Module 4 Task

Module 4: Greenhouse Gasses
Unit 9 (p. 179)

1) **Quickwrite**. Take 2 minutes to analyze the axis-filtered scatterplot (middle of the page). Use your understanding of various emissions and their causes as well as the data in the plot to determine and explain the correlations (if any) between CO2 and CH4 (kt) rates and between their respective 10 yr. changes.

2) **Graph and Switch**. Work with a partner and use the bottom table of the app where it provides the top 10 and bottom 10 contributors to the various emissions. Each of you will create a scatterplot. One of you will plot the CH4 (kt) emissions of the top 10 countries against their respective populations, and the other will plot the CH4 (kt) emissions of the bottom 10 countries against their respective populations. Cross check each other's work and make a remark about the characteristics of the graphs.

3) **Debate**. With the same neighbor, or individually, make an argument for and against the prompt below appealing to the data of the emissions and population apps and the data therein.

   "Population is a direct contributor to increased CH4 emissions over time."

CollegeBoard AP

INCLUDES
- Course framework
- Instructional section
- Sample exam questions

AP® Environmental Science

COURSE AND EXAM DESCRIPTION

Effective
Fall 2020

Instructional Strategies

The AP Environmental Science course framework outlines the concepts and skills students need to master to be successful on the AP Exam. In order to address those concepts and skills effectively, it helps to incorporate a variety of instructional approaches into daily lessons and activities. The following table presents strategies that can help students apply their understanding of course concepts.

Strategy	Definition	Purpose	Example
Ask the Expert (or Students as Experts)	Students are assigned as "experts" on problems they have mastered; groups rotate through the expert stations to learn about problems they have not yet mastered.	Provides opportunities for students to share their knowledge and learn from one another.	Assign students as "experts" on environmental legislation. Have students rotate through stations in groups, working with the station expert to complete a series of questions on the topic.
Construct an Argument	Students use scientific reasoning to present assumptions about biological situations, support conjectures with scientifically relevant and accurate data, and provide a logical progression of ideas leading to a conclusion that makes sense.	Helps develop the process of evaluating scientific information, developing reasoning skills, and enhancing communication skills in supporting conjectures and conclusions.	Present students with a written or visual scenario of the results of a laboratory investigation and then have them work together to draw conclusions about scientific investigations. They can support their conclusions with data by having each student or group of students add a sentence to the conclusion. Once the conclusion is complete, read it (or show it on a screen) and then facilitate a class discussion.
Debate	Engaging in an informal or formal argumentation of an issue.	Provides an opportunity for students to collect and orally present evidence supporting the affirmative and negative arguments of a proposition or issue.	Have students debate realistic solutions to environmental problems. This can be more meaningful for students if the problem selected is specific to the school and students have the opportunity to present their solutions to school administrators.

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Strategy	Definition	Purpose	Example
Error Analysis	Students analyze an existing solution to determine whether (or where) errors have occurred.	Allows students to troubleshoot errors and focus on solutions that may arise when they do the same procedures themselves.	Have students analyze their work to determine whether their answer is realistic. For example, if they are working on an energy calculation, they can't end up with more energy than they started with.
Fishbowl	Some students form an inner circle and model appropriate discussion techniques, while an outer circle of students listens, responds, and evaluates.	Provides students with an opportunity to engage in a formal discussion and to experience the roles of both participant and active listener; students also have the responsibility of supporting their opinions and responses using specific evidence.	Divide students into two groups and ask them to form two concentric circles. The inner circle can explain ecosystem services to the students in the outer circle, and the outer circle can explain ecological services to students in the inner circle. The circles rotate to enable students to share their knowledge and learn to communicate with their peers.
Graph and Switch	Generating a graph to represent data and then switch papers to review each other's representations.	Allows students to practice creating different representations of data and both give and receive feedback on each other's work.	Give students a data table and ask them to graph the data. Then have them switch papers and offer one another feedback on whether they graphed the data appropriately. This can be scaffolded by distributing multiple data tables that require different types of graphs.
Idea Spinner	The teacher creates a spinner marked into four quadrants and labeled "Predict," "Explain," "Summarize," and "Evaluate." After new material is presented, the teacher spins the spinner and asks students to answer a question based on the location of the spinner. For example, if the spinner lands in the "Summarize" quadrant, the teacher might say, "List the key concepts just presented."	Functions as a formative assessment technique.	Present students with a written or visual scenario of the results of a laboratory investigation. Using the spinner, ask students to predict what would happen if one of the experimental conditions changed, explain the results, summarize the results, and evaluate the methods used.

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Strategy	Definition	Purpose	Example
Index Card Summaries/ Questions	Periodically, distribute index cards and ask students to write on both sides, with these instructions: (Side 1) Based on our study of (unit topic), list a big idea that you understand and word it as a summary statement. (Side 2) Identify something about (unit topic) that you do not yet fully understand and word it as a statement or question.	Functions as a formative assessment technique.	At the beginning or end of class, show students an image of food chains or food webs. On one side of an index card, have students summarize energy flow through ecosystems. On the other side, have them write a question they have about the topic. Collect the cards and read through them, noting any trends in student responses. Address all questions that day (if done at the beginning of class) or the next day (if given at the end of class).
Misconception Check	Present students with common or predictable misconceptions about a designated concept, principle, or process. Ask them whether they agree or disagree and to explain why. The misconception check can also be presented in the form of a multiple-choice or true or false quiz.	Functions as a formative assessment technique.	Provide students with a statement on the board, or on paper, such as, "Climate change and ozone depletion are the same." Ask them whether the statement is true or false and then ask them to explain their reasoning. Address any misconceptions according to the answers they give.
One-Minute Essay	A one-minute essay question (or a one-minute question) is a focused question with a specific goal that can, in fact, be answered within a minute or two.	Functions as a formative assessment technique.	Give students one minute to respond to a prompt, such as, "Explain the relationship between photosynthesis at the cellular level and environmental carbon cycling."
Quickwrite	Writing for a short, specific amount of time about a designated topic related to a text.	Helps students generate multiple ideas in a quick fashion that could be turned into longer pieces of writing at a later time (may be considered as part of the drafting process).	Prior to teaching about endangered species, ask students to take a few minutes to explain whether the Endangered Species Act is necessary. At the conclusion of the lesson, students can revisit their answer and revise it to reflect what they learned.

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Strategy	Definition	Purpose	Example
Think–Pair–Share	Considering and thinking about a topic or question and then writing what has been learned; pairing with a peer or a small group to share ideas; and sharing ideas and discussion with a larger group.	Helps students to construct meaning about a topic or question; test thinking in relation to the ideas of others; and prepare for a discussion with a larger group.	When engaging students in a post-lab discussion, have students reflect on their analysis of the data by asking them, "What is the relationship between the dependent variable and the independent variable?" After 1–2 minutes of reflection, have students turn to a neighbor and share their answer. After 2–3 minutes of sharing, engage the class in a whole-group discussion to ensure that students are building the necessary foundational understandings.

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UNIT 9

15–20% AP EXAM WEIGHTING | ~19–20 CLASS PERIODS

Global Change

BIG IDEA 3
Interactions Between Different Species and the Environment EIN
Why are laws created to protect endangered species?

BIG IDEA 2
Sustainability STB
How can local human activities have a global impact?

Building Understanding

A central aspect of environmental science is to understand the global impact of local and regional human activities. Humans can mitigate their impact through sustainable use of resources. Human activities can cause ozone depletion in the stratosphere and increases in the greenhouse gases in the atmosphere. Increases in greenhouse gases can cause human health and environmental problems. These environmental problems include global climate change, ocean warming, and endangered species. Overall, this course provides an opportunity to examine the interrelationships among the natural world and challenges students to evaluate and propose solutions to a variety of environmental problems.

Building the Science Practices

1.A 1.B 1.C 7.A 7.B 7.C 7.D 7.E

In this final unit, the goal is for students to describe and explain global changes in the environment, the causes of these changes, and their consequences. Students can build on their skills from previous units, where they described and evaluated solutions, to propose their own solutions as they learn about problems caused by global changes in the environment. They can practice using data as evidence to support their proposed solution or legislation. Students can also explain how the solution or legislation solves the problem in question.

Preparing for the APExam

On the AP Exam, students often struggle with discussing strategies that would prevent extinction. Students are able to identify a strategy, but they are not able to explain how the strategy could be implemented to prevent extinction. Students incorrectly imply that small populations are threatened populations. To combat this, teachers can provide opportunities for students to read multiple sources that allow them to propose realistic solutions that would prevent the extinction of certain species. Students may benefit from opportunities to explain the advantages, disadvantages, or unintended consequences of efforts to prevent extinction.

Students also confuse the terms global climate change and ozone depletion. Teachers can provide multiple opportunities to practice using scientific vocabulary in the proper context in verbal and written explanations of environmental concepts. Diagrams and models that illustrate global climate change can also be helpful. Emphasis can be placed on the effects of global climate change with visual representations of changes over time. Students can then explain how the visual representation illustrates an environmental science concept or process.

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UNIT AT A GLANCE

Enduring Understanding	Topic	Suggested Skill	Class Periods ~19–20 CLASS PERIODS
STB-4	9.1 Stratospheric Ozone Depletion	1.A Describe environmental concepts and processes.	
	9.2 Reducing Ozone Depletion	7.B Describe potential responses or approaches to environmental problems.	
	9.3 The Greenhouse Effect	1.B Explain environmental concepts and processes.	
	9.4 Increases in the Greenhouse Gases	2.C Explain how environmental concepts and processes represented visually relate to broader environmental issues.	
	9.5 Global Climate Change	5.D Interpret experimental data and results in relation to a given hypothesis.	
	9.6 Ocean Warming	7.A Describe environmental problems.	
	9.7 Ocean Acidification	1.C Explain environmental concepts, processes, or models in applied contexts.	
EIN-4	9.8 Invasive Species	7.E Make a claim that proposes a solution to an environmental problem in an applied context.	
	9.9 Endangered Species	7.D Use data and evidence to support a potential solution.	
	9.10 Human Impacts on Biodiversity	7.C Describe disadvantages, advantages, or unintended consequences for potential solutions.	
	Go to AP Classroom to assign the **Personal Progress Check** for Unit 9. Review the results in class to identify and address any student misunderstandings.		

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SAMPLE INSTRUCTIONALACTIVITIES

The sample activities on this page are optional and are offered to provide possible ways to incorporate various instructional approaches into the classroom. They were developed in partnership with teachers from the AP community to share ways that they approach teaching some of the topics in this unit. Please refer to the Instructional Approaches section beginning on p. 201 for more examples of activities and strategies.

Activity	Topic	Sample Activity
1	9.8	**Ask the Expert (or Students as Experts)** Divide students into groups. Each group will become experts on a case study involving a classic invasive species (e.g., zebra mussels, cane toad, and black rats). Then have students rotate through the groups to learn about each invasive species.
2	9.10	**Debate** Provide students with the following scenario: *There is a proposal to construct a new mall. The mall would be located in a 20-acre wetland estuary near a wooded section adjacent to the school.* Divide the class into two teams. One team argues that biodiversity will not be affected by the mall; the other team argues that it will. The debate should focus on the impact of the eliminated waterway.

Unit Planning Notes

Use the space below to plan your approach to the unit.

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SUGGESTED SKILL

Concept Explanation

1.A

Describe environmental concepts and processes.

AVAILABLE RESOURCES

Classroom Resource > AP Environmental Science Teacher's Guide

External Resource > Environmental Literacy Council's AP Environmental Science Course Material

External Source > GLOBE for the Environmental Science Classroom

TOPIC 9.1
Stratospheric Ozone Depletion

Required Course Content

ENDURING UNDERSTANDING

STB-4

Local and regional human activities can have impacts at the global level.

LEARNING OBJECTIVE

STB-4.A

Explain the importance of stratospheric ozone to life on Earth.

ESSENTIAL KNOWLEDGE

STB-4.A.1

The stratospheric ozone layer is important to the evolution of life on Earth and the continued health and survival of life on Earth.

STB-4.A.2

Stratospheric ozone depletion is caused by anthropogenic factors, such as chlorofluorocarbons (CFCs), and natural factors, such as the melting of ice crystals in the atmosphere at the beginning of the Antarctic spring.

STB-4.A.3

A decrease in stratospheric ozone increases the UV rays that reach the Earth's surface. Exposure to UV rays can lead to skin cancer and cataracts in humans.

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TOPIC 9.2
Reducing Ozone Depletion

SUGGESTED SKILL

Environmental Solutions

7.B
Describe potential responses or approaches to environmental problems.

AVAILABLE RESOURCES

Classroom Resource > AP Environmental Science Teacher's Guide

External Resource > Environmental Literacy Council's AP Environmental Science Course Material

External Source > GLOBE for the Environmental Science Classroom

Required Course Content

ENDURING UNDERSTANDING

STB-4

Local and regional human activities can have impacts at the global level.

LEARNING OBJECTIVE

STB-4.B

Describe chemicals used to substitute for chlorofluorocarbons (CFCs).

ESSENTIAL KNOWLEDGE

STB-4.B.1

Ozone depletion can be mitigated by replacing ozone-depleting chemicals with substitutes that do not deplete the ozone layer. Hydrofluorocarbons (HFCs) are one such replacement, but some are strong greenhouse gases.

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SUGGESTED SKILL

Concept Explanation

1.B

Explain environmental concepts and processes.

AVAILABLE RESOURCES

Classroom Resource > AP Environmental Science Teacher's Guide

External Resource > Environmental Literacy Council's AP Environmental Science Course Material

External Source > GLOBE for the Environmental Science Classroom

TOPIC 9.3
The Greenhouse Effect

Required Course Content

ENDURING UNDERSTANDING

STB-4

Local and regional human activities can have impacts at the global level.

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
STB-4.C Identify the greenhouse gases.	STB-4.C.1 The principal greenhouse gases are carbon dioxide, methane, water vapor, nitrous oxide, and chlorofluorocarbons (CFCs). STB-4.C.2 While water vapor is a greenhouse gas, it doesn't contribute significantly to global climate change because it has a short residence time in the atmosphere. STB-4.C.3 The greenhouse effect results in the surface temperature necessary for life on Earth to exist.
STB-4.D Identify the sources and potency of the greenhouse gases.	STB-4.D.1 Carbon dioxide, which has a global warming potential (GWP) of 1, is used as a reference point for the comparison of different greenhouse gases and their impacts on global climate change. Chlorofluorocarbons (CFCs) have the highest GWP, followed by nitrous oxide, then methane.

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TOPIC 9.4
Increases in the Greenhouse Gases

Required Course Content

ENDURING UNDERSTANDING

STB-4

Local and regional human activities can have impacts at the global level.

LEARNING OBJECTIVE

STB-4.E

Identify the threats to human health and the environment posed by an increase in greenhouse gases.

ESSENTIAL KNOWLEDGE

STB-4.E.1

Global climate change, caused by excess greenhouse gases in the atmosphere, can lead to a variety of environmental problems including rising sea levels resulting from melting ice sheets and ocean water expansion, and disease vectors spreading from the tropics toward the poles. These problems can lead to changes in population dynamics and population movements in response.

SUGGESTED SKILL

Visual Representations

2.C

Explain how environmental concepts and processes represented visually relate to broader environmental issues.

AVAILABLE RESOURCES

Classroom Resource > AP Environmental Science Teacher's Guide

External Resource > Environmental Literacy Council's AP Environmental Science Course Material

External Source > GLOBE for the Environmental Science Classroom

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SUGGESTED SKILL

Data Analysis

5.D

Interpret experimental data and results in relation to a given hypothesis.

AVAILABLE RESOURCES

Classroom Resource > AP Environmental Science Teacher's Guide

External Resource > Environmental Literacy Council's AP Environmental Science Course Material

External Source > GLOBE for the Environmental Science Classroom

The Exam > Student Performance Q&A 2014, Q4

The Exam > Samples and Commentary 2014, Q4

TOPIC 9.5
Global Climate Change

Required Course Content

ENDURING UNDERSTANDING

STB-4

Local and regional human activities can have impacts at the global level.

LEARNING OBJECTIVE

STB-4.F

Explain how changes in climate, both short- and long-term, impact ecosystems.

ESSENTIAL KNOWLEDGE

STB-4.F.1

The Earth has undergone climate change throughout geologic time, with major shifts in global temperatures causing periods of warming and cooling as recorded with CO_2 data and ice cores.

STB-4.F.2

Effects of climate change include rising temperatures, melting permafrost and sea ice, rising sea levels, and displacement of coastal populations.

STB-4.F.3

Marine ecosystems are affected by changes in sea level, some positively, such as in newly created habitats on now-flooded continental shelves, and some negatively, such as deeper communities that may no longer be in the photic zone of seawater.

STB-4.F.4

Winds generated by atmospheric circulation help transport heat throughout the Earth. Climate change may change circulation patterns, as temperature changes may impact Hadley cells and the jet stream.

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LEARNING OBJECTIVE

STB-4.F

Explain how changes in climate, both short- and long-term, impact ecosystems.

ESSENTIAL KNOWLEDGE

STB-4.F.5

Oceanic currents, or the ocean conveyor belt, carry heat throughout the world. When these currents change, it can have a big impact on global climate, especially in coastal regions.

STB-4.F.6

Climate change can affect soil through changes in temperature and rainfall, which can impact soil's viability and potentially increase erosion.

STB-4.F.7

Earth's polar regions are showing faster response times to global climate change because ice and snow in these regions reflect the most energy back out to space, leading to a positive feedback loop.

STB-4.F.8

As the Earth warms, this ice and snow melts, meaning less solar energy is radiated back into space and instead is absorbed by the Earth's surface. This in turn causes more warming of the polar regions.

STB-4.F.9

Global climate change response time in the Arctic is due to positive feedback loops involving melting sea ice and thawing tundra, and the subsequent release of greenhouse gases like methane.

STB-4.F.10

One consequence of the loss of ice and snow in polar regions is the effect on species that depend on the ice for habitat and food.

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SUGGESTED SKILL

Environmental Solutions

7.A
Describe environmental problems.

AVAILABLE RESOURCES

Classroom Resource > AP Environmental Science Teacher's Guide

External Resource > Environmental Literacy Council's AP Environmental Science Course Material

TOPIC 9.6
Ocean Warming

Required Course Content

ENDURING UNDERSTANDING

STB-4

Local and regional human activities can have impacts at the global level.

LEARNING OBJECTIVE

STB-4.G

Explain the causes and effects of ocean warming.

ESSENTIAL KNOWLEDGE

STB-4.G.1

Ocean warming is caused by the increase in greenhouse gases in the atmosphere.

STB-4.G.2

Ocean warming can affect marine species in a variety of ways, including loss of habitat, and metabolic and reproductive changes.

STB-4.G.3

Ocean warming is causing coral bleaching, which occurs when the loss of algae within corals cause the corals to bleach white. Some corals recover and some die.

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TOPIC 9.7 Ocean Acidification

SUGGESTED SKILL

Concept Explanation

1.C

Explain environmental concepts, processes, or models in applied contexts.

AVAILABLE RESOURCES

Classroom Resource > AP Environmental Science Teacher's Guide

External Resource > Environmental Literacy Council's AP Environmental Science Course Material

Required Course Content

ENDURING UNDERSTANDING

STB-4

Local and regional human activities can have impacts at the global level.

LEARNING OBJECTIVE

STB-4.H

Explain the causes and effects of ocean acidification.

ESSENTIAL KNOWLEDGE

STB-4.H.1

Ocean acidification is the decrease in pH of the oceans, primarily due to increased CO_2 concentrations in the atmosphere, and can be expressed as chemical equations.

STB-4.H.2

As more CO_2 is released into the atmosphere, the oceans, which absorb a large part of that CO_2, become more acidic.

STB-4.H.3

Anthropogenic activities that contribute to ocean acidification are those that lead to increased CO_2 concentrations in the atmosphere: burning of fossil fuels, vehicle emissions, and deforestation.

STB-4.H.4

Ocean acidification damages coral because acidification makes it difficult for them to form shells, due to the loss of calcium carbonate.

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SUGGESTED SKILL

Environmental Solutions

7.E

Make a claim that proposes a solution to an environmental problem in an applied context.

AVAILABLE RESOURCES

Classroom Resource > AP Environmental Science Teacher's Guide

TOPIC 9.8
Invasive Species

Required Course Content

ENDURING UNDERSTANDING

EIN-4

The health of a species is closely tied to its ecosystem, and minor environmental changes can have a large impact.

LEARNING OBJECTIVE

EIN-4.A

Explain the environmental problems associated with invasive species and strategies to control them.

ESSENTIAL KNOWLEDGE

EIN-4.A.1

Invasive species are species that can live, and sometimes thrive, outside of their normal habitat. Invasive species can sometimes be beneficial, but they are considered invasive when they threaten native species.

EIN-4.A.2

Invasive species are often generalist, r-selected species and therefore may outcompete native species for resources.

EIN-4.A.3

Invasive species can be controlled through a variety of human interventions.

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TOPIC 9.9
Endangered Species

Required Course Content

ENDURING UNDERSTANDING

EIN-4

The health of a species is closely tied to its ecosystem, and minor environmental changes can have a large impact.

LEARNING OBJECTIVE

EIN-4.B

Explain how species become endangered and strategies to combat the problem.

ESSENTIAL KNOWLEDGE

EIN-4.B.1

A variety of factors can lead to a species becoming threatened with extinction, such as being extensively hunted, having limited diet, being outcompeted by invasive species, or having specific and limited habitat requirements.

EIN-4.B.2

Not all species will be in danger of extinction when exposed to the same changes in their ecosystem. Species that are able to adapt to changes in their environment or that are able to move to a new environment are less likely to face extinction.

EIN-4.B.3

Selective pressures are any factors that change the behaviors and fitness of organisms within an environment.

EIN-4.B.4

Species in a given ecosystem compete for resources like territory, food, mates, and habitat, and this competition may lead to endangerment or extinction.

EIN-4.B.5

Strategies to protect animal populations include criminalizing poaching, protecting animal habitats, and legislation.

SUGGESTED SKILL

Environmental Solutions

7.D

Use data and evidence to support a potential solution.

AVAILABLE RESOURCES

Classroom Resource > AP Environmental Science Teacher's Guide

External Resource > Environmental Literacy Council's AP Environmental Science Course Material

External Resource > GLOBE for the Environmental Science Classroom

The Exam > Chief Reader Report 2017, Q2

The Exam > Student Performance Q&A 2016, Q1

The Exam > Samples and Commentary (2017, Q2, 2016, Q1)

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SUGGESTED SKILL

Environmental Solutions

7.C

Describe disadvantages, advantages, or unintended consequences for potential solutions.

AVAILABLE RESOURCES

Classroom Resource > AP Environmental Science Teacher's Guide

TOPIC 9.10
Human Impacts on Biodiversity

Required Course Content

ENDURING UNDERSTANDING

EIN-4

The health of a species is closely tied to its ecosystem, and minor environmental changes can have a large impact.

LEARNING OBJECTIVE

EIN-4.C

Explain how human activities affect biodiversity and strategies to combat the problem.

ESSENTIAL KNOWLEDGE

EIN-4.C.1

HIPPCO (habitat destruction, invasive species, population growth, pollution, climate change, and over exploitation) describes the main factors leading to a decrease in biodiversity.

EIN-4.C.2

Habitat fragmentation occurs when large habitats are broken into smaller, isolated areas. Causes of habitat fragmentation include the construction of roads and pipelines, clearing for agriculture or development, and logging.

EIN-4.C.3

The scale of habitat fragmentation that has an adverse effect on the inhabitants of a given ecosystem will vary from species to species within that ecosystem.

EIN-4.C.4

Global climate change can cause habitat loss via changes in temperature, precipitation, and sea level rise.

EIN-4.C.5

Some organisms have been somewhat or completely domesticated and are now managed for economic returns, such as honeybee colonies and domestic livestock. This domestication can have a negative impact on the biodiversity of that organism.

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LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
EIN-4.C Explain how human activities affect biodiversity and strategies to combat the problem.	EIN-4.C.6 Some ways humans can mitigate the impact of loss of biodiversity include creating protected areas, use of habitat corridors, promoting sustainable land use practices, and restoring lost habitats.

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