Hellbender Education

LESSON PLAN 3: WATERSHED EXPLORATION

MIDDLE SCHOOL STANDARDS ADDRESSED (BY STATE):

NGSS (Kentucky, Maryland)	**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.** ***Clarification Statement:*** Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources. ***Disciplinary Core Ideas:*** • Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. • 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. • Growth of organisms and population increases are limited by access to resources. **MS-LS2-2: Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.** ***Clarification Statement:*** Emphasis is on predicting consistent patterns of interactions in different ecosystems in terms of the relationships among and between organisms and abiotic components of ecosystems. Examples of types of interactions could include competitive, predatory, and mutually beneficial. ***Disciplinary Core Ideas:*** • Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared. **MS-LS2-3: Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.** ***Clarification Statement:*** Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system. ***Disciplinary Core Ideas:*** • Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within 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-LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.** ***Clarification Statement:*** Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems. ***Disciplinary Core Ideas:*** ● 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-LS2-5: competing design solutions for maintaining biodiversity and ecosystem services.** ***Clarification Statement:*** Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations. ***Disciplinary Core Ideas:*** ● Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. 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, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling. *(secondary)* ● (ETS1.B) There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. *(secondary)*
Pennsylvania	**4.1.7.A.: Describe the relationships between biotic and abiotic components of an ecosystem.** ● Compare and contrast different biomes and their characteristics. ● Describe symbiotic and predator/ prey relationships. **4.5.6.D.: Identify reasons why organisms become threatened, endangered, and extinct.** **4.2.7.A: Explain how water enters, moves through, and leaves a watershed.** ● Explain the concept of stream order. ● Describe factors that affect the flow and water quality within a watershed. **4.2.6.C.: Identify natural and human- made factors that affect water quality.**

	4.2.7.C.: Use appropriate tools and techniques to analyze a freshwater environment. ● Interpret physical, chemical, and biological data as a means of assessing the environmental quality of a freshwater environment. **4.2.8.C.: Describe how a diversity index is used to assess water quality.**
West Virginia	**S.6.LS.1: Students will construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.** **S.6.LS.5: Students will analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.** **S.6.LS.6: Students will develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.** **S.6.LS.7: Students will construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.** **S.8.LS.2: Students will construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.**
Virginia	**LS.6: The student will investigate and understand that organisms within an ecosystem are dependent on one another and on non living components of the environment. Key concepts include** a) the carbon, water, and nitrogen cycles; b) interactions resulting in a flow of energy and matter throughout the system; c) complex relationships within terrestrial, freshwater, and marine ecosystems; and d) energy flow in food webs and energy pyramids. **LS.9: The student will investigate and understand how organisms adapt to biotic and abiotic factors in an ecosystem. Key concepts include** a) differences between ecosystems and biomes; b) characteristics of land, marine, and freshwater ecosystems; and c) adaptations that enable organisms to survive within a specific ecosystem. **LS.10: The student will investigate and understand that ecosystems, communities, populations, and organisms are dynamic, change over time, and respond to daily, seasonal, and long-term changes in their environment. Key concepts include** a) phototropism, hibernation, and dormancy; b) factors that increase or decrease population size; and c) eutrophication, climate changes, and catastrophic disturbances.

	LS.11: The student will investigate and understand the relationships between ecosystem dynamics and human activity. Key concepts include a) food production and harvest; b) change in habitat size, quality, or structure; c) change in species competition; d) population disturbances and factors that threaten or enhance species survival; and e) environmental issues.
North Carolina	**8.L.3: Understand how organisms interact with and respond to the biotic and abiotic components of their environment.** ● 8.L.3.1: Explain how factors such as food, water, shelter and space affect populations in an ecosystem. ● 8.L.3.3: Explain how the flow of energy within food webs is interconnected with the cycling of matter (including water, nitrogen, carbon dioxide and oxygen
Tennessee	**6.LS2: Ecosystems: Interactions, Energy, and Dynamics** 1. Evaluate and communicate the impact of environmental variables on population size. 2. Determine the impact of competitive, symbiotic, and predatory interactions in an ecosystem. 3. Draw conclusions about the transfer of energy through a food web and energy pyramid in an ecosystem. 6. Research the ways in which an ecosystem has changed over time in response to changes in physical conditions, population balances, human interactions, and natural catastrophes. 7. Compare and contrast auditory and visual methods of communication among organisms in relation to survival strategies of a population. **7.LS2: Ecosystems: Interactions, Energy, and Dynamics** 1. Develop a model to depict the cycling of matter, including carbon and oxygen, including the flow of energy among biotic and abiotic parts of an ecosystem.

HIGH SCHOOL STANDARDS ADDRESSED (BY STATE):

NGSS (Kentucky, Maryland)	**HS-LS2-2: Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.** ***Clarification Statement:*** Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data. ***Disciplinary Core Ideas:*** ● Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such

challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem.

- A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.

HS-LS2-6: Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.

Disciplinary Core Ideas:

- A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.

HS-LS2-7: Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

Clarification Statement: Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.

Disciplinary Core Ideas:

- Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species.
- Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). *(secondary)*
- Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation,

	overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. *(secondary)* ● (ETS1.B) When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts. *(secondary)*
Pennsylvania	**4.1.12.E.: Research solutions addressing human impacts on ecosystems over time.** **4.2.10.A.: Examine the interactions between abiotic and biotic factors within a watershed.** ● Describe how topography influences the flow of water in a watershed. ● Describe how vegetation affects water runoff. ● Investigate and analyze the effects of land use on the quality of water in a watershed. **4.2.12.A.: Examine environmental laws related to land use management and its impact on the water quality and flow within a watershed.** **4.2.10.C.: Explain the relationship between water quality and the diversity of life in a freshwater ecosystem.** ● Explain how limiting factors affect the growth and reproduction of freshwater organisms. **4.2.12.C.: Analyze the effects of policies and regulations at various governmental levels on water quality.** ● Assess the intended and unintended effects of public policies and regulations relating to water quality.
West Virginia	**S.10.LS.11: Students will use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.** **S.10.LS.12: Students will evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.** **S.10.LS.13: Students will design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.**

	S.HS.ENV.21: Students will use GIS data to analyze the parameters of a watershed and interpret physical, chemical and biological data as a means of assessing environmental quality.
Virginia	**BIO.8: The student will investigate and understand dynamic equilibria within populations, communities, and ecosystems. Key concepts include** a) interactions within and among populations including carrying capacities, limiting factors, and growth curves; b) nutrient cycling with energy flow through ecosystems; c) succession patterns in ecosystems; d) the effects of natural events and human activities on ecosystems; and e) analysis of the flora, fauna, and microorganisms of Virginia ecosystems.
North Carolina	**Bio2.2: Understand the impact of human activities on the environment (one generation affects the next).** ● Bio2.2.1: Infer how human activities (including population growth, pollution, global warming, burning of fossil fuels, habitat destruction and introduction of nonnative species) may impact the environment. ● Bio2.2.2: Explain how the use, protection and conservation of natural resources by humans impact the environment from one generation to the next.
Tennessee	**BIO1.LS2: Ecosystems: Interactions, Energy, and Dynamics** 1. Analyze mathematical and/or computational representations of population data that support explanations of factors that affect population size and carrying capacities of populations within an ecosystem. Examine a representative ecosystem and, based on interdependent relationships present, predict population size effects due to a given disturbance.

STUDENT OBJECTIVE: Students will:

a) Understand that habitats throughout Appalachia are connected by various processes.
b) Evaluate the impact that habitat connectivity has on Appalachian fauna, particularly hellbender salamanders.
c) Relate the concept of stream order to the way that water flows through a watershed across multiple spatial scales.
d) Recognize the multitude of ways that human activity can impact water quality and species within the watershed.

LESSON OVERVIEW:

Time	Instructional Sequence	Activity Summary
10 min	Engage	*Where is your Watershed?* Google Earth
40 min	Explore	*Build a Watershed* Activity
20 min	Explain	*Watersheds and Human Impacts* Powerpoint
40 min	Elaborate	*Your Impaired Waterways* Activity (Google Earth)

10 min	Evaluate	*A Letter to Your Representative* (could be given as an out-of-class assignment)

LESSON STEP 1: ENGAGE
Objective: Students will review the watershed concept and relate this to their local geography.

Materials:
- Computer with internet access and a projector
- Google Earth application
- KML Watershed Index downloaded from the USGS website (found here)
- WATERSKMZ file downloaded from the EPA website (found here)

Sequence:
1. Prior to class, teacher should ensure that the Google Earth application is downloaded on their computer, along with the KML Watershed Index file.
2. The teacher should facilitate a short discussion that elicits students' prior knowledge of watersheds (many states teach this concept as early as elementary school) by asking the following questions:

   What does the word "watershed" mean?

   When it rains here, where does the water go?

   Why do you think it important to study stream and river ecosystems at the "watershed" scale?

3. The teacher should open the KML Watershed Index file in the Google Earth application and zoom in on their particular region to identify the watershed. Again, the teacher can facilitate class discussion by asking the following questions:

   Where does the water flow from where we are?

   How does this watershed compare in size to some of the other ones around us?

LESSON STEP 2: EXPLORE
Objective: Students will construct their own watershed model to
1. Understand how water flows from headwaters to higher order rivers.
2. Identify stream order.
3. Recognize the connectivity of terrestrial and aquatic habitats.

Materials:
- Large aluminum pans, 1 per group
- Sand, dirt, and/or gravel
- Large pieces of heavy duty aluminum foil, 1 per group
- Spray bottle filled with water
- Food coloring

- *Build a Watershed* Student Handout
- *Build a Watershed* PowerPoint

Sequence:

1. Teacher should gather all materials at stations for groups prior to the start of class.
2. Teacher should begin by displaying a diagram of a watershed on the screen (in the *Build a Watershed* PowerPoint).
3. Students will examine the numbering of stream orders in the displayed picture in order to devise a set of 3 rules about how stream order is determined.
4. Teacher should ask for student groups to contribute one rule each that they came up with in order to have a consensus on the rules for determining stream order.
5. The rules for determining stream order are:
   Rule 1: Stream order only increases when two streams of the same order come together.
   Rule 2: Increase in stream order happens only by one increment.
   Rule 3: When two streams of different order join, the stream remains the higher number.
6. Students should record these three rules on their handout.
7. Students should answer the pre-lab questions.
8. Students should proceed to build their watershed and then test waterflow in their watershed with supervision from the teacher.
9. Students should create a diagram of their watershed and label stream order and confluences.
10. Students should answer the post-lab questions.

LESSON STEP 3: EXPLAIN
Objective: Students will review stream order, key watershed features, and human impacts in watersheds.

Materials:

- Computer and projector
- *Watersheds and Human Impacts* PowerPoint
- *Watersheds and Human Impacts* Student Notes Sheet

Sequence:

1. Once students are finished with the *Build a Watershed* activity, teacher should present this PowerPoint.
2. Students should record notes on their Student Notes sheet during the teacher's presentation.

LESSON STEP 4: ELABORATE – *Your Impaired Waterways* Activity
Objective: Students will examine data on surface water from the Environmental Protection Agency in order to

1. Recognize proximity to local rivers and streams.
2. Identify the impact that land cover has on waterways.
3. Understand how biologists use bioindicator species to help determine the health of a particular waterway.

Materials:

- Computer with internet access, Google Earth, and WATERSKMZ (downloaded from the EPA website)

- *Your Impaired Waterways* Student Handout

Sequence:

1. Prior to class, teacher should set up computers with Google Earth software (free download) and download the WATERSKMZ file from EPA.gov onto the desktop of each computer.
2. Students should work in pairs.
3. Teacher can go over the background section of the student handout with the class, and then should allow students to work through the handout.
4. Teacher should circulate to help students with answering questions and assist with Google Earth mapping.
5. At the end of the activity, teacher can facilitate a discussion of some of the questions from the packet, particularly the last question about hellbenders.

LESSON STEP 5: EVALUATE

Objective: Students will demonstrate their knowledge of habitat connectivity, the watershed concept, and human impacts in watersheds.

Materials:

- *A Letter to Your Representative* Student Handout

Sequence:

1. This assignment can be given as homework.
2. If completed in class, the teacher should explain the objectives of the assignment and that it will be used as an assessment for the lesson, and then let students write quietly.