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**MSU Coastal Research & Extension Center**

**Lesson 5: Ecosystem Connectivity – The Mississippi River**

**Theme**

* Environmental Science/Ecology

**Grade Level**

* 9th – 12th

**Class Size**

* 10-30 Students

**Length**

* 1.5 hours

**Materials**

* 3 tin cake pans with their lids
* 2-3 sponges
* 4-6 large zip ties
* sugar (about half the volume of the sponges used); \*used up for each demonstration\*
* 1-2 liters of muddy water (mixing some potting soil w/ fertilizer is ideal for discussion's sake)
* something to prop up one end of the cake pans to create a slope

**Instructional Methods**

* Lecture inside, Carbon and nitrogen connectivity activities inside

**Evaluation Method**

* Essay

**Date Prepared / Modified:**

* August 10th, 2022

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## Goal: This lesson explores the inherent interactions between ecosystems, by tracing fertilizer and carbon as constituents in water as each moves between defined systems, interacting with each system along the way.

## Learning Objectives:

## Interpret the Law of Unintended Consequences

## Describe source/sink mechanics

## Describe limiting nutrient concept

## Explain eutrophication

**Mississippi College and Career-Readiness Standards:**

* Aligns with ENV.1.5, ENV.2.5, ENV.3.1

**Prerequisite Instructor Knowledge:**

Scientific theory, method, and design.

**References:**  <https://nagt.org/nagt/teaching_resources/teachingmaterials/57695.html>

**INTRODUCTION**

**Ecosystem Connectivity Lesson Overview:**

* Engage with students prior to the lecture to conduct the Sponge Wetlands activity
* Conduct Ecosystem Connectivity Activity: Carbon and Ecosystem Connectivity Activity: Nitrogen
* Share results and determine implications of Ecosystem Connectivity Activities: Carbon & Nitrogen
* Evaluate students understanding of concepts by assigning them to research and write an essay on a different water system

**LECTURE**

**Engage with students by conducting the Sponge Wetlands activity (10 min)**

1. Review provided reference PPT slides to introduce key concepts of this lesson.

[**5\_Reference Slides**](https://docs.google.com/presentation/d/1laC8aILlw9Q6wYs7-fAps_Jj9K4LwbGg_SwSo275NCQ/edit?usp=sharing)**- \*SEE PROVIDED PPT SLIDES\***

1. Begin this lecture with an interactive activity. The Sponge Wetlands activity demonstrates several landscape-level wetland processes that function as ecosystem services to human interests.

[**Sponge Wetlands Description**](https://docs.google.com/document/d/1dKQqXYL33K6SiVs-LDi8r4tRW4X036iEl_ceiLXvHyo/edit?usp=sharing)**- \*SEE PROVIDED DOC FOR ACTIVITY DESCRIPTION\***

\*Preparation and setup are included in the above document.

**Demonstration:**

* The general premise is to model sediment-laden, nutrient-rich water running down the landscape, over comparable terrains (Wetland, Mudflat, Asphalt). The results offer a range of discussion opportunities, and you can touch on as many/little of them as you like.
* Successively go through each Cake Pan (recommended: Asphalt first, Mudflat second, Wetland third). Tell students you will pour the muddy water into the elevated end of the cake pan. Ask students to hypothesize what they expect to happen in regard to...

1) flux of water movement (from elevated end to lower end); ie, SPEED and AMOUNT

2) clarity of water at the lower end ("ocean") when it reaches there

3) amount of fertilizer reaching the lower end ("ocean")

4) amount of water that leaks into the lid ("aquifer")

5) clarity of water that leaks into the lid

6) sustainability of the system (ie, if you continued pouring muddy water, would the system react the same way?)

7) amount of water trapped upland (ie, in sponges)

8) amount of sediment and/or fertilizer trapped upland

**Conduct Ecosystem Connectivity Activity: Carbon & Nitrogen activities (30 minutes)**

* There are two similar activities in this lesson, one on the nitrogen cycle and the other on the carbon cycle.
* The two activities in this lesson have been modified from the National Association of Geoscience Teachers  ‘The Carbon Cycle Game” available at: <https://nagt.org/nagt/teaching_resources/teachingmaterials/57695.html>
  + Refer to the link for full activity instructions.

**\*SEE BELOW FOR PREPARED RESOURCES\***

**-**[**Paper Dice Template**](https://docs.google.com/document/d/11TecbFZQ41WznbGM7fhH4QFSIV5UsMkw-QD4qNbgiwQ/edit?usp=sharing) **- \*Needed for both activities\***

**-**[**Nitrogen Journey Reservior Cards**](https://docs.google.com/document/d/1IPlqf_KplHHJpWeYsBN4u5gKH7X6i1iUIU4btke_f5M/edit?usp=sharing) **- \*Used for nitrogen activity\***

**-**[**student\_handout\_nitrogen\_cycle**](https://docs.google.com/document/d/1KQNz-pPSXvusKWgLArKp4-aHh_ZoBVEY4NSC5YbwbDw/edit?usp=sharing) **- \*Print for students - nitrogen activity\***

**-**[**Carbon Journey Reservior Cards**](https://docs.google.com/document/d/1Co8PS3EC6pwZanaKEY8YzDqGlJVJz4KtOSSKrc6niaA/edit?usp=sharing)**- \*Used for carbon activity\***

**-**[**student\_handout\_carbon\_cycle**](https://docs.google.com/document/d/1KmbzIGJfJVRDK6q2EdbZrOCKz5GtoFmR6fmslm6fQIU/edit?usp=sharing) **- \*Print for students - carbon activity\***

**Ecosystem Connectivity Activity: Nitrogen**

**Materials**:

* Reservoir signs for each station.
* Dice (14, At least one for each station, but it is helpful to have more than one )
* Copies of the Student worksheet for each student.
* Place the reservoir cards around the room, each with one or more dice.

**Guiding Students through Activity:**

1. Assign students to the different reservoirs as follows:
   * Have approximately half of your students start in the three Nitrogen Gas reservoirs, with most of them in the atmosphere. The rest of the students can be scattered evenly throughout the other reservoirs.  For small class sizes, start your students all off as atmospheric nitrogen.
2. Make sure students record every roll, including those times when they remain in a reservoir.

1. Students will get “stuck” in certain reservoirs and may think they have done something wrong.  Encourage them to follow the instructions.
2. When students have filled their recording sheets, have them return to their seats to draw their concept maps indicating flux mechanisms as arrows and reservoirs as bubbles.
3. When students have completed their concept maps, change the Reservoir cards to the Round 2 cards. Have the students begin with the same ratios as in the first round and have them repeat the process.
4. When students have completed Round 2, make sure they make a new concept map and write a paragraph or sketch a Venn Diagram comparing the two concept maps.
5. Discuss observations with the whole class.

**Ecosystem Connectivity Activity: Carbon**

**Materials:**

* Reservoir signs for each station.
* Dice (9, At least one for each station, but it is helpful to have more than one)
* Copies of the Student worksheet for each student.
* Place the reservoir cards around the room, each with one or more dice.

**Guiding Students through Activity:**

1.Assign students to the different reservoirs to estimate the relative abundance of carbon in each reservoir in our simulated region using the table below as a guide. Have them move to those stations.

* Almost all carbon (>99.9%) on earth is trapped in sediments, rock, and the deep ocean, so in reality, every student should be located in that reservoir.  However, for practicality, the students will not start there and instead represent the abundances in the rest of the reservoirs.  They will use all reservoirs for the game, however.
* For small class sizes, have all students start as fossil fuels.

|  |  |
| --- | --- |
| *Reservoir* | *# of students out of 30* |
| **Atmosphere** | 1 |
| **Soil** | 6 |
| **Subtidal Marsh Channels** | 1 |
| **Marine Biosphere** | 3 |
| **Deep Ocean** | \*\*\* |
| **Marsh Grass, Lowland Forest, and Upland Prairie** | 2 |
| **Marine Sediment & Rocks** | \*\*\*\* |
| **Fossil Fuels** | 16 |
| **Freshwater, River Delta, and Estuary** | 1 |

2. Make sure students record every roll, including those times when they remain in a reservoir.

3. Students will get “stuck” in certain reservoirs and may think they have done something wrong.  Encourage them to follow the instructions.

4. When students have filled their recording sheets, have them return to their seats to draw their concept maps indicating flux mechanisms as arrows and reservoirs as bubbles.

5. When students have completed their concept maps, change the Reservoir cards to the Round 2 cards.  Have the students begin with the same ratios as in the first round and have them repeat the process.

6. When students have completed Round 2, make sure they make a new concept map and write a paragraph or sketch a Venn Diagram comparing the two concept maps.

7. Discuss observations with the whole class.

**Elaborate on Results with Class (20 minutes)**

* In assessing and understanding the connectivity between ecosystems, it is critical to first *define your system*. This will determine whether a segment within that system is a *source* or a *sink*.

1. Test students’ understanding of defining systems and of sources and sinks within a defined system. Also test ambiguities when the system isn’t well defined (consider time scales as well).

2. Bring it all back to the small system you defined in the Sponge Wetlands Activity.

* What is your defined system?
* What are sources and sinks?
* What are the potential impacts if this really were a metaphor for a larger scale system?

-When the ocean and the atmosphere become the sink for carbon in the form of CO2, it has impacts on inhabitants existing within those sinks, directly and indirectly. Not to be fully explored, but CO2 is accumulating in the atmosphere and oceans. Physically, we know the direct impact it CAN have on systems, but what we don’t fully understand and are continuing to explore is how those systems respond, if they’re resistant or resilient enough for this forcing.

**EVALUATION**

**Evaluate Students Understanding - Essay Prompts (5 min)**

* Research Essay: choose a system other than the Mississippi River. Based on what you’ve learned in this lesson…

1. Define your system (where do you start to track the water; where does it end up). Identify at least 4 specific major biomes within your system. (10%)
2. Identify two substantial sources within your system for each of the following: carbon, nitrogen, phosphorus, and water. For each constituent, identify the largest sink within the system you define. (40%)
3. As far as nutrient pollution goes and human communities’ ability to influence the amount of nitrogen and phosphorus inputs, give your system a health rating: A, B, C, D, or F. Cite two strong reasons for your health rating. (10%)
4. Offer one change human communities in your system could make to improve their health rating. Would that change be enough to increase the system’s health rating one letter grade, by your measure? Justify your response. (40%)

* Offer students several options from around the world, basically any river system will do.

* Have students assess the relative abundance of agricultural, riverine, lacustrine (lakes), and marsh before hitting the ocean. Alternatively, lakes may serve as the final sink.

* Three strong indications of success are unique propositions students offer (suggestive of engagement on a creative level), abundance of detail in response/relationships between substantiations (engagement on enthusiasm level), and/or soundness of practical application (suggestive of comprehensive/knowledge engagement).

* It is important that their *reasoning* is logical. It is less important that students hit all categories of creativity, detail, and practical applicability. There is value in each, and it’s a honed process that professionals slowly develop each aspect.