**Geospatial Inquiry Template**

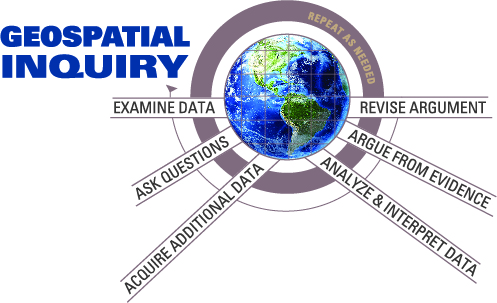
**EXAMPLE**

**Grade level(s): High School**

**Subject(s): Environmental Science**

**Existing lesson/unit to be *enhanced* by Geospatial Inquiry: The Global Carbon Landscape**

**Anticipated timeframe: 3 hours**



**Begin with the End in Mind**

What essential understanding will students gain from completing this Geospatial Inquiry-enhanced lesson/unit? A concept is an idea that can be applied in multiple contexts to explain and/or predict outcomes. Conceptual understanding is ability to apply a big idea/concept in multiple contexts to explain and/or predict outcomes.

The Earth itself is one interconnected system.

* + Natural systems change over time and space.
  + Biogeochemical systems vary in ability to recover from disturbances.

Net Primary Productivity has broad implications within and across human and environmental systems

*Have you written a statement that allows students to apply a broad idea in multiple contexts to explain and/or predict outcomes?*

Specific Objectives:

* Learners will be able to draw and describe the carbon cycle and apply their understanding of the cycle to explain patterns in global carbon storage.
* Learners will be able to identify and describe seasonal patterns of change in global net primary productivity and identify factors (or events) most closely associated with changes in primary productivity
* Learners will be able to describe how changes in net primary productivity impact social and environmental systems around the world.

Identify 2-3 key skills and/or cross-disciplinary practices students will learn or use during this Geospatial Inquiry-enhanced lesson/unit (e.g. collaboration, communication)

* Collaboration: Students work in groups to share information and collectively build their conceptual understanding
* Communication: Students articulate their understandings in relation to the concepts under study through discourse and writing

Which types of geospatial analyses will students conduct to find relationships and patterns in order to develop conceptual understanding?

Check all that apply:

* **X** Finding where things are (in relation to other things)
* **X** Finding what’s nearby
* Examining what’s inside
* Comparing most and least
* **X** Finding areas of concentration (density)
* **X** Examining change over time

For each item checked above, what will students analyze, compare, and/or interpret (not specific datasets, but big ideas)?

Finding where things are: Students examine topographic features and identify habitat types such as desert, forest, and prairie.

Finding what’s near by: Students use their home location as the initial point for landscape analysis (using bookmark) and then broaden their search to areas nearby to examine differences in habitat types and leaf area index (using measuring tools to determine the distance from their home location)

Finding areas of concentration: Students examine areas of concentration for leaf area and biomass

Examining change over time: Students examine change over time (seasonally and across years) in leaf area index and compare with changes in net primary productivity over time

**Ask Questions**

Craft a guiding question which provides a purpose for engaging in the Geospatial Inquiry-enhanced lesson/unit. The statement should encompass all content and outcomes and should require to answer a question, solve a problem or explain a phenomenon.

* What is the relationship of the carbon cycle and global net primary productivity?
* What factors (or events) are most closely associated with changes in primary productivity?
* How do changes in net primary productivity impact environmental systems and human lives?

*Have you posed an authentic problem or significant question that engages students and requires core subject knowledge to solve or answer?*

**Evidence of Student Learning**

Define the student products for the Geospatial Inquiry-enhanced lesson/unit.

Which of these (or other products) will you assess? Which products require feedback to enable students to refine their thinking?

Early on: Diagram and describe the global carbon cycle and demonstrate understanding of the key processes in the carbon cycle by telling the story of the carbon cycle on a small scale and in a regional environment.

In the middle: Analyze geospatial data to prepare and present (orally and in writing) an explanation for the seasonal changes in global carbon storage.

Final product: Present a claim (supported by geospatial evidence and reasoning) to a group of peers to explain the impact of changes in net-primary productivity and carbon storage on environmental and social systems around the world.

*Do students have multiple opportunities to ask questions, analyze and interpret geospatial data, argue from evidence, present their arguments, and revise their thinking?*

**Quality of Evidence**

State the criteria for exemplary performance for each product:

Product: Students complete a diagram of the Global Carbon cycle and connect the global-scale cycle to a regional scale example illustrating the pathways of carbon transfer through their local environment.

Criteria: Carbon Cycle diagram includes description of pathways through the biosphere, hydrosphere, and geosphere and includes descriptions of key processes in carbon storage and exchange.

Product: Students construct a relevant claim about the reasons for temporal shifts in Net Primary Productivity (from March – Sept 2015). Students support the claim with a piece of geospatial evidence and construct explicit reasoning that links their evidence to their claim.

Criteria: Use the Learning Progression for Argumentation in Science from Stanford University to evaluate the students claim. <http://scientificargumentation.stanford.edu/project/>

Product: Students evaluate a classmate’s claim and propose an alternative claim or counterargument.

Criteria: Use the Learning Progression for Argumentation in Science from Stanford University to evaluate the students counterclaim. <http://scientificargumentation.stanford.edu/project/>

*Do the products and criteria align with identified outcomes?* *Do the products and tasks give all students the opportunity to demonstrate what they have learned not only through visual representations, but also through writing and speaking?*

**Examine Geospatial Data**

What maps or data could students explore to spark questions and engage them in the investigation? Is a video or news story appropriate to introduce these maps or data?

In the introduction, students examine an animation of Global Net Primary Productivity (downloaded from earth observatory at NASA). The animation shows patterns of primary productivity across the globe and seasonal and yearly changes from February 2000 to November 2016. <https://earthobservatory.nasa.gov/GlobalMaps/view.php?d1=MOD17A2_M_PSN>.

During the focus of the lesson, students examine data layers on ArcGIS online related to Carbon Storage, global biomass, and leaf area index. Additional data layers may include temperature, rainfall, and soil type. Learners examine data layers in 2-3 different seasons (\*data available for 2015 March & September)

As part of the wrap-up, students watch the TED talk with Greg Asner. Asner is an ecologist using spectrometry to map carbon. Students look for examples of the types of the types of analysis they engaged with during their Geospatial Inquiry and the Asner’s work mapping global carbon geographies. <https://www.ted.com/talks/greg_asner_ecology_from_the_air/transcript?language=en>

**Map the Geospatial Inquiry**

You have defined the problem or question and the student products for a Geospatial Inquiry-enhanced lesson/unit above. What knowledge and skills do students need in order to make the decision, explain the phenomenon, or answer the guiding question? What additional learning activities (hands on investigations, readings, etc.) must be completed to accompany the Geospatial Inquiry? Please describe the major activities for the entire lesson/unit, before, during, and after the Geospatial Inquiry, as appropriate.

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| **Activity Description** | **Learning Goal** | **How it helps students address the guiding question** |
| Formative Assessment of student conceptual understanding of the carbon cycle (\*taught in a previous lesson). Students draw and describe the carbon cycle and use map notes to make a prediction about patterns in global carbon storage. | Learners will be able to draw and describe the carbon cycle and apply their understanding of the cycle to explain patterns in global carbon storage. | Through analysis of patterns in the carbon cycle and comparing those patterns with spatial data on global carbon storage, students will address the guiding question: What is the relationship of the carbon cycle and global net primary productivity? |
| Examine the features of the Imagery basemap. Identify different landforms including areas of desert, water, vegetation etc. Ask learners to describe what this map indicates about the surface of the earth and what information is missing.  Ask students to identify the area where they live and add a bookmark. Ask students to compare where they live to a spot at least 1,000 miles away (using the measure tool) and a spot at least 7,000 miles away. Ask students to describe any differences in landforms in these locations (specifically the amount of vegetative cover). Students first share with their partner and then the whole class.  Examine Leaf area index map from spring (March 2016). Students examine their book marked areas, first zooming into their home location and then zooming out to see all three locations simultaneously. Ask students to describe what they notice differently between the two scales.  Repeat the process using a fall data layer (September 2015)  Ask learners to describe what they notice regarding seasonal changes in leaf area between the March and September data. On class chart, collect themes from the discussion. | Learners will be able to identify and describe seasonal patterns of change in global net primary productivity and identify factors (or events) most closely associated with changes in primary productivity | Through comparison of patterns in NPP and other seasonally impacted environmental conditions, students will address the guiding question: What factors (or events) are most closely associated with changes in primary productivity? |
| Students build from the themes on the class chart to determine factors that contribute to changes in net primary productivity.  Ask students to first discuss what they think is the relationship between the amount of vegetation (as seen on the maps) and the amount of carbon dioxide in the atmosphere. Explain that net primary productivity is the difference in Carbon Dioxide stored by plants and Carbon Dioxide which is released by plants. Ask students to refer back to their carbon cycle diagram and insert a description of net-primary productivity.  In small groups – students independently explore data to support their claim regarding the reason for seasonal variation in net-primary productivity. Ask students to consider multiple factors that may be related to these changes (eg. precipitation, temperature, soil type etc)  Final product: Present a claim (supported by geospatial evidence and reasoning) to a group of peers to describe how changes in net-primary productivity can impact environmental and social systems. | Learners will be able to describe how changes in net primary productivity impact social and environmental systems around the world. | Through development of a claim supported by geospatial evidence and appropriate reasoning (about the impact of changing NPP on human and environmental systems), students will address the guiding question- How do changes in net primary productivity impact environmental systems and human lives? |
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Identify activities which require scaffolds for writing or participation.

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| **Activity** | **Type of Scaffold** |
| Analysis of Geospatial Data | Demonstrations of Analysis tools for areas of concentration when examining patterns in leaf area index and comparing with biomass and net primary productivity. |
| Whole –Class discussion of patterns in the data | Use sentence starters from Ambitious Science Teaching to facilitate and sustain productive academic talk in group discussion of data to deepen conceptual understanding and identify gaps. http://uwcoeast.wpengine.com/tools-scaffolding/ |
| Individual learner development of a CER | Use the Science Explanation tool from BSCS to guide students to review their claims evidence and reasoning and determine what is needed to further develop their CER into an evidence-based and well-reasoned science explanation. https://bscs.org/sites/default/files/\_media/about/downloads/ap\_bio\_scientific\_explanation\_tool.pdf |
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*Have you identified opportunities to promote productive talk?*

What challenges or problems might arise in this Geospatial Inquiry-enhanced lesson/unit? How will you overcome these challenges?

Learners may be challenged transfer their understanding of the meaning of the patterns in data to an explanation of the phenomena (seasonal shifts in net primary-productivity). To overcome these challenges, students will engage in structured discourse and use prompts as starting points for their explanations.