West Windsor-Plainsboro Regional School District
Course Title: AP Environmental Science
Grades: 11-12

The Mission of the West Windsor-Plainsboro Science Department

Our mission is to cultivate science learners who have the foundational knowledge to make ethical, scientifically literate decisions and the ability to apply scientific practices in order to contribute to the needs of society and a changing world.

- **Vision**

  We envision a K-12 science experience that supports and challenges every student in their science learning journey. We will:
  - *Capitalize on diversity by reaching and exciting students at all levels and interests by differentiating learning within classrooms and by offering a robust program of studies.*
  - *Emphasize authentic science and engineering practices and leverage the interdisciplinary nature of science with arts, technology, math, reading, and writing.*
  - *Integrate scientific knowledge and 21st century competencies to prepare students to make informed decisions and take action to address real world problems.*

Unit 1: The Living World - Ecosystems	
Content Area: Science	
Course & Grade Level: AP Environmental Science, 11-12	
Summary and Rationale	
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. This unit will start with an introductory section where students examine what environmental science is and how humans find information and make decisions around environmental issues. In the bulk of this unit students will focus on the connections between biotic and abiotic factors that make up the main ecosystems on Earth. Students will use their understanding of the interactions between organisms among species, major biomes on Earth, the flow of energy into, through, and out of systems and knowledge of biogeochemical cycles to propose solutions to problems. Students will demonstrate understanding by conducting high-level inquiry investigations and effectively communicating their findings to an audience. Students will also utilize mathematical simulations to engage in argument from evidence.	
Recommended Pacing	
12 days - 4 cycles	
Standards/Performance Expectations	
Standard	
HS-LS2-1	**Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales. [Clarification Statement: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.]**
HS-LS2-2	**Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. [Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.] [*Assessment Boundary: Assessment is limited to provided data.*]**
HS-LS2-4	**Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. [Clarification Statement: Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and that matter and energy are conserved as matter cycles and energy flows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen and nitrogen being conserved as they move through an ecosystem.]**
HS-LS2-6	**Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem. [Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.]**
HS-LS2-7	**Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.* [Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.]**

Connecting with English Language Arts/Literacy and Mathematics

English Language Arts/Literacy

- Cite specific textual evidence to support an explanation for the cycling of matter and flow of energy in aerobic and anaerobic conditions, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- Develop and write an explanation, based on evidence, for the cycling of matter and flow of energy in aerobic and anaerobic conditions by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples.
- Develop and strengthen an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

Mathematics

- Represent the cycling of matter and flow of energy among organisms in an ecosystem symbolically and manipulate the representing symbols. Make sense of quantities of and relationships between matter and energy as they cycle and flow through an ecosystem.
- Use a mathematical model to describe the cycling of matter and flow of energy among organisms in an ecosystem. Identify important quantities in the cycling of matter and flow of energy among organisms in an ecosystem and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.
- Use units as a way to understand the cycling of matter and flow of energy among organisms in an ecosystem. Choose and interpret units consistently in formulas to determine the cycling of matter and flow of energy among organisms in an ecosystem. Choose and interpret the scale and the origin in graphs and data displays representing the cycling of matter and flow of energy among organisms in an ecosystem.
- Define appropriate quantities to represent matter and energy for the purpose of descriptive modeling of their cycling and flow among organisms in ecosystems.
- Choose a level of accuracy appropriate to limitations on measurement when reporting quantities representing matter cycles and energy flows among organisms in ecosystems.

21st Century Life and Careers/Technology Standards:

8.1 Educational Technology: All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.
8.2 Technology Education, Engineering, Design, and Computational Thinking - Programming:
All students will develop an understanding of the nature and impact of technology, engineering, technological design, computational thinking and the designed world as they relate to the individual, global society, and the environment.
9.2.12.C.4 Analyze how economic conditions and societal changes influence employment trends and future education.

9.2.12.C.3 Identify transferable career skills and design alternate career plans.

Social Studies

Standard 6.1 U.S. History: America in the World. All students will acquire the knowledge and skills to think analytically about how past and present interactions of people, cultures, and the environment shape the American heritage. Such knowledge and skills enable students to make informed decisions that reflect fundamental rights and core democratic values as productive citizens in local, national, and global communities.
Standard 6.2 World History: Global Studies: All students will acquire the knowledge and skills to think analytically and systematically about how past interactions of people, cultures, and the environment affect issues across time

and cultures. Such knowledge and skills enable students to make informed decisions as socially and ethically responsible world citizens in the 21st century.

Instructional Focus

Unit Enduring Understandings

- Some organisms produce the biological molecules that they need using abiotic energy, others survive by consuming other organisms, and others live on the wastes and remains of organisms while recycling nutrients that are used again by producer organisms
- Human activities are altering the flow of energy through the nutrient cycles and food webs on Earth
- The major biomes on Earth are caused by long-term differences in average temperature and precipitation
- Biodiversity of species is critical to the success of ecosystems and food webs and increases the overall productivity of the system
- Ecosystems are the result of biotic and abiotic interactions
- Energy can be converted from one form to another

Unit Essential Questions

- How are ecosystems around the world the same? How do they differ?
- How is energy transferred from one organism to another?
- How do human activities affect the different biomes on Earth?
- How do organisms in different trophic levels gain enough energy to survive and reproduce?
- How do abiotic and biotic factors impact an ecosystem?

Content Statements (DCI)

LS2.B: Cycles of Matter and Energy Transfer in Ecosystems

- Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved. (HS-LS2-4)

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

- A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. (HS-LS2-2),(HS-LS2-6)
- Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. (HS-LS2-7)

Ability Objectives

General for all units:

- Students will be able to construct explanations from given or collected data to explain various phenomena
- Students will be able to create 3D and 2D models of environmental science concepts and revise their models based on feedback
- Students will be able to plan and carry out scientific investigations
- Students will be able to engage in argument from evidence

- Students will be able to propose solutions for complex real world problems and communicate their findings to diverse audiences

Sample Performance Tasks - Specific for Unit 1: SWBAT:

- **Food web construction and analysis**
  - SWBAT construct a model showing the interactions between organisms at different trophic levels and the flow of energy and nutrients between them
- **GPS and mapping abiotic factors of edge zones**
  - SWBAT construct an explanation for the effects of edge zones on the populations that occupy the area
- **Interspecific and Intraspecific interactions investigation**
  - SWBAT understand how interactions between organisms that compete with each other affect the dynamics of an ecosystem
- **Biome presentations**
  - SWBAT construct explanations using evidence for the existence of different biomes on Earth

Resources

Core Text: Exploring Environmental Science for AP, from Cengage/National Geographic, by Miller and Spoolman, Copyright 2019

- **Chapters: 1, 2, 3, 5**

Suggested Resources: Textbook Online Resource, https://secure-media.collegeboard.org/apc/ap-environmental-science-course-description.pdf

Bozeman Environmental Science

http://www.bozemanscience.com/ap-es-001-environmental-science

http://www.bozemanscience.com/ap-es-002-environmental-systems

http://www.bozemanscience.com/ap-es-008-energy-flow-in-ecosystems

http://www.bozemanscience.com/ap-es-011-biogeochemical-cycles

Suggested Virtual Resources:

Food Webs Game

Biomes Activity

Cycles Dice Game

Unit 2: The Living World - Biodiversity
Content Area: Science
Course & Grade Level: AP Environmental Science, 11-12
Summary and Rationale
Biodiversity, which includes genetic, species, and habitat diversity, is critically important to ecosystems. Biodiversity in ecosystems is a key component to sustaining life within the living world. Variation in local biodiversity is due to many factors, some of which have profound management implications on human impacted areas. Natural and human disruptions have short- and long-term impacts on ecosystems. Ecological succession can occur in terrestrial and aquatic ecosystems in both developed and developing areas. Organisms within ecosystems must adapt to the changes created by these disruptions. Students will demonstrate understanding by conducting high-level inquiry investigations and effectively communicating their findings to an audience. Students will also utilize mathematical simulations to engage in argument from evidence.
Recommended Pacing
12 days - 4 cycles
Standards/Performance Expectations

Standard	
HS-LS2-1	**Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales. [Clarification Statement: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.]**
HS-LS2-2	**Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. [Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.] [*Assessment Boundary: Assessment is limited to provided data*.]**
HS-LS2-6	**Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem. [Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.]**
HS-LS2-7	**Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.* [Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.]**

Connecting with English Language Arts/Literacy and Mathematics
English Language Arts/Literacy ● Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations describing how variations in the flow of energy into and out of Earth's systems result in changes in climate to enhance understanding of findings, reasoning, and evidence and to add interest. ● Cite specific textual evidence of the availability of natural resources, occurrence of natural hazards, and changes in climate and their influence on human activity.

- Use empirical evidence to write an explanation for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

Mathematics

- Represent symbolically an explanation for how variations in the flow of energy into and out of Earth's systems result in changes in climate, and manipulate the representing symbols. Use symbols to make sense of quantities and relationships about how variations in the flow of energy into and out of Earth's systems result in changes in climate, symbolically and manipulate the representing symbols.
- Use a mathematical model to explain how variations in the flow of energy into and out of Earth's systems result in changes in climate. Identify important quantities in variations in the flow of energy into and out of Earth's systems result in changes in climate and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.
- Use units as a way to understand problems and to guide the solution of multistep problems about how variations in the flow of energy into and out of Earth's systems result in changes in climate; choose and interpret units consistently in formulas representing how variations in the flow of energy into and out of Earth's systems result in changes in climate; choose and interpret the scale and the origin in graphs and data displays representing how variations in the flow of energy into and out of Earth's systems result in changes in climate.
- Define appropriate quantities for the purpose of descriptive modeling of how variations in the flow of energy into and out of Earth's systems result in changes in climate.
- Choose a level of accuracy appropriate to limitations on measurement when reporting quantities to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.
- Represent symbolically the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere, and manipulate the representing symbols. Make sense of quantities and relationships in the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

21st Century Life and Careers/Technology Standards:

8.1 Educational Technology: All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.
8.2 Technology Education, Engineering, Design, and Computational Thinking - Programming:
All students will develop an understanding of the nature and impact of technology, engineering, technological design, computational thinking and the designed world as they relate to the individual, global society, and the environment.
9.2.12.C.4 Analyze how economic conditions and societal changes influence employment trends and future education.

9.2.12.C.3 Identify transferable career skills and design alternate career plans.

Social Studies

Instructional Focus

Unit Enduring Understandings

- Ecosystems have structure and diversity that change over time
- Ecosystem services are contributions to humans that are obtained from ecosystems
- Anthropogenic activities can disrupt ecosystem services, potentially resulting in economic and ecological consequences.
- Biodiversity provides us with many natural resources upon which we depend, and understand that the loss of biodiversity can impact economies world-wide

- Environmental changes, either sudden or gradual, may threaten a species' survival requiring individuals to alter behaviors, move, or perish
- Succession in a disturbed ecosystem will affect the total biomass, species richness, and net productivity over time.

Unit Essential Questions

- How can you create a new community after an abrupt change through ecological succession?
- How are organisms impacted when an ecosystem is destroyed?
- Why is biodiversity important?
- What human actions are associated with biodiversity loss?

Content Statements (DCI)

LS4.D: Biodiversity and Humans

- Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). *(secondary to HS-LS2-7)*
- Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. *(secondary to HS-LS2-7) (Note: This Disciplinary Core Idea is also addressed by HS-LS4-6.)*

Ability Objectives

General for all units:

- Students will be able to construct explanations from given or collected data to explain various phenomena
- Students will be able to create 3D and 2D models of environmental science concepts and revise their models based on feedback
- Students will be able to plan and carry out scientific investigations
- Students will be able to engage in argument from evidence
- Students will be able to propose solutions for complex real world problems and communicate their findings to diverse audiences

Sample Performance Tasks - Specific for Unit 2: SWBAT:

- **Human impacts engineering design solution proposals**
  - SWBAT design solutions for reducing human impacts on the environment or biodiversity (ex: urbanization, invasive species, etc.)
- **Island Biogeography investigation and graphing activity**
  - SWBAT describe island biogeography by analyzing and graphing distribution of organisms on islands at varying distances from the mainland
- **Ecosystem services project**
  - SWBAT compare and contrast differing types of ecosystem services and their roles in the environment
- **Shannon index biodiversity measurement lab**
  - SWBAT analyze and interpret the biodiversity index of organisms present in their community

Resources

Core Text: Exploring Environmental Science for AP, from Cengage/National Geographic, by Miller and Spoolman, Copyright 2019

- **Chapters:** 4, 6, 9

Suggested Resources: Textbook Online Resource, https://secure-media.collegeboard.org/apc/ap-environmental-science-course-description.pdf

Bozeman Environmental Science

http://www.bozemanscience.com/ap-es-009-ecosystem-diversity

http://www.bozemanscience.com/ap-es-010-natural-ecosystem-change

Suggested Virtual Resources:
Ecosystem services
Succession Video
Ecological Tolerance

Unit 3: Populations	
Content Area: Science	
Course & Grade Level: AP Environmental Science, 11-12	
Summary and Rationale	
Students will become adept at explaining how populations of organisms change through time. They will use this ability to propose solutions to environmental challenges. Students will begin to explore and understand the implications of the rapid worldwide human population growth that is currently happening on Earth, and also of the societal implications of regional shrinking populations. Students will analyze possible limiting factors to this growth and predict the carrying capacity for humans on this planet. Students will also take into consideration the disparity of different countries' resource use as it relates to population growth. Students will demonstrate understanding by analyzing simulations of population growth in different countries and by carrying out investigations of the impacts of population growth on a community of organisms.	
Recommended Pacing	
12 days - 4 cycles	
NGSS Standards/Performance Expectations	
Standard	
HS-LS2-1	**Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales. [Clarification Statement: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.]**
HS-LS2-2	**Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. [Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.] [*Assessment Boundary: Assessment is limited to provided data.*]**
HS-ESS3-3	**Create a computational simulation to illustrate the relationships among the management of natural resources, the sustainability of human populations, and biodiversity. [Clarification Statement: Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.] [*Assessment Boundary: Assessment for computational simulations is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations.*]**

Connecting with English Language Arts/Literacy and Mathematics
English Language Arts/Literacy ● Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations describing how variations in the flow of energy into and out of Earth's systems result in changes in climate to enhance understanding of findings, reasoning, and evidence and to add interest. ● Cite specific textual evidence of the availability of natural resources, occurrence of natural hazards, and changes in climate and their influence on human activity. ● Use empirical evidence to write an explanation for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

Mathematics

- Represent symbolically an explanation for how variations in the flow of energy into and out of Earth's systems result in changes in climate, and manipulate the representing symbols. Use symbols to make sense of quantities and relationships about how variations in the flow of energy into and out of Earth's systems result in changes in climate, symbolically and manipulate the representing symbols.
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9.2.12.C.4 Analyze how economic conditions and societal changes influence employment trends and future education.

9.2.12.C.3 Identify transferable career skills and design alternate career plans.

Social Studies

Standard 6.1 U.S. History: America in the World. All students will acquire the knowledge and skills to think analytically about how past and present interactions of people, cultures, and the environment shape the American heritage. Such knowledge and skills enable students to make informed decisions that reflect fundamental rights and core democratic values as productive citizens in local, national, and global communities.
Standard 6.2 World History: Global Studies: All students will acquire the knowledge and skills to think analytically and systematically about how past interactions of people, cultures, and the environment affect issues across time and cultures. Such knowledge and skills enable students to make informed decisions as socially and ethically responsible world citizens in the 21st century.

Instructional Focus

Unit Enduring Understandings

- Human population growth is exponential and may soon reach, or might already have reached, its environmental limit
- Resource use is inequitable across the globe and strategies for sustainability must be put in place in order to avoid the disappearance of these resources
- Population growth and the age structure of the population are different in different areas of the world mainly depending upon technological advancement and poverty levels
- Populations change over time in reaction to a variety of factors
- Human populations change in reaction to a variety of factors, including social and cultural factors

Unit Essential Questions

- How can we reduce the rate of human population growth?
- What factors work to limit the growth of populations on Earth?
- Does living in a certain country affect your use of resources and expectations for having children?
- What are some strategies currently being used to limit population growth?
- How do changes in habitats influence changes in species over time?
- How is educational opportunity for women connected to human population changes?

Content Statements (DCI)

LS2.A: Interdependent Relationships in Ecosystems

- Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. (HS-LS2-1),(HS-LS2-2)

ESS3.C: Human Impacts on Earth Systems

- The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (HS-ESS3-3)

Ability Objectives

General for all units:

- Students will be able to construct explanations from given or collected data to explain various phenomena
- Students will be able to create 3D and 2D models of environmental science concepts and revise their models based on feedback
- Students will be able to plan and carry out scientific investigations
- Students will be able to engage in argument from evidence
- Students will be able to propose solutions for complex real world problems and communicate their findings to diverse audiences

Sample Performance Tasks - Specific for Unit 3: SWBAT:

- **Daphnia population investigation**
  - SWBAT design and conduct and investigation regarding Daphnia population rates and factors that may affect their carrying capacity
- **Mark, recapture population sampling and statistical analysis**
  - SWBAT conduct an investigation analyzing population and biodiversity data in their community
- **Carrying capacity prediction and discussion, simulation using data**
  - SWBAT use mathematical representations to construct explanations of factors that affect the carrying capacity of a population
- **Human population growth - specific country analysis and population model creation**

- SWBAT construct a model showing the differences between population growth in developed and undeveloped countries around the world

Resources

Core Text: Exploring Environmental Science for AP, from Cengage/National Geographic, by Miller and Spoolman, Copyright 2019

- **Chapters:** 7, 8

Suggested Resources: Textbook Online Resource, https://secure-media.collegeboard.org/apc/ap-environmental-science-course-description.pdf

Bozeman Environmental Science

http://www.bozemanscience.com/ap-es-012-population-ecology

http://www.bozemanscience.com/ap-es-013-human-population-dynamics

http://www.bozemanscience.com/ap-es-014-human-population-size

http://www.bozemanscience.com/ap-es-015-human-population-impacts

Suggested Virtual Resources:

Cemetery Data

Population Video

Unit 4: Earth Systems and Resources	
Content Area: Science	
Course & Grade Level: AP Environmental Science, 11-12	
Summary and Rationale	
Students begin to construct explanations for the ways in which systems on earth interact with each other to form a cohesive planet. Students will explore how the systems and resources available on earth affect humans including plate tectonics, atmospheric circulation, and soil dynamics. Students will demonstrate their understanding through creating and revising models, planning and carrying out investigations and communicating research to their peers.	
Recommended Pacing	
12 days - 4 cycles	
Standards/Performance Expectations	
Standard	
HS-ESS2-1	**Develop a model to illustrate how Earth is internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features. [Clarification Statement: Emphasis is on how the appearance of land features (such as mountains, valleys, and plateaus) and sea-floor features (such as trenches, ridges, and seamounts) are a result of both constructive forces (such as volcanism, tectonic uplift, and orogeny) and destructive mechanisms (such as weathering, mass wasting, and coastal erosion).]**
HS-ESS2-2	**Analyze geoscience data to make the claim that one change to Earth's surface can create feedback that causes changes to other Earth systems. [Clarification Statement: Examples should include climate feedback, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion.]**
HS-ESS2-4	**Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. [Clarification Statement: Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).]**
HS-ESS2-5	**Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. [Clarification Statement: Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).]**
HS-ESS2-7	**Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth. [Clarification Statement: Emphasis is on the dynamic causes, effects, and feedbacks between the biosphere and Earth's other systems, whereby geoscience factors**

	control the evolution of life, which in turn continuously alters Earth's surface. Examples include how photosynthetic life altered the atmosphere through the production of oxygen, which in turn increased weathering rates and allowed for the evolution of animal life; how microbial life on land increased the formation of soil, which in turn allowed for the evolution of land plants; or how the evolution of corals created reefs that altered patterns of erosion and deposition along coastlines and provided habitats for the evolution of new life forms.]
HS-ESS3-1	**Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]**

Connecting with English Language Arts/Literacy and Mathematics

English Language Arts/Literacy

- Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations describing how variations in the flow of energy into and out of Earth's systems result in changes in climate to enhance understanding of findings, reasoning, and evidence and to add interest.
- Cite specific textual evidence of the availability of natural resources, occurrence of natural hazards, and changes in climate and their influence on human activity.
- Use empirical evidence to write an explanation for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

Mathematics

- Represent symbolically an explanation for how variations in the flow of energy into and out of Earth's systems result in changes in climate, and manipulate the representing symbols. Use symbols to make sense of quantities and relationships about how variations in the flow of energy into and out of Earth's systems result in changes in climate, symbolically and manipulate the representing symbols.
- Use a mathematical model to explain how variations in the flow of energy into and out of Earth's systems result in changes in climate. Identify important quantities in variations in the flow of energy into and out of Earth's systems result in changes in climate and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.
- Use units as a way to understand problems and to guide the solution of multistep problems about how variations in the flow of energy into and out of Earth's systems result in changes in climate; choose and interpret units consistently in formulas representing how variations in the flow of energy into and out of Earth's systems result in changes in climate; choose and interpret the scale and the origin in graphs and data displays representing how variations in the flow of energy into and out of Earth's systems result in changes in climate.
- Define appropriate quantities for the purpose of descriptive modeling of how variations in the flow of energy into and out of Earth's systems result in changes in climate.

- Choose a level of accuracy appropriate to limitations on measurement when reporting quantities to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.
- Represent symbolically the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere, and manipulate the representing symbols. Make sense of quantities and relationships in the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

21st Century Life and Careers/Technology Standards:

8.1 Educational Technology: All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.
8.2 Technology Education, Engineering, Design, and Computational Thinking - Programming:
All students will develop an understanding of the nature and impact of technology, engineering, technological design, computational thinking and the designed world as they relate to the individual, global society, and the environment.
9.2.12.C.4 Analyze how economic conditions and societal changes influence employment trends and future education.

9.2.12.C.3 Identify transferable career skills and design alternate career plans.

Social Studies

Standard 6.1 U.S. History: America in the World. All students will acquire the knowledge and skills to think analytically about how past and present interactions of people, cultures, and the environment shape the American heritage. Such knowledge and skills enable students to make informed decisions that reflect fundamental rights and core democratic values as productive citizens in local, national, and global communities.
Standard 6.2 World History: Global Studies: All students will acquire the knowledge and skills to think analytically and systematically about how past interactions of people, cultures, and the environment affect issues across time and cultures. Such knowledge and skills enable students to make informed decisions as socially and ethically responsible world citizens in the 21st century.

Instructional Focus

Unit Enduring Understandings

- Human presence has an impact on all of Earth's systems
- The Earth's aquatic and terrestrial ecosystems provide important ecosystem and economic services
- Survival of the planet and all of the organisms that live on Earth depend upon the construction and maintenance of sustainable systems
- Natural systems change over time and human activity has contributed to these changes
- All life on Earth is connected through biogeochemical cycles
- Earth's systems interact, resulting in a state of balance over time
- Most of the Earth's atmospheric processes are driven by input of energy from the sun

Unit Essential Questions

- How do Earth's systems interact with each other?
- How does the interior of the planet affect us?
- Why is it important to conserve water and soil resources?
- How do certain factors such as solar intensity and climate affect atmosphere and ocean circulation patterns?
- How do the nonliving parts of Earth's systems provide the basic materials to support life?
- How does energy from the sun influence the weather?

Content Statements (DCI)

ESS2.A: Earth Materials and Systems

- Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.

- Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior.
- The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.

ESS2.B: Plate Tectonics and Large-Scale System Interactions

- The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection.
- Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust.

ESS2.C: The Roles of Water in Earth's Surface Processes

- The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.

ESS3.A: Natural Resources

- Resource availability has guided the development of human society.
- All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors.

Ability Objectives

General for all units:

- Students will be able to construct explanations from given or collected data to explain various phenomena
- Students will be able to create 3D and 2D models of environmental science concepts and revise their models based on feedback
- Students will be able to plan and carry out scientific investigations
- Students will be able to engage in argument from evidence
- Students will be able to propose solutions for complex real world problems and communicate their findings to diverse audiences

<u>Sample Performance Tasks - Specific for Unit 4: SWBAT:</u>

- **Tragedy of the Commons lab**
  - SWBAT construct an explanation based on evidence for how the availability of natural resources have influenced human activity
- **Eco-footprint analysis and discussion**
  - SWBAT analyze their own carbon footprint and discuss solutions to reduce their impact on the Earth
- **Plate tectonics lab**
  - SWBAT develop a model showing the effects of tectonic plate movement on the Earth and the creation of its continental and ocean-floor features

- **Soil porosity and permeability testing**
  - SWBAT design and conduct an investigation to understand the effects of porosity and permeability on the water supply that is available to humans
- **Soil salinization inquiry lab**
  - SWBAT design and conduct an investigation to understand the effects of soil salinization on crops and will design solutions to mitigate this damage
- **Plate tectonics model construction and revision**
  - SWBAT develop a model showing the effects of tectonic plate movement on the Earth and the creation of its continental and ocean-floor features

Resources

Core Text: Exploring Environmental Science for AP, from Cengage/National Geographic, by Miller and Spoolman, Copyright 2019

- **Chapters:** 11

Suggested Resources: Textbook Online Resource, https://secure-media.collegeboard.org/apc/ap-environmental-science-course-description.pdf
Bozeman Environmental Science
http://www.bozemanscience.com/ap-es-003-geology
http://www.bozemanscience.com/ap-es-006-soil-soil-dynamics
http://www.bozemanscience.com/ap-es-019-mining

Suggested Virtual Resources:
Eco Footprint
Tragedy of the Commons, Website 1 or Website 2
Plate Tectonics
Watershed Creator
Layers of the Atmosphere
El Nino
Virtual Soil Lab

Unit 5: Land and Water Use	
Content Area: Science	
Course & Grade Level: AP Environmental Science, 11-12	
Summary and Rationale	
In this unit students will study human land use patterns in the past, present and predicted future. They will gain an understanding of how people depend upon renewable and non-renewable resources for survival and lifestyle support. Students will be able to ask questions and define problems regarding agricultural, forestry, rangelands, urban, mining, fishing and global economic systems. The students will also focus on water use within and between each of these systems. They will critically analyze the sustainability of various land use practices and work to identify best practices to make human impact as benevolent as possible to sustainability and natural systems.	
Recommended Pacing	
15 days - 5 cycles	
Standards/Performance Expectations	
Standard	
HS-ESS3-1	**Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]**
HS-ESS3-2	**Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.* [Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.]**
HS-ETS1-1	**Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.**

Connecting with English Language Arts/Literacy and Mathematics

English Language Arts/Literacy

- Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations describing how variations in the flow of energy into and out of Earth's systems result in changes in climate to enhance understanding of findings, reasoning, and evidence and to add interest.
- Cite specific textual evidence of the availability of natural resources, occurrence of natural hazards, and changes in climate and their influence on human activity.
- Use empirical evidence to write an explanation for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

Mathematics

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9.2.12.C.4 Analyze how economic conditions and societal changes influence employment trends and future education.

9.2.12.C.3 Identify transferable career skills and design alternate career plans.

Social Studies

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Standard 6.2 World History: Global Studies: All students will acquire the knowledge and skills to think analytically and systematically about how past interactions of people, cultures, and the environment affect issues across time and cultures. Such knowledge and skills enable students to make informed decisions as socially and ethically responsible world citizens in the 21st century.

Instructional Focus

Unit Enduring Understandings

- Unmitigated human activities are leading to rapid habitat destruction on the land and sea
- Sustainable strategies must be developed in order to maintain resource use over time

- Humanity relies heavily on the large-scale extraction of land and water resources in order to power our society
- When humans use natural resources, they alter natural systems
- Humans can mitigate their impact on land and water resources through sustainable use
- Clean fresh water is a limited resource in many parts of the world and the maintenance of systems that assure fresh water supplies are critical components of a stable society.

Unit Essential Questions

- Where does the food in the grocery stores actually come from?
- How can we make sure that we are utilizing our agricultural systems sustainably?
- What are some strategies that humans can use to conserve the land?
- How do humans harvest minerals and resources from the land? What are the consequences of these activities?
- How can we reduce the environmental impacts from land and water resource use?
- How does your use of natural resources impact the world?
- Why are sustainable practices difficult to implement?
- How can we manage land and human systems to maintain or increase freshwater supplies for society?

Content Statements (DCI)

ESS3.A: Natural Resources

- Resource availability has guided the development of human society. (HS-ESS3-1)
- All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (HS-ESS3-2)

ESS3.B: Natural Hazards

- Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations. (HS-ESS3-1)

ETS1.A: Defining and Delimiting Engineering Problems

- Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS-ETS1-1)
- Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (HS-ETS1-1)

Ability Objectives

General for all units:

- Students will be able to construct explanations from given or collected data to explain various phenomena
- Students will be able to create 3D and 2D models of environmental science concepts and revise their models based on feedback
- Students will be able to plan and carry out scientific investigations
- Students will be able to engage in argument from evidence
- Students will be able to propose solutions for complex real world problems and communicate their findings to diverse audiences

<u>Sample Performance Tasks - Specific for Unit 5: SWBAT:</u>

- **Food desert exploration**
  - SWBAT analyze the challenge of healthy food availability in poor areas and design solutions for the mitigation of this problem
- **Coastal land use debate**
  - SWBAT engage in argument using evidence to support their claim of how coastal land should be used primarily in order to best maintain the environment

- **Resource use analysis**
    - SWBAT analyze and interpret data regarding the differences in resource use between developed and undeveloped countries
- **Habitat fragmentation, forestry exploration**
    - SWBAT explore and analyze the effects of habitat fragmentation on biodiversity and community interactions
- **Cookie mining**
    - SWBAT conduct an investigation determining the most detrimental types of mining on the land

Resources

Core Text: Exploring Environmental Science for AP, from Cengage/National Geographic, by Miller and Spoolman, Copyright 2019

- **Chapters:** 10, 12, 13

Suggested Resources: Textbook Online Resource, https://secure-media.collegeboard.org/apc/ap-environmental-science-course-description.pdf

Bozeman Environmental Science

http://www.bozemanscience.com/ap-es-016-agriculture

http://www.bozemanscience.com/ap-es-017-forestry-rangelands

http://www.bozemanscience.com/ap-es-018-land-use

http://www.bozemanscience.com/ap-es-020-fishing

http://www.bozemanscience.com/ap-es-021-environmental-economics

http://www.bozemanscience.com/ap-es-005-water-resources

Suggested Virtual Resources:

Forestry

Aquaculture

Urban Runoff

Unit 6: Energy Resources and Consumption	
Content Area: Science	
Course & Grade Level: AP Environmental Science, 11-12	
Summary and Rationale	
In this unit students will explore human uses of energy through historical time and examine present and potential future methods of generating and using electrical and combustible fuel energy. This unit will include study for both renewable and non-renewable energy sources and will ask the students to critically examine environmental, economic, and social costs and opportunities for each energy type.	
Recommended Pacing	
12 days - 4 cycles	
Standards/Performance Expectations	
Standard	
HS-ESS3-2	**Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.*[Clarification Statement: Examples should include climate feedback, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.]**
HS-ETS1-1	**Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.**

Connecting with English Language Arts/Literacy and Mathematics

English Language Arts/Literacy

- Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations describing how variations in the flow of energy into and out of Earth's systems result in changes in climate to enhance understanding of findings, reasoning, and evidence and to add interest.
- Cite specific textual evidence of the availability of natural resources, occurrence of natural hazards, and changes in climate and their influence on human activity.
- Use empirical evidence to write an explanation for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

Mathematics

- Represent symbolically an explanation for how variations in the flow of energy into and out of Earth's systems result in changes in climate, and manipulate the representing symbols. Use symbols to make sense of quantities and relationships about how variations in the flow of energy into and out of Earth's systems result in changes in climate, symbolically and manipulate the representing symbols.
- Use a mathematical model to explain how variations in the flow of energy into and out of Earth's systems result in changes in climate. Identify important quantities in variations in the flow of energy into and out of Earth's systems result in changes in climate and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.

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- Define appropriate quantities for the purpose of descriptive modeling of how variations in the flow of energy into and out of Earth's systems result in changes in climate.
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9.2.12.C.4 Analyze how economic conditions and societal changes influence employment trends and future education.

9.2.12.C.3 Identify transferable career skills and design alternate career plans.

Social Studies

Standard 6.1 U.S. History: America in the World. All students will acquire the knowledge and skills to think analytically about how past and present interactions of people, cultures, and the environment shape the American heritage. Such knowledge and skills enable students to make informed decisions that reflect fundamental rights and core democratic values as productive citizens in local, national, and global communities.
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Instructional Focus

Unit Enduring Understandings

- Humans must weigh several costs and benefits when considering their energy use and resource use
- Often, money is the driving force behind humans sticking to traditional methods of energy consumption
- The Earth's current energy use is not sustainable and strategies must be put in place to redirect our energy use to different sources
- Humans use energy from a variety of sources, resulting in positive and negative consequences

Unit Essential Questions

- What are the costs and benefits of each type of non-renewable energy source that we use? Why do we continue to utilize these sources of energy even as they work to damage our planet?
- What are the costs and benefits of each type of renewable energy source that we use? What is preventing society from immediately switching over to these options that are better for the planet?
- How are fossil fuels extracted and used?
- How are renewable resources extracted and used?

- What are the main ways that electricity is generated in the United States?
- What does the Earth's energy future look like?
- Why are fossil fuels the most widely used energy resources if they are nonrenewable?

Content Statements (DCI)

ESS3.A: Natural Resources

- All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (HS-ESS3-2)

ETS1.A: Defining and Delimiting Engineering Problems

- Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS-ETS1-1)
- Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (HS-ETS1-1)

Ability Objectives

General for all units:

- Students will be able to construct explanations from given or collected data to explain various phenomena
- Students will be able to create 3D and 2D models of environmental science concepts and revise their models based on feedback
- Students will be able to plan and carry out scientific investigations
- Students will be able to engage in argument from evidence
- Students will be able to propose solutions for complex real world problems and communicate their findings to diverse audiences

Sample Performance Tasks - Specific for Unit 6: SWBAT:

- **Radiation and radioactive decay analysis with Vernier probes**
  - SWBAT construct explanations using evidence for the pros and cons of nuclear radiation
- **Solar Oven design lab**
  - SWBAT design a solar oven using minimal materials in order to reduce energy use in the home
- **Fossil fuel speed dating presentations**
  - SWBAT construct explanations for the benefits and drawbacks of different types of fossil fuels and energy types
- **Home energy audit**
  - SWBAT conduct an audit of all energy use in their home and analyze potential ways to reduce their impact on the environment
- **Green home design**
  - SWBAT design a model of a home that is energy efficient and reduces the use of resources as much as possible

Resources

Core Text: Exploring Environmental Science for AP, from Cengage/National Geographic, by Miller and Spoolman, Copyright 2019

- **Chapters:** 14, 15

Suggested Resources: Textbook Online Resource, https://secure-media.collegeboard.org/apc/ap-environmental-science-course-description.pdf

Bozeman Environmental Science

http://www.bozemanscience.com/ap-es-022-energy-concepts

http://www.bozemanscience.com/ap-es-023-energy-consumption

http://www.bozemanscience.com/ap-es-024-fossil-fuel-resources

http://www.bozemanscience.com/ap-es-025-nuclear-energy
http://www.bozemanscience.com/ap-es-026-hydroelectric-power
http://www.bozemanscience.com/ap-es-027-energy-conservation
http://www.bozemanscience.com/ap-es-028-renewable-energy

Suggested Virtual Resources:

Renewable Energy
Fossil Fuel Quality
Energy Use (by source)
Hydrogen Fuel Cells

Unit 7: Aquatic and Terrestrial Pollution	
Content Area: Science	
Course & Grade Level: AP Environmental Science, 11-12	
Summary and Rationale	
Pollution created by human activities directly impacts ecosystems in the air, on land, and in water. The source of pollution can sometimes be easy to identify, but other times the source is diffused. There are many human health issues that can be linked to pollution. Legislation has been created to reduce discharges of pollution in water and regulate drinking water. Increases in waste cause global concerns for organisms that live on land and in water.	
Recommended Pacing	
9 days - 3 cycles	
Standards/Performance Expectations	
Standards	
HS-ESS3-1	**Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]**
HS-ESS3-4	**Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.* [Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).]**
HS-ESS3-6	**Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [*Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.*]**

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English Language Arts/Literacy

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Mathematics

- Represent symbolically an explanation for how variations in the flow of energy into and out of Earth's systems result in changes in climate, and manipulate the representing symbols. Use symbols to make sense of quantities and relationships about how variations in the flow of energy into and out of Earth's systems result in changes in climate, symbolically and manipulate the representing symbols.
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9.2.12.C.3 Identify transferable career skills and design alternate career plans.

Social Studies

Standard 6.1 U.S. History: America in the World. All students will acquire the knowledge and skills to think analytically about how past and present interactions of people, cultures, and the environment shape the American heritage. Such knowledge and skills enable students to make informed decisions that reflect fundamental rights and core democratic values as productive citizens in local, national, and global communities.
Standard 6.2 World History: Global Studies: All students will acquire the knowledge and skills to think analytically and systematically about how past interactions of people, cultures, and the environment affect issues across time and cultures. Such knowledge and skills enable students to make informed decisions as socially and ethically responsible world citizens in the 21st century.

Instructional Focus

Unit Enduring Understandings

- Pollution caused by human activities is encroaching upon many critical ecosystems that humans also rely on to live
- Solutions can be designed in order to reduce the impacts that human activities have on the surrounding environment
- There are various methods of waste disposal that humans use, each with their own pros and cons that should be analyzed on a situational basis
- Human activities, including the use of resources, have physical, chemical, and biological consequences for ecosystems
- Pollutants can have both direct and indirect impacts on the health of organisms, including humans

Unit Essential Questions

- What processes are used to keep our water and land clean?
- How does pollution affect the organisms that live on Earth?
- What are some ways that people create land and water pollution?
- Why are clean water and clean land important to the organisms on Earth? What processes require these materials to function?
- How does pollution impact your health?
- How can you decrease waste?

Content Statements (DCI)

ESS3.C: Human Impacts on Earth Systems

- Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. (HS-ESS3-4)

ESS3.D: Global Climate Change

- Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities. (HS-ESS3-6)

Ability Objectives

General for all units:

- Students will be able to construct explanations from given or collected data to explain various phenomena
- Students will be able to create 3D and 2D models of environmental science concepts and revise their models based on feedback
- Students will be able to plan and carry out scientific investigations
- Students will be able to engage in argument from evidence
- Students will be able to propose solutions for complex real world problems and communicate their findings to diverse audiences

<u>Sample Performance Tasks - Specific for Unit 7: SWBAT:</u>

- **Particulates, Ozone and Lichen survey**

- SWBAT make claims using evidence and reasoning for the effects of different types of pollution on natural systems

- **Acid Deposition lab**
  - SWBAT explore the causes of acid rain and construct explanations using evidence for how human activity contributes to acid deposition
- **Oil spill remediation**
  - SWBAT construct explanations for the effects of an oil spill on organisms in an ecosystem and design solutions to prevent oil spills from occurring
- **Water quality testing**
  - SWBAT plan and conduct an investigation on water quality and the effects of water pollution on present organisms
- **LD50 determination**
  - SWBAT conduct an investigation regarding the lethal dose of a toxin on an organism in relation to the amount of pollution the organism is exposed to

Resources

Core Text: Exploring Environmental Science for AP, from Cengage/National Geographic, by Miller and Spoolman, Copyright 2019

- **Chapters:** 16, 17, 18

Suggested Resources: Textbook Online Resource, https://secure-media.collegeboard.org/apc/ap-environmental-science-course-description.pdf

Bozeman Environmental Science

http://www.bozemanscience.com/ap-es-030-water-pollution

http://www.bozemanscience.com/ap-es-031-solid-waste

http://www.bozemanscience.com/ap-es-032-health-impacts

Suggested Virtual Resources:

Wastewater Treatment

Wastewater Treatment Video

Solid Waste Disposal

Water Quality

Water Sampling

Unit 8: Atmospheric Pollution	
Content Area: Science	
Course & Grade Level: AP Environmental Science, 11-12	
Summary and Rationale	
Air pollution has many sources and effects, both indoors and outdoors, both natural and anthropogenic. Air is a natural resource that covers the Earth and crosses many system boundaries. Through legislation, the Clean Air Act regulates the emission of air pollutants that affect human health. Once air pollution sources are identified, methods can be used to reduce pollution.	
Recommended Pacing	
9 days - 3 cycles	
Standards/Performance Expectations	
Standards	
HS-ESS3-1	**Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]**
HS-ESS3-4	**Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.* [Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).]**
HS-ESS3-6	**Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [*Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.*]**

Connecting with English Language Arts/Literacy and Mathematics

English Language Arts/Literacy

- Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations describing how variations in the flow of energy into and out of Earth's systems result in changes in climate to enhance understanding of findings, reasoning, and evidence and to add interest.
- Cite specific textual evidence of the availability of natural resources, occurrence of natural hazards, and changes in climate and their influence on human activity.
- Use empirical evidence to write an explanation for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

Mathematics

- Represent symbolically an explanation for how variations in the flow of energy into and out of Earth's systems result in changes in climate, and manipulate the representing symbols. Use symbols to make sense of quantities and relationships about how variations in the flow of energy into and out of Earth's systems result in changes in climate, symbolically and manipulate the representing symbols.
- Use a mathematical model to explain how variations in the flow of energy into and out of Earth's systems result in changes in climate. Identify important quantities in variations in the flow of energy into and out of Earth's systems result in changes in climate and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.
- Use units as a way to understand problems and to guide the solution of multistep problems about how variations in the flow of energy into and out of Earth's systems result in changes in climate; choose and interpret units consistently in formulas representing how variations in the flow of energy into and out of Earth's systems result in changes in climate; choose and interpret the scale and the origin in graphs and data displays representing how variations in the flow of energy into and out of Earth's systems result in changes in climate.
- Define appropriate quantities for the purpose of descriptive modeling of how variations in the flow of energy into and out of Earth's systems result in changes in climate.
- Choose a level of accuracy appropriate to limitations on measurement when reporting quantities to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.
- Represent symbolically the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere, and manipulate the representing symbols. Make sense of quantities and relationships in the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

21st Century Life and Careers/Technology Standards:

8.1 Educational Technology: All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.
8.2 Technology Education, Engineering, Design, and Computational Thinking - Programming:
All students will develop an understanding of the nature and impact of technology, engineering, technological design, computational thinking and the designed world as they relate to the individual, global society, and the environment.
9.2.12.C.4 Analyze how economic conditions and societal changes influence employment trends and future education.

9.2.12.C.3 Identify transferable career skills and design alternate career plans.

Social Studies

Standard 6.1 U.S. History: America in the World. All students will acquire the knowledge and skills to think analytically about how past and present interactions of people, cultures, and the environment shape the American heritage. Such knowledge and skills enable students to make informed decisions that reflect fundamental rights and core democratic values as productive citizens in local, national, and global communities.
Standard 6.2 World History: Global Studies: All students will acquire the knowledge and skills to think analytically and systematically about how past interactions of people, cultures, and the environment affect issues across time and cultures. Such knowledge and skills enable students to make informed decisions as socially and ethically responsible world citizens in the 21st century.

Instructional Focus

Unit Enduring Understandings

- Pollution caused by human activities is encroaching upon many critical ecosystems that humans also rely on to live
- Solutions can be designed in order to reduce the impacts that human activities have on the surrounding environment
- Human activities have physical, chemical, and biological consequences for the atmosphere
- Human activities, including the use of resources, have physical, chemical, and biological consequences for ecosystems
- Pollutants can have both direct and indirect impacts on the health of organisms, including humans

Unit Essential Questions

- What processes are used to keep our air clean?
- How does pollution affect the organisms that live on Earth?
- What are some ways that people create air pollution?
- Why is clean air important to the organisms on Earth? What processes require this to function?
- Where does air pollution go once it is airborne?
- How does air pollution impact your health?

Content Statements (DCI)

ESS3.C: Human Impacts on Earth Systems

- Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. (HS-ESS3-4)

ESS3.D: Global Climate Change

- Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities. (HS-ESS3-6)

Ability Objectives

General for all units:

- Students will be able to construct explanations from given or collected data to explain various phenomena
- Students will be able to create 3D and 2D models of environmental science concepts and revise their models based on feedback
- Students will be able to plan and carry out scientific investigations
- Students will be able to engage in argument from evidence
- Students will be able to propose solutions for complex real world problems and communicate their findings to diverse audiences

<u>Sample Performance Tasks - Specific for Unit 8: SWBAT:</u>

- **Particulates, Ozone and Lichen survey**
  - SWBAT make claims using evidence and reasoning for the effects of different types of pollution on natural systems
- **Pollution Research projects**
  - SWBAT research and effectively communicate the many different types of pollution and their individual impacts on natural systems

- **Air Pollution Mysteries**
    - SWBAT explore the different types of air pollutants and match their symptoms in humans to the cause

Resources

Core Text: Exploring Environmental Science for AP, from Cengage/National Geographic, by Miller and Spoolman, Copyright 2019

- **Chapters: 19**

Suggested Resources: Textbook Online Resource, https://secure-media.collegeboard.org/apc/ap-environmental-science-course-description.pdf
Bozeman Environmental Science
http://www.bozemanscience.com/ap-es-029-air-pollution

Suggested Virtual Resources:
Air Quality
Air Pollution
Acid Rain
Smog

Unit 9: Global Change	
Content Area: Science	
Course & Grade Level: AP Environmental Science, 11-12	
Summary and Rationale	
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.	
Recommended Pacing	
12 days - 4 cycles	
Standards/Performance Expectations	
Standards	
HS-ESS2-2	**Analyze geoscience data to make the claim that one change to Earth's surface can create feedback that causes changes to other Earth systems. [Clarification Statement: Examples should include climate feedback, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.]**
HS-ESS2-4	**Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. [Clarification Statement: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.] [*Assessment Boundary: Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.*]**
HS-ESS3-5	**Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth's systems. [Clarification Statement: Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).] [*Assessment Boundary: Assessment is limited to one example of a climate change and its associated impacts.*]**
HS-ESS3-6	**Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [*Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.*]**

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Instructional Focus

Unit Enduring Understandings

- Human impacts on the environment must be reduced in order to slow the rate of global climate change
- All of the systems on Earth are interconnected, so a change to one will also produce changes in the other systems over time
- Human activities directly affect the amount of biodiversity present on Earth
- Local and regional human activities can have impacts at the global level
- The health of a species is closely tied to its ecosystem, and minor environmental changes can have a large impact

Unit Essential Questions

- How are human activities directly causing changes to global systems? What is the potential outlook of our planet if these activities continue at their same rate?
- What needs to happen to convince the general population to make changes to their lifestyle?
- How do certain countries play more of a role in climate change than others?
- What laws and treaties are currently in place in order to limit climate change?
- What role do humans play in the extinction of species on Earth?
- Why are laws created to protect endangered species?

Content Statements (DCI)

ESS2.A: Earth Materials and Systems

- Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-1),(HS-ESS2-2)
- The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. (HS-ESS2-4)

ESS3.D: Global Climate Change

- Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. (HS-ESS3-5)
- Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities. (HS-ESS3-6)

Ability Objectives

General for all units:

- Students will be able to construct explanations from given or collected data to explain various phenomena
- Students will be able to create 3D and 2D models of environmental science concepts and revise their models based on feedback

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- Students will be able to engage in argument from evidence
- Students will be able to propose solutions for complex real world problems and communicate their findings to diverse audiences

Sample Performance Tasks - Specific for Unit 9: SWBAT:

- **Effect of CO2 enrichment on photosynthetic rate lab**
  - SWBAT analyze the effects of a greater prevalence of CO2 on the rate of photosynthesis in plants
- **Data analysis - CO2 levels, global temperature trends**
  - SWBAT analyze computational and mathematical representations in order to explain general global trends in CO2 levels and temperature
- **Ozone hole computer analysis**
  - SWBAT analyze computational simulations in order to understand the effects of ozone depletion
- **El Nino prediction computer analysis**
  - SWBAT analyze and interpret computational representations of El Nino and predict the expected effects on organisms in the area
- **Climate change debate and policy analysis**
  - SWBAT engage in argument from evidence in order to debate the best policies that may be put in place to reduce climate change
- **Invasive species investigation**
  - SWBAT analyze and predict the effects of invasive species dissemination across the United States

Resources

Core Text: Exploring Environmental Science for AP, from Cengage/National Geographic, by Miller and Spoolman, Copyright 2019

- **Chapters:** 20

Suggested Resources: Textbook Online Resource, https://secure-media.collegeboard.org/apc/ap-environmental-science-course-description.pdf

Bozeman Environmental Science

http://www.bozemanscience.com/new-page

http://www.bozemanscience.com/ap-es-034-global-climate-change

http://www.bozemanscience.com/ap-es-035-loss-of-biodiversity

Suggested Virtual Resources:

Climate Change

Ocean Acidification

Reducing Ozone Depletion

Climate Solutions Simulator