Unit 1: Ecosystems
UNIT PLAN

TABLE OF CONTENTS

UNIT NARRATIVE

The focus of this unit is on explaining the abiotic and biotic processes and relationships that define healthy ecosystems.

This unit has 3 main sections:

1. Culture Day Lessons & first 3 lessons – Students will be introduced to the concept of sustainability by watching The Lorax with analysis questions and discussion and by exploring the concept of Ecological Footprints using an online calculator. Now students will experience an engaging simulation lab that will help them describe the environmental phenomenon called The Tragedy of the Commons from firsthand experience before ever hearing the vocabulary. To conclude the introduction to sustainability students will engage in an analysis of the real-world environmental debate about paper vs plastic bags. This is intended to help students understand that environmental problems are complicated and to help students make connections between their regular life decisions and environmental issues. The goal is for students to view the rest of the course through the lens of sustainability because starting with Unit 3 the rest of the course focuses largely on how human actions are affecting the systems and processes that make life as we know it on Earth a hospitable place for life as we know it. This part of the unit covers three Topics/Learning Objectives from Unit 5 (5.1, 5.10, 5.11).

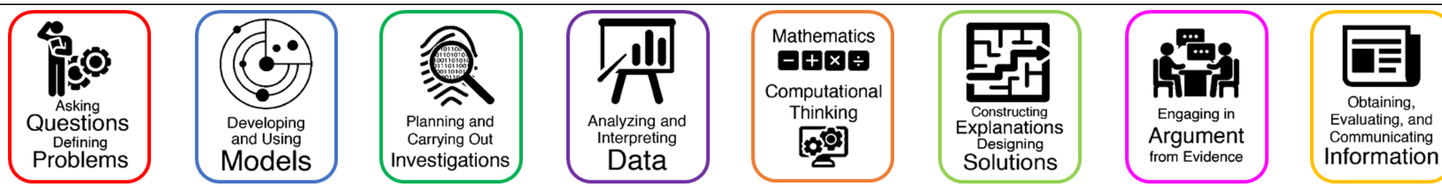
2. Introduction to ecosystems (7 days) – This section of the unit begins with students creating and analyzing food webs to describe trophic levels, produces and consumers, and how changes to a species can impact a food web. This is a good way to start this section because this content has largely been covered in Pre-AP Biology so it is familiar for students, and they can being to make connections between food webs and sustainability. Then students will work in groups to explore key terrestrial and aquatic biomes using online readings and videos to describe the key abiotic factors that define each biome, and some characteristic species of each biome. Next students will explore the base of the food chain with a multi-day lab investigation to calculate the Net Primary productivity of an aquatic plant species. Taking the measurements and calculating the NPP of an actual aquatics plant helps build conceptual understanding better than abstract calculations. This section concludes with two case students , about Moose and Bears, that focus on specific species and biomes but more generally help students make connections between topics in the unit, and Unit 2: Biodiversity, that helps create connected schema for deeper understanding.

3. The final section of this unit covers the four biogeochemical cycles that are important in this course, Hydrologic, Carbon, Nitrogen, Phosphorous. Students will spend one lesson on each cycle, and each will be explored in a different way. By the end of this section students should be able to explain the primary reservoirs and processes for each cycle well enough that they can make connections between these cycles and future content to describe anthropogenic impacts on the biogeochemical cycles. The hydrologic (water) cycle will be first because it is the one most students are familiar with this cycle and its vocabulary already, so it makes for an easy introduction. The next cycle is the carbon cycle, where students will create a diagram of the carbon cycle that includes the quantitative size of each carbon reservoir and of carbon that moves between reservoirs so that students can practice making observations and claims using the quantitative data. The nitrogen cycle is the most complicated cycle, mostly because it includes a lot of big vocabulary, so students will explore this cycle by creating and describing the nitrogen cycle using reservoir and process cards that they work in groups to draw and explain the connection between. The phosphorous cycle is last because it is the most simple of the four cycles and it has some key differences from the other three cycles which provides the opportunity to compare and contrast to review and make connections between all four cycles. For each cycle students will be introduced to anthropogenic impacts on the cycle as preview of future units, but this is not the primary focus of this unit.

   Note: Many of the learning objectives in this unit have been covered or touched on in Pre-AP Biology, but it has been 2 or more years for most students since they took that course.

Focus on Disciplinary Literacy

In science, disciplinary literacy is synonymous with the science and engineering practices. The SEPs are the context through which all science concepts should be taught. In the lessons, you will find the Science and Engineering practices icons when the SEPs are being explicitly used by students.



UNPACKED STANDARDS

Below are the standards **taught** and **assessed** in this unit.

Learning Objective				*Essential Knowledge*	
1.1	Introduction to Ecosystems	ERT-1.A	Explain how the availability of resources influences species interactions.	ERT-1.A.1	In a predator-prey relationship, the predator is an organism that eats another organism (the prey).
				ERT-1.A.2	Symbiosis is a close and long-term interaction between two species in an ecosystem. Types of symbiosis include mutualism, commensalism, and parasitism.
				ERT-1.A.3	Competition can occur within or between species in an ecosystem where there are limited resources. Resource partitioning— using the resources in different ways, places, or at different times—can reduce the negative impact of competition on survival.
1.2	Terrestrial Biomes	ERT-1.B	Describe the global distribution and principal environmental aspects of terrestrial biomes.	ERT-1.B.1	A biome contains characteristic communities of plants and animals that result from, and are adapted to, its climate.
				ERT-1.B.2	Major terrestrial biomes include taiga, temperate rainforests, temperate seasonal forests, tropical rainforests, shrubland, temperate grassland, savanna, desert, and tundra.
				ERT-1.B.3	The global distribution of nonmineral terrestrial natural resources, such as water and trees for lumber, varies because of some combination of climate, geography, latitude and altitude, nutrient availability, and soil.
				ERT-1.B.4	The worldwide distribution of biomes is dynamic; the distribution has changed in the past and may again shift as a result of global climate changes.
1.3	Aquatic Biomes	ERT-1.C	Describe the global distribution and principal environmental aspects of aquatic biomes.	ERT-1.C.1	Freshwater biomes include streams, rivers, ponds, and lakes. These freshwater biomes are a vital resource for drinking water.
				ERT-1.C.2	Marine biomes include oceans, coral reefs, marshland, and estuaries. Algae in marine biomes supply a large portion of the Earth's oxygen, and also take in carbon dioxide from the atmosphere.
				ERT-1.C.3	The global distribution of nonmineral marine natural resources, such as different types of fish, varies because of some combination of salinity, depth, turbidity, nutrient availability, and temperature.
1.4	The Carbon Cycle	ERT-1.D	Explain the steps and reservoir interactions in the carbon cycle.	ERT-1.D.1	The carbon cycle is the movement of atoms and molecules containing the element carbon between sources and sinks.
				ERT-1.D.2	Some of the reservoirs in which carbon compounds occur in the carbon cycle hold those compounds for long periods of time, while some hold them for relatively short periods of time.
				ERT-1.D.3	Carbon cycles between photosynthesis and cellular respiration in living things.
				ERT-1.D.4	Plant and animal decomposition have led to the storage of carbon over millions of years. The burning of fossil fuels quickly moves that stored carbon into atmospheric carbon, in the form of carbon dioxide.
1.5	The Nitrogen Cycle	ERT-1.E		ERT-1.E.1	The nitrogen cycle is the movement of atoms and molecules containing the element nitrogen between sources and sinks.

			Explain the steps and reservoir interactions in the nitrogen cycle.	ERT-1.E.2	Most of the reservoirs in which nitrogen compounds occur in the nitrogen cycle hold those compounds for relatively short periods of time.
				ERT-1.E.3	Nitrogen fixation is the process in which atmospheric nitrogen is converted into a form of nitrogen (primarily ammonia) that is available for uptake by plants and that can be synthesized into plant tissue.
				ERT-1.E.4	The atmosphere is the major reservoir of nitrogen.
1.6	The Phosphorus Cycle	ERT-1.F	Explain the steps and reservoir interactions in the phosphorus cycle.	ERT-1.F.1	The phosphorus cycle is the movement of atoms and molecules containing the element phosphorus between sources and sinks.
				ERT-1.F.2	The major reservoirs of phosphorus in the phosphorus cycle are rock and sediments that contain phosphorus-bearing minerals.
				ERT-1.F.3	There is no atmospheric component in the phosphorus cycle, and the limitations this imposes on the return of phosphorus from the ocean to land make phosphorus naturally scarce in aquatic and many terrestrial ecosystems. In undisturbed ecosystems, phosphorus is the limiting factor in biological systems.
1.7	The Water (Hydrologic) Cycle	ERT-1.G	Explain the steps and reservoir interactions in the hydrologic cycle.	ERT-1.G.1	The hydrologic cycle, which is powered by the sun, is the movement of water in its various solid, liquid, and gaseous phases between sources and sinks.
				ERT-1.G.2	The oceans are the primary reservoir of water at the Earth’s surface, with ice caps and groundwater acting as much smaller reservoirs.
1.8	Primary Productivity	ENG-1.A	Explain how solar energy is acquired and transferred by living organisms.	ENG-1.A.1	Primary productivity is the rate at which solar energy (sunlight) is converted into organic compounds via photosynthesis over a unit of time.
				ENG-1.A.2	Gross primary productivity is the total rate of photosynthesis in a given area.
				ENG-1.A.3	Net primary productivity is the rate of energy storage by photosynthesizers in a given area, after subtracting the energy lost to respiration.
				ENG-1.A.4	Productivity is measured in units of energy per unit area per unit time (e.g., kcal/m2/yr).
				ENG-1.A.5	Most red light is absorbed in the upper 1m of water, and blue light only penetrates deeper than 100m in the clearest water. This affects photosynthesis in aquatic ecosystems, whose photosynthesizers have adapted mechanisms to address the lack of visible light.
1.9	Trophic Levels	ENG-1.B	Explain how energy flows and matter cycles through trophic levels	ENG-1.B.1	All ecosystems depend on a continuous inflow of high-quality energy in order to maintain their structure and function of transferring matter between the environment and organisms via biogeochemical cycles.
				ENG-1.B.2	Biogeochemical cycles are essential for life and each cycle demonstrates the conservation of matter
				ENG-1.B.3	In terrestrial and near-surface marine communities, energy flows from the sun to producers in the lowest trophic levels and then upward to higher trophic levels.
1.10	Energy Flow and the 10% Rule	ENG-1.C	Determine how the energy decreases as it	ENG-1.C.1	The 10% rule approximates that in the transfer of energy from one trophic level to the next, only about 10% of the energy is passed on.

			flows through ecosystems.	ENG-1.C.2	The loss of energy that occurs when energy moves from lower to higher trophic levels can be explained through the laws of thermodynamics.
1.11	Food Chains and Food Webs	ENG-1.D	Describe food chains and food webs, and their constituent members by trophic level.	ENG-1.D.1	A food web is a model of an interlocking pattern of food chains that depicts the flow of energy and nutrients in two or more food chains.
				ENG-1.D.2	Positive and negative feedback loops can each play a role in food webs. When one species is removed from or added to a specific food web, the rest of the food web can be affected.
5.1	Tragedy of the Commons	EIN-2.A	Explain the concept of the tragedy of the commons.	EIN-2.A.1	The tragedy of the commons suggests that individuals will use shared resources in their own self-interest rather than in keeping with the common good, thereby depleting the resources.
5.11	Ecological Footprints			EIN-2.N.1	Ecological footprints compare resource demands and waste production required for an individual or a society.
5.12	Introduction to Sustainability	STB-1.A	Explain the concept of sustainability.	STB-1.A.1	Sustainability refers to humans living on Earth and their use of resources without depletion of the resources for future generations. Environmental indicators that can guide humans to sustainability include biological diversity, food production, average global surface temperatures and CO_2 concentrations, human population, and resource depletion.
				STB-1.A.2	Sustainable yield is the amount of a renewable resource that can be taken without reducing the available supply.

UNDERSTANDINGS AND QUESTIONS

Important big ideas and processes for the unit.

Key Understandings

- ❑ Identify and Describe environmental commons.
- ❑ Explain the phenomenon called the tragedy of the commons.
- ❑ Explain the concept of sustainability.
- ❑ Identify key factors that affect an ecological footprint.
- ❑ Describe how key factors affect an ecological footprint.
- ❑ Explain how an ecological footprint can be used to measure sustainability.
- ❑ Describe the types of interactions between species in an ecosystem.
- ❑ Describe the main terrestrial biomes using their abiotic characteristics.
- ❑ Describe the main aquatic biomes using their abiotic characteristics.
- ❑ Explain the importance of the biogeochemical cycles.
- ❑ Explain how to calculate Net Primary Productivity (NPP).
- ❑ Describe the importance of NPP for a biome or trophic pyramid.
- ❑ Describe the relative NPP of different biomes.
- ❑ Identify the trophic level of a species using a food chain/web.
- ❑ Explain the impacts of significant changes to a species population using a food chain/web.
- ❑ Describe the flow of energy through an ecosystem using a food chain/web.
- ❑ Describe the primary reservoirs and processes that make up the carbon cycle.
- ❑ Describe the primary reservoirs and processes that make up the water cycle.
- ❑ Describe the primary reservoirs and processes that make up the nitrogen cycle.
- ❑ Describe the primary reservoirs and processes that make up the phosphorous cycle.
- ❑ Describe the key difference between the phosphorous cycle and the other nutrient cycles.

Key Questions

BIG IDEA 1 - Energy Transfer

- How does energy change forms?
- How does energy move through ecosystems?

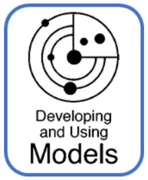
BIG IDEA 2 - Interactions Between Earth Systems

- How does matter move through ecosystems and the biosphere?
- How old is the water you drink?

ROADMAP

AT A Glance: Unit #:			
Day	**Date**	**Lesson**	**Lesson Title**
There is one flex day built into this unit to use as needed. Flex days can be used for lessons that take longer than one day, for reteaching material the students may not have gotten during tier 1 instruction, or for reviewing for the Unit Exam.			
1		01	Tragedy of the Commons – Day 1
2		02	Tragedy of the Commons – Day 2
3		03	Sustainability of Paper vs Plastic
4		04	Food Chains & Webs
5		05	Terrestrial Biomes
6		06	Aquatic Biomes
7		07	Net Primary Productivity Lab – Day 1
8		08	Case Study - Who Set the Moose Loose?
9		09	Case Study - Beavers
10		10	Net Primary Productivity Lab – Day 2
11		11	The Water Cycle
12		12	The Carbon Cycle
13		13	The Nitrogen Cycle
14		14	The Phosphorous Cycle
15		Flex	
16		Unit Exam	TX_SCI_APEnvironmentalScience_F24_UE1
17		Success Day	**Time Permitting** - Use the Success Day Lesson Plan to review the UE FRQ and gaps from the MC.

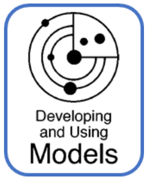
Lesson	Objective(s) and Standard(s)	Instructional Notes	Resources
Day 1 **Tragedy of the Commons Part I** **Day 2** **Tragedy of the Commons Part II**	Topic 5.1 EIN-2.A - Explain the concept of the tragedy of the commons. **SWBAT: Explain** how environmental commons are degraded by the process known as the Tragedy of the Commons and describe possible solutions for the Tragedy of the Commons. **CFS: I have mastered the LO if I can…** ☐ Describe the characteristics that define an environmental common. ☐ Identify environmental commons in a given scenario. ☐ Explain how humans typically use environmental commons and the effect this has on these commons. ☐ Describe how humans can use commons in ways that avoid the Tragedy of the Commons.	**<u>Day 01</u>** • Students will complete the lab activity to simulate the use of the shared resource of fish in a lake/ocean that exemplifies The Tragedy of the Commons using common kitchen and household supplies. **<u>Day 02</u>** • Students will complete the analysis and discussion about the Tragedy of the Commons lab activity including analysis questions that require them to: ○ Describe a common. ○ Describe the Tragedy of the Commons ○ Describe potential solutions for the Tragedy of the Commons including advantages & disadvantages. **Making Connections** • Most natural resources can be viewed as Commons at some level and most are used in an unsustainable ways due to people taking more that their "fair share" because the environmental impacts of overusing resources from commons and not easily observable or take a long time to become obvious. **Teacher Background** • **Earth.org – Tragedy of the Commons** • **What is the tragedy of the commons? - Nicholas Amendolare - YouTube**	**<u>Lab Supplies</u>** • Fish – several bags of goldfish, marshmallows, or small candy (M&M's or skittles) • Fishing equipment - Straws (1 per student) • Water body – bowls or tray • Student boats - Paper towels or napkins • Optional – Scotch tape Engaging in Argument from Evidence
Day 3 **Paper or Plastic**	Topic 5.12 STB-1.A - Explain the concept of sustainability. **SWBAT**: **Make a Claim** about the more sustainable option between paper or plastic bags using evidence from an infographic to support the claim. **CFS: I have mastered the LO if I can…**	Students will make claims about the sustainability of paper vs plastic grocery bags using environmental facts about each from an infographic as evidence and reasoning. **Making Connections** • Paper bags are made from trees, which are often obtained from forests on public land which makes them a shared resource making the overuse of these trees related to the Tragedy of the Commons situation.	U1-Ecology-Day03-PaperPlastic.docx Engaging in Argument from Evidence

Lesson	Objective(s) and Standard(s)	Instructional Notes	Resources
	☐ Describe the characteristics of sustainable processes. ☐ Compare each process in the life cycle of paper vs plastic bags to determine the most sustainable option. ☐ Sum up the total sustainability, qualitatively, of paper vs plastic bag life cycle. ☐ Use reasoning to connect the evidence with the claim of the more sustainable option.	• Deforestation is linked to MANY other environmental science topics, loss of biodiversity, erosion, secondary succession, and climate change **Teacher Background** • NatGeo - Sustainability • Earth.org – What is Sustainability?	
Day 4 **Food Chains & Webs & Trophic Levels**	**Topic 1.9** -Trophic Levels ENG-1.B Explain how energy flows and matter **Topic 1.10** – Energy Flow and the 10% Rule ENG-1.C Determine how the energy decreases as it flows through ecosystems. **Topic 1.11** – Food Chains & Food Webs ENG-1.D - Describe food chains and food webs, and their constituent members by trophic level. cycles through trophic levels **SWBAT: Identify** different trophic levels and describe flow of energy and matter through a food web (or ecosystem) a food web or food chain.	Pre-AP Biology covers these Topics, and they should be a review for many/most students. Students will build a food web for a terrestrial and/or aquatic ecosystem and analyze the relationships between species and make claims about how changes to the population of a single species will impact the rest of the food web. Students will also review species relationships (other than predator-prey) including symbiotic relationships and resource partitioning. **Teacher Background** • Khan Academy – Food Webs – Matter & Energy • Khan Academy – Food Chains & Webs Article • Khan Academy - Example – Identifying roles in a Food Web • Khan Academy – Example – Analyzing Ocean Food Web	
Day 5 **Terrestrial Biomes**	**Topic 1.2** – Terrestrial Biomes ERT-1.B - Describe the global distribution and principal environmental aspects of terrestrial biomes. **SWBAT: Describe** the key characteristics of the major terrestrial biomes including, global distribution, climate (temp and precipitation), number and types of species, and natural	Students will explore the characteristics of five key types of terrestrial biomes to make comparisons and identify trends in both abiotic and biotic characteristics. Students will use two different online resources to read about and view graphical data about each biome. • Tropical Rainforest • Desert • Tundra • Boreal Forest/Taiga • Grassland/ Tall grass Prairie	• Biome Viewer 

Lesson	Objective(s) and Standard(s)	Instructional Notes	Resources
	resources using a virtual simulation of different terrestrial biomes.	• Temperate Deciduous/Seasonal Forest **Making Connections** • A diversity of biomes provides habitat for a diversity of species. These two types of diversity or interrelated. • Terrestrial biomes are defined by their abiotic characteristics (primarily climate patterns of temperature and precipitation). The local climate of a geography depends on many characteristics including latitude, altitude, wind patterns and proximity to ocean currents (Unit 4). **Teacher Background** • [Khan Academy – Terrestrial Biomes] • [Libre Texts – 44.3 Terrestrial Biomes]	**Students will need access to computers, at a ratio of at least 2 students to 1 computer**
Day 6 **Aquatic Biomes**	**Topic 1.3** – Aquatic Biomes ERT-1.C - Describe the global distribution and principal environmental aspects of aquatic biomes. **SWBAT: Describe** the major aquatic biomes including abiotic and biotic characteristics, key species, and ecological importance by watching videos about each aquatic biome.	Students will explore the characteristics of five key types of aquatic biomes to make comparisons and identify trends in both abiotic and biotic characteristics. Students will use two different online resources to read about and view graphical data about each aquatic biome. • River & streams • Lakes & Ponds • Inland Wetlands • Estuaries • Ocean • Coral reefs **Making Connections** • Aquatic Biomes are primarily distinguished by the abiotic characteristics of salinity and temperature • Photosynthesis of aquatic plants and algae produces oxygen that is dissolved in water (DO) that is vital to aquatic species in this ecosystem. Oxygen can also be abiotically dissolved into water by turbulent water like rapids in a river or crashing waves. • Aquatic photosynthetic organisms (mainly plankton) produce about half of all the oxygen on Earth. [NOAA citation] **Teacher Background** • [Khan Academy – Freshwater Biomes]	

Lesson	Objective(s) and Standard(s)	Instructional Notes	Resources
Day 7 **Ney Primary Productivity Lab Day 01**	**Topic 1.8** – Primary Productivity ENG-1.A - Explain how solar energy is acquired and transferred by living organisms. **SWBAT**: Describe the process of measuring net primary productivity (NPP). **SWBAT**: Describe the importance of NPP to the flow of energy through an ecosystem	**The timing of these Lab days should be adjusted so that Day 02 occurs 2-4 calendar days after Day 01.** Students will complete the pre-lab and the setup of this lab by measuring the Dissolved Oxygen in water samples and setting up two aquatic plants in identical conditions except that one is blocked off from sunlight and the other is not. **Making Connections** • How does NPP relate to the number of trophic levels in an ecosystem (or number of consumer species)? → because NPP in the amount of energy an ecosystem has to support all the trophic levels/species then the larger the NPP the higher the number of consumer species and the more likely there is to be fourth and sometimes fifth trophic levels **Teacher Background** • Khan Academy – Primary Productivity in Ecosystems – covers the math and calculations. • NPP – discusses NPP across different biomes	**Lab Equipment/Supplies** • Vernier Dissolved Oxygen (DO) Meters (shared) • Student computers to connect to DO meters • 300-600mL aquarium, pond or river water (per group) • Elodea or other healthy aquatic plant – 2 pieces of 2-4 cm per group • 2 BOD bottles per group – OR identical bottles with lids • Black construction paper or other opaque paper • Scissors 
Day 8 **Case Study – Loose Moose**	**Topic 1.11** – Food Chains and Food Webs ENG-1.D - **Describe** food chains and food webs, and their constituent members by trophic level. **Topic 1.** ENG-1.B **Explain** how energy flows and matter cycles through trophic levels	Pre-AP Biology covers this Topic, and it should be a review for students. The teacher will guide students through this PPT case study with embedded Clicker questions using PPT or Peardeck. Students will explore a case that they may have seen before in PAP Bio regarding the changes to Yellowstone National Park due to the absence of wolves for many decades and the reintroduction of Canadian Wolves in 1995.	

Lesson	Objective(s) and Standard(s)	Instructional Notes	Resources
	SWBAT: Explain how the removal of a single species from an ecosystem can impact many different trophic levels.	**Making Connections** • Many of the symbiotic species relationships important components of Regulating Ecosystem Services because they are vital to maintain healthy ecosystems which clean air and filter water, maintain and build soil, flood and erosion control, store carbon and regulate climate. • **Pollination** is a specific symbiotic relationship that is a critical Regulating Ecosystem service that makes production of many plant foods possible (which is a Provisioning Service). • Trophic cascade – this phenomenon demonstrates how food chain/webs and trophic levels are tied together in non-obvious ways that often lead to unexpected environmental issues in the real world	Developing and Using Models
Day 9 **Case Study - Beavers**	**Topic 1.11** – Food Chains and Food Webs ENG-1.D Describe food chains and food webs, and their constituent members by trophic level. **Topic 1.1** – Introduction to Ecosystems ERT-1.A Explain how the availability of resources influences species interactions. **SWBAT: Explain** how a keystone species is defined by its impact on the ecosystem.	Pre-AP Biology covers much of this Topic, and it should be a review for students. This is a paper case that students will work on in small groups of 2-3. This case study provides an opportunity for students to be introduced to the concept of keystone species and how they impact their ecosystem, practice with APES mathematical routines of percent change and dimensional analysis, tragedy of the commons, and introduction to evaluating environmental solutions using CER. **Making Connections** • This case study introduces students to some of the real-world tradeoffs between economic interests and environmental sustainability including ecosystem services • How do beavers change the NPP of an ecosystem? • How do beavers change the biodiversity of an ecosystem? **Teacher Background** N/A	Constructing Explanations Designing Solutions
Day 10 **NPP Lab**	**Topic 1.8** – Primary Productivity ENG-1.A - **Explain** how solar energy is acquired and transferred by living organisms.	Students will complete the lab procedure by taking measurements and collecting data. Then students will complete the analysis (qualitative and quantitative) of their data and participate in a class discussion. Students	Same as Day 07

Lesson	Objective(s) and Standard(s)	Instructional Notes	Resources
Day 02	**SWBAT**: **Explain** the process of calculating Net Primary Productivity (NPP) experimentally by conducting the NPP experiment. **SWBAT**: Describe the importance of NPP to the flow of energy through an ecosystem	will practice calculating the NPP of a plant given data about the GPP and respiration rate. **Making Connections** • Analogy to the real world – Businesses seek to make profit (NPP), by making as much sales as possible which is called revenue (GPP), but in the process they have costs of producing their good or service (respiration) → profit = revenue – costs → NPP = GPP - Respiration	
Day 11 **Water Cycle**	**Topic 1.7** – The Water (hydrologic) Cycle ERT-1.G **Explain** the steps and reservoir interactions in the hydrologic cycle. **SWBAT**: **Describe** the processes that move water through the primary reservoirs in the hydrologic cycle.	Students will create a model of the hydrologic cycle using a template, then revise their model while watching and discussing a video about the water cycle, then explore how different human(anthropogenic) actions impact the water cycle. **Making Connections** • Humans depend on the water cycle to purify/filter and desalinate water for agriculture and human consumption (ecosystem services explored in Unit 2) • Water is a basic human need and basic human right but water rights, access to surface water resources, by both individuals and corporations is a hotly debated and legal issue • Surface water resources can be common resources, when not on private land, and can lead to the drying up of rivers in a Tragedy of the Commons scenario. One of the most infamous examples is the Colorado River that runs straight through the heart of the United States and is the sources of water for millions of people and farmers. ○ The Colorado River drought crisis: How did this happen? Can it be fixed? **Teacher Background** • The Hydrologic & Carbon Cycles: Always Recycle 1 - Crash Course Ecology #8 • Khan Academy – The Water Cycle	
Day 12	**Topic 1.4** – The Carbon Cycle	Students will explore the reservoirs that hold different forms of carbon and the process that move carbon through the carbon cycle (natural and	

Lesson	Objective(s) and Standard(s)	Instructional Notes	Resources
Carbon Cycle	ERT-1.D **Explain** the major processes that move carbon through the major reservoirs in the carbon cycle. **SWBAT: Describe** the processes that move carbon through the primary reservoirs in the carbon cycle.	anthropogenic) by labeling the size of each reservoir and flux of carbon and then analyzing the change in the amount of carbon is the atmosphere and the ocean due to these processes. **Making Connections** • This lesson is only an introduction to the carbon cycle and the cycle will be referenced many times throughout the year in terms of anthropogenic effects on the carbon cycle, especially as it pertains to Global Climate Change (Unit 9) • The most fundamental natural processes that move carbon in the carbon cycle are photosynthesis vs respiration, which are the two main processes in Net Primary Productivity **Teacher Background** • The Hydrologic & Carbon Cycles: Always Recycle 1 - Crash Course Ecology #8 • Khan Academy – The Carbon Cycle	Developing and Using Models
Day 13 **Nitrogen Cycle**	**Topic 1.5** – The Nitrogen Cycle ERT-1.E - **Explain** the steps and reservoir interactions in the nitrogen cycle. **SWBAT**: **Describe** the processes that move nitrogen through the primary reservoirs in the nitrogen cycle.	Students will review the reservoirs and processes the cycle nitrogen through the biosphere by playing a game where their piece is a nitrogen atom moving through the biosphere. **Making Connections** • This lesson is an introduction to major reservoirs, natural processes, and anthropogenic processes in the Nitrogen Cycle. They will be discussed in more detail in Unit 8 on the topic of Eutrophication, which is largely caused by excess nitrogen in fertilizers washing into surface water systems. **Teacher Background** • Nitrogen & Phosphorous Cycles: Always Recycle 2 - Crash Course Ecology #9 • Khan Academy – The Nitrogen Cycle	Developing and Using Models
Day 14 **Phosphorous Cycle**	**Topic 1.6** – The Phosphorous Cycle ERT-1.F - **Explain** the steps and reservoir interactions in the phosphorus cycle.	Students will read an article about the significant benefits to society from mining phosphorous resources and the significant environmental degradation causing by mining phosphorous resources as a way to build context about the delicate balance of phosphorous in ecosystems. Then they will explore the phosphorous cycle to compare its processes with those of the nitrogen and carbon cycles.	Developing and Using Models

Lesson	Objective(s) and Standard(s)	Instructional Notes	Resources
	SWBAT: **Describe** the processes that move phosphorous through the primary reservoirs in the phosphorous cycle.	**Making Connections** • Sea bird guano is high in phosphorous and nitrogen because of an interesting species interaction between different ecosystems - they eat a diet of largely marine species and marine ecosystems are typically higher in these nutrients than terrestrial ecosystems so when they fly back to land to nest they poop out a large amount of these nutrients effectively moving these nutrients from the ocean to the land • Conservation scientists attempt to justify the conservation of bird species (many of which have decreasing populations) by the value of their guano as a resource of nutrient. Is this a good strategy to justify the protection of a species? ○ Seabird poop is worth millions, say scientists trying to save the birds ○ 5 Facts about Seabird Guano • Why do many detergents advertise on their label that they are Phosphate Free? **Teacher Background** • Nitrogen & Phosphorous Cycles: Always Recycle 2 - Crash Course Ecology #9	
Day 15 **Flex/Review**	Flex and/or Review as needed • Use Unit 1: Ecosystems Progress Check on AP Classroom (will not cover topics 5.1, 5.11, 5.12) • 30 MCQ and 1 Partial FRQ – Analyze an environmental problem and propose a solution.		
Day 16 **UE1**	**Texas - TX_SCI_APEnvironmentalScience_F25_UE1** **Scanning Deadline Sept 18, 2025**		
Day 17 **Success Day**	**Time Permitting – Use the APES Success Day Lesson Plan to review the UE1 FRQ and student gaps from the MC section of the exam.**		

VERTICAL STANDARDS

This section details the **progression** of key student expectations/standards** in the courses **before** and **after** this course. This will help you understand what **prior knowledge skills to build upon** and guide you in knowing what **skills you are preparing your students** for in the subsequent course.

BEFORE AP Environmental Science
<u>Grade 6</u> **6(11) Earth and space. The student understands how resources are managed. The student is expected to:** • 6(11)(A) research and describe why resource management is important in reducing global energy, poverty, malnutrition, and air and water pollution, and • 6(11)(B) explain how conservation, increased efficiency, and technology can help manage air, water, soil, and energy resources. **6(12) Organisms and environments. The student knows that interdependence occurs between living systems and the environment. The student is expected to:** • 6(12)(A) investigate how organisms and populations in an ecosystem depend on and may compete for biotic factors such as food and abiotic factors such as availability of light and water, range of temperatures, or soil composition; • 6(12)(B) describe and give examples of predatory, competitive, and symbiotic relationships between organisms, including mutualism, parasitism, and commensalism; and •
<u>Grade 7</u> **7(9) Earth and space. The student understands the patterns of movement, organization, and characteristics of components of our solar system. The student is expected to:** • 7(9)(C) analyze the characteristics of Earth that allow life to exist such as the proximity of the Sun, presence of water, and composition of the atmosphere. **7(12) Organisms and environments. The student understands that ecosystems are dependent upon the cycling of matter and the flow of energy. The student is expected to:** • 7(12)(A) diagram the flow of energy within trophic levels and describe how the available energy decreases in successive trophic levels in energy pyramids; and • 7(12)(B) describe how ecosystems are sustained by the continuous flow of energy and the recycling of matter and nutrients within the biosphere.
<u>Grade 8</u> **8(6) Matter and energy. The student understands that matter can be classified according to its properties and matter is conserved in chemical changes that occur within closed systems. The student is expected to:** • 8(6)(E) investigate how mass is conserved in chemical reactions and relate conservation of mass to the rearrangement of atoms using chemical equations, including photosynthesis **8(11) Earth and space. The student knows that natural events and human activity can impact global climate. The student is expected to:** • 8(11)(C) describe the carbon cycle. **8(12) Organisms and environments. The student understands stability and change in populations and ecosystems. The student is expected to:**

- 8(12)(A) explain how disruptions such as population changes, natural disasters, and human intervention impact the transfer of energy in food webs in ecosystems.

8(6) Matter and energy. The student understands that matter can be classified according to its properties and matter is conserved in chemical changes that occur within closed systems. The student is expected to:

- 8(6)(E) investigate how mass is conserved in chemical reactions and relate conservation of mass to the rearrangement of atoms using chemical equations, including photosynthesis.

Pre-AP Biology (Grade 8 or 9)

- **ECO 1: Cycling of Matter in the Biosphere**
    - (1.1) Hydrologic Cycle – Water cycles between abiotic and biotic systems in a process known as the hydrologic cycle.
        - ECO 1.1(a) Explain how the unique properties and phase changes of water enable and regulate biological reactions and/or processes.
        - ECO 1.1(b) Create and/or use a model to explain how biological systems function in the hydrologic cycle as water is transferred, transported, and/or stored.
    - (1.2) Carbon & Nutrient Cycles – Elements that are building blocks of macromolecules are transported from abiotic to biotic systems through gaseous and sedimentary cycles.
        - ECO 1.2(a) Explain the importance of the cycling of carbon for biological systems.
        - ECO 1.2 (b) Create and/or use models to illustrate how organisms' capture and use of energy plays a role I the cycling of carbon in ecosystems.
        - ECO 1.2(c) Explain the importance of cycling of nutrients for biological systems.
        - ECO 1.2 (d) Create and/or use models to describe the cycling of nitrogen between biotic and abiotic systems.
- **ECO 2: Population Dynamics**
    - (2.3) Food webs and Transfer of Energy in Ecosystems – Energy availability helps shape ecological communities.
        - ECO 2.3(a) Create and/or use models to explain the transfer of energy through the food web of a community.
        - ECO 2.3(b) Analyze data about species distributions to make predictions about the availability of resources.
        - ECO 2.3(c) Make predictions about the energy distribution in an ecosystem based on the energy available to organisms.
- **ECO 3: Defining Ecological Communities**
    - (3.2) Types of Ecological Communities
        - (3.2.1) Terrestrial biomes are classified by geographic locations and the abiotic factors that shape the unique ecological communities.
        - (3.2.2) Aquatic biomes can generally be classified according to their salt concentrations: ocean, brackish and fresh water.
- **ECO 4: Ecological Community Dynamics**
    - (4.1) Interspecific Competition – Competition between species drives complex interactions in ecosystems.
        - ECO 4.1(a) Explain how competition shapes community characteristics
        - ECO 4.1(b) Use data to analyze how competition influences niche-partitioning in an ecological community.
        - ECO 4.1(c) Create and/or use models to explain predictions about the possible effects of changes in the availability of resources on the interactions between species.
    - (4.2) Symbiosis – Competition in ecosystems has led to symbiotic relationships where two or more species live closely together.

- ECO 4.2(a) Describe what type of symbiotic relationship exists between two organisms.
- ECO 4.2(b) Explain how a symbiotic relationship provides an advantage for an organism by reducing one or more environmental pressures.

- **CELLS 6: Photosynthesis** (6.1.1) Photosynthetic organisms have the cellular structure to absorb solar radiation and convert it into chemical energy.
    - CELLS 6.1(a) Explain why the products of photosynthesis are ecologically important.
    - CELLS 6.1(b) Create and/or use models to explain the process of converting solar energy into chemical energy through photosynthesis.
    - CELLS 6.1(c) Use data to describe what factors affect rates of photosynthesis.

Pre-AP Chemistry (Grade 9 or 10)

- 1.1.A.1 Create and/or evaluate models that illustrate how the motion and arrangement of particles differ among solids, liquids, and gases.
- 1.2.B.1 Use data to explain the direction of energy flow into or out of a system.
- 3.2.A.1 Create and/or evaluate models of chemical transformations.
- 3.2.B.1 Explain the relationship between the quantity of reactants consumed and the quantity of products formed in a chemical transformation.
- 3.2.C.1 Create and/or evaluate models of a reaction mixture before and/or after a reaction has occurred, including situations with a limiting reactant.
- 3.2.D.1 Calculate the theoretical yield and/or percent yield of a chemical reaction.
- 4.4.A.1 Create and/or evaluate a claim about whether a reaction is endothermic or exothermic from experimental observations.
- 4.4.A.2 Explain the relationship between the measured change in temperature of a solution and the energy transferred by a chemical reaction.
- 4.4.B.1 Create and/or evaluate a claim about the energy transferred as a result of a chemical reaction based on bond energies.
- 4.5.A.2 Explain how experimental changes in the rate of a reaction are related to changes in the concentration, temperature, or surface area of the reactants.

After AP Environmental Science

AP Biology (Grade 10, 11 or 12)

Unit 3: Cellular Energetics

- **ENE-1 The highly complex organization of living systems requires constant input of energy and the exchange of macromolecules.**
    - **Topic 3.5 Photosynthesis**
        - ENE-1.I Describe the photosynthetic processes that allow organisms to capture and store energy.
        - ENE-1.J Explain how cells capture energy from light and transfer it to biological molecules for storage and use.
    - **Topic 3.6 Cellular Respiration**
        - ENE-1.K Describe the processes that allow organisms to use energy stored in biological macromolecules.
        - ENE-1.L Explain how cells obtain energy from biological macromolecules in order to power cellular functions.

Unit 8: Ecology

- **ENE-3 Timing and coordination of biological mechanisms involved in growth, reproduction, and homeostasis depend on organisms responding to environmental cues.**
- **IST-5 Transmission of information results in changes within and between biological systems.**
- **ENE-1 The highly complex organization of living systems requires constant input of energy and the exchange of macromolecules.**

- Topic 8.1 Responses to the Environment
    - ENE-3.D Explain how the behavioral and/or physiological response of an organism is related to changes in internal or external environment.
    - IST-5.A Explain how the behavioral responses of organisms affect their overall fitness and may contribute to the success of the population.

- **ENE-1 The highly complex organization of living systems requires constant input of energy and the exchange of macromolecules.**
  - **Topic 8.2: Energy Flow Through Ecosystems**
    - ENE-1.M Describe the strategies organisms use to acquire and use energy.
    - ENE-1.N Explain how changes in energy availability affect populations and ecosystems.
    - ENE-1.G Explain how the activities of autotrophs and heterotrophs enable the flow of energy within an ecosystem.

- **ENE-4 Communities and ecosystems change on the basis of interactions among populations and disruptions to the environment.**
  - **Topic 8.5: Community Ecology**
    - ENE-4.A Describe the structure of a community according to its species composition and diversity.
    - ENE-4.B Explain how interactions within and among populations influence community structure.
    - ENE-4.C Explain how community structure is related to energy availability in the environment.

AP Chemistry

VOCABULARY GLOSSARY

Domain-specific words and definitions for this unit.

Key Content Vocabulary
Commons – *a shared resource that is not owned by individual people or groups* ***Tragedy of the Commons –*** *a situation where individuals acting independently and in their own self-interest, and contrary to the common good, degrade or deplete a common resource* ***Ecological Footprint –*** *the amount of productive land and seas required to provide the renewable resources that a person/population consumes and to absorb the waste it generates* ***Sustainability –*** *focus on meeting the needs of the present without compromising the ability of future generations to meet their own needs* ***Ecosystem –*** *consists of all the organisms and the physical environment with which they interact.*[2]:458 *These biotic and abiotic components are linked together through nutrient cycles and energy flows.* ***Biome –*** *a large collection of flora and fauna occupying a major habitat.* ***Climatograph or Climatogram –*** *a graphical representation of a location basic climate* ***Biogeochemical Cycle –*** *biogeochemical cycle is a pathway by which a chemical substance is turned over or moves through the biotic (biosphere) and the abiotic (lithosphere, atmosphere, and hydrosphere) compartments of Earth* ***Photosynthesis*** *– the process in which light energy is converted into chemical energy by green plants and some other organisms. During photosynthesis light energy is captured and used to convert water and carbon dioxide into energy-rich organic compounds (sugars) and oxygen.* $$CO_2 + H_2O \rightarrow CH_2O + O_2$$ ***Gross primary production (GPP)*** *- the amount of chemical energy, typically expressed as carbon biomass, that primary producers create in a given length of time.* ***Net Primary Productivity (NPP)*** *– The amount of chemical energy remaining in producers after they use some of their stored energy for cellular respiration.* ***NPP = GPP – respiration*** *(by plants)* ***Cellular Respiration (R)*** *– the process where cells use chemical energy (sugars) for energy, and releases carbon dioxide and water.* $$CH_2O \rightarrow CO_2 + H_2O$$ ***Trophic Level –*** *the position of an organism in a food chain or energy pyramid.* ***Food Web –*** *the natural interconnection of food chains and a graphical representation of what-eats-what in an ecological community.* ***Food Chains –*** *a linear network of links in a food web starting from producer organisms (such as grass or trees which use radiation from the Sun to make their food) and ending at an apex predator species (like grizzly bears or killer whales), detritivores (like earthworms or woodlice), or decomposer species (such as fungi or bacteria).* ***10% Rule –*** *when energy is passed in an ecosystem from one trophic level to the next, only ten percent of the energy will be passed on.*

***Trophic Cascade** – is powerful indirect interactions that can control entire ecosystems, occurring when a trophic level in a food web is suppressed. For example, a top-down cascade will occur if predators are effective enough in predation to reduce the abundance, or alter the behavior of their prey, thereby releasing the next lower trophic level from predation*

***Hydrologic Cycle** – The biogeochemical cycle that describes how **water** cycles through the atmosphere, biosphere, hydrosphere, and other key reservoirs on planet Earth.*

***Evaporation –** the change of a liquid into a gas (vapor)*

***Precipitation –** water that falls to the Earth in any form (rain, snow, hail, mist, sleet, etc.).*

***Transpiration** – the process by which plants give of water vapor through the stomata in their leaves*

***Infiltration** (water) – the process of water that falls the ground soaking or seeping into the soil*

***Runoff** (water) – when water that falls on the Earth's surface does not infiltrate into the land but flows over the land or "runs off" downhill*

***Carbon Cycle** – the biogeochemical cycle by which carbon is exchanged among the biosphere, pedosphere, geosphere, hydrosphere, and atmosphere of Earth.*

***Nitrogen Cycle** – the biogeochemical cycle by which nitrogen is converted into multiple chemical forms as it circulates among atmospheric, terrestrial, and marine ecosystems.*

***Nitrogen Fixation -** a chemical process by which molecular nitrogen (N_2), which has a strong triple covalent bond, is converted into ammonia (NH_3) or related nitrogenous compounds, biotically by organisms in the soil or abiotically by lightning and also in industry.*

***Nitrification** - the process by which ammonia (NH_3) or ammonium ($NH4^+$) is converted to nitrate (NO_3^-). Nitrification is the net result of two distinct processes: oxidation of ammonium to nitrite (NO_2^-) by nitrifying or ammonia-oxidizing bacteria and oxidation of nitrite (NO_2^-) to nitrate (NO_3^-) by the nitrite-oxidizing bacteria. Nitrification is an important step in the nitrogen cycle in soil. Nitrification is an aerobic process performed by small groups of autotrophic bacteria and archaea.*

***Assimilation** – the absorption of nutrients by plants through their roots.*

***Denitrification** – the reduction of nitrates or nitrites by bacteria in the soil the results in the release of nitrogen to the atmosphere. This is an anaerobic process.*

***Phosphorous Cycle** - the biogeochemical cycle that describes the movement of phosphorus through the lithosphere, hydrosphere, and biosphere.*

***Salinity** – the saltiness or amount of salt dissolved in a body of water, called saline water. It is usually measured in g/L or g/kg (grams of salt per liter/kilogram of water; the latter is dimensionless and equal to ‰).*

***Dissolved oxygen (DO)** - a measure of how much oxygen is dissolved in the water - the amount of oxygen available to living aquatic organisms. Typically measured in parts per million (ppm) or milligrams per liter (mg/L)*

***Turbidity** - is the cloudiness or haziness of a fluid caused by large numbers of individual particles that are generally invisible to the naked eye, similar to smoke in air. The measurement of turbidity is a key test of both water clarity and water quality.*

***Biogeochemical cycle** -a cycle of matter. The movement and transformation of chemical elements and compounds between living organisms, the atmosphere, the hydrosphere and the Earth's crust.*

***Reservoir or sink (in biogeochemical cycles)–** a location in a biogeochemical cycle where a large amount of the chemical resides for a short or long time*

***Evaporation –** a type of vaporization that occurs on the surface of a liquid as it changes into the gas phase.*

***Transpiration (aka evapotranspiration) –** the process of water movement through a plant and its evaporation from aerial parts, such as leaves, stems and flowers. Water is necessary for plants but only a small amount of water taken up by the roots is used for growth and metabolism. The remaining 97–99.5% is lost by transpiration and other processes.*

Condensation - *the change of the state of matter from the gas phase into the liquid phase, and is the reverse of vaporization.*
Precipitation – *any product of the condensation of atmospheric water vapor that falls from clouds due to gravitational pull.[2] The main forms of precipitation include drizzle, rain, sleet, snow, ice pellets, graupel and hail.*
Infiltration – *the process by which water on the ground surface enters the soil.*
Percolation - *refers to the movement and filtering of fluids through porous materials like soil.*
Runoff – *the flow of water across the earth that happens when more water falls on the surface than can infiltrate into the ground*
Fossil Fuels – *natural fuel such as coal or gas, formed in the geological past from the remains of living organisms.*
Flux - *the action or process of flowing or flowing out*
Net Flux – *the sum of all the incoming fluxes minus all the outgoing fluxes*

$$Net\ Flux = Sum\ Flux\ In - Sum\ Flux\ Out$$

Nitrogen Fixation: *Nitrogen Fixation is the conversion of atmospheric nitrogen (N_2) into reactive compounds such as ammonia (NH_3) and nitrate (NO_3^-). The breaking of the bonds between the nitrogen atoms requires a great deal of energy and occurs naturally in two primary ways: abiotic fixation (lightning, cosmic radiation) and biotic fixation (aerobic and anaerobic bacteria).*
Abiotic Fixation: *Nitrate is the result of high energy fixation in the atmosphere from lightning and cosmic radiation. In this process, N_2 is combined with oxygen to form nitrogen oxides such as NO and NO_2, which are carried to the earth's surface in rainfall as nitric acid (HNO_3). This high energy fixation accounts for approximately 10% of the nitrate entering the nitrogen cycle.*
Biological fixation: *Biological fixation is accomplished by a series of soil micro-organisms such as aerobic and anaerobic bacteria. Often, symbiotic bacteria such as Rhizobium are found in the roots of legumes and provide a direct source of ammonia to the plants. In root nodules of these legumes, the bacteria split molecular nitrogen into two free nitrogen atoms, which combine with hydrogen to form ammonia (NH_3). The following plants are common examples of legumes: clover, alfalfa, soybeans, and chickpeas. The breakdown of these legumes by bacteria during ammonification actually returns excess nitrogen not utilized by the plant to the surrounding soil. Therefore, to promote sustainable soil fertility, it is beneficial to use these agricultural crops in rotation with other plants, such as corn, that are more profitable but deplete the available nitrogen in the soil-Some free-living aerobic bacteria, such as Azotobacter, and anaerobic bacteria, like Clostridium, freely fix nitrogen in the soil and in aquatic environments. Some members of the photosynthetic Cyanobacteria phylum fix nitrogen in aquatic environments as well.*
Nitrification: *Nitrification is the process by which ammonia is oxidized to nitrite ions (NO_2^-) and then to nitrate ions (NO_3^-), which is the form most usable by plants. The two groups of microorganisms involved in the process are Nitrosomonas and Nitrobacter. Nitrosomonas oxidize ammonia to nitrite and Nitrobacter oxidize nitrite to nitrate.*
Ammonification: *In ammonification, a host of decomposing microorganisms, such as bacteria and fungi, break down nitrogenous wastes and organic matter found in animal waste and dead plants and animals and convert it to inorganic ammonia (NH_3) for absorption by plants as ammonium ions. Therefore, decomposition rates affect the level of nutrients available to primary producers.*
Denitrification: *Denitrification is the process by which nitrates are reduced to gaseous nitrogen (N_2) and lost to the atmosphere. This process occurs by facultative anaerobes in anaerobic environments. Farmers with waterlogged fields and soils that have high clay content are especially vulnerable to nitrogen losses due to denitrification.*

Related Vocabulary

<u>*Terrestrial Biomes*</u> *Tropical Rainforest* *Temperate Rainforest* *Temperate Seasonal Forest (Deciduous)* *Boreal Forest (Taiga)* *Shrubland* *Temperate grassland* *Savanna* *Desert* *Tundra*	<u>*Marine Aquatic Biomes*</u> *Oceans* *Coral Reefs* *Marshland* *Estuaries* *Mangrove Forest*	<u>*Freshwater Aquatic Biomes*</u> *Streams & Rivers* *Ponds* *Lakes* *Marsh, Bog, swap*	***Anthropogenic*** *Maximum Sustainable Yield* *Primary Producer* *Primary Consumer* *Secondary Consumer* *Tertiary Consumer* *Riparian Habitat* *Keystone species* *Weathering* *Geologic Uplift*