Biosphere Learning Progression-Grades 6-8: GLOBE Protocols Aligned with NASA and NGSS

NGSS Disciplinary Core Ideas Content Progression: In grades 6-8, students explore how the biosphere has been altered by human activities, sometimes damaging it, although changes to environments can have different impacts for different living things. Activities and technologies can be engineered to reduce people's impacts on Earth. Ecosystem characteristics vary over time. Disruptions to any part of an ecosystem can lead to shifts in all of its populations. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health. Changes in biodiversity can influence humans' resources and ecosystem services they rely on. Through participating in a series of GLOBE and NASA learning activities, and collecting data using the GLOBE protocols, students have the opportunity to engage in authentic science data collection as they explore the world in which they live, developing data literacy skills. Using GLOBE and MY NASA DATA educators and students will access NASA satellite data to examine a variety of Earth system interactions.
(NASA Langley GLOBE Resource Page: www.globe.gov/web/nasa-langley-research-center/home/resources)

NGSS Performance Expectations: (Note: the following Performance Expectations and 3 Dimensional Learning are aligned with GLOBE and NASA Resources and are meant to support the development of the associated content and skill development but may not lead to complete mastery)

MS-LS1-5 Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.
MS-LS1-6 Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.
MS-LS2-1 Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
MS-LS2-3 Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
MS-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
MS-ESS3-3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
MS-ESS3-4 Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.
MS-ESS3-5 Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

NGSS Science Practices:	NGSS Disciplinary Core Idea:	NGSS Crosscutting Concepts:
Asking Questions and Defining Problems: Ask questions to identify and clarify evidence of an argument. (MS-ESS3-5) **Developing and Using Models** Develop a model to describe phenomena. (MS-LS2-3, MS-ESS1-1) **Analyzing and Interpreting Data:** Analyze and interpret data to determine similarities and differences in findings.	**LS1.B Growth and Development of Organisms** Genetic factors as well as local conditions affect the growth of the adult plant. (MS-LS1-5) **LS1.C Organization for Matter and Energy Flow in Organisms:** Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. (MS-LS1-6) **LS2.A Interdependent Relationships in Ecosystems** Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with non living factors. (MS-LS2-1) In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. (MS-LS2-1) Growth of organisms and population increases are limited by access to resources. (MS-LS2-1) **LS2.B Cycle of Matter and Energy Transfer in Ecosystems** Food webs are models that demonstrate how matter and energy are transferred	**Patterns** Patterns can be used to identify cause and effect relationships. (MS-ESS1-1) **Stability and Change** Stability might be disturbed either by sudden events or gradual changes that accumulate over time. (MS-ESS3-5) Small changes in one part of a system might cause large changes in other parts. (MS-LS2-4) **Cause and Effect** Relationships can be classified as causal or correlational, and

Analyze and interpret data to provide evidence for phenomena. (MS-LS2-1)

Constructing Explanations and Designing Solutions:
Construct a scientific explanation based on valid and reliable evidence obtained from sources (including students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (MS-LS1-5, MS-LS1-6)
Apply scientific principles to design an object, tool, process or system. (MS-ESS3-3)

Engaging in Argument from Evidence:
Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (MS-LS2-4, MS-ESS3-4)

between producers, consumers, and decomposers as the three groups interact with an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. (MS-LS2-3

LS2.C Ecosystem Dynamics, Functioning, and Resilience
Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (MS-LS2-4)

LS4.D Biodiversity and humans:
Changes in biodiversity can influence humans' resources, such as food, energy and medicines, as well as ecosystem services that humans rely on – for example, water purification and recycling.

PS3.D Energy in Chemical Processes and Everyday Life
The chemical reaction by which plants produce complex food molecules requires an energy input (i.e. sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen. (MS-LS1-6)

ESS1.A The Universe and its Stars
Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted,and explained with models. (MS-ESS1-1)

ESS1.B Earth and the Solar System
This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight in different areas of Earth across the year. (MS-ESS1-1)

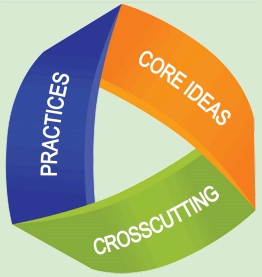
ESS3.A Natural Resources:
Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.

ESS3.C Human impacts on Earth systems:
Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments have different impacts (negative and positive) for different living things. (MS-ESS3-3)
Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MS-ESS3-3, MS-ESS3-4)

ESS3.D Global Climate Change:
Human activities, such as the release of greenhouse gases from burning fossil fuels, are

correlation does not necessarily imply causation. (MS-ESS3-3)
Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-LS2-1, MS-ESS3-4)
Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. (MS-LS1-5)

Energy and Matter
Within a natural system, the transfer of energy drives the motion and/or cycling of matter. (MS-LS1-6)
The transfer of energy can be tracked as energy flows through a natural system. (MS-LS2-3)



	major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities. (MS-ESS3-5)	

GLOBE Application

GLOBE Protocols:

- Air Temperature
- Precipitation
- Surface Temperature
- Water Temperature
- Land Cover Classification
- Carbon Cycle
- Green-up Green-down
- Tree Height
- Fire Fuel

GLOBE Data Sheets

- Green-Up Trees/Shrubs
- Green Down
- Fire Fuel
- Land Cover Sample Site
- Land Cover Summary Data Sheet
- Tree Height on Level Ground
- Tree

GLOBE Learning Activities:

1. Limiting Factors in Ecosystems: Learners develop an understanding that physical factors—temperature and precipitation—limit the growth of vegetative ecosystems (MS-LS1-5, MS-LS2-1, MS-LS2-4)
2. GLOBE Trees Sapling Science Journey: Use the one-pager to guide learners' understanding and exploration of trees satellite data as it relates to the health of forest areas and changes that are occurring to the planet. (MS-LS2-1, MS-LS2-3, MS-LS2-4, MS-ESS3-4)
3. Land Cover Change Detection: Using Multi-Spec software, learners compare two registered images, acquired several years apart, of a GLOBE Study Site and identify changes in land cover. (MS-LS2-4, MS-ESS3-3, MS-ESS3-4, MS-ESS3-5)
4. Global Patterns in Green-up and Green-down: Learners investigate the annual cycle of plant growth and decline using visualizations and graphs (MS-LS1-5, MS-LS2-3, MS-LS2-4)
5. Carbon Travel Game: Learners learn that carbon is one of the most important, and abundant elements on Earth and can be found everywhere. (MS-LS1-6, MS-LS2-3, MS-LS2-4, MS-ESS3-3, MS-ESS3-4, MS-ESS3-5)
6. Getting to Know Global Carbon: Learners use the scientist-designed global carbon cycle diagram as a facilitation tool for discussing important global carbon cycle concepts. (MS-LS1-6, MS-LS2-3, MS-LS2-4, MS-ESS3-3, MS-ESS3-4, MS-ESS3-5)
7. Your Regional to Global Connection: Learners identify specifically how one's own region is connected with others, and to discover the interconnected nature of the Earth's regions as systems. (MS-LS1-6, MS-LS2-3, MS-LS2-4, MS-ESS3-3, MS-ESS3-4, MS-ESS3-5)
8. Effects of Inputs and Outputs: Learners identify what enters and leaves the regional system, and how changes in the input or output of one component can affect other components. (MS-LS1-6, MS-LS2-3, MS-LS2-4, MS-ESS3-3, MS-ESS3-4, MS-ESS3-5)
9. Getting to Know Your Satellite Imagery and Study Site: To introduce learners to the Landsat images of the GLOBE Study Site, the iterative nature of mapping and how to identify land cover types in images. (All)
10. Manual Land Cover Mapping: Learners produce a land cover type map of the 15 km x 15 km GLOBE Study Site from hard copies of Landsat satellite images. (All)
11. Do You Know Your MUC: Learners determine and produce a land cover map of plant life at a site to determine the Modified UNESCO Classification (MUC). (All)

Guiding Question(s):

1. Considering both environmental and genetic factors, what are some of the most effective strategies for maximizing the growth of commercially important organisms in a sustainable way?
2. How might human activities alter environmental factors and consequently affect the growth of various organisms, both positively and negatively?
3. What is photosynthesis, in simple terms? What are the main things that go into this process, and what are the main products?
4. In what ways does photosynthesis connect the nonliving parts of an ecosystem (like the atmosphere and sunlight) with the living parts (plants and other producers)?
5. How can we collect and analyze data to understand the relationship between resource availability and the number of organisms in

Circumference **GLOBE Supporting Resources:** • GLOBE Investigation Instruments • Clinometer Instructions • Clinometer Sheet • Green-Up Cards Note: (Using these as an example you can collect sets of cards for your local area.)	12. Discovery Area Post-Mapping Activity: Learners use a land cover type map to make environmentally sound decisions. (MS-ESS3-3, MS-ESS3-4, MS-ESS3-5) 13. Plant a Plant Hands-On Photosynthesis Experiments: Learners will observe how seeds grow into sprouts and then use and derive experiments that manipulate environmental conditions to investigate how different factors (water, light, temperature, mineral nutrients, and carbon dioxide) affect plant growth. Learners will document plant growth and record observations. **Teacher Note:** This activity is listed for high school; however, with support and modifications it can be used in middle school to support the performance expectation. (MS-LS1-6) 14. Plant a Plant Temperature Laboratory Guide: Prepare conditions for the cultivation of maize in a closed system (plastic bottle). You will observe the influence of different temperatures on growth. You will achieve different temperatures by shading a third of the plastic bottle. Compare the increase in biomass between the different modifications. (MS-LS1-5, MS-LS2-3, MS-LS2-4) 15. Plant a Plant Water Laboratory Guide: Prepare conditions for growing maize seedlings with different amounts of water. Plant seedlings in plastic bottles, set up a constant water resource and observe how much water uptake occurs. Develop a control system to account for changes in water level not caused by plant uptake. After the experiment is complete you will compare the change in plant biomass of the different water treatments. (MS-LS1-5, MS-LS2-3, MS-LS2-4) 16. Site Seeing: Intermediate: These pre-protocol activities introduce learners to the concept of a system. The learners will explore different scales of the system, identify the components, and try to determine their relationship to each other. (All) 17. Biomass Accumulation Model: Predicting Net Primary Productivity and Biomass Using Temperature, Precipitation, and Biomes: Learners will learn to use a simple model that predicts the biomass and average growth rate in ecosystems, net primary productivity, based on temperature and precipitation. (MS-LS1-5, MS-LS2-1, MS-LS2-4) 18. An Alaskan Spring Mystery - A GLOBE Data Exploration Learners analyze data about the timing of budburst for a tree species over three years in the same location. They investigate two different hypotheses for why timing differs by analyzing weather data from the same time period. (MS-LS1-5, MS-LS2-1, MS-LS2-4) 19. Using GLOBE Data to Analyze Land Cover: Learners develop hypotheses about which environmental factors are most important to plants growing in a local Land Cover Sample Site by comparing local GLOBE data to those of other GLOBE schools reporting the same MUC class. (MS-LS2-4, MS-ESS3-3, MS-ESS3-4, MS-ESS3-5 20. Climate and Latitude: A GLOBE Data Exploration: Learners match GLOBE air temperature data with location given what they know about the relationship between latitude and seasonal temperature variations. (MS-LS2-4,(MS-ESS3-5) 21. Data Entry: After learners have returned from the field with their paper data sheets, data can be shared with the GLOBE and scientific community by entering it into the GLOBE online science database (https://data.globe.gov). (All)	a population? What kinds of graphs or charts might be helpful? 6. Can you think of examples from the real world where changes in resource availability have led to increases or decreases in specific populations? What was the resource and what were the effects? 7. What are the main components that should be included in a model showing the cycling of matter and flow of energy in an ecosystem? 8. What are some examples of biological components of an ecosystem? How might changes in these components affect other populations? 9. Can you design a method to monitor a specific human impact on the environment? What data would you collect and how would you analyze it? 10. How do scientists use evidence to determine the primary causes of the recent rise in global temperatures? What kinds of data and models do they use?

NASA Assets

NASA Resources:

- Earth Observatory Global Maps
- NASA Worldview
- Seeing Climate through the Lives of Plants
- The Carbon Cycle

NASA Lessons and Activities:

- Building Out Chattanooga
- Drones to the Rescue
- Joint Polar Satellite System STEM Activity: Printing Tree Rings
- Visible Earth
- Carbon and Climate Resources
- Landsat Science Education
- Picture Post
- Our Blue Marble

MY NASA DATA Visualization Tool: Earth System Data Explorer (The Earth System Data Explorer is a data visualization tool that can be used by the educator to prepare lessons for the learner, or can be accessed by the learner to support independent research.)

My NASA Supporting Resources:

- Locating Data and Imagery for Student Investigations
- Using NASA Earth Observations (NEO)
- GLOBE Connections: Plant Growth Patterns
- Data Collections: Earth System Data Explorer
- About the Biosphere
- Biosphere Mini-Lessons
- Deforestation
- Plant Growth Patterns
- Land Use Change Over Time
- GLOBE Earth System Poster
- Earth as a System Graphic Organizer

My NASA Data Lessons/Activities:

- Blossoms Blooming: Analyzing Plant Growth Patterns (MS-LS2-3, MS-LS2-4, MS-ESS3-5)
- Stability and Change: Observing and Measuring Plants (MS-ESS2-1)
- Analyzing Seasonal Vegetation & Leaf Index (MS-ESS2-1)
- How Can a Series of Landsat Images Help Scientists Estimate Forest's Age Over Time? (MS-ESS3-3, MS-ESS3-4)
- Exploring Energy and Matter with Chlorophyll Data (MS-LS2-3)
- Global Phytoplankton Distribution (MS-LS2-3)
- Exploring Seasonal Chlorophyll Concentrations (MS-LS2-3)
- Greenhouse Gases: Importance and Human Impact (MS-ESS3-5)
- Tracking Change Over Time - Understanding Remote Sensing (MS-LS2-4, MS-ESS3-3, MS-ESS3-4)
- Where in the World are Major Environmental Changes? (MS-LS1-5, MS-ESS3-3)
- What's Hot at the Mall? (MS-ESS3-3, MS-ESS3-4, MS-ESS3-5)
- Urban Heat Islands (MS-LS2-4, MS-ESS3-3, MS-ESS3-4, MS-ESS3-5)

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