Global Watershed Unit Overview Template
Ashley Coble

1. Unit Title: Ecology: trophic levels, populations, & nutrient cycling

2. Target Grade Level: High School Biology (10^{th} Grade)

3. Content Standards Addressed:
B3.2C Draw the flow of energy through an ecosystem. Predict changes in the food web when one or more organisms are removed.
B3.3A Use a food web to identify and distinguish producers, consumers, and decomposers and explain the transfer of energy through trophic levels.
B3.5A Graph changes in population growth, given a data table
B3.5B Explain the influences that affect population growth
B3.5Ee Recognize that and describe how the physical or chemical environment may influence the rate, extent and nature of population dynamics within ecosystems.
B3.5f Graph an example of exponential growth. Then show the population leveling off at the carrying capacity of the environment.
L3.p2C Describe the role of decomposers in the transfer of energy in an ecosystem
L3.p3B Distinguish between the living (biotic) and nonliving (abiotic) components of an ecosystem.
L3.p3C Explain how biotic and abiotic factors cycle in an ecosystem (water, carbon, oxygen, and nitrogen)
L3.p3D Predict how changes in one population might affect other populations based upon their relationships in a food web.
L3.p4A Recognize that, and describe how, human beings are part of Earth's ecosystems. Note that human activities can deliberately or inadvertently alter the equilibrium in ecosystems.
L3.p2B Describe common ecological relationships between and among species and their environments (competition, territory, carrying capacity, natural balance, population, dependence, survival, and other biotic and abiotic factors.

4. Learning Objectives- How students will demonstrate the knowledge and skills they have gained from this unit.

- Students will be able to describe abiotic and biotic factors which have caused a change in the population sizes of wolves and moose.
- Students will be able to graph changes in population biomass at each level of the food chain based on changes in top predator biomass (1. strong year class; 2. partial winter kill).
- Students will be able to describe the flow of energy through an ecosystem and will discuss how the food web will change when one or more organisms are removed.
- Students will be able to draw their own food web and to identify producers, consumers and decomposers.
- Students will be able to explain the transfer of energy through each of these trophic levels.
- Students will be able to graph change in population growth based on a table of number of individuals and time, which the students will generate. Students will graph an example of exponential growth and then they will show the population leveling off at carrying capacity.

- Students will be able to explain which density independent and density-dependent factors may affect population sizes of coaster brook trout. These explanations will be discussed in class and the students will include their explanations in their lab reports.
- Student will be able to describe how the physical or chemical environment may change population dynamics in an aquatic ecosystem. This will be discussed in class and incorporated into their final lab reports
- Students will be able to explain the multiple factors that can affect population growth. Students will explain potential factors that affect population size of native coaster brook trout. This will be discussed in class and incorporated into their final lab reports
- Students will understand the role of decomposers in the transfer of energy by describing the role of decomposition in a fen, bog, and lake. Students will show their understanding during a class discussion and reinforce their understanding by completing a decomposition experiment.
- Students will be able to distinguish between living and nonliving components of an ecosystem and they will demonstrate this to their teacher during a field trip to Lake Perrault.
- Students will explain how biotic and abiotic factors cycle in an ecosystem by describing these processes to their teacher and classmates during a field trip. Students will measure nutrient concentrations and water quality parameters and discuss why these factors vary in different ecosystems (lake, bog, fen)
- Students will recognize and describe how human activities can alter the equilibrium of a fen and bog and will discuss the sensitivities of these ecosystems in class.
- Conduct background research prior to the field trip and experiment
- Formulate hypotheses based on background information prior to conducting the experiment
- Through observations of species present at Lake Perrault students will be able to describe how species are connected with their environments by explaining it to their teacher and including this on their interpretive sign.
- Students will be able to describe the role of decomposers in the transfer of energy in an ecosystem by describing the role of decomposition in a fen versus other ecosystem types.
- Students will be able to distinguish between living and nonliving components of an ecosystem and they will demonstrate this to their teacher during a field trip to Lake Perrault.
- Students will be able to explain how biotic and abiotic factors cycle in an ecosystem by describing these processes to their teacher and classmates during a field trip and including examples of each on an interpretive sign.
- Students will be able to recognize and describe how human activities can alter the equilibrium of a fen and will discuss the sensitivities of a fen in class. The students will also include a section on either the importance of conserving the fen or on human impacts on their interpretive sign.

5. Brief Summary of Unit

Through this unit students will gain a better understanding of how organisms interact with their environment. Students require a basic understanding of ecosystem ecology, regardless of their future career paths, because they will need to make decisions regarding the use of their local watersheds to preserve biodiversity, ecosystem function, and water quality. Additionally, students may utilize this knowledge to encourage others to appreciate and value bogs, fens, lakes, and the biological communities they support. Understanding nutrient cycling is integral for understanding carbon and its role in climate change. It is also important for understanding

nitrogen (N) and phosphorus (P) and their role in maintaining healthy aquatic and terrestrial organisms. For example, eutrophic systems (too much N or P) can negatively affect fish populations, which are an important source of food in the Great Lakes region and elsewhere. Additionally, timber is another important industry in much of the United States, and all terrestrial plants and trees rely on N and P for growth. Each of these lessons will provide students with a better understanding of their local watersheds.

This unit can be taught at the beginning of the fall semester. The field trip should take place in late summer or early fall before plants freeze. Freezing is also an issue for retrieving leaf litter bags.

This ecology unit ties in with many other units in Biology such as: photosynthesis, genetics (of plants, animals, humans), and evolution. Ecology itself teaches students how organisms interact in their environment. Each of the other units in Biology are related to this concept. For example, genetics are relevant to the lesson on coaster brook trout. The number of spawning locations of coasters has declined over time; however, the coaster is not genetically distinct from brook trout and it is considered the same species as brook trout. If coaster brook trout were a genetically distinct species, they would likely be protected by law considering their low population size.

For the first lesson, it is expected that students will have been introduced to food chains in previous years. Students will be comfortable creating their own food chains, and in this lesson will use their previous knowledge to understand how changes at one trophic level affect all other trophic levels. For the second lesson, the teacher will remind students that in a food web, a change at any trophic level can affect all other organisms in the community (learned in lesson 1). Students will use this prior knowledge to answer questions such as: what factors affect the size of a population? Which factors may cause a decline in population size? How may resource availability affect population size? Are all factors dependent on the size of a population? For the third lesson, students should have previously been introduced to basic nutrient cycling concepts (N,P, C), water cycling, abiotic & biotic factors, and invasive species (through lessons from their teacher, not part of this unit). The fourth lesson will be introduced prior to the students' field trip to a bog, fen, and lake so they can formulate ideas for the interpretive sign while on the field trip. This lesson will integrate their knowledge from all previous lessons in the unit. It will be expected that students have prior knowledge of trophic levels (Lesson 1), potential human impacts (Lesson 2), nutrient cycling (Lesson 3), and invasive species, bogs and fens (Lesson 3).

6. Table of Lessons

Lesson Title- Brief Description	Learning Objectives	Content Standards
Predator prey relationships & predicting changes in a food web prey – Determining how a change in top predator population affects other trophic levels and graphing expected changes over time	• Students will be able to describe abiotic and biotic factors which have caused a change in the population sizes of wolves and moose. • Students will be able to graph changes in population biomass at each level of the food chain based on changes in top predator biomass (1. strong year class; 2. partial winter kill). • Students will be able to describe the flow of energy through an ecosystem and will discuss how the food web will change when one or more organisms are removed. • Students will be able to draw their own food web and to identify producers, consumers and decomposers. • Students will be able to explain the transfer of energy through each of these trophic levels.	L3.p3D Predict how changes in one population might affect other populations based upon their relationships in a food web B3.2C Draw the flow of energy through an ecosystem. Predict changes in the food web when one or more organisms are removed. B3.3A Use a food web to identify and distinguish producers, consumers, and decomposers and explain the transfer of energy through trophic levels.
Population dynamics and migratory brook trout (a.k.a. coasters)– graphing changes in populations, understanding how native coaster brook trout populations relate to historic	• Students will be able to graph change in population growth based on a table of number of individuals and time, which the students will generate. Students will graph an example of exponential growth and then they will show the population leveling off at carrying capacity.	B3.5A Graph changes in population growth, given a data table B3.5B Explain the influences that affect population growth B3.5E Recognize that and describe how the physical or chemical environment may influence the rate, extent and nature of population dynamics within ecosystems. B3.5f Graph an example of exponential growth. Then show the population leveling off at the carrying capacity of

populations, and identifying causes of population decline over time	• Students will be able to explain which density independent and density-dependent factors may affect population sizes of coaster brook trout. These explanations will be discussed in class and the students will include their explanations in their lab reports. • Student will be able to describe how the physical or chemical environment may change population dynamics in an aquatic ecosystem. This will be discussed in class and incorporated into their final lab reports • Students will be able to explain the multiple factors that can affect population growth. Students will explain potential factors that affect population size of native coaster brook trout. This will be discussed in class and incorporated into their final lab reports	the environment.
Decomposition and water quality in bogs, fens, and lakes– After learning about decomposition and water quality characteristics, the student will take a field trip where they will collect water samples to analyze in the lab.	• Students will understand the role of decomposers in the transfer of energy by describing the role of decomposition in a fen, bog, and lake. Students will show their understanding during a class discussion and reinforce their understanding by completing a decomposition	L3.p2C Describe the role of decomposers in the transfer of energy in an ecosystem L3.p3B Distinguish between the living (biotic) and nonliving (abiotic) components of an ecosystem. L3.p3C Explain how biotic and abiotic factors cycle in an ecosystem (water, carbon, oxygen, and nitrogen) L3.p4A Recognize that, and describe how, human beings are part of Earth's ecosystems. Note that human activities can deliberately or inadvertently alter

They will take field notes and distinguish between abiotic and biotic factors.	experiment. • Students will be able to distinguish between living and nonliving components of an ecosystem and they will demonstrate this to their teacher during a field trip to Lake Perrault. • Students will explain how biotic and abiotic factors cycle in an ecosystem by describing these processes to their teacher and classmates during a field trip. Students will measure nutrient concentrations and water quality parameters and discuss why these factors vary in different ecosystems (lake, bog, fen) • Students will recognize and describe how human activities can alter the equilibrium of a fen and bog and will discuss the sensitivities of these ecosystems in class. • Conduct background research prior to the field trip and experiment • Formulate hypotheses based on background information prior to conducting the experiment	the equilibrium in ecosystems.
Understanding fen, bog, & lake ecosystems through an interpretive sign – Students will develop an interpretive sign to	• Through observations of species present at the field sites students will describe how species are connected with their environments through their interpretive sign. • Students will understand	L3.p2B Describe common ecological relationships between and among species and their environments (competition, territory, carrying capacity, natural balance, population, dependence, survival, and other biotic and abiotic factors. L3.p2C Describe the role of

be placed at Lake Perrault (& nearby fen) and will incorporate knowledge learned throughout the ecology unit	the role of decomposers in the transfer of energy by describing the role of decomposition in a fen versus other ecosystem types. This will be shown through a decomposition experiment (lesson 3) and reported on their interpretive sign. • Students will be able to distinguish between living and nonliving components of an ecosystem and they will demonstrate this by describing abiotic and biotic factors on their interpretive sign. • Students will explain how biotic and abiotic factors cycle in an ecosystem by including examples of each on an interpretive sign. • Students will recognize and describe how human activities can alter the equilibrium of a fen. The students will also include a section on either the importance of conserving fens or bogs or on human impacts on their interpretive sign.	decomposers in the transfer of energy in an ecosystem L3.p3B Distinguish between the living (biotic) and nonliving (abiotic) components of an ecosystem. L3.p3C Explain how biotic and abiotic factors cycle in an ecosystem (water, carbon, oxygen, and nitrogen) L3.p4A Recognize that, and describe how, human beings are part of Earth's ecosystems. Note that human activities can deliberately or inadvertently alter the equilibrium in ecosystems.

7. Materials List for Each Lesson

Lesson 1:

- Graph paper
- Pencils
- Powerpoint of lesson
- Student handout

Lesson 2:

- Brown paper lunch bags (one per group)

- Goldfish crackers (5 different colors/types): rainbow and pretzel flavors; alternatively use colored beads or beans
- Scale: The teacher may choose to use a balance to weigh out portions of goldfish rather than counting; should be prepared prior to class and proportioned so that there is a "current" and "historical" population
- Marker (1 per group)
- Student handouts: instructions, data sheet
- Calculators
- Pencils
- Computer lab – if desired to have students create graphs in Excel

Lesson 3

- Vernier probes that measure: turbidity, nitrate (ion-selective electrode), pH, dissolved oxygen, & conductivity (2 or 3 of each, as available; 1 per group)
- Handheld device with Vernier software (TI calculator, LabPro, and connector cable) or Computer (with LabPro and connector cable) (1 per group)
- Thermometers (2 or 3)
- Clean bottles or mason jars for collecting water if analyzing samples in lab and not in the field (3/site; the water can be split for different analyses)
- Labeling tape and marker to label bottles
- Mesh bags (onion bags)
- Rocks to place in mesh bags for deployment (can be found at the field site)
- Rope or string to attach leaf bags
- Notebook for field notes
- Plant identification guide (recommended)
- Stake to secure rope
- Waders or boots
- Encourage students to bring cameras
- Computers equipped with Microsoft Excel

Lesson 4:

- Powerpoint Presentation: showing examples of interpretive signs (good & bad)
- Grading rubrics (1/per student): students can critique interpretive signs
- Computer access: create their poster in powerpoint & access to additional information
- Student handout: Create a poster in Microsoft Powerpoint
- Lab Reports and figures from these lab reports (collected previously in Lesson 3)
- Pictures from field sites (taken previously in Lesson 3)
- Posterboard or printing services will be required for final Interpretive sign which will be posted at the field site

8. Safety Considerations

Lesson 1: None; students will be graphing changes in various levels of a food chain based on an alteration at the top of the food chain.

Lesson 2:

Paper cuts

Students will not be working with any dangerous materials and will simply be recording data and analyzing it.
If food items are kept clean then students may eat the goldfish after completion of the lesson.
Lesson 3: Students will be working near water and should dress appropriately with waders. Students should be careful not to soak their clothes while collecting samples, particularly on a cold day. Students will be working with calibration solutions, but none of these contain harmful chemicals.
Lesson 4: None; students will be creating their interpretive sign either in the classroom or in the computer lab using material they have already collected during the field trip (described in Lesson 2).

9. Evaluation Plan-Indicates the formative and summative assessment tools that will be used and the purpose of each tool.
Lesson 1: Students will draw food webs and will be graded using the rubric "Food Web Rubric". Students will be asked about their prior knowledge of food chains and food webs. Students will draw graphs showing how they think A.) the population of a piscivore (top predator); and B.) the biomass of primary producers will change in response to: 1) a strong year class of piscivores; and 2) a partial winter kill of piscivores. Through this assessment tool students will demonstrate their knowledge of how a change in one trophic level will affect other trophic levels. Through a class discussion of how populations will change at each trophic level students will gain experience interpreting graphs and will also gain experience in creating their own graphs. The class discussion will also explore the changes in a population at 5 year intervals. Students will also be evaluated based on their participation in these discussions.
Lesson 2: As a formative assessment, students will be asked about their knowledge of coaster brook trout. Students will also be asked about their understanding of historical changes in the Great Lakes basin that may affect fish communities. Students will have an opportunity to relate their local knowledge with changes in coaster brook trout populations over time. As a summative assessment, students will write conclusions based on data they collected during the laboratory and will their data as a figure(s) supporting their conclusions. Students will turn in a "partial" lab report, which will include their results (presented as figures) and their conclusions. The purpose of this assessment tool is to encourage students to understand why "historic" and "current" populations differ and to understand that many factors (natural and human-caused) can contribute to population size. The coaster.grading.rubric will be used to evaluate the partial lab report.
Lesson 3: While on the field trip, the teacher will ask the students questions about their observations. Students will be expected to identify some invasive plants or aquatic species while at the site. Students will compile their data as a class and produce their own lab reports. Each student will be expected to make connections between water quality, decomposition rates, and community dynamics. Each student will also be required to conclude whether or not their hypothesis was supported by the data. The purpose of this tool is to allow students to think critically about their data and learn to interpret the results. Furthermore, this tool will be useful when students prepare their interpretive signs (in lesson 4).
Lesson 4: Students will create an interpretive sign that will be displayed at Lake Perrault to inform visitors about the local fen ecosystem and Lake Perrault. The interpretive sign will include information about diversity of plants at Lake Perrault and the students will include their understanding of peat formation, rates of decomposition, water quality measurements (pH,

temperature, nutrient availability), and plant productivity to create their interpretive sign. The purpose of this assessment tool is for students to integrate their knowledge acquired during the ecology unit. Students will make connections among abiotic and biotic factors in a local ecosystem.

10. Resources (websites)

Lesson 1:

Material used for discussion of wolves and moose of Isle Royale acquired from:
http://isleroyalewolf.org/overview/overview/at_a_glance.html

Additional material shown in powerpoint was acquired from the following article:

Carpenter S.R., Kitchell J.F., Hodgson J.R. 1985. Cascading interactions and lake productivity. BioScience 35(10):634-639

Lesson 2: Maps of coaster brook trout populations acquired from:
http://www.tu.org/conservation/watershed-restoration-home-rivers-initiative/coaster-brookies-mn-wi-mi-on/background

List of native and non-native fish found in Lake Superior acquired from:
http://www.seagrant.umn.edu/fisheries/superior_fish_species

Video of coaster brook trout spawning available from:
http://www.superiorideas.org/projects/brook-trout

Additional material on coaster brook trout was acquired from the following article:

Huckins CJ, Baker E.A., Fausch K.D., Leonard J.B. 2008. Ecology and Life History of Coaster Brook Trout and Potential Bottlenecks in Their Rehabilitation. North American Journal of Fisheries Management 28:1321-1342. DOI:10.1577/M05-191.1

Lesson 3: General information about wetlands

These websites may be useful resources for the students.
http://water.epa.gov/type/wetlands/upload/2005_01_12_wetlands_overview.pdf
http://water.epa.gov/type/wetlands/bog.cfm
http://water.epa.gov/type/wetlands/fen.cfm
http://www.michigandnr.com/publications/pdfs/huntingwildlifehabitat/Landowners_Guide/Resource_Dir/Acrobat/BogsFens.PDF

This website provides vegetation identification keys for plants found in Michigan's Upper Pensinsula and may be useful for teachers in the region.
http://uptreeid.com/

All photographs of items found in bogs were collected online and are referenced in the powerpoint.

Lesson 4: Some examples of Interpretive Signs found at the following websites. However, I plan to photograph other interpretive signs to show students rather than rely on website images.
http://envirosigns.com/interpretive-design
http://gaiagraphics.com/new-interpretive-signs-for-the-morro-bay-national-estuary-program/

11. Brief description of how this unit relates to your graduate research.

This ecology unit encompasses a variety of topics in ecology and biology, and addresses the Michigan content standards as they relate to ecology. My dissertation research focuses on stream biogeochemistry utilizing an ecosystem ecology perspective. My research examines nutrient cycling in Lake Superior tributaries across seasons and spatial scales. My measurements incorporate field measurements to assess rates of nutrient uptake and laboratory measurements to assess biodegradation rates of dissolved organic carbon over time.

This ecology unit is closely related to my research interests. Understanding nutrient cycling is integral to understanding trophic levels in a food chain or web. Much of my work investigates the bottom of the food chain. I am interested in nutrients that are then incorporated into biomass. I am also interested in organic matter decomposition, which is another focus of the food web and nutrient cycling concepts that students are expected to learn. These concepts are covered by lessons one and three. The second lesson on coaster brook trout populations is peripherally related to my work. I am collaborating with Casey Huckins' at one of my research sites, the Salmon Trout River (Marquette county). This particular site is one of the few sites on the south shore of Lake Superior where coaster brook trout spawn. While it is not the focus of my research, it is the focus of Huckins' research group. As an ecosystem ecologist my work does not focus on one specific species, but rather considers the ecosystem as a whole. This ecosystem approach is highlighted throughout the ecology unit because students are expected to learn about food web dynamics, abiotic and biotic factors, and are further expected to make connections among these topics.

My work is best represented in the lesson on water quality characteristics of a lake, bog, and fen because the students will have an opportunity to analyze water chemistry. I am constantly measuring water chemistry of streams and the students will be measuring many of the characteristics that scientists often measure. The students will be expected to make connections between nutrients in the water, water temperature, pH, and the biological communities present. Additionally, in lesson three, I have proposed that students conduct their own experiment on decomposition. Decomposition is often measured by ecologists in terrestrial and aquatic ecosystems. I am currently measuring leaf decomposition at one of my study sites as part of an organic matter budget. The students will hopefully have an opportunity to tie in the differences in nutrient availability and water characteristics with rates of decomposition. Overall, this unit covers a variety of topics in ecology that relate to my research in different ways. I am striving to incorporate my own work into the lessons to give students a better understanding of how what they are measuring is similar to work conducted by scientists.