to determine the need for increased food production through increased land use for agriculture or increased use of genetically modified organisms to improve yield.

Individual Performance: (Elaborate and Evaluate)

- Write an argument for your explanation that relates to gathered information and evidence supporting the need for increased food production to accommodate the increasing global population.

Group Discussion: (Elaborate)

- Use the evidence and explanations shared from others to refine or confirm your model and argument.

Teacher Reflection: (Evaluate)

- Reflect on students' ability to develop an argument where the explanation is supported by evidence.
- Reflect on students' ability to conclude that an increase in food production is necessary to provide adequate resources for the growing population seen in real-world scenarios and is supported by evidence.

Additional notes on student supports

Materials

Each student will need:

- 1 green-colored resource card
- 1 blue-colored resource card
- 1 yellow-colored resource card

For a class of 30 students:

- 30 green-colored resource cards
- 30 blue-colored resource cards
- 30 yellow-colored resource cards

Teacher Notes: To last longer, you may use laminated construction paper or ask a local retailer for paint chip cards.

Students will continuously be obtaining, evaluating, and communicating information. This is not a linear process. Students should be communicating through writing and discussions to allow for formative assessment. This benefits the teacher, student, and whole group to guide instruction to clarify misconceptions or extend content.

Engaging Learners	**Phenomenon** Show Population Growth video on human population growth since 1 A.D. to present and extrapolated to 2050. Human Population Through Time Obtaining: Conduct human population growth (exponential growth) activity. *Teacher Notes: You will need a container (small plastic tub, paper sack, large baggie, etc.) where you will put all the double-sided numbers you have cut out of the activity sheet per group. Students will need a flat desk, table or the floor and the data collection sheet. Each group begins the activity with 10 randomly selected numbers from the container. In each successive generation, a #3 or #6 results in a birth added to the population and a #1 results in a death (you may want to make sure every group has at least one more # 3 or # 6 than they do #1's to start with so that births occur). Once they determine how many deaths, they will place that many numbered squares (representing people) back into the container. Once they determine the number of births, they will add that many numbered squares to their population and complete the data table by the correct generation. After 10 generations have been completed, students will graph the growth pattern that will show exponential growth. Other examples of modeling exponential growth can be found online.* Students analyze and interpret global human population data.

	Teacher Notes: Students may explore United States Census Bureau Population Clock *to look at the impact state and local population patterns have on global population. Connections to the patterns of inheritance in Punnett square ratios can be addressed by analyzing the male to female ratio.*
	Communicating Students develop a model depicting differences in global human carrying capacities estimates based on resource consumption. *Teacher Notes: If all people consumed resources like the average American, the carrying capacity is estimated to be 2 billion. If all people consumed only necessary amounts of resources, it is estimated to be 40 billion.* Ask students if human population growth patterns and the reasons for it can be extrapolated to animal and plant populations in a variety of ecosystems? *Obtaining* Students carry out the "I'm A Survivor!" activity to obtain information: Activity Slides: I'm a Survivor (Can be found on Teacher Resource Link) Activity Handout: I'm a Survivor! *Teacher Notes: This activity requires the use of the activity slides. The activity is a modified version of the "Oh, Deer!" activity from Georgia DNR and Project WILD. Combining classes if possible is recommended because large student numbers offer the best results. Students will each have the 3 colored resource cards. Three students are the initial population. The resources and population line up several feet away from each other facing in opposite directions. They select the resource they need/want to be for the round. On the signal, they turn to face each other. The population must run to find only one corresponding resource. The resource returns with them to the population line to become a new member since the original member was able to survive and reproduce. If a member cannot find a corresponding resource, they did not survive and must become a resource. Repeat the process for 10+ rounds. More rounds tend to allow the data to reflect reaching carrying capacity.*
	Evaluating Students analyze and interpret data of the population growth collected during the activity. *Teacher Notes: Data should fluctuate around the carrying capacity. If possible, have students compare graphs with other classes (or other organisms) to analyze the correlation between number of students/resources and the carrying capacity.*
	Communicating Students develop a model to represent the data collected during the activity. *Obtaining/communicating*

<table>
<tr>
<td></td>
<td>Using a Placemat Technique, students look on the internet to find as many ways as they can that environmental change impacts populations in an ecosystem. Each person adds their findings to their corner of the placemat. Share your findings with your group and put in the home box those that your group thinks are a direct result of human activity. Be able to defend your group answers in a Popcorn Round Robin format (one student is selected from each group to be the spokesperson and the teacher quickly goes from group to group giving them 30 seconds to defend group answers).

Teacher Notes: Make connections between fitness and resource availability. Regardless of fitness, an organism will not survive if resources are not available. The teacher should ask, "which of these are density- dependent and which are density- independent? Have students tease apart the two terms and use background knowledge to determine the answers. The focus is on birth rates and death rates, but connections to evolution may be addressed by including gene flow and gene pools in response to immigration and emigration.

Ask students what role has human population growth had on earth's ecosystems health? They may supply a list of ideas and this video will provide many more:
Human activities that threaten biodiversity

Evaluating
Use Concept Attainment to differentiate among the factors that can impact populations in an ecosystem.

Teacher Note: Here is one concept attainment data set for density dependent vs density independent factors that affect population growth:
<table>
<tr><th>Yes Examples</th><th>No Examples</th></tr>
<tr><td>Excessive rain</td><td>Pesticide use on farmland</td></tr>
<tr><td>Drought</td><td>Insecticides on crops</td></tr>
<tr><td>Natural disasters (fire, volcanic eruptions, hurricanes, storms)</td><td>Deforestation</td></tr>
<tr><td>Excessive snow pack</td><td>Poaching</td></tr>
<tr><td>Overpopulation</td><td>Use of fossil fuels for energy</td></tr>
<tr><td>Natural selection</td><td>Water pollution</td></tr>
<tr><td>Disease</td><td>Air pollution</td></tr>
<tr><td>Predation</td><td>Habitat destruction (logging, agricultural, clearing, housing, etc)</td></tr>
<tr><td>Birth rate</td><td>Introduction of non-native species</td></tr>
<tr><td>Death rate</td><td>Greenhouse gases</td></tr>
</table>

Additional notes on topic, focus, and phenomena</td>
</tr>
<tr>
<td>Exploring
Revising Model</td>
<td>Communicating
Students construct explanations to explain all the factors that limit population growth in a specific area. Construct an argument to predict the impact of environmental change on the stability of an ecosystem. Students make a claim and provide evidence and reasoning about the environmental health of an ecosystem or the ecosystem of a specific organism in your area of Georgia. For example: in South Georgia you may provide students choices from these examples: Longleaf pine ecosystem, Ptilimnium nodosum</td>
</tr>
</table>

	or harperella plant, red-cockaded woodpecker, northern long-eared bat, ***Elliptoideus sloatianus*** or purple bankclimber, right whale, piping plover, eastern indigo snake, etc. This site will provide you with other Georgia endangered organisms: Threatened and Endangered Species by the Georgia Ecological Services Field Offices of the U.S. Fish and Wildlife Service. Students engage in arguments to support environmental conservation efforts and determine strategies to conserve resources for the growing human population. *Communicating* Have students create a mind map connecting how environmental changes impact ecosystems based on density-dependent and density-independent factors. There are many good mind mapping digital programs that you can find by doing a search. *Evaluating* Students engage in arguments to support environmental conservation efforts and determine strategies to conserve resources for the growing human population. ***Formative Assessment of Student Learning*** *The following may be assessed through discussions, writings, or analysis of images/models.* Students use evidence from the ENGAGE scenario and the EXPLORE activity to argue the claim that population growth of organisms are limited by the availability of resources. Once carrying capacity is reached, organisms will not survive because of a lack of resources. Additional factors may also influence the population growth of organisms.
	Phenomenon- **GMO Crops** Scientists are genetically modifying crops to contend with the increase in human population along with the shifting climate and reduction of resources. *Teacher Notes: Resources can be found online that describe existing crops that are genetically modified. Modify the crop based on student interest for increased differentiation. The focus of this phenomenon is on feeding the growing global population by comparing and contrasting increasing land use for agriculture or increasing use of genetically modified crops. Connections to genetics in regard to how crops are genetically engineered may be included. Connections to evolution in regard to developing genetically engineered crops in response to pesticide resistance. This may also be extended to preview food webs--the increase in crops is not solely for human consumption, but also for the consumption of livestock that humans also consume.*
	Obtaining Students ask questions and obtain information about current genetic modifications to crops to increase yields. Students ask questions and obtain information about increasing land use for agriculture while human population continues to increase.
Explaining Finalizing Model	*Evaluating* Students analyze and interpret data of yield sizes of genetically modified crops and non-genetically modified crops.

	Students construct an explanation for the cause of changes in yield sizes in genetically modified crops and non-genetically modified crops. Students analyze and interpret data of agricultural and non-agricultural land use. *Teacher Notes: Non-agricultural land use may be expanded to inhabitable and uninhabitable land.*
Elaborating Applying Model to Solve a Problem	*Communicating* Students develop a model to demonstrate how yield sizes of genetically modified crops have changed over time. Students develop a model to demonstrate how much of the total land area is used for agriculture. *Teacher Notes: This could be narrowed down to Georgia.* Students use evidence from the ENGAGE, EXPLORE, and EXPLAIN activities to engage in argument to determine the need for increased food production through increased land use for agriculture or increased use of genetically modified organisms to improve yield.
Evaluation	***Assessment of Student Learning*** *In models:* Students develop models to demonstrate the limiting population growth in response to resource availability. *In writing:* Students use evidence from models to argue the claim that a population's carrying capacity is limited in response to different limiting factors like resource availability. *In writing:* Students engage in arguments supported by evidence to determine the need for increased food production through increased land use for agriculture or increased use of genetically modified organisms to improve yield.
SEP, CCC, DCI	**Science Essentials**
Science and Engineering Practices	• Planning and carrying out investigations • Engaging in argument from evidence • Designing solutions • Asking questions and defining problems
Crosscutting Concepts	• Patterns • Scale, Proportion, and Quantity • Cause and Effect • Stability and Change
Disciplinary Core Ideas	From ***A Framework for K-12 Science Education:*** LS2.A: Interdependent Relationships in Ecosystems LS2.B: Cycles of Matter and Energy Transfer in Ecosystems LS2.C: Ecosystem Dynamics, Functioning, and Resilience LS4.D: Biodiversity and Humans

Human Population Growth Activity

These numbers MUST be printed on both sides of the paper.

1	2	3	4	5	6
1	2	3	4	5	6
1	2	3	4	5	6
1	2	3	4	5	6
1	2	3	4	5	6
1	2	3	4	5	6
1	2	3	4	5	6

Key: 3 or 6 = A birth 1= A death			
Beginning Population=10	# births	# deaths	Total population
1st generation			
2nd generation			
3rd generation			
4th generation			
5th generation			
6th generation			
7th generation			
8th generation			
9th generation			
10th generation			

Use an excel spreadsheet to graph the population change over 10 generations.

If it takes approximately 1.5 acres of rangeland (crop and meat) to feed one person, what is the carrying capacity of earth?

At this rate of growth, how long before we reach the carrying capacity of earth?

Return to Instructional Segment

I'm a Survivor! Student Handout

Claim:

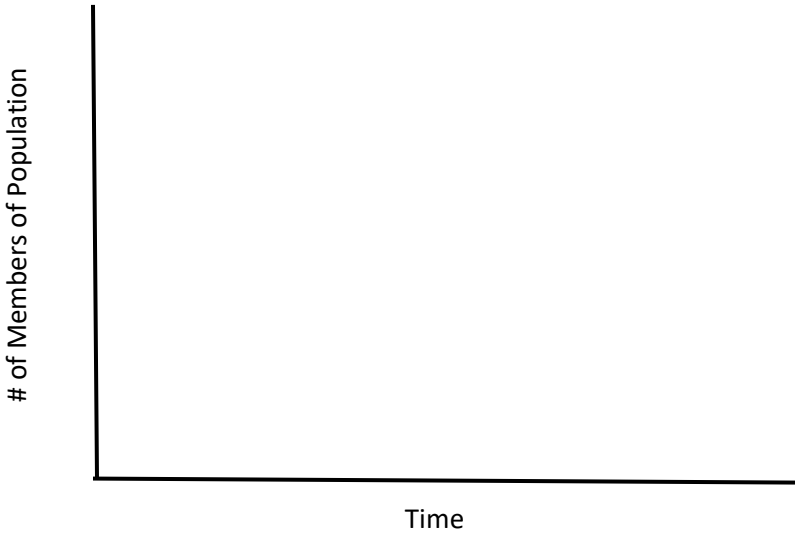
The BIG idea

Evidence:

I'm a Survivor! Summary Fill in the table to the right

Create a line graph below using that data to show trends

	# of Members
Round 1	
Round 2	
Round 3	
Round 4	
Round 5	
Round 6	
Round 7	
Round 8	
Round 9	
Round 10	
Round 11	
Round 12	



1. What resources were the members of the population for?

2. Why did the resources that were picked become new members of the population?

3. Why did members that did not get their resources become resources themselves?

4. What trend did you notice as the rounds continued?

Reasoning:

Explain how natural selection and the competition for limited resources limits the population growth in a specific area.

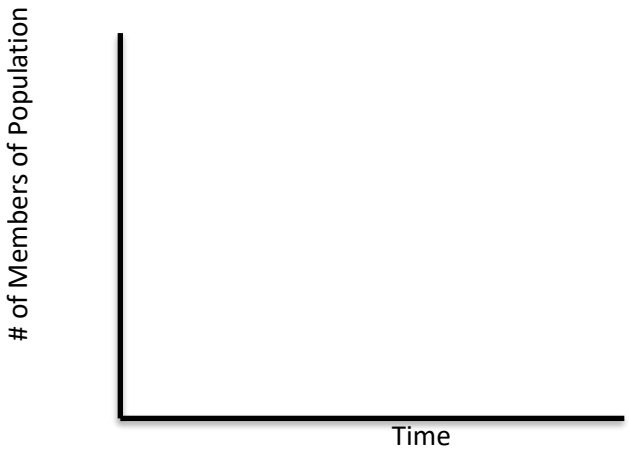
Think About It:

Does being “fit” guarantee survival?

Factors That Affect Population Growth:

Global Human Population Growth:

Sketch the Global Population Graph below:



Why has human population been able to experience rapid exponential growth over the past century?

How many people can the Earth support?

If everyone lived like the average American (the average consumption rate of food and water), the global carrying capacity should be 2 billion.

What does this mean?

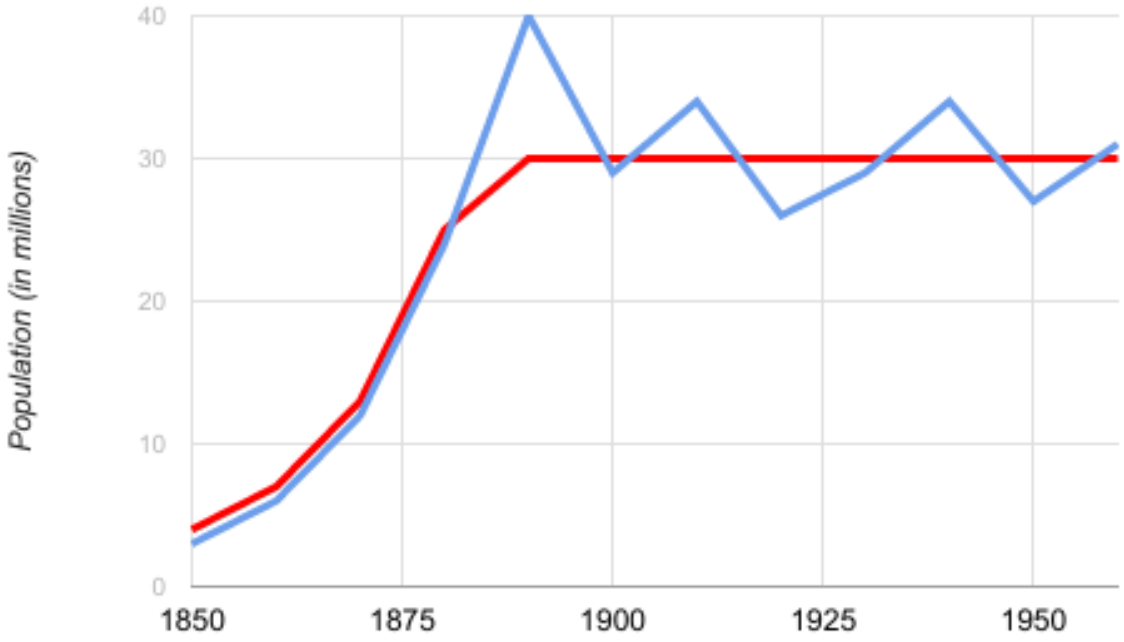
What could be done differently?

What should we be doing?

Are we willing to do anything differently?

Population Growth Curve:

Label the following graph:



Carrying Capacity:

Written Reflection:

Compare and contrast the I'm a Survivor! and Human Population graphs.

What allows the human population to grow uncontrollably?

What do you think will happen to the world population in the next century?

What impact does human population growth have on the environment?

How will advances in biotechnology in agriculture affect the human population growth?

Return to Instructional Segment

Stability & Change in Ecosystems GSE: **SB1e, SB2c, SB5a, SB5b, SB5c, SB5d, SB5e, SB6a, SB6b**			
Anchoring Phenomenon: Human activities can cause major shifts in ecosystems. Desertification is causing global impacts.			
Topic	**Focus**	**Lesson Phenomenon**	**GSE/Notes/Language**
Ecosystems & Adaptations	Initial overview of how the latitude of the Earth affects ecosystems; introduction of plant and animal adaptations may be addressed here and revisited later in adapting to changing conditions.	Skin color is a trait that has a wide variation of phenotypes that tends to be concentrated in different ecosystems.	SB5c/SB3a/SB3b/SB6b Discussions on the evolution and inheritance of skin color are beneficial in connecting this instructional segment with Patterns in Heredity & Selection: Different Strokes for Different Folks. Make connections between the evolutionary benefits of having variations in DNA & fitness related to different regions of the Earth.
Human Population Growth	Human growth rate has been exponentially increasing since advancements in agriculture and medicine. The large human population uses a significant amount of limited natural resources and is exceeding our natural carrying capacity. Density-dependent and density-independent limiting factors regulate populations of organisms.	**Biotechnology Connection:** Deer in Georgia were almost eliminated but hunting regulations have successfully restored their population. Scientists are genetically modifying crops to contend with the increase in human population along with the shifting climate and reduction of resources.	SB2c/SB5a/SB5d It is beneficial to discuss carrying capacity and limiting factors in populations of other organisms (i.e. deer) before applying those concepts to human population growth.
Human Impact	The increase in human	Controlled burns and	

on Land Use	population requires more land for living and agriculture; deforestation occurs. Emphasize ecological succession (primary and secondary). Relate deforestation to the impact on the carbon cycle by revisiting photosynthesis and cellular respiration.	clear-cutting forests affect ecosystems differently. Atmospheric carbon levels are altered by increasing human population and clearing land.	SB5b/SB5c/SB5d Revisit cycling of carbon through photosynthesis and cellular respiration to make a connection between human impact on the carbon cycle and energy flow between producers and consumers.
Human Impact on Agriculture	Deforestation negatively affects the number of producers in an ecosystem that are the sole provider of energy to consumers. Energy flows from producers to consumers and is modeled using a food chain/food web. Farming practices include the use of fertilizers that are high in nitrogen that runoff into aquatic ecosystems and can cause eutrophication, upsetting the natural flow of matter and energy. Ecological pyramids show the relationship of	**Biotechnology Link:** Scientists are genetically modifying crops to contend with the increase in human population along with the shifting climate and reduction of resources. Minamata disease results from humans eating mercury contaminated seafood. Ponds that have a thick layer of algae tend to have a low population of fish.	SB1e/SB2c/SB5a/SB5b/SB5d Revisit cycling of carbon through photosynthesis and cellular respiration. Include deforestation and effect on runoff and water cycle. Emphasize human dependence on producers and other consumers. Biomagnification results from contaminants being passed through the food chain. Integrate necessity of genetically modified foods and mass farming of produce and meat to sustain the growing population to ethical concerns. Highlight the need for cycling of nitrogen and phosphorus through discussion of farming practices.

	energy, population numbers and biomass among trophic levels.		
Human Impact on Ecosystems & Biodiversity	Keystone species are a pivotal part of an ecosystem. If removed, all aspects of the ecosystem will be affected.	Urchin barrens significantly increased during a time of increased sea otter hunting. The wolves of Yellowstone were eliminated in the 1920s but have been reintroduced to the area in the 1990s, and it has had a widespread effect.	SB5a/SB5c/SB5d/SB5e/SB6a/SB6b Focus on community interactions and how humans have positively and/or negatively influenced these interactions. Discuss the positive and negative impacts that conservation efforts may have on an ecosystem.
	Introduction of non-native species may be detrimental to an ecosystem.	Kudzu has seemed to "take over" the south by growing uncontrollably.	
	Emphasize different community interactions (predation and competition) and symbiotic relationships (mutualism, parasitism, commensalism).	The population of arctic hares tend to be much larger than the population of snow leopards. Mosquitos steal nutrients from a host by sucking blood and can transmit diseases to host.	
	Plants and animals have specific adaptations that increase their fitness in specific ecosystems. Emphasize plant tropisms.	Plants Vines "climb" trees to reach sunlight while leaves in the understory are very wide with pointed drip leaves.	The sickle cell trait evolved in response to parasitism. Instructional Segment: Can't We All Just Get Along?
	Humans are constantly	Globally, deserts are	

	impacting ecosystems, altering the biodiversity of plants and animals that can survive and withstand the different environment	expanding. There are large numbers of threatened, endangered, and extinct species.	
Natural Impact on Ecosystems & Biodiversity	Geological evidence of the history of the Earth shows it has changed drastically over time, altering the biodiversity of plants and animals that can survive and withstand the different environment.	Related species are sometimes found on separate continents.	SB6a/SB6b Revisit the evolutionary idea that organisms adapt to changing environments; the natural geologic history of the earth has impacted the processes of speciation and shifts in biodiversity. Revisit the evolutionary concepts of adaptive radiation and convergent evolution.

Anchoring Phenomenon:

Human activities can cause major shifts in ecosystems. Desertification is causing global impacts.

Students should be able to explain the phenomenon using the following concepts:

- Plants and animals have different adaptations that increase fitness in different ecosystems.
- Increasing human populations requires the use of more limited resources.
- Misuse of these resources may result in an increase of carbon in the atmosphere, causing climate change.
- Improper farming practices in areas with high biodiversity may have drastic effects on the soil, plants, and water.
- These areas can experience desertification, affecting plants and animals native to the biome.
- Plants and animals must adapt to human induced or naturally changing ecosystems.
- Conservation efforts may help slow or reverse the negative effects of humans on ecosystems.

Additional Supports for struggling learners:

The following supports are suggestions for this lesson and are not the only options to support

students in the classroom. These supports target students that struggle with science material, this lesson or a previous lesson. These are generalized supports and do not take the place of IEP accommodations as required by each student's Individualized Education Program.

General supports for the following categories:

Reading:	Writing:	Math:
1. Provide reading support by reading aloud or doing partner reads 2. Have the teacher model what they are thinking when reading the text 3. Annotate the text with students so that they may refer to it as they work through the lab	1. The teacher can provide a sentence starter for the students. 2. The teacher can give students an audience to write to (i.e. Write a letter to your sibling explaining this topic). 3. The teacher can provide constructive feedback during the writing process to help students understand the expectations.	1. The teacher should model analyzing data for this activity. 2. The teacher can model what they are thinking as they look over a sample data set.

Supports for this specific lesson if needed:

Performance expectations for instruction:

1. The teacher should provide multiple formats that the student can use to express their knowledge.
2. At the end of the lesson the teacher should reflect on the following topics:

   -The teacher should reflect on grouping of students. Was it beneficial and were all students able to contribute? Why or Why not?

   -The teacher should reflect on supports for struggling learners. Were the supports enough for the student population? Why or why not? Then make a list of other supports that the teacher can try in the classroom.

Engaging Learners:

1. The students may need to view the video on human population growth more than once. Show the video as needed for students with processing issues to be able to recall the important facts. 2. The teacher may need to explain the directions to the lab multiple times to keep students on track. 3. The teacher can show other models of exponential growth to help students see the trends that appear in the data. 4. Students may need additional time to construct the model. 5. Some students will need warning and preparation if the teacher is planning on combining classes. The teacher should warn students the day before combining classes. 6. The teacher may need to ask questions as the students analyze data. This will keep the students on track and from getting overwhelmed looking at the data. 7. When using the placemat technique, the teacher can assign different colors to different students. This way the teacher can see what each student is writing. This could be used as a formative assessment tool.
Exploring: 1. The teacher should offer multiple formats for the students to express the explanation. Some options of formats are writing an explanation, drawing a picture or verbally explaining. 2. The teacher should remind students of the definition of a scientific argument. 3. The teacher should provide some sort of graphic organizer to create a mind map on. This will cut down on the student's anxiety of looking at a blank page. 4. Students should be provided the claim in advance to allow students with processing disorders to begin to formulate their argument.
Explaining: 1. The teacher should record questions that the students have on the board or a piece of chart paper. The teacher can then help the students determine which questions go with this topic and these questions can be used to guide their research. This will cut down on time wasting of students that have difficulty prioritizing. 2. The students should be given the opportunity to express their knowledge in various formats. This can include writing, drawing or explaining verbally.
Elaborating: 1. The students may require additional time to develop the models.
Evaluating: 1. The students may require additional time to develop models. 2. The students should be given the opportunity to express their knowledge in various formats. This can include writing, drawing or explaining verbally.

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