

**Sixth-Grade Outdoor Environmental
Education Program at the BSD Gordon
Carter Environmental Education Site**

**Huxley College of the Environment, Western
Washington University**

**In partnership with Whatcom Middle School,
Bellingham Public Schools**

May 9-17, 2013

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Vision

We, as environmental educators, want to help sixth grade students from Whatcom Middle School develop a sense of place and an appreciation for their “own backyards”- the land around the Lake Whatcom watershed in which they live. Meanwhile educating them about the watershed that supplies Bellingham’s drinking water. By facilitating exploration and introducing local environmental issues that affect their lives (including the concepts of habitat, niches, tolerance, limiting factors, nutrient overloading, pollution, watershed ecology, and human interactions), we hope to inspire and encourage our students to become stewards of their environment and develop a deeper understanding of the natural world and their influence within it.

Goals

- Develop a sense of place towards Lake Whatcom and the Greater Bellingham area among students
- Educate students about the Lake Whatcom watershed so that they can apply the information in their simulated county council meeting lesson while considering diverse perspectives
- Help reinforce as well as foster a foundation of scientific ecological knowledge
- Encourage students’ critical thinking and problem solving skills
- Inspire students to become stewards of Lake Whatcom, the surrounding area, and the natural world

Creative Approach/Theme

To help the students further understand the natural history, ecology, and issues regarding Lake Whatcom we will examine the watershed throughout time. We will be taking the Whatcom Middle School students back in time to the year 1886. Once the students arrive in 1886, guided by their time traveling naturalists, we will meet up with a Lake Whatcom homesteader. The very knowledgeable yet ungrammatical homesteader, who lives close to the land and knows the Lake Whatcom area well, will help guide the students in learning about how humans have treated Lake Whatcom in the past. By the end of the two days of Outdoor school, the time traveler naturalist and hillbilly homesteader will have provided the Whatcom Middle School students with the knowledge and motivation to live and work towards a cleaner Lake Whatcom in the future.

Note: Each teaching group will be using a different variation of this creative theme.

Learners:

Characteristics to utilize with Learners:

- Engage & perform best by making it social
- Lots of physicality; very capable intellectually
- Freedom in class - communicates trust, respect & expectation of responsibility.
- Friendly, communicate liking them, supportive, warm empathic tone, smile a lot!

Effective Approaches Towards the 6th Grade Learners

- Provide transition into activity - eg, by reminding of previous similar work
- Multi-modal -- visual, auditory, tactile
- Front-load & realistically frame learning big ideas, essential questions, goals and performance
- Big ideas articulated, come through clearly in design, and iterated at end & assess for transfer

- Share and explain own answers
- Calm, clear speech, relaxed manner
- Self-grading: go through answers led by teacher, self-assess
- Use questions to stimulate attn. to task
- Clear instructions and hands-on activity structure without competing activity
- Adjustments & flexibility
- Address issue or discipline not by singling out, but by raising it with group, providing metaphor, discussing w/ whole
- Encourage / call for confidence. Model.
- Counteract low self-efficacy beliefs with observation of past success
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General Overview of Learners

The students at Whatcom middle school are a predominantly Caucasian but there are some other ethnicities in the classes. They range from age 11-12 and there seemed to be a fairly even ratio of girls to boys. The students range from kids who seem very engaged in the assignments to kids who just wanted to talk with their friends and goof off. From given knowledge and resources, the students come from all types of family backgrounds; some seem very mature for their age (independently studying and working far ahead of other students), most seem like they are as mature as any 11 year old should be. They seem to learn the best by doing hands on assignments (example: experiment where they pull rubber bands to measure force in lbs). There are a lot of very unique personalities in this group of students; it will be a great group to bring out to a natural setting and have them get to know each other and the forest better.

In general, 11-12 year old students learn best by incorporating multi-modal activities. At this age they are beginning to learn who they are as individuals. Engaging in multiple senses and ways of thinking can help to create a full picture. Incorporating hands on activities can make conceptualizing ideas easier. Clear communication up front, supporting curiosity and giving them the freedom to explore their curiosity is key to effective lessons.

Consistent Themes to Utilize with the 6th Grade Learners include:

- WMS 6th grade "Pillars": Show compassion, be a good steward, strive for excellence, be tenacious.
- "Gratitudes" / gratitude journals: write or talk about things they are grateful for
- To get attention: drumming on desk; 5-4-3-2-1clap; tell story of own experience
- Thinking maps

Institutional Partners:

Whatcom Middle School, like all of the schools in the Whatcom school district follow the *Bellingham Promise*. This promise lays out a set of beliefs and values that Whatcom Middle School lives by:

Vision: We, as a community, make a collective commitment to Bellingham's children. We will empower every child to discover and develop a passion, contribute to their community, and achieve a fulfilling and productive life.

Mission: We collectively commit that our students are cared for and respected, and that they will graduate from our schools prepared for success in the global community. Each will be exceptional in his or her own way, with strong character, a passion for

learning, and ready for the widest range of educational and vocational options to support a diversity of life choices.

Core Beliefs:

- all children should be loved
- the whole child is important
- every child can learn at high levels
- early learning and development are critical
- learning is lifelong and essential to a high quality of life
- compassion and service build community
- teaching children to do their best involves self-reflection and reaching higher
- diversity enhances a strong and healthy community
- together we achieve more than alone

Each and every Spring Block student's aims to meet these needs set out by the Bellingham School District. We hope that through experiential learning, we can help students foster a natural love for the outdoors and at the same time, educate them about wilderness ecosystems and the life/processes that occur inside these beautiful places.

Location

The Gordon L. Carter Environmental Education Site (GCEES) sits on the south end of the Lake Whatcom Reservoir. The 126 acre property is owned by Bellingham Public Schools. GCEES was originally sold for \$1 to the County in 1918. The deed states that the land was for:

“the use and benefit of the Common Schools and the school children of Whatcom County... It being the desire of the grantor that the said premises shall be for the purpose of nature study by the school children of Whatcom County for the study of birds, plants, trees and all forms of natural life... and for the purpose of a conservation post to study the activities and the progress of man in Whatcom County.”

The land was transferred to the BSD in 1954 under the leadership of Superintendent Gordon L. Carter. A two-day (or longer) 6th grade program ran every year from 1960 through 2008. GCEES contains an “A” frame shelter, small parking area/turnaround, grass field and a log cabin used for teaching about local pioneer history. In the 1980s seven wooden sleeping shelters were built by parents and kids for use during overnights that used to take place. there is also a mothballed ropes course.

The forest sits on glacial till and Darrington phyllite bedrock. It was logged sometime before the original deeding, approximately 100 years ago. Part of the property was logged again in the 1980s The two ages of the forest can be easily seen. A corner of the property includes a short stretch of Brannian Creek, a tributary to Lake Whatcom and water source for the Lake Whatcom kokanee hatchery.

Contact Info

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WWU

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(all WWU participants have completed the SP background/ fingerprinting process & other
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All WWU participants have completed the SP background/ fingerprinting process & other
BSD & WWU procedures.

Risk Management

Bellingham School District and Whatcom Middle School make their students safety their
number one priority, and have risk management procedures in place for this event, which is
treated as a field trip.

Potential hazards at the Gordon Carter Site include slippery logs and rocks, unsafe climbing
areas, cold water, rain, cool air temperatures, steep undefined trails, and confusing trail
systems without obvious navigational aids. Low perceived risk/low harm hazards include
blisters, rainy weather, injuries to poorly protected feet, and scrapes on trees and rocks. To
mitigate these risks, the facilitator, Whatcom leaders, and SB assistants will:

- Require students to stay off of logs and rocks without supervision and to stay within
sight of the group unless otherwise directed.

- Before each lesson begins boundaries of acceptable wandering (if any) will be stated along with what is unacceptable behavior (listed below).
- Utilize the buddy systems for students and staff to quickly discover who may be missing from the group after moving from one place to the next.
- Require closed toed shoes, rain gear, and layers
- Require students to not pick up or handle sticks or other vegetation without supervision
- No climbing
- No wrestling
- No careless utilizations of sticks, woody debris, and lowing hanging branches unless directed by a facilitator
- Investigating and preventing employee and student accidents
- Analyzing risk associated with employee and student activities
- In case of emergency, notify Whatcom MS staff on site first then Huxley staff
- Report near misses and other injury/evacuation incidents using SB forms, regardless of who has the incident
- Students who misbehave will be given two warnings before being accompanied by a chaperone to the A-frame to wait for the day and not be allowed to participate in group activities. Also any punishment deemed fit by their teacher.
- Students with medical issues must be cleared to participate
- Investigating and preventing employee and student accidents
- Analyzing risk associated with employee and student activities
- Teachers will be aware of all known special conditions or allergies students have
- Students on medications that are taken during the day are set up with the school nurse and left with the teacher to administer the student during the day

Environmental Impact Policies

During our time at Gordon Carter Leave No Trace Principles will be used throughout. However, while we do understand the need to limit behaviors that will lead to long term impacts on the site we also want students to feel that they can properly explore this area. Due to the small amount of use the Gordon Carter Site receives we feel students should be able to have a more intimate experience with the site. Use will be determined in each group by the Spring Blockers in charge according to whether or not they believe the actions of the students during this outing will be visible at the time students enter the site next year.

Lesson synopses:

Winter Wren's Eye View

Students will understand that:

- 1) The structure and quality of an ecosystem's parts can change over time.
- 2) Collecting data from multiple sites allows us to compare characteristics of those sites, as well as predict the different plant and animal species each site might support.
- 3) Some animals (like the winter wren) have specific habitat needs. The structure of an ecosystem determines habitat possibilities and thus species distribution and abundance.

Students will compare a 100 year old forest to a recently logged forest through the frame of the winter wren's habitat needs; they will draw, measure tree diameter, and make note of ground debris in both forest stands.

Macroinvertebrates

Students will understand that:

- 1) Living things have a **range of tolerance**, or range of conditions, in which they can live.
- 2) Living things are **adapted** to specific environments. Some living things (like macroinvertebrates) have very specific habitat needs. Some habitats may suit those needs and some may not.
- 3) If a habitat changes, an organism may not be able to survive in the new environment.

Students will learn about the Lake Whatcom watershed and the source of our drinking water.

They will observe various macroinvertebrates, identify them and their relative pollution tolerance, and infer stream health based on the presence (or lack thereof) of macroinvertebrates.

Phosphorus and the Lake Whatcom Watershed

Students will understand:

- 1) That drinking water quality in the reservoir is most sensitive to phosphorus inputs.
- 2) The implications of soil-disturbing practices such as logging on phosphorus level and increased erosion.
- 3) The detrimental implications of an extreme input of phosphorus into the Lake Whatcom watershed.

Students will learn about the effects of phosphorus and causes of increased phosphorus levels in the Lake Whatcom watershed. They will observe erosion around Pioneer Creek, compare duff with disturbed soil, and identify the ways in which humans impact the watershed and increased phosphorus levels.

Wren's Eye View: Forest Comparison REVISED 6May13

Big ideas: Ecosystem Change and Comparison, Investigation, Specific habitat needs

Enduring understandings:

Students will understand that...

- 1) The structure and quality of an ecosystem's parts can change over time.
- 2) Collecting data from multiple sites allows us to compare characteristics of those sites, as well as predict the different plant and animal species each site might support.
- 3) Some animals (like the winter wren) have specific habitat needs. The structure of an ecosystem determines habitat possibilities and thus species distribution and abundance.

Essential questions:

- 1) Is it possible for an ecosystem to *not* change over time?
- 2) Do we need to measure and quantify nature?
- 3) Why don't deer live in a lake? Why don't fresh water fish live in the ocean? (Overarching question: Why do some organisms live in certain habitats but not others?)

Learning Standards:

6-8 EALR 2 Inquiry A - Scientific inquiry involves asking and answering questions and comparing the answer with what scientists already know about the world.

6-8 INQC Investigate - Collecting, analyzing, and displaying data are essential aspects of all investigations.

6-8 LS2D Ecosystems are continuously changing. Causes of these changes include nonliving factors such as the amount of light, range of temperatures, and availability of water, as well as living factors such as the disappearance of different species through disease, predation, habitat destruction and overuse of resources or the introduction of new species.

Materials-

- Student journals/pencils
- Meter tape (2)
- Diameter tapes (4)
- Frames (4)
- medium and short tripods (2 of each)

-Flagging tape in 3 colors

-Permanent marker (1)

Set-Up

Scout out the area to be used in the older and newer growth forests (this may have already been done). You will need to set up the following stations in adjacent areas (it will take 30-45-minutes):

a. Woody Debris Transect

i. Lay a meter tape out to make about a 20-meter transect line . It should cross a characteristic sampling of dead and downed wood in the forest type being sampled (i.e., in the older growth forest there should be a greater quantity of large diameter woody debris and a greater variety of sizes than in the newer growth forest).

b. Tree diameter

- i. Mark three to six trees that are representative of the size of trees found in the forest type being sampled (i.e., in the older forest the trees should be bigger).
- ii. Wrap flagging tape around each tree at a height of 1 meter (be consistent across trees). Label the flagging tapes Tree 1, Tree 2.... (Alternatively you could have the students identify a range of sizes of tree and record several measurements, then average them.)

c. Wren's Eye View Frames

- i. Each forest type has two frames. Find two spots within the forest type which have representative views of that forest. For example, in the older forest the view might include downed trees, nurse logs, larger trees and/or trees of varying sizes, and clumps of ground cover plants. The new forest view might contain even-aged trees, little ground cover, and less diversity of forest structure. It may not be possible to gain a "perfect" view: the point is to draw a clear contrast between forest types.
- ii. One frame should include a "macro" view and one should include a "micro" view of the forest type, ideally a feature such as a nook near the forest floor where the wren might forage
- iii. Position the frames on tripods that the views you wish to convey are framed. Make sure the front of the frame (with label) is facing the students so they will look through it in the desired direction. Use a stake and flagging tape to mark where students should stand or sit while drawing.

Location: Winter Wren Site (see Gordon Carter Map)

Time Required: 60 Minutes

Number of Students: 10-15 students

Number of Instructors: 2 Instructors

Procedure

1) (0:00-0:01) **(H)** Start in the older forest stand. (**Important:** try not to refer to the forest areas as *new* and *old growth* or any other hinting descriptors- instead use *Forest 1* and *2* or similar.) Introduction: If pacific wren(s) are signing, call attention to the call. Then suggest that actually the call can be translated into words. Listen and then verbally explain what is in the letter below. One of the instructors reads the Winter Wren Letter aloud to students, preferably in a winter wren voice. Read expressively with the appropriate emotion. Hide behind other instructor or in a typical wren location & height position in the trees. (1 min.):

Dear Wildlife Biologists,

*I know you want us to move into the **new** forest neighborhood, but we just don't like it! It doesn't have the types of homes we need. Our predators will easily see us because there are no good places to hide! We might not even be able to find the kinds of food we like- nice, juicy bugs that like to live in dark hidden places.*

The new neighborhood just doesn't feel right for us. Something's not the same as our old neighborhood, but I can't quite put my feather on it. Maybe you know what's different?

2) (0:01-0:02) **(W)** Introduce the goal: "We are wildlife biologists! We want to help the winter wrens by giving them lots of places to live. We are currently in the forest neighborhood that wrens like. We tried to set them up in a new forest neighborhood, but according to their letter they don't like it.

We need to determine what is different about the forest neighborhood the wrens like and the forest neighborhood the wrens don't like." (1 min.)

3) (0:02-0:03) "Since we are wildlife biologists: we will collect data and compare the results. What kinds of data might we collect about the forest?" Elicit potential answers. *Some guiding hints for students: what are some objects in a forest? What can we measure about those objects?* (affirm and build on responses; don't waste much time with "guess what I'm thinking" questioning: tell them if you need to)(1 min.)

4) (0:03-0:09) **(E1)** "We are going to compare two different forests using tools and techniques scientists actually use":

Split students into 3 groups, putting some capable students in each . While students are still all assembled make sure students know where to find the instructions for tool use in the journal. Call for volunteer students to and instruct them in modeling use of each the tools as you describe how to do it. Have students follow along in journals.. Then pass out tools to groups. (6 min.)

Meter tape & diameter tape = Measuring Tree Diameter.

To complete: at a height of 1.0 meters, wrap the tape around the tree and record the measure (numbers directly represent diameter in centimeters) in journal.. No calculations are required: Diameter tape has pi built into the measurement. It might help some students to visually compare the tree to the same reading on a meter tape or stick. Facilitate their choosing sample trees if you want to involve them more in the construction of the study methods.

Transect line = Measuring Woody Debris.

To complete: Start at one end of the transect. Walk along the transect until there is a piece of woody debris directly underneath the line (ie, visually touching the line when viewed from straight above). Record how big it is in the table.

Frames = A Wren's Eye View.

Prompt students to create drawings that capture the major features and some details of the framed view. What visual information will you need later to compare the forests? Encourage students to position themselves to get the intended view through each frame, demonstrating getting down to look closely through the small frame. Several students may need to look at once, or take turns looking and then drawing.

5) (0:09-0:24 or less) Using tools and corresponding journal pages, students should complete the above activities in the older forest stand. Each group will start at a station and rotate according to the rotation chart (located at the end of the lesson).

a. An instructor or parent should signal switch times (every 5 minutes, with a 1 minute warning) so students complete each activity. This can be a bird call, whistle, or other obvious signal. Tell the students what the signal will be before splitting into groups.

b. Other instructor and/or chaperones should circulate to help the groups complete the activities.

c. **(R)** Informal evaluation questions to use throughout the lesson:

i. "How would you describe this area?"

ii. "What is this tool measuring?" (15 min.)

6) (0:24-0:25) Travel to newer forest stand. (1 min)

7) (0:25-0:40) Ask students if there was any confusion during the activities. Repeat Step 5 in the new location. (15 min, or less)

8) (0:40-0:45) **(E2)** Reconvene to discuss the data they collected.

a. "Wildlife biologists collect data for many reasons. This time we wanted to help the winter wren move into a new forest neighborhood so there could be more room for more wrens. We wanted to compare two forest sites to each other."

b. "How are the two forest sites different? How are they the same?"

i. In the first forest site...

ii. In the second forest site...

<iii. note: questions from them, or prompted by you that call into question the methods are welcome... foster open discussion on the way the activity is set up as well as how trained biologists might ask the same question... It is okay to not have definitive answers>

c. "Which site do you think is older? Why do you think that?"

d. "Do you think that the newer forest will eventually look like the older forest? What **changes** will happen to make it look that way?" (5 min.)

9) (0:45-0:50) "The winter wrens told us they didn't like their new forest neighborhood because it didn't have the types of homes, places to hide, or things to eat that their previous forest neighborhood had."

Call on a few volunteers to share their drawings.

"What did the first forest have that the second forest did not?"

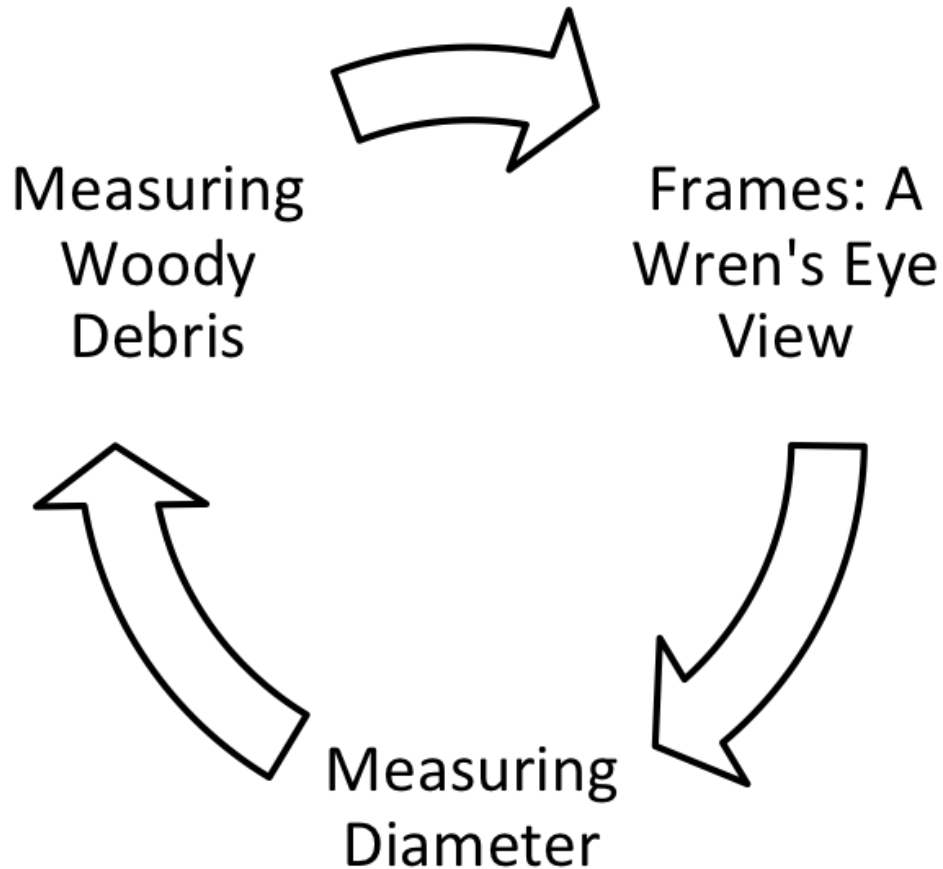
Why are those differences important?

What do these differences say about the habitat needs of the winter wren?" (5 min.)

10) (0:50-0:60) Conclusion:

1. Why don't you see gulls in the forest? Why aren't owls at the seashore? (avoid 'guess what I'm thinking' game, but use these *hints to guide student responses: Can animals or plants live anywhere? What determines where they live?*)
 - i. Animals need specific habitats to survive.
2. Will winter wrens ever prefer to live in the second forest site? When?
 - i. When the site provides the type of habitat the wrens need
3. Students if there was any confusion during the activities.
4. Create a link to the culminating activity by modeling a discussion about forest practices. It could be enacted, or more 'debated' or just discussed, showing back and forth of different perspectives. It's important not to be too judgmental about the 'traditional' perspective, but to take the attitude that students can and should make up their own minds. Read the information on old and new logger perspectives below, and stage a dialogue between these points of view. Use a little drama, but don't put either side down. prime students for answering the following questions (dialogue located in the stewardship portion of the curriculum).

Forest Data Collection Rotation Chart



Lesson Extensions: Stakeholders and Stewardship

By Virginia J. Cleaveland

This provides some information to help connect this activity to the perspectives expressed in the culminating county council hearing.

Stakeholders

Loggers build roads into the forest and clear-cut the trees from certain areas to sell as timber. The land belongs to different people, including timber companies, private individuals, or as National Forest land for parks, and there are different rules about logging in different areas. When loggers clear-cut the forests, they eliminate the habitat for the plants and animals living there. Government regulations require loggers

to replant the area with trees, but they often don't plant the same types of trees that were there before, or they don't plant as many different species of trees (this is called mono-cropping, AKA only planting one species). Cutting down trees removes the original habitat for a species living in an area, but other plants and animals will slowly move into those habitats over time.

Winter wrens like to live in woody areas with lots of downed trees. In areas that were logged long time ago (or not at all), the habitat is more diverse because it has had time to grow. There are different sizes and heights of trees that create gaps in the canopy. More trees have fallen over and are decomposing, creating nutrient-rich soil. The winter wrens like this habitat because they like to stay close to the ground, where they can build their homes, hide from predators. And search for bugs Gordon Carter boasts this type of habitat, but other areas have been logged more recently, and the trees that were planted afterwards are in a younger forest. There is usually only one canopy layer, the trees are closer together and mainly the same size, and there is less diversity in the habitat. Winter wrens don't like to live in this habitat because they have fewer places to hide from predators.

Wildlife biologists study what kinds of animals and plants live in different habitats. They also study how different changes, like those created by loggers, developers and residents, can change the habitats and what it means for the plants and animals that live there. Wildlife biologists like to observe lots of different plants and animals in the area they are studying because it means the forest is a healthy home for everything living there; this concept is called biodiversity. Wildlife biologists are advocates for plants and animals, and work with industries (loggers, developers) and the government to come up with sustainable management policies for the forests that help preserve the original habitats.

Stewardship understandings: Plants and animals are only adapted to certain habitats, and changes to those habitats can cause the death of individual animals or even a species. Species biodiversity indicates the health of an ecosystem, because more species means the habitat is suited to support a variety of plants and animals. Humans are the only exception, and can live in almost every single habitat on Earth because they rely on technologies like clothing and electricity.

Stewardship goals: I can encourage biodiversity by advocating for the protection and sustainable management of the habitats where animals and plants live, while also meeting human needs from certain industries in sustainable ways.

Outline for illustrating old logging vs. new logging practices

Stage a discussion between an old-time forester/logger and someone who advocates "new forestry" or "ecoforestry."

Points for traditional approach:

- This is prime tree-growing country and it makes sense to grow them here.
- Logging is a part of the traditions of this area, and some people say we should keep our traditions.
- Logging can provide a decent income for workers.
- Clear-cutting is in some ways like natural disturbances like forest fires, and favors establishment of douglas-fir, a high-quality and fast-growing wood tree. Clear cutting may be less destructive than some high-intensity forest fires.

- Making money on logging is not easy. Not only is the work hard and dangerous, it takes a very long time before the trees are ready to harvest. Because so much can change in the economy over several decades, timber companies cannot be certain they will make money... so they need to be able to plan on cutting trees about every 40 years. If they waited longer than that it might make more sense to invest their money in some other kind of thing like the technology industry.
- All logging in Washington that's not governed by National Forest laws must meet the Wash. Forest Practices Act requirements for things like building roads, leaving trees to provide seeds, using herbicides or pesticides, protecting streams, and replanting more trees.
- Forest lands in the Lake Whatcom watershed are also governed by a landscape management plan that restricts logging to less steep areas and reduces risk of erosion.
- We *ought* to use the forest to meet our needs. Some say it was put there for our use. Others say we need jobs. Others say if we don't grow the trees for the wood and paper we use, the materials will come from some place else where it may be more destructive environmentally, and that would be worse.

Points for new forestry:

- The present practice of waiting only 40 years to cut trees is too fast to allow the formation of diverse habitats and niches in the forest, nor for many species of animals such as slow moving salamanders to re-colonize the forest.
- The practice of replanting with the single species, douglas-fir, further reduces biodiversity
- If trees were allowed to grow past 40 years, the amount of wood they put on would continue to increase every year for nearly 200 years.
- Only with a fairly old forest does biodiversity regain strength as animals and plants re-colonize the site and invasive exotic plants get crowded out. An older forest has more sizes and shapes of trees, snags, and spaces for animals.
- Logging at a (on average) 1% / year rate (100 year cutting cycle) would allow some old growth features to emerge, supporting sensitive species, and allowing topsoil to build up, preventing more erosion. A 40 year cycle will create spikes in erosion going into the lake.
- A slow rate of logging is compatible with lower impacts of getting the logs that are cut out of the woods. The logs can be cut selectively and removed in sections using draft horses or means that do not require a road.
- Roads cause much of the erosion in logging. They are cut into the side of the hill, interrupting ground water, which then is collected in ditches, leading to culverts, which are placed at streams. During prolonged heavy rains, this means that very large amounts of water are directed into the streams and culverts. Besides just washing more soil to the lake, this also increases the risk of a culvert getting jammed with wood and the water eroding around it or through the road, causing a "debris torrent" of soil, rock, and trees. This happened in Lake W. in 1983, and a house was pushed off its foundations and into the lake, with someone inside.
- We can meet our needs for wood partly by *reducing* our use of it.
- The woods *ought to* contain lots of species of plants and animals. That's not a fact, it's a values statement. Why should there be lots of species? Because people enjoy them the woods more when it is rich with life. Also, some believe the living wild things value their own lives and should be allowed to live. Others believe that a complete ecosystem is required for it to provide people with the benefits like clean water. In particular, if we log very much in the Lake Whatcom Watershed, then it will cause erosion, add phosphorus to the lake, and degrade our water supply—while there are other places we can cut trees, there is only one place where we get our drinking water.
- While we do use forest products, we should adjust to using less if it is not possible to maintain our degree of use either here or elsewhere.

Phosphorus and the Lake Whatcom Watershed

Lesson Adapted by Miranda Laine and Mawley Elder
Gordon Carter Environmental Education Curriculum 2012
Huxley College, WWU

Target Audience: Bellingham 6th graders (approximately 12 years of age)

Subject: The effects of phosphorous and causes of increased phosphorus levels in the Lake Whatcom watershed.

Duration: 45 – 50 Minutes

Group Size/Instructor Numbers: 12 or 18 students, 2 instructors

Location and Rational: Upper Pioneer Creek, local stream ecosystem in the Gordon L. Carter Environmental Education Site.

EALRS:

6-8 SYSC The *output* of one *system* can become the *input* of another *system*.

6-8 ES2G Landforms are created by processes that build up structures and processes that break down and carry away material through erosion and weathering.

Essential Questions:

- How do phosphorus levels rise in a stream or lake? What are the implications of this?
- How can phosphorus be both toxic (or a problem), AND an essential nutrient?
- Are erosion and phosphorus related? Why?
- What kinds of human activity in the watershed are most likely to increase phosphorus inputs to the Lake Whatcom system?

Objectives:

1. Students will be able to explain the benefits of phosphorus in a natural ecosystem and the harmful effects that human-caused phosphorus loading creates.
2. Students will be able to identify three human activities that impact phosphorus levels.
3. Students will be able to contextualize erosional features as contributing factors to phosphorus overloading.

Goals:

1. Students will be able to understand that drinking water quality in the reservoir is most sensitive to phosphorus inputs.
2. Students will be able to understand the implications of soil-disturbing practices such as logging on phosphorus level and increased erosion.
3. Students will understand the detrimental implications of an extreme input of phosphorus into the Lake Whatcom watershed.

Materials:

- 5 gallon bucket
- Picture of Canadian experimental lake, Lake Whatcom development, microscopic view of algae
- Net
- Small white tray
- 6 trowels
- 6 measuring sticks
- Worksheets (one for observation, one for duff thickness)

Vocabulary: great

Phosphorus - An element that forms many compounds with other elements. It is a naturally occurring nutrient in soils.

Watershed 1) The area of land where all of the water that is under it or drains off of it goes into the same place

2) The region or area drained by a river, stream, etc.; drainage area.

Oligotrophic - Nutrient-poor and oxygen rich.

Eutrophication - The gradual increase in the concentration of phosphorus, nitrogen, and other plant nutrients in an aging aquatic system.

Sediment 1) the matter that settles to the bottom of a liquid

2) material deposited by wind, water, or glaciers

Erosion - The process by which the surface of the earth is worn away by the action of water, glaciers, winds, waves, etc

Limiting Factors - An environmental factor that tends to limit population size ... sounds like a population regulation derived definition -- correct; in this case we mean algae population. For this lesson may be clearer to define as a resource that is scarce relative to the demand for it. Other resources (e.g., for plant growth) may be plentiful; but growth will be limited by the factor that is least available relative to need.

Nutrients- a chemical that an organism needs to live and grow or a substance used in an organism's metabolism which must be taken in from its environment

Humus/Duff -Organic matter such as sticks, twigs, needles and leaves that is at various stages of decomposition and conversion to the organic component of the top layer of soil

Hook: The two water samples skit with story.

Algae Water Demo& Story: (15 minutes)

- 1) Collect a quart jar full of algae rich water from Lake Whatcom.

- 2) Have two jars visible, one with potable, clear water and the other with the green algae.
- 3) The teaching pair should designate the roles of *Bellingham City Resident* and *Watershed Scientist*. the (female) scientist wears a tan hat and possibly a pair of glasses if available. The (male) citizen of Bellingham wears a mustache and a grey flannel shirt.
- 4) The teaching pairs approach the two jars, the scientist gets there first and chugs the glass of clear, clean water finishing it with a satisfying, “Ah!” The Bellingham City Resident picks up the jar of algae and looks at it in disgust.
- 5) The dialogue follows as:

BCR: What is this green stuff? Where in buckets name did you get this water?

WS: That is what we Watershed Scientists call an algae bloom or eutrophication. It is water from Lake Whatcom, where all of Bellingham gets their drinking water.

BCR: Are you serious!?! I live in Bellingham! Is this really my drinking water? How did it get this way?

WS: Yes, indeed it is. Well, dear friend let me tell you a little story about how Lake Whatcom came to be the way it is...

(Watershed Scientist turns into the spirit of Lake Whatcom and the Bellingham Resident transforms into the Phosphorus Dragon by putting on the provided hand-puppets)

Spirit of Lake Whatcom: I am the spirit of Lake Whatcom. I am going to tell you an alarming narrative of my life. I was born from the retreating waters of the glaciers that blanketed this area thousands of years ago. During my young and formative years I was pure and untouched by humankind. My waters were clear, clean and full of oxygen! Baby lakes like these are called **oligotrophic** because they are so full of oxygen, lacking nutrients to support little to no plant or animal life. After a few hundred years passed I allowed a few creatures to live in me. I became lonely, you know? A vast and wide lake with no friends, inconceivable. A tame, harmless creature emerged from the soils that lie dormant in my banks – she became my pet dragon whom I named Phosphorus. She is a vital nutrient to my lake life cycle and occurs as a natural element in soils. Phosphorus kept me in good company and invited many other plant and animal friends to come live with us. Nice! Plants, animals and bacteria began coexisting in me and we thrived in balance for a long time. As time progressed she became rather spoiled, demanding more space and oxygen to provide for her hungry lake guests. She also invited one of the most bizarre species to come live on my banks, humans. This scheming, fierce phosphorus dragon knew how much humans love phosphorus. These humans would use phosphorus-based fertilizers to grow their lush green lawns, phosphorus-based soaps to wash their cars, luckily phosphorus based soaps are now outlawed. But now the phosphorus is coming from soil disturbance caused by logging and land development. Why, this exposes phosphorus rich soil to erosion and it comes flowing from all over the lake Whatcom watershed right down these very hills to me: lake Whatcom. My old friend and new enemy, the phosphorus dragon, loves the loading of the lake with these nutrients. In her selfish desire to grow, she produced green algae that spanned my entire shorelines. These algae died, sank to the bottom and were eaten by oxygen consuming bacteria. The phosphorus dragon began to grow, expanding her green fire all across my shores. This is where am now. I am frightened by the quick progression of my life as a lake. I am too quickly headed towards my elderly form of lakehood, **eutrophication**. This means that I am so nutrient rich that all of my water is

filled with algae growth and aerobic bacteria dominating the oxygen supply. How would you like to discover that for every one year you are ageing ten? In just a few years you'd be eighty. Well that's what eutrophication is like for me. My dragon is unfortunately fed by human habits that leave no room for me to breathe. I've had enough

"Phosphorus Dragon, you know I can't live this way! There are too many creatures asking for oxygen to breathe! I am choking!"

Phosphorus Dragon: "Sorry, Lake Whatcom. You are my lake now! I am abundant and strong. You are becoming an old lake. Everyone gets old, you know?"

Lake Whatcom: "I should not be aging this fast, you phosphorus beast! Your plentiful presence is ruining me! The humans have been feeding you and I see your algae all over the lake. This will be the end of me if you don't stop loading me with your green fire! And it will cause great trouble for those weird humans themselves because they need you to clear out if they are to keep drinking my water

Phosphorus Dragon: "I am the way I am, but my human friends could learn a lesson or two about my power. They are drinking your water, after all!"

Lake Whatcom: "how does that dragon work anyway? Where does it get all that phosphorus it's putting in me? Could it have to do with erosion? YES!"

Erosion Demonstration: (5 minutes)

Materials: Bucket, water from creek

- 1) Gather students around and have them note the visual difference between the eroded ATV trail (DON'T TELL THEM ITS AN ATV TRAIL) area and the humus covered area to the left and right, well off to the sides where there are plants growing out of the duff.
- 2) Describe how the ATV trail is representative of other disturbances that cause phosphorus loading like logging or housing development because it disturbs the roots and soil leaving it exposed.
- 3) Then have your partner bring you a big bucket full of water and have a student volunteer demonstrate a large rain event by pouring the water directly on to the ATV trail. Ask what they see. "Is it clear? Brown? Are there particles? Yes. What do you call this? (erosion) Well these particles likely contain phosphorous because it is common in soil minerals." Say that the erosion effects the stream too because large amounts of sediment rich water rush through and deposit sediments, fill in the pools undercut and steeply cut banks, and cause large curves or meanders because channel gets filled up.

Observing Erosion on Pioneer Creek! (10 Minutes)

Materials:

- Students need worksheets
- Net
- White tray

Procedure:

- 1) Say "please take out your worksheets and turn to the page that looks like this (hold journal page). Use the stream to find evidence of erosion." Explain the four questions they are going to

answer on the journal pages:

- 2) "Draw and label a five feet section of the creek. Observe what the stream channel looks like, including rocks, plants, pools, etc. Note the sizes of the rocks.
- 3) Get down at level of creek and look upstream. Draw and label the profile of the banks on both sides and the stream in the middle. Show how deep the stream is" instructor actually demonstrates this process by "getting down" and pointing to these features.
- 4) Look at the areas on either side of the stream where people have used this area. Draw and label any soil disturbances you see. Write in a hypothesis of what activity you think might have caused them.
- 5) Set boundaries before they leave. Stay out of mud. Don't jump over creek. No running. Will have to come back here if you break the rules, after 2 warnings (be sure to enforce if it starts to be a problem>Don't go more than 50' away from sides of stream, all you need to observe is right here. Tell them how long (10 min should be enough. During this, call out to be sure to move on and examine all 3 questions on their worksheet
- 6) Debrief: Do you think Pioneer creek has always looked like this? Describe evidence that you think shows it has changed. Toward the end of the debrief, the partner who isn't talking comes running up from the creek with a tray with nothing in particular except pebbles and water in it and exclaims, "Look at this, look at this! [Act really excited!] Are there macroinvertebrates in this creek?" "Nooooo! Then they say, "This is an unhealthy stream, heavily impacted by erosion. Erosion is a sign of excess phosphorus input from the environment. Erosion makes it difficult for animals of any kind to attach themselves safely to rocks because the sediment particles suspended in the water actually scrub them right off. What might be a reason for this erosion?" Affirm the reasons they suggest and proceed to talk about logging. "Logging...Upstream there was a clear-cut 25 yrs ago, and it is still affecting stream health"
- 7) Transition to duff comparison by saying, "Were going to go look at the nearby clear-cut in a minute but first lets check out this duff stuff." <maybe transition like this. "Okay, now you've found evidence of erosion. - Phosphorus-laden sediment going directly into the creek. What do you think normally stops water from carrying sediment right into the creek? (answers) What could be on top of the sediment that might keep it from moving so fast?"

Duff Comparison: (17 Minutes)

Materials: 6 trowels

Procedure:

- 1) Go back to the area where you did the erosion demonstration the first time (ATV trail with duff on right and left). Repeat the same thing, except this time have them compare how the water behaves on the ATV trail vs. the area covered in duff.
- 2) Ask two student volunteers to simulate large rain events on each surface (the water will soak immediately into the duff, but will run uncontrolled down the ATV trail). Ask what they observed.
- 3) Ask them to recap what erosion means. Remind them that anything that removes the duff layer over a large area can cause massive erosion and sediment loading. This in turn increases the phosphorous load.
- 4) Ask them to remind you where pioneer creek goes (Lake Whatcom) and what the phosphorous does in the lake (eutrophication). Ask, "So if we logged an area, and removed this soft absorbent

duff, then what could occur?" Erosion." What then? "Phosphorus. "What then?" Eutrophication. So this stuff (pick up duff) really matters when it comes to erosion and phosphorus loading.

5) Next, use aerial photo of site:

Gather group and point out the line that indicates the clear cut. Explain, "There was a clear cut at this site 25 years ago. We are in the part that was not cut. What might cutting down trees and removing them do that could cause more erosion?" Let them guess a bit, then say "Want to see for yourself?"

6) "I want each pair (or 3-some) to take a trowel and gently examine the duff below these trees (indicate deep duff back up hill slightly from creek, not in impacted area) –roughly how deep is it? How does it feel if you squeeze it (springiness) (Have each pair report out loud) Remember what that duff did when I dumped water on it? (Could even do it again, looking really close) Who can say why you think it was able to absorb water so well?"

7) "Now let's go see what the soil looks like in the clear cut area, follow me, and bring your trowels." Go up new trail, being sure to guide them around the muddy spot. Be sure they go single file. Station yourself in middle.

8) Once whole group is in the cut area, but not to the creek overlook yet, have each pair examine the duff again. Prompt for what differences they see; have each pair report the depth. Have them squeeze the duff; compare what it feels like to the first site. What would happen if we dumped water on here? What if it rained hard for 3 days here, where would the water go? What would it take with it? Take group rest of way up to narrow buffer where you can see creek channel through a few shrubs. Point out evidence of erosion due to loss of humus: bare dirt bank, vertical or undercut banks, no deep pools. Note there is green filamentous algae growing in clumps on bottom: this is because there is more sunlight hitting the creek here, and the same sunlight may warm this water, making it less habitable for small creatures and fish, which is yet another reason why macroinvertebrates don't live down stream.

Conclusion: (5 minutes)

Go back to the green glass of water, ask: how can we prevent our water from becoming like this? What do we have to stop? (Erosion, soil disturbance) What human actions cause the most of these? For each person, and for us as a whole community, there are things we have already done, like banning phosphorus lawn fertilizer. And there is more we can do, like changing where and how we log and build houses and having a community wide discussion on the issue of Lake Whatcom's water quality. At the end of our time you all will come up with your own sustainability plan for lake Whatcom watershed by playing stakeholders in the community like scientists and citizens, which you all are!

Background Information:

1. Whatcom County Storm water Division: Lake Whatcom Management Website

<http://www.co.whatcom.wa.us/publicworks/water/lakewhatcom.jsp>

-Whatcom is Lummi word for loud water

-Drinking water for 85,700 residents Bellingham/Whatcom County/250 lake residents

-10 miles long, 1 mile wide

-Within three jurisdictions: Bellingham, Whatcom County, Lake Whatcom Water and Sewer District

-Popular boating, fishing, swimming

-About 80% of the watershed is comprised of forestlands, largely surrounding sub-basin 3.

-There are approximately 5,000 homes currently in the watershed. High-density development and development potential exists around sub-basins 1 and 2. The major residential development around sub-basin 3 is Sudden Valley, a private community that has about 1,700 homes with the potential for more.

-The lake is divided into three basins. Basin 1, the Silver Beach Basin is the furthest north, and has a maximum depth of 100 feet (30 m). Land use in Basin 1 is primarily residential development, with one large park and several small parks.

-Basin 2, the Geneva Basin is the central basin where the drinking water for the city of Bellingham is withdrawn. This basin is the shallowest, with a maximum depth of just 40–60 feet (12–18 m). Land use is still primarily residential with a mix of lake protection program properties and some rural forestry.

-Basin 3 is the southernmost basin, and is the most remote. At its greatest depth basin 3 is 328 feet (100 m) deep, and is estimated to contain 96% of the lake's total water volume. Land use in Basin 3 is composed of scattered residential development, mostly in the community of Sudden Valley, as well as rural and commercial forestry. The total area of the Lake Whatcom Watershed is 142 square kilometers (or 56 square miles).

-There are 9 annual streams and approximately 25 additional small creeks and tributaries that flow into Lake Whatcom. Accounting for 23 sub-watersheds in all. Lake Whatcom drains into Bellingham Bay by way of Whatcom Creek.

2. The Natural History of Puget Sound Country By: Arthur Kruckeberg

-The geologic history of the Pacific Northwest is shaped by glaciers, thousands of years ago

-During the last Ice Age, glacial ice covered western Whatcom County to depths greater than 5,500 feet. This tremendous volume of ice scoured the underlying rock.

-The current lake bathymetry, or underwater topography, was created as the glacier advanced and retreated multiple times. It scoured the less resistant rock, while leaving the two sills of resistant material that now divide the lake into its three distinct basins.

-The tremendous weight of the ice also depressed the land beneath it, much like a finger pushed into a balloon. As the ice retreated approximately 10,000 years ago, the weight was relieved and the land began to rebound.

3. Lake Whatcom Management Program Website: Geologic History of Lake Whatcom

http://www.lakewhatcom.whatcomcounty.org/asub_fldr/about_the_watershed/geo.shtml

-Beneath the surface of the watershed lie the sedimentary rocks of the Chuckanut Formation with a metamorphic rock called phyllite and glacially derived sand and gravel being exposed at the far south end of the lake.

-The Chuckanut Formation, often referred to as Chuckanut Sandstone, extends from the Cascade Range to Lummi Island and is actually a group of rocks that includes layers of sandstone, conglomerate, shale, and coal.

-There are a couple of things about the watershed that indicate this possible past connection with marine waters — fossils and fish:

1. Marine fossils have been found in deposits near the northern portion of the lake.
2. Kokanee, the land-locked form of sockeye salmon, are found in Lake Whatcom. These fish probably became isolated from their ocean-going counterparts as the land rebounded. As the land rebounded, the lake became higher than Bellingham Bay and natural barriers formed between the marine and lake system, such as the multiple waterfalls in Whatcom Falls Park.

-The soils that are derived from the Chuckanut Formation and the steep topography of some portions of the watershed leave the area naturally prone to landslides. Land uses such as timber harvest, forest road building and usage, residential development, and utility installation and maintenance can all increase the natural rates and timing of sediment delivery, with associated effects on stream and lake water quality, fish and fish habitat, and ultimately human health and safety.

4. National Geographic: Freshwater

<http://environment.nationalgeographic.com/environment/freshwater>

-The water you drink today has likely been around in one form or another since dinosaurs roamed the Earth, hundreds of millions of years ago.

-Freshwater makes up a very small fraction of all water on the planet. While nearly 70 percent of the world is covered by water, only 2.5 percent of it is fresh. The rest is saline and ocean-based. Even then, just 1 percent of our freshwater is easily accessible, with much of it trapped in glaciers and snowfields. In essence, only 0.007 percent of the planet's water is available to fuel and feed its 6.8 billion people.

-Wetlands, rivers, lakes, and coastal estuaries are all aquatic ecosystems—critical elements of Earth's dynamic processes and essential to human economies and health.

-Wetlands connect land and water, serving as natural filters, reducing pollution, controlling floods, and acting as nurseries for many aquatic species. Rivers, lakes, and estuaries serve as important transportation, recreation, and wildlife hubs.

-Learning more about the ecosystems within your watershed—all the water in your region that drains to the same point—can help you better understand how everything is connected and what is at stake with freshwater overuse, pollution, and drought.

-Global extinction rates for freshwater species are four to six times higher than those for terrestrial or marine species—freshwater species are disappearing faster than marine or terrestrial species. In the U.S. half the 573 endangered species are freshwater species.

-In 2008, Ecuador put the rights of nature into its constitution saying nature “has the right to exist, persist, maintain, and regenerate its vital cycles, structure, functions, and its processes in evolution.” With these rules, citizens can file suit on behalf of an injured watershed.

5. Lake Whatcom Management Program Website: Mammals, Birds, Reptiles and Amphibians

http://www.lakewhatcom.whatcomcounty.org/asub_fldr/about_the_watershed/wildlife.shtml

-Lake Whatcom watershed is home to a variety of wildlife species. As a result of years of human caused change to the environment, several species that were thought to once live here have been

extirpated from the area. These species include: northern spotted owl, gray wolf, wolverine, fisher, marbled murrelet, grizzly bear, marten, and elk.

-Most wildlife is dependent on and requires very specific types of habitat, especially while mating and caring for their young. For example, many birds and mammals throughout their life stages will utilize snags (partially or completely dead trees) for nests or dens. Without these snags they are more prone to predation and have less chance for survival.

-Additionally, if an animal is generally used to human disturbance in their habitat, they are less likely to be affected by their presence, however if a particular species lives and raises its young in secluded, quiet areas, they are much more likely to be negatively impacted by the presence of humans.

-Of the 10 amphibian, 2 reptile, 125 bird, and 49 mammal species that are found in the area, many are considered to be “species of interest”, meaning that concern exists for the future of their populations, generally due to a loss of habitat.

6. City of Bellingham Guide to Lake Whatcom: Stewards of the Lake

www.cob.org/documents/pw/.../stewardship-of-lake-whatcom.pdf

-Phosphorus flows into the lake from sources including stream bank erosion; exposed soil from construction, landscaping and logging; lawn fertilizers; leaves and grass clippings; pesticides; pet and wildlife droppings; failing septic systems; sewage spills and leaking sewer pipes; and phosphorus-based soaps, detergents and chemicals.

-The Washington State Department of Ecology was concerned enough about algae growth in Lake Whatcom, in 1998, to place the lake on the state list of water bodies that fail to meet water quality standards. That listing, required under the federal Clean Water Act, triggered a mandatory water quality improvement plan.

-When too much phosphorus is introduced into a water body like Lake Whatcom, some plant species, such as algae, experience explosive growth

-When algae die, they sink to the bottom of the lake and begin to decompose. Bacteria feed on the decomposing algae and consume oxygen in the water.

-Low oxygen levels cause sediments on the bottom of the lake to release mercury, which is then absorbed by fish, and phosphorus, which stimulates the growth of even more algae

-Phosphorus is a naturally occurring nutrient, found in water, soil and air. It helps stimulate plant growth and is essential for animal and plant life.

-Naturally balanced levels of phosphorus promote natural levels of growth. Human activities are increasing phosphorus levels in the lake.

7. Lake Whatcom Watershed Total Phosphorus and Bacteria Total Maximum Daily Loads

<http://www.ecy.wa.gov/biblio/0803024.html>

-Lake Whatcom is impaired for dissolved oxygen due to phosphorus loading. Tributaries to the lake fail to meet Washington State standards for fecal coliform bacteria. The goal of this study is to determine Total Maximum Daily Loads (TMDLs) of these two pollutants.

-Bacteria levels in 11 tributary streams and drains did not meet standards.

-In response to requirements of the federal Clean Water Act, the Washington State Department of Ecology (Ecology) has conducted a study that lays the groundwork for restoring dissolved oxygen

in Lake Whatcom and reducing fecal coliform bacteria in some of the lake's tributaries to levels that meet Washington State standards.

-Meeting those standards will ensure that the lake will continue to (1) be a clean source of drinking water for 96,000 people in Bellingham and Whatcom County, (2) support fish, birds, plants and animals, and (3) provide aesthetic and recreational value to the community.

-Researchers have determined that excess phosphorus in the lake is the main cause of declining oxygen levels. This study quantifies how much phosphorus the lake can process naturally and still supply enough oxygen to meet state standards.

Phosphorous Problem

-In Washington State at least 260 bodies of water are polluted because of phosphorus.

-Phosphorus is a common ingredient in household detergents and fertilizers, is used in many industrial processes, and occurs naturally in soil and human and animal wastes.

-Phosphorus behaves as a fertilizer, accelerating plant and algae growth. When plants and algae die, bacteria consume oxygen that is dissolved in the water, leaving less oxygen. Oxygen is essential for fish and aquatic life to survive.

-The results of accelerated plant and algae growth in the water can require an increase in drinking water treatment chemicals that form carcinogenic byproducts and add treatment costs. Increasing oxygen by decreasing phosphorus

-Aquatic organisms are very sensitive to reductions in the level of dissolved oxygen in the water. The health of fish and other aquatic species depends on maintaining an adequate supply of oxygen dissolved in the water.

-Growth rates, swimming ability, susceptibility to disease, and the relative ability to endure other environmental stressors and pollutants are all affected by dissolved oxygen levels. While direct mortality due to inadequate dissolved oxygen can occur, the state's criteria are designed to maintain conditions that support healthy populations of fish and other aquatic life.

-Oxygen levels can fluctuate over the day and night in response to changes in climatic conditions as well as the respiratory requirements of aquatic plants and algae. In a lake, oxygen levels can also vary seasonally as the deeper, cooler layer of the lake (the hypolimnion) is isolated from sources of oxygen in warmer surface waters (the epilimnion) in the warm months, and respiration of aquatic life in the hypolimnion consumes the supply of oxygen. Typically the hypolimnion develops in the spring, maintains its maximum thickness during the summer, and erodes from the top downward in the fall, until the lake is again fully mixed in the winter.

-Bacteria criteria are set to protect people who work and play in and on the water from waterborne illnesses. Bacteria Problem.

-In the Washington State water quality standards, fecal coliform is used as an *indicator bacteria* for the state's freshwaters (e.g., lakes and streams), because it indicates the presence of waste from humans and other warm-blooded animals.

-Waste from warm-blooded animals is more likely to contain pathogens that will cause illness in humans than waste from cold-blooded animals. The fecal coliform criteria are set at levels that have been shown to maintain low rates of serious intestinal illness (gastroenteritis) in people.

Pollutant sources

-Key watershed processes important to this TMDL study are the deposition, release, and transport

of phosphorus in the watershed.

-Deposition of phosphorus in domestic livestock and pet manure, both on the land and directly into storm conveyances and streams.

-Use of phosphorus-based fertilizers on lawns, gardens, landscaping, and commercial agriculture and silviculture.

-Release of phosphorus from on-site sewage disposal (septic systems) both from surfacing wastewater and from percolation of wastewater into shallow interflow or deep groundwater soil layers. Phosphorus in wastewater can enter wastewater both from human body waste and from phosphorus detergents and other household products.

-Transport of phosphorus adsorbed to soil particles by erosion. Erosion can occur from the heavy rainfall on the land surface, especially from dirt roads, construction sites, and other areas cleared of vegetation, and from streambank erosion. Sediment in stormwater conveyances and streams can also be deposited and resuspended by variation in flow.

-Aerial deposition on a regional scale of phosphorus adsorbed to dust particles.

8. Lake Whatcom Total Maximum Daily Load Groundwater Study

<http://www.ecy.wa.gov/biblio/0503001.html>

-Lake Whatcom is listed on the 1998 Washington State 303(d) list of waterbodies not attaining the water quality criterion for dissolved oxygen. Evidence indicates that oxygen depletion in the lake is the result of several factors, including eutrophication processes driven by the availability of phosphorus and nitrogen-based nutrients. A Total Maximum Daily Load study has been initiated in order to develop a water quality model and make recommendations for reduction and allocation of pollutant loads for the lake.

-The federal Clean Water Act (1972), Section 303(d), requires that states report waterbodies that do not meet ambient water quality standards. A Total Maximum Daily Load (TMDL) study is required for all impaired waterbodies assigned to the 303(d) inventory list. A TMDL is an assessment of the pollutant loading capacity of a waterbody that still allows the waterbody to meet the assigned water quality criteria and support beneficial use.

-Evidence indicates that the oxygen depletion, a seasonal condition observed in the lake at water depths below the thermocline (8-10 meters), has been significantly increasing over the past two decades (Pelletier, 1998). This change is interpreted to be the result of several factors, including the direct loading of organic matter from the surrounding watershed, and eutrophication processes driven by the availability of phosphorus and nitrogen-based nutrients (Cusimano et al., 2002).

9. Advanced background, from Institute for Watershed Studies 2009-2010 report:

http://ceratium.ietc.wvu.edu/IWS2/lake/lakestudies/lakewhatcom/online_html/2010/LW_2010.htm

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Phosphorus: Although the Lake Whatcom microbiota require nitrogen, phosphorus is usually what limits microbial growth (Bittner, 1993; Liang, 1994; Matthews, et al., 2002a; McDonald, 1994). The total phosphorus concentration in the water column is a complex mixture of soluble and insoluble phosphorus compounds, only some of which can be used by algae to sustain growth. Soluble forms of phosphorus (e.g., orthophosphate) are easily taken up by algae and other microbiota, and, as a result, are rarely found in high concentrations in the water column. Insoluble phosphorus can be present in the water column bound to the surface of tiny particles or as suspended organic

matter (e.g., live or dead algae). Because competition for phosphorus is so intense, microbiota have developed many mechanisms for obtaining phosphorus from the surface of particles or from decomposing organic matter. Liang (1994) found that 50% of the total phosphorus bound to the surface of soil collected from a construction site in the Lake Whatcom watershed was “bioavailable” and could be extracted by algae.

When hypolimnetic oxygen concentrations are low, sediment-bound phosphorus becomes soluble and leaches into the overlying water. Prior to destratification, hypolimnetic phosphorus may be taken up by microbiota in the hypolimnion or metalimnion (see Section 2.3.2 and Matthews and DeLuna, 2008). When the lake mixes in the fall, the hypolimnetic phosphorus will be mixed throughout the water column. As oxygen concentrations increase during mixing, any soluble phosphorus that has not been taken up by biota will usually be converted back into insoluble phosphorus. Because phosphorus moves back and forth between soluble and insoluble forms and between organic and inorganic compounds, it can be difficult to interpret total phosphorus trends. For example, when algal densities increase, their growth usually results in the reduction of soluble and bioavailable fractions of phosphorus in the epilimnion, similar to the epilimnetic DIN reduction that was described for nitrogen. But, since this uptake simply moves the phosphorus into the “live-algae” fraction of organic phosphorus, total phosphorus concentrations may actually increase in the epilimnion.

In Lake Whatcom, total phosphorus and soluble phosphate concentrations were usually low except in the hypolimnion at Sites 1 and 2 just prior to destratification (Figures B96–B100, pages 4–4 and B101–B105, pages 4–4). Epilimnetic total phosphorus concentrations are usually lower than late-summer hypolimnetic peaks. Prior to 2000, the median epilimnetic phosphorus concentrations were <5 µg-P/L at Sites 2–4 and approximately 5–8 µg-P/L at Site 1 (Figure 9, page 4). The epilimnetic phosphorus levels have increased significantly at Sites 1, 2, and 4 (Figure 9, page 4); however, the pattern is quite erratic, reflecting the complicated nature of phosphorus movement in the water column. It is important to note that low water column phosphorus concentrations do not always match up with low algal densities, and may instead indicate rapid and efficient cycling of phosphorus among the lake biota.

2.3.6 Chlorophyll, plankton, and Secchi depth

Site 1 continued to have the highest chlorophyll concentrations of all the sites (Figures B106–B110, pages 4–4). Peak chlorophyll concentrations were usually collected at 0–15 m, while samples from 20 m had relatively low chlorophyll concentrations because light levels are not optimal for algal growth at this depth.

The Lake Whatcom plankton counts were usually dominated by Chrysophyta, consisting primarily of diatoms, Dinobryon, and Mallomonas (Figures B121–B130, pages 4–4). Substantial blooms of bluegreen bacteria (Cyanobacteria) and green algae (Chlorophyta) were also measured at all sites during summer and late fall. Previous analyses of algal biomass in Lake Whatcom indicated that although Chrysophyta dominate the numerical plankton counts, Cyanobacteria and Chlorophyta often dominate the plankton biomass, particularly in late summer and early fall (Ashurst, 2003; Matthews, et al., 2002b).

Secchi depths (Figures [B111–B115](#), pages [◆–◆](#)) showed no clear seasonal pattern because transparency in Lake Whatcom is affected by particulates from storm events and the Nooksack River diversion as well as algal blooms.

Indications of eutrophication: Eutrophication is the term used to describe a lake that is becoming more biologically productive. It can apply to an unproductive lake that is becoming slightly more eutrophic, or a productive lake that is becoming extremely eutrophic (see Wetzel, 2001, for more about eutrophication and Matthews, et al., 2005, for a description of the chemical and biological indicators of eutrophication in Lake Whatcom).

The median near-surface summer chlorophyll concentrations were higher in 2010 compared to 2009 (Figure [10](#), page [◆](#)), but the algae counts (all sites combined) were about the same (Figures [11–12](#), pages [◆–◆](#)). This discrepancy between chlorophyll and algae counts reflects the difference between numerical density and biomass. Chlorophyll is a direct measure of algal biomass and is best used to evaluate trophic changes in the lake (e.g., is the lake becoming more biologically productive?). Algal counts are a numerical way to look for trends within the same type of algae (e.g., are the numbers of Cyanobacteria increasing?). The relationship between chlorophyll and cell density is complex. The amount of chlorophyll in an algal cell is influenced by the physiological age and condition of the cell, light intensity, nutrient availability, and many other factors. In addition, while most types of algae are counted by individual cells, a few types must be counted by colonies because the cells are too difficult to see. Even if the amount of chlorophyll was constant in each cell, it would take many tiny cells to equal the chlorophyll biomass in one large colony.

One of the eutrophication trends in Lake Whatcom has been a fairly steady increase in the numbers of Cyanobacteria at all sites. This trend is best viewed using a \log_{10} plot (Figure [12](#), page [◆](#)), which shows the counts increasing from 1994 through 2004 or 2005. During the past five years the counts have been more or less consistent, going up or down slightly depending on the site and year.

Lake Whatcom algal blooms: An unusual algal bloom developed during the summer of 2009 that caused the City's water treatment filters to clog very rapidly. This affected the rate at which water could be treated and resulting in the City imposing mandatory restrictions on water use. In order to help identify the source of the problem, IWS analyzed plankton samples collected during August 2009 from raw water after it passed through the screen house to see whether there were algae present that might be affecting the water treatment rates (Matthews, et al., 2010). Most of the algae in the August 2009 samples were tiny rod-shaped and spherical Cyanobacteria that have been collectively referred to as Aphanocapsa and Aphanothece. Unlike the closely related *Microcystis flos-aquae*, Aphanocapsa and Aphanothece are not considered to be toxic Cyanobacteria (Gran [◆](#)li and Turner, 2006). They are, however, exceedingly slimy because the individual cells are embedded in a thick, sticky colonial mucilage.

Beginning in December 2009, IWS started collecting supplemental monthly plankton samples from 10 meters at Site 2 and the Intake and from the City's raw water gatehouse. Our goal was to generate detailed information about the algae responsible for filter clogging events using samples collected at the gatehouse and at depths close to the water withdrawal depth in basin 2. The supplemental algal counts were identified to a much lower taxonomic level than our regular algal counts using a settling chamber method (Hamilton, et al., 2001) that captures tiny individual algal

cells (<20 µm diameter) that can pass through our regular plankton net. Because of the different concentration methods and sampling depths, the settled algae counts are not directly comparable to the historic algal counts collected using a plankton net (Figures B121–B130, pages 4–4), but the general taxonomic patterns will be similar.

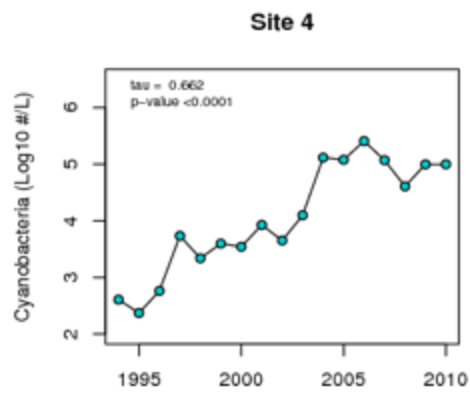
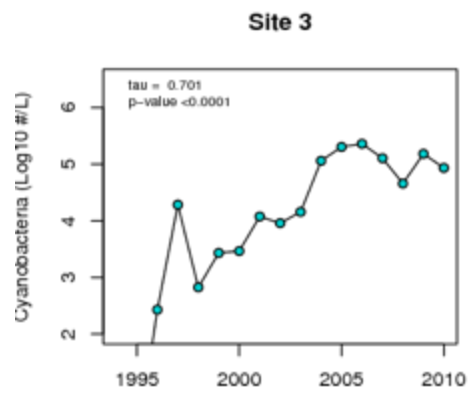
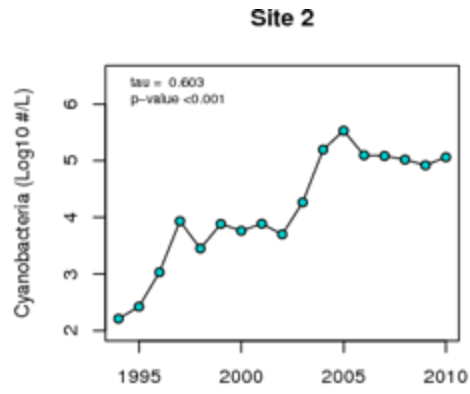
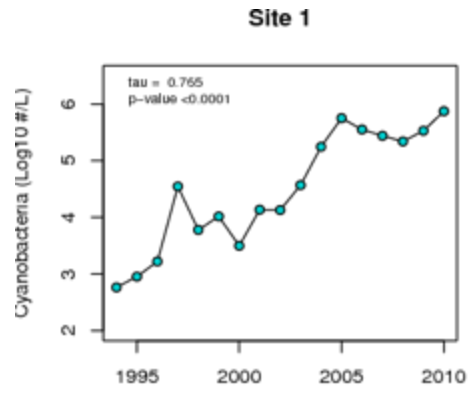
Dense, sticky colonies of *Aphanocapsa* and *Aphanothece* were exceeding abundant in the settled samples, comprising nearly 85% of the total cell count (Tables 10–11, pages 4–4 and Figure 13, page 4). The densities of *Aphanocapsa* and *Aphanothece* increased during the summer, coinciding with a decrease in the City's water production rate (Figure 14, page 4).¹⁴

The third most abundant group of algae in the samples was *Cyclotella* and *Thalassiosira*, which were combined for this report because they have similar filter-clogging features (Figure 15, page 4). Both taxa excrete long thread-like filaments that probably benefit the diatoms by slowing sinking rates or discouraging predation by filter-feeding zooplankton. In the City's water filters, however, the filaments may help create an algal mat stuck together by *Cyanobacteria* glue.

Although these taxa were moderately common in the settled samples, especially during the late summer when *Aphanocapsa* and *Aphanothece* were abundant, their density was not as useful for predicting poor water production rates (Figure 16, page 4).

Total algae counts from the gatehouse, Intake (10 m), and Site 2 (10 m) were used to predict water production rates using simple linear regression (Figure 17, page 4). All three regressions were statistically significant, with adjusted r^2 values of 0.640–0.719. Because most of the cells in the settled samples were *Aphanocapsa* and *Aphanothece*, similar regressions could be built using just those taxa. The advantage to using a smaller subset of algae is that future sampling efforts could focus on those two taxa, saving a considerable amount of analysis time. The best regression between water production rates and *Aphanocapsa*+*Aphanothece* was created using data from the Intake, resulting in an adjusted r^2 value of 0.694 (Figure 18, page 4).

We will continue counting settled samples during 2011 to help evaluate factors affecting the City's water production rates. In particular, we will try to confirm whether *Aphanocapsa* and *Aphanothece* densities, or other water quality factors, can be used to predict when water production rates are likely to decline.



Who Lives in the Stream?

Big ideas: Range of tolerance, Adaptation, Specific habitat needs, Ecosystem change

Enduring understandings:

Students will understand that...

- 1) Living things have a ***range of tolerance***, or range of conditions, in which they can live.
- 2) Living things are ***adapted*** to specific environments. Some living things (like macroinvertebrates) have very specific habitat needs. Some habitats may suit those needs and some may not.
- 3) If a habitat changes, an organism may not be able to survive in the new environment.
- 4) Stable environments allow the development of biodiversity, or many different forms of life, occupying many different niches.

Essential questions:

- 1) If an animal likes to live in cold water, what might happen to it if the water it lives in turns hot? What about if the water heats up by only a few degrees?
- 2) Is it possible for a habitat to be perfect for one animal and yet harmful for another animal?
- 3) When is it good to have bugs in your drinking water?

Learning Standards:

EALR 4 Life Science: Adaptations are physical or behavioral changes that are inherited and enhance the ability of an organism to survive and reproduce in a particular environment. The habitat is the particular part of the environment in which a species normally lives.

6-8 LS2D Ecosystems are continuously changing. Causes of these changes include nonliving factors such as the amount of light, range of temperatures, and availability of water, as well as living factors such as the disappearance of different species through disease, predation, habitat destruction and overuse of resources or the introduction of new species.

Materials-

- Student Journals/pencils
- Thermometer (1)
- White trays (5)
- Magnifying Lens (5)
- Ice Cube Trays (5)
- Nets (5)
- 11" x 17" Laminated Macroinvertebrate Identification Chart
- Extra Bug/Insect/Macroinvertebrate Identification Books

Location: Brannian Creek (see Gordon Carter Map)

Time Required: 60 Minutes (including 15 minutes travel time)

Number of Students: 10-15 Students

Number of Instructors: 2 Instructors, plus helpful chaperones

Set-Up:

Ask teachers to encourage students to bring extra shoes and socks (preferably rubber boots).

Who Lives in the Stream?

Check out the stream for safety hazards before bringing students to the site. Remove hazards, or identify hazards for students before allowing them to move about the creek. Potential hazards include: slippery rocks, wet and unstable banks, and attempting to cross the stream.

Environmental impact considerations:

The accessible part of the stream is small and cannot withstand repeated sampling over several successive days and still produce a variety of insects. Thus, wading in the creek should be minimized. Sampling should be done by hand not foot, and early each day trays full of bugs should be set aside for later groups that day. Release bugs upstream of the part of the stream we access. Gaining the group's cooperation to minimize impacts on the stream, its inhabitants, and later groups is key to making this succeed every group.

Vocabulary

Habitat: The place a plant or animal lives with the specific food, shelter, and space it needs.

Niche: The role played by a plant or animal within a habitat. A *niche* describes how an organism fits into the natural community, including how tolerant the organism is to ranges of food, water, shelter, and space.

Adaptation/Adapted: Plant and animal parents can pass on features that may help a young organism survive. For example, the parents of a fish might pass on the feature of bigger fins, which help the fish swim away from predators. The parent can't decide whether to pass on the feature or not- it just happens. Also, sometimes parents pass on a feature that is unhelpful for their young.

Range of Tolerance: The range of conditions in which a plant or animal can survive.

Macroinvertebrate: An animal with no backbone that is large enough to be seen without using a microscope. Examples: insects, flatworms, ribbon worms, snails.

Procedure

- 1) (0:00- 0:10) Hike to lesson location. Stop when approaching the riparian corridor, before getting there and ask students to close eyes and remain quiet, and say what temperature they feel, and what they hear. Then open eyes and walk closer. Stop again when everyone has just entered the older trees in the riparian corridor. Ask them to close their eyes again and notice what they hear and feel. Let them just experience for 30 seconds or so. Then have them open their eyes and ask what differences they noticed. Ask them to look around notice differences they can see compared to where they just walked. Have them share with a person next to them what they notice. (10 min, including hiking.)
- 2) (0:10-0:17) Introduce the stream as Briannan Creek and tell them it is a healthy stream. explain how we know that, using these five characteristics – as you explain these, ask

Who Lives in the Stream?

them to look down at creek and identify each feature that they can see as you describe them. (some will require closer inspection):

- a. Wood: provides food, forms pools (which allows for a variety of habitats)
- b. Substrate (requires closer inspection: explain you will look when you're at creek): a mixture of substrates, such as silt, sand, pebble, small and large rocks (provides differentiated habitat, oxygenation can happen when rocks or other blockages cause riffles in the water. In an unstable stream that has too much erosion small sediments fill in the pools, and around the rocks. The gravel is also filled in, leaving fewer kinds of niches for diverse macroinvertebrates. Large moss covered rocks in and near the channel are a good sign)
- c. Bank condition: bank stability, presence of vegetation, amount of erosion
- d. Maximum pool depth: on a medium stream, pools that are at least 3 feet deep at their deepest (fish, etc. can linger here in the slow-moving water)
- e. Canopy cover: well covered, with a variety of plant types and species (cover keeps water cool, and also indicates stable banks; note that this creek has canopy cover only because the Washington Forest Practices Act requires "riparian buffers" (ie, uncut areas along the length of year-round streams).

3) (0:17-0:18) **(H)** "This water is traveling towards Lake Whatcom, and will eventually become our drinking water for Bellingham. But... did you know there could be tiny creatures in this water? Ask if they think that is a good thing or a bad thing if we're going to drink the water. They can tell us whether our stream water is healthy. Today we are going to be watershed scientists and discover more about our water." (1 min.)

4) (0:18-0:19) "These small creatures are called macroinvertebrates. Any ideas about what a macroinvertebrate is?" *Guide students to pull apart the word: macro=big, vertebrae=backbone, in=no.*

"A **macroinvertebrate**: An animal with no backbone that is large enough to be seen without using a microscope. Examples: insects (including many larval stages), flatworms, ribbon worms, snails." **show diagram of life-cycle of a caddisfly, make connection that macro inverts in stream are insects** (1 min.)

5) (0:19-0:22) "Many macroinvertebrates need a specific habitat, or place to live. They are **adapted** to this habitat, which means they were have bodies that help them live in this place. As they grow, they may change body forms and move to new areas that fit their new needs."

"For example, stonefly larvae like cold, clear water that does not have a lot of pollution in it, because..."

- Cold, clear water often has more oxygen in it than warmer water. (That's because oxygen can dissolve into colder water at higher rates. Also, clear water is less likely to have organic matter that uses up oxygen, and floating debris can

Who Lives in the Stream?

cause water to soak up more heat energy from the sun.) *What's oxygen good for? Breathing!*

- Some macroinvertebrates may be very sensitive to pollution in the water (essentially it's toxic). Others may be less bothered by pollutants and can tolerate some - this difference is an example of **range of tolerance**.
- The more types of macroinvertebrates living in a stream the more likely the water is to be healthy, because there are probably low enough levels of pollution to let the very sensitive organisms survive! And the more tolerant ones do fine it it too. (Extension: the importance of biodiversity). (3 min.)

- 6) (0:22-0:23) **(W)** "We're going to see if we can find any macroinvertebrates in this stream and if we do we will try to identify them.

Our goal is to determine if this stream is healthy or not. Identifying macroinvertebrates and making stream observations will help us do that." (1 min.)

- 7) (0:23-0:28) **(E1)** Give directions for stream exploration. Behavior of large group by stream can become chaotic, so it's important to set clear boundaries and expectations. Consider 'zoning' the creek, with each group getting a slice from shore upwards to sample and where they can put trays and other tools. Use co-leader and chaperone to help conduct the activity with the smaller groups. Give very clear instructions to the whole group before groups start activity.

"Here's how it's going to work..."

a. *Divide students into groups (all they to choose groups), so that each group has a complete kit containing one net, one tray, one identification chart, bug box, and spoon.*

b. *Select one group and use them as an example on how to use the equipment when looking for macroinvertebrates. - **Be sure to guide them explicitly to follow procedures correctly (correct the action before moving on to next step with this demo group: fill tray and ice cube trays with water first. Netter then can search for animals. Keeping feet on dry stream bank, hold net again bottom in a current. lift rocks directly upstream, and use hand to gently wash off the surface in the water heading for the net. Other organisms should float down. Turn net upside down into tray. Show how to catch an invert and with spoon and place in one cell of ice cube tray. Demonstrate how to use the steps of the key.***

c. *The students are not allowed to enter the stream, only can search from the streambank. Use the seine net provided to find macros if none are found by the students.*

d. *Guide each group to their designated spot (there should be 3 spots along the streambank.*

- i. This may create group management issues, so be sure to set boundaries and enlist parents to help keep students within those boundaries. Determine a signal to gain students' attention (a whistle or call). Also, remind students that if they get their shoes wet and they don't have

Who Lives in the Stream?

another pair they will be wet all day!

ii. This may also cause negative stream impacts if a lot of students are in and out of the creek- be aware of very sensitive areas and set boundaries excluding them. It may also help to set a number for how many students can be in the creek at once (if many are prepared with proper shoes!)

iii. Note: some small scrapers will not come off and can be more easily gently brushed off rocks into trays.

c. Once there are some macroinvertebrates in the net, we will turn them out into the shallow pans.

d. We can move individual organisms to the ice cube trays using spoons for further inspection.

e. Using the identification charts and magnifying lenses, we will identify the macroinvertebrates they found.

d. Lastly, we will release the organisms we find upstream.

8) (0:28-0:45) Students look for and identify macroinvertebrates in the stream following the above directions. Have them find the general group on the pollution tolerance chart as they go. (17 min.)

9) <steps 9-11 and maybe 12 too could probably be skipped if short on time, and instead emphasize the ideas of diversity of the bugs you found, and the pollution tolerances they show. Use information in the extension section to create a link to the final lesson>

(0:45-0:48) (E1) "Earlier we talked about how many macroinvertebrates like a specific kind of habitat. Their bodies are adapted to this habitat. One of the ways they are adapted to survive here is in the way they eat. There are three types of macroinvertebrate eaters: **Shredders, strainers, scrapers and predators**. How do you think shredders eat? What about strainers? Scrapers?" Lead students in acting out the type of feeding that is suggested, or prompt examples and get group to copy. Point out areas where each type of feeder might like to live: holding onto rocks, in calm areas, in good areas to strain.)

Shredder: A type of macroinvertebrate that gets its food by "shredding" up tiny pieces of plants and fungi in a stream. Shredders generally eat already dead matter.

Strainer: A type of macroinvertebrate that gets its foods from "straining" algae out of a stream. Strainers filter the tiny (sometimes living) particles from the water.

Scraper: A type of macroinvertebrate that gets its food by "scraping" algae off rocks in a stream. Scrapers feed on algae that are living on rocks and larger plant surfaces.

Predator: A type of macroinvertebrate that eats other small organisms for energy and nutrients.

10) (0:48-0:51) (T) "Did you find any shredders? Scrapers? Strainers?" If the students found macroinvertebrates of these types, give them a chance to draw their choice of what they saw and label them in their journals. Encourage the students to create scientific

Who Lives in the Stream?

illustration-type drawings using many details. One way to do this is to draw a “zoomed in” look of the macroinvertebrate as if it were under a microscope. If students find more than two of any type of macroinvertebrate the drawing space in the journals can be repurposed for whatever they find. (5 min.)

11) (0:51-0:52) **(R)** "Now, we said that macroinvertebrates could help us decide if we had healthy stream water. We said that many of these creatures need cold water, clear water, pollution-free water. We also said that the more types of macroinvertebrates we found, the more likely our water is to be healthy. And the more pollution-sensitive the bugs we find, the cleaner the water. Based on what you have found, what do you think about the health of the stream so far? Are these good bugs to be in a stream leading to our drinking water lake? (1 min.)

12) (0:52-0:57) **(R & E2)** "Let's take a few more observations of the stream to help us really decide if our stream water is healthy! We will use the **Stream Observations Journal Page.**"

Stream Observations

- 1) Observe a jar full of water. How does the water look? Circle one: Clear Muddy
- 2) What do you see in the water? Elicit potential food for strainers.
- 3) Does the stream feel warm or cold? Should feel cold
- 4) What is the temperature of the stream? In Fahrenheit and Celsius

After exploring the stream...

- 5) Do you think this stream is healthy? Why or why not?
- 6) Many of the macroinvertebrates you observed like to live in cold, clear water. What might happen to them if the water became muddy or warm?
They would not survive- many are too small to move to other streams or travel across dry areas. They could become food for other living things if they died. (5 min.)

13) (0:57-0:60) **(R)** "We saw many different macroinvertebrates today. As you can see from this identification chart, there are lots and lots of different kinds- even if you look in a different stream in Bellingham you may find different kinds of macroinvertebrates. They each have a certain place they like to live. They each have a certain way they like to eat. Review:

a) **Create review of riparian quality, pollution tolerance and biodiversity**

OR

b) **(if this was covered above) What are the four kinds of eaters again?"** (1 min.)

"To help us remember everything we've learned I have a dance for you! It's called the macro-dance!" (make up motions for the different feeding strategies, give it a good beat!)

Who Lives in the Stream?

Macro-Dance:

What's a macroinvertebrate?

No backbone!

The macroinvertebrates we found like what kind of water?

Cold

And how do they eat?

Shredder!

Strainer!

Scraper!

Predator!

FASTER!

(repeat) (2 min.)

Extension to connect this lesson to the County Council culminating lesson:

Explain (or play) the role of watershed scientist:

Watershed scientists study streams and rivers (like Brannian Creek) and the plants and animals living in them to understand how healthy the stream is. They are concerned with any actions that may cause pollutants to enter Brannian Creek and upset the health of the stream (and other streams like it) because it feeds into Lake Whatcom, which is the source of our drinking water. Watershed scientists like to study the macroinvertebrates in a stream because they are very sensitive to changes in their habitat and are a reflection of stream health. Watershed scientists also look at the plants and trees around the stream: more trees means more roots and more humus on top of the mineral soil that will help filter rainwater before it enters the stream. In an area that has been clear-cut by loggers with no trees, there is less humus and less downed trees, which means more pollutants can wash into the creek. In neighborhoods with lots of houses, there is more pavement, which causes pollutants to wash into the water instead of being filtered through the soil, and more lawns and landscaped areas, which can be eroded. Once the pollutants (like phosphorous) get into Lake Whatcom they can cause lots of issues that affect the quality of our drinking water.

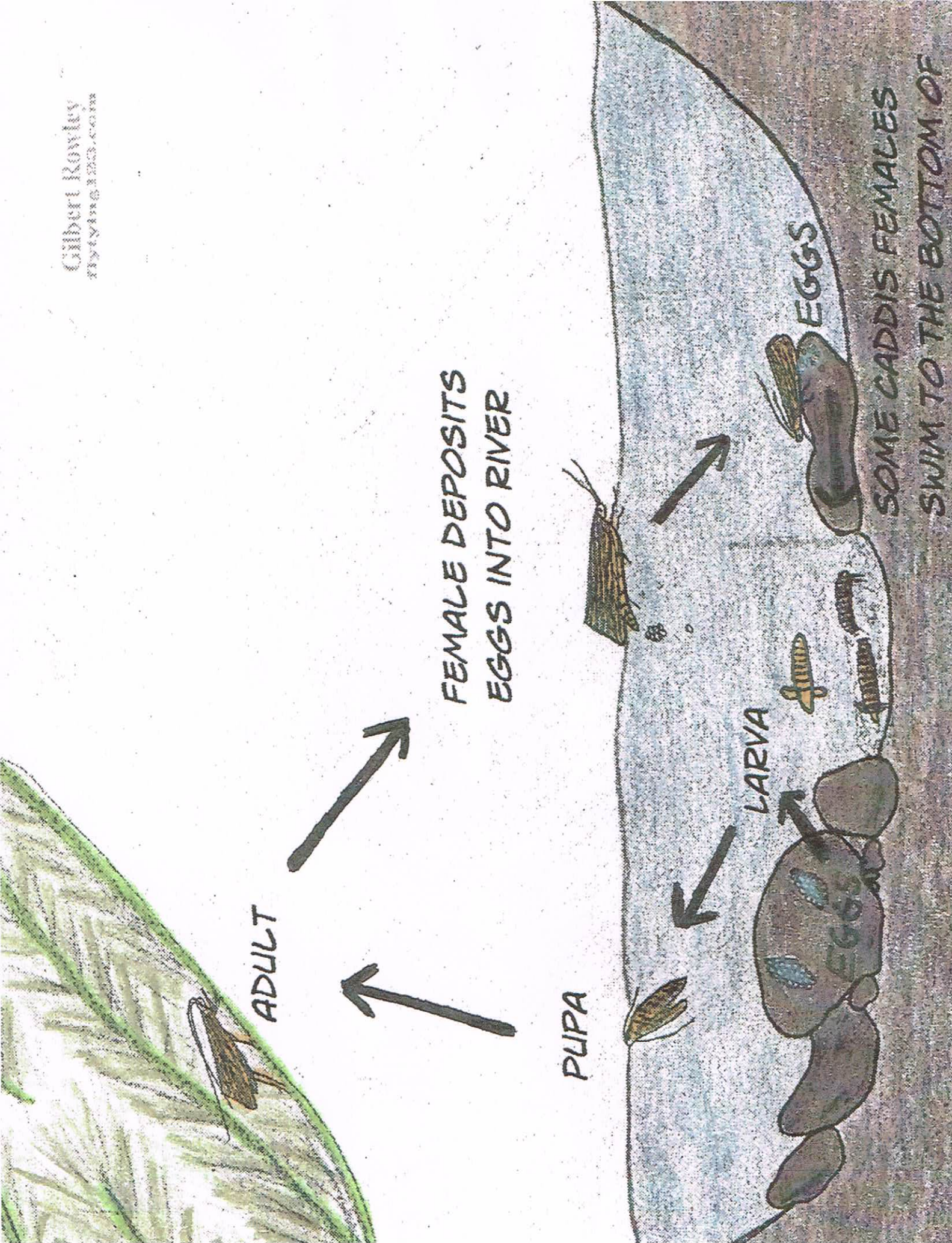
Stewardship understandings: Plants and animals are only adapted to certain habitats, and changes to those habitats can lead to the death of a species. Species biodiversity indicates the health of an ecosystem, because more species means the habitat is suited to support a variety of plants and animals. Macroinvertebrates are especially good indicators of the health of a stream habitat because they are very sensitive to pollution in the water, so if there are macroinvertebrates in a stream that don't tolerate pollution well, it is an indicator of good stream health.

Stewardship goals: I can encourage biodiversity by advocating for the protection and sustainable management of the habitats where animals and plants live, while also meeting human needs from certain industries in sustainable ways.

Who Lives in the Stream?

Extended Assessment Option

Present students with a different habitat in which they can sample or observe organisms that have small ranges of tolerance. Students should be able to identify species using identification charts. They should also be able to determine the necessary features of the habitat that those organisms need. This will involve taking observations of the habitat.



ADULT

FEMALE DEPOSITS
EGGS INTO RIVER

PUPA

LARVA

EGGS

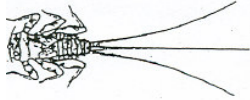

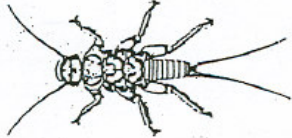

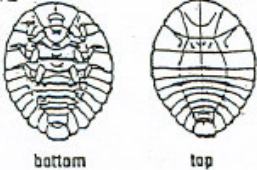
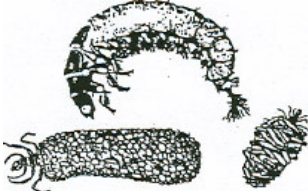




SOME CADDIS FEMALES
SWIM TO THE BOTTOM OF

STREAM MACROINVERTEBRATE IDENTIFICATION CHART

SIZES ARE APPROXIMATE AS MOST COMMONLY FOUND

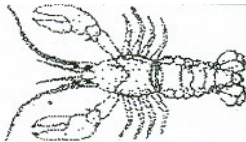
GROUP 1

Very sensitive to pollution.

	LARVA OR NYMPH	ADULT
<p>Mayfly - As adults, mayflies live only a few hours or days, living only long enough to mate and lay eggs. The nymphs live under water up to two years, move to land, and shed as adults. The legs have a single claw and there may be two to three tails.</p>	 1"	 1-2"
<p>Stonefly - As a nymph, the stonefly lives under water for one or more years. Nymphs live under rocks in the fast-moving water. Adult stoneflies live only a short time, then die. They possess two tails and each leg has a pair of hooks at the end. The gills are often visible on or behind each leg.</p>	 1 1/2-2"	 1-2"
<p>Water Penny - The adult lives on land, but the flat, round larva securely clings to the underside of rocks in cold-water streams. The segmented, plate-like covering protects the insect's head, legs, and gills on the underside. Their color is brown, black, or tan.</p>	 1/4-1/2"	
<p>Caddisfly - The unusual larva build cases of sand or plant debris, cemented together by silk. Cases built by different species are quite distinctive. Larva feed on small water plants and animals, and in turn are food for fish and other predators.</p>	 1/2-1"	 1-2"
<p>Dobsonfly (hellgrammite) - These insects spend up to three years as larva before turning into adults. Larva live under stones in the swiftest part of the stream and may grow to be 4 inches long. As their large jaws suggest, they are carnivorous and may bite.</p>	 1-2"	 1-3"
<p>Gilled snail - These snails have gills and rely on cold fast-moving water. With the opening facing you and the shell tip pointing up, the opening will be on the right side. The shells have an operculum (plate-like door), are black and are easily seen attached to rocks.</p>		 1/2-3/4"

GROUP 2

Somewhat sensitive to pollution.




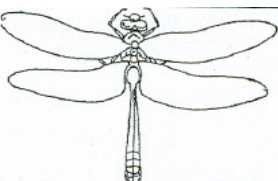
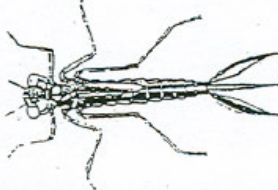
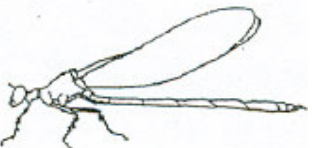

	LARVA OR NYMPH	ADULT
<p>Crayfish - Crayfish have five pair of legs, the first being armed with large claws. If a leg is lost, another will grow in its place. If threatened a crayfish will flip its fan-like tail down, propelling itself backwards to escape.</p>		 1-4"

GROUP 2

Somewhat sensitive to pollution.

LARVA OR NYMPH

ADULT





<p>Crane fly - Cranefly adults look like large mosquitoes but do not bite. They are long and slender, with long legs. Larva are plump, have a segmented body, and appear to be transparent.</p>	 <p>1-2"</p>	 <p>2"</p>
<p>Dragonfly - The commonly seen adult is slender and hold their large, clear wings out flat when at rest. The nymph has a wide abdomen and no gills. Nymphs may spend up to a year underwater before becoming adults. Adults and nymphs are carnivorous.</p>	 <p>1"</p>	 <p>2-4"</p>
<p>Damselfly - Adults hold their wings together and above the body when at rest. The nymph stage may range from several weeks or months to 4 years and are usually found in slower moving water. Like a dragonfly, damselflies are predators but the body is more slender. Three tail structures serve as gills.</p>	 <p>1-2"</p>	 <p>2-3"</p>
<p>Scud - Scuds resemble freshwater shrimp. They are lighter in color and 7 pairs of tiny segmented legs. Scuds swim rapidly on their sides and are scavengers of plant and animal matter.</p>		 <p>1/3"</p>

GROUP 3

Generally tolerant to pollution

LARVA OR NYMPH

ADULT

<p>Lunged snail - These snails obtain oxygen from air trapped in their shell. The shell has no operculum (plate-like door). With the shell opening facing you, and the tip pointing up, the opening will be on the left side. Lunged snails prefer slower moving waters.</p>		 <p>1/2"</p>
<p>Aquatic worms - Most are small and thread-like. Their color may be red, tan, black, or brown. Movement is done similar to earthworms, stretching and pulling its body slower moving waters.</p>		 <p>1-5"</p>
<p>Midge Fly - Can be found in all but the most polluted waters. Their length is up to 1/2 inch long. The body is slightly curved and segmented, often with a distinct dark head. One tiny pair of legs exist below the head and another pair is at the back end.</p>	 <p>1/2"</p>	
<p>Black Fly - The segmented body may be up to 1/3 inch long with a small sucker at the end of the widened abdomen. Tiny gills filter food from the water. These larva are often found attached to rocks and sticks.</p>	 <p>1/3"</p>	

Watershed Stewardship and County Council Meeting

Nicole Jordan, Virginia J. Cleaveland, Kaci Darsow and Jonathan Cooper

Gordon Carter Environmental Education 6th Grade WMS Curriculum; modified, 2013

Target Audience: 6th Grade Social Studies after visiting Gordon Carter Site

Duration: 1 Hour

Group Size: 10-15 students and 2 instructors

Location: Whatcom Middle School

Materials: Student journals, writing utensil, large topographical map of Lake Whatcom/Bellingham, role sheets, data packet, (whiteboard and pen for instructors)

EALRs/ESEs

--ESE Standard 1 Ecological, Social, and Economic Systems: Students develop knowledge of the interconnections and interdependency of ecological, social, and economic systems. They demonstrate understanding of how the health of these systems determines the sustainability of natural and human communities at local, regional, national, and global levels.

--ESE Standard 3 Sustainability and Civic Responsibility: Students develop and apply the knowledge, perspective, vision, skills, and habits of mind necessary to make personal and collective decisions and take actions that promote sustainability.

--EALR SS-G 3.2.1: Understands and analyzes how the environment has affected people and how people have affected the environment in the past or present.

--EALR SS-SS 5.1.1: Understands positions on an issue or event.

--EALR SS-SS 5.1.2: Evaluates the significance of information used to support positions on an issue or event.

--EALR SS 5.3.1: Engages in discussions that clarify and address multiple viewpoints on public issues.

Objectives

Big ideas: Sustainable management of energy cycles and watershed habitat, compromise of stakeholders' interests through government regulations

Essential question: How can stakeholders compromise to meet human needs for certain activities in the watershed (logging, housing and recreation) while (1) maintaining sustainable energy cycles and (2) encouraging sustainable management of the habitat?

Understandings: Stakeholders have competing interests in the Lake Whatcom watershed and must compromise by working with other stakeholders to help the County Council create a sustainable management plan.

Procedure

Part 1: Check-in/Recap

(0:00-0:05) --Divide large classes into small groups worked with at Gordon Carter site. Spring Blockers recap the week for students: We have been learning about energy cycles and plant and animal habitats in the Lake Whatcom watershed so we can understand how different stakeholders depend on and can cause changes to those energy cycles and habitats.

-- Ask students: What information and concepts have you learned that apply to the LakeWhatcom watershed? (Solicit responses.)

Phosphorous lesson: How much phosphorous is in our bodies? How did it get there? Where else is phosphorous found on Earth? How does phosphorous affect water quality? Why did the Real Estate Agent/Loggers care about the Lake Whatcom watershed?

Winter wren lesson: Which habitat in the Lake Whatcom watershed do winter wrens like to live in? Which habitat do winter wrens not like? How did those habitats get that way? Why did the loggers care about the forest? What resources does Wren habitat provide for humans?

Macroinvertebrates lesson: What are some identifying factors of a healthy or non-healthy stream? Why is it important to have healthy streams that feed into Lake Whatcom? Why was the Wildlife Biologist concerned about Macroinvertebrates in the creek?

-- Explain: In our next activity, you will be considering the perspectives of different stakeholders and how they can work together to come up with the best plan for sustainable management of the Lake Whatcom watershed.

-- What does sustainable management mean to you? (Solicit responses.)

Definition: Sustainable management is a way of treating the land so you use only what you need and leave the rest so it will be there for future generations. It is a way to maintain ecosystem balances and energy cycles without destroying the resources, while still meeting the needs of stakeholders in present and future generations.

Part 2: Roles and Perspectives

(00:05-0:10) -- Right now we're going to brainstorm as a group who the different stakeholders are that affect and are affected by the Lake Whatcom watershed.

Who are some of the stakeholders you've already learned about in the LakeWhatcom watershed? What about the non-human stakeholders? Who should be responsible for advocating for the trees, plants and animals living in the LakeWhatcom watershed? (Solicit responses.)

-- Introduce role-play as a format. It is acting or pretending to be a real person in a realistic situation. Some of the roles here will be citizen government official or business owner. The

stakeholder roles we are going to act out were chosen because they relate to Lake Whatcom sustainable watershed management and the quality of our drinking water.

(00:10-00:20) Assign students roles (in groups of 2 or 3). The student roles are in your journals. (Instructors circulate and help to clarify student positions as needed.)

--Your goal is to read the position and come up with a way your expert or stakeholder can meet human needs for certain activities in the watershed (like logging, places to live and recreation) while (1) Encouraging sustainable energy cycles in the Lake Whatcom watershed and (2) Encouraging sustainable management of the habitats in the Lake Whatcom watershed to help protect the plants and animals. Be sure to address at least one other stakeholder's perspective on the watershed, how your proposed idea might affect them, and how you will work with them to come up with a sustainable management plan for the LakeWhatcom watershed.

Part 3: County Council Meeting

(0:20-0:45 min)--Once students understand the perspective of their expert or stakeholder they will be involved in a county council meeting that will develop rules and regulations surrounding the protection of the LakeWhatcom watershed. Instructors will act as the County Council members, and the students will be the experts and stakeholders. An important piece of this step is to have the students declare their stakeholder's role, what they would like to have done, as well as understanding how it will affect other stakeholders. (The instructors are in a formal decision-maker role, but during the role-play your job is to facilitate the solution being in their hands.)

-- The spring block instructors, acting as the County Council, should follow this script:

Council: "Welcome, thank you for coming to our County Council meeting. LakeWhatcom is listed as an degraded water body under the Clean Water Act. As a result of this, the Washington State Department of Ecology requires the County Council to create a plan to improve the condition of the lake. The council is trying to write a proposal that will stop the amount of phosphorus runoff into the lake from increasing, and ultimately come up with a plan that will encourage sustainable management of the watershed while still meeting the needs of all the stakeholders. WE NEED YOUR HELP! We've got some experts with us today to give some background on this situation. After everyone has had the chance to introduce themselves and

propose their ideas, there will be a discussion in which you will tell us what to do. Experts, we would like to hear from you now.”

--Watershed scientist: Share research.

--City water technician: Share water quality facts.

--Wildlife biologist: Share facts about plants and animals in watershed.

County Council: “Before we open the discussion, please consider these guidelines:

--All are welcome to contribute, including the scientific experts.

--Remember to keep this discussion civil, respectful, and productive.

--Remember that the goal of the proposal should be to stop the amount of phosphorus runoff from increasing, and to come up with a sustainable management plan for the Lake Whatcom watershed while still meeting the needs of all the stakeholders.

--**Most importantly:** When you present a proposal, be sure to address at least one other perspective on the watershed, how your proposed idea might affect them, and how you will work with them to manage the lands. (Instructors should not let discussion go on if this is not happening.)

County Council: “Will all the members of the public and other stakeholders please stand up and introduce yourselves? (Allow introduction of TITLES only.) Now, who has some ideas about how we could reduce phosphorus runoff in the lake? Please go one at a time and explain to us (1) why you are a stakeholder in the watershed (2) how you will reduce phosphorous runoff in the watershed, and (3) how you will work with another stakeholder for sustainable management of the Lake Whatcom watershed.” Instructors should anticipate needing to remind esp. first few to speak to follow these latter 2

--Students should present: Loggers, developers, watershed residents and city of Bellingham residents.

Discussion: Council members take notes on whiteboards with points of agreement (especially how stakeholders want to work together, and ideas for sustainable management).

County Council members: Thank you all for your valuable input and for attending our meeting today. We will use your ideas to draft a proposal to the state that includes (cite specific ideas that the students discussed and agreed on).

Part 4: Conclusion (0:45-0:50)

-After the County Council meeting, transition out of roles of stakeholders and back into roles of students.

-Ask students: “What has this activity made you think about how people can work together to solve big problems?” Where there any surprises in the conclusion of the meeting? In what ways has this changed your view of environmental debates?

Extensions: What can you as a student do to encourage sustainable management of the Lake Whatcom watershed?

Background

--Lake Whatcom is a large natural lake in Whatcom County. The northwest end of the lake lies within the city of Bellingham, and 22 small watersheds drain into the lake. Lake Whatcom serves as the drinking water source for about 96,000 people in the Bellingham area. The lake is popular for recreation, and the area around it has become a popular place to live.

--Water quality problems in Lake Whatcom have triggered a water quality improvement project by Ecology. These projects begin with a study of pollutants. For Lake Whatcom, Ecology is working to determine the allowable limits of phosphorus in the lake and fecal coliform bacteria in the tributaries, to meet water quality standards. Ecology will work with local governments (County Council, city councils, Department of Natural Resources) to determine how to achieve those limits.

--Based on historic data, Ecology officially recognized in 1998 that Lake Whatcom fails to meet federal standards for dissolved oxygen. This put Lake Whatcom on the state’s Clean Water Act 303(d) list of impaired water bodies.

Phosphorous runoff

--Phosphorus is the main cause of Lake Whatcom's low-oxygen problem. Phosphorus occurs naturally, but soil disturbances, such as logging and development, increase phosphorus entering the lake in storm water. Computer predictions show the lake would meet state standards for oxygen if there was 86 percent less development than existed in 2003. Since then, zoning laws have allowed more development in the watershed.

--Sources of phosphorous: Runoff from bare soil and developed areas. Phosphorus occurs naturally in soil and human and animal waste, and is added to some fertilizers.

--Connection to algae and oxygen: Lake Whatcom is naturally in a stage where it is still "nutrient limited." The key limiting nutrient for algae growth is phosphorus. There are enough other nutrients for lots of algae to grow, but phosphorus is in short supply, keeping algae growth in check. Phosphorus feeds algae growth. Bacteria that consume dying algae deplete the oxygen that fish and other aquatic life need to survive. When oxygen levels are low, phosphorus is released from lake sediment and re-enters the water, perpetuating the cycle. The dissolved oxygen levels in Lake Whatcom fail to meet state water quality standards now, and they have the potential to get much worse, making the problem much harder to fix.

Logging:

Roughly half of the DNR (Department of Natural Resources)-managed land around Lake Whatcom was granted at statehood to support schools, while the other half belongs to the county. These were private lands which the county claimed after tax defaults early last century. State law allows counties to transfer (or "reconvey") such land back away from the DNR providing the counties have a recreation plan for the lands.

A proposed new Lake Whatcom forest preserve park, once approved, will protect fragile soils from logging and associated road building, protecting drinking water, keeping neighborhoods safe from landslides, and providing low-impact trails.

Part private land, part state-managed land, Lake Whatcom has several communities built right down to the lake shore; boats and engines are allowed on the lake waters, and logging promoted on the state lands.

But DNR will still be logging substantial areas, including clear-cuts of up to 100 acres, within the Lake Whatcom watershed by constructing dozens of miles of new road, in some cases across steep, unstable slopes. Reconveyence will prevent this by consolidating (through intertrust land

swap) county land onto the steepest slopes of Lookout and Stewart Mountains, and placing them into forest preserve. In 2013 the County Council passed the reconveyance, and the parties are poised to move ahead, except for a court challenge from the logging industry claiming that lands designated to support the forest industry cannot be removed from that status. The court case has not been heard.

Treatment of drinking water

--Excess phosphorus creates larger algae blooms, which require more treatment to make the water safe for drinking. That treatment process creates more trihalomethanes, a byproduct that some studies link to cancer.

--Effect of development: Roofs, driveways and lawns interrupt the absorption and filtration provided by forests and soils, instead sending phosphorus-laden storm water rushing to the lake. Communities must modify existing and future development to create the same effect as removing development.

--On January 10, 2011 the city of Bellingham filed a petition to have the Lake Whatcom Watershed closed to additional groundwater withdrawals. The city's petition argues that phosphorus-laden runoff from cleared and developed land is impairing the city's ability to exercise its municipal water right from Lake Whatcom and supply water to nearly 100,000 people.

--Elevated levels of phosphorus have resulted in low dissolved oxygen levels and excessive growth of algae blooms in the lake that has slowed operations at the city's water treatment plant. The algae blooms clog water filters and sometimes require the city to use millions of gallons of treated water to flush the filters.

Solutions

--Since 1990, the city and county have worked to develop a strategy to improve water quality in Lake Whatcom to meet state and federal standards for dissolved oxygen. The lake is on the state's 303(d) list of impaired water bodies, and local governments must meet the pollution limits identified through the state water quality improvement process (called a TMDL). But that process is not intended to address these immediate concerns about the city's compromised water rights, and immediate concerns about the continuing degradation of the environment in the watershed.

In 2000, Conservation Northwest and others persuaded the Legislature to unanimously pass the Lake Whatcom bill requiring DNR to develop a landscape plan to protect water and local neighborhoods. In 2004, DNR adopted a Lake Whatcom Landscape Management Plan, developed in consultation with a local advisory committee. The landscape plan is in effect, it rests on a strong legal foundation and is rooted in community support, and regulates logging on DNR land here to a higher standard than anywhere else in the state.

--Under the Administrative Procedures Act, Ecology can:

--Grant Bellingham's petition.

--Deny the petition with an explanation.

--Deny the petition but provide an alternative means to address the concerns of the petition.

--Ecology chose the third option and accepted Whatcom County's proposal to amend its development regulations in the Lake Whatcom watershed in the next several months to ensure no additional phosphorus contamination of the lake. A letter from the county executive to Ecology states the county's goals of amending the regulations to:

--Prevent additions of phosphorus to Lake Whatcom from new development projects.

--Achieve a consistent and predictable set of development regulations.

--Ecology believes if the amended regulations are adopted and effectively implemented, the goals of the city's petition will be achieved. If the amendments are not adopted or properly implemented, Ecology reserves the right to take additional regulatory action to ensure that our water quality goals for the lake are achieved.

Role descriptions – SAME COPY AS LARGE TEXT COPIES USED BY STUDENT GROUPS:

Watershed Scientist

You are a research scientist who has been studying Lake Whatcom for over 20 years. For the past 12 years, water quality has been decreasing. Based on this work, in 1998 the Washington State Department of Ecology put Lake Whatcom on the federal Clean Water Act list of degrading water bodies.

High levels of phosphorus are the main problem in the lake. When too much phosphorus is introduced to the lake, algae grows rapidly. The abundance of algae dies and is eaten by bacteria, which uses a lot of oxygen. This lowers the levels of dissolved oxygen in the water, which impact species living in the lake, such as the fish.

The biggest sources of phosphorus runoff in the watershed are bare soil and disturbed soil. Logging and development can cause these problems. Phosphorus levels are so high that changes that normally happen in hundreds of years have happened in 15 years.

You have studied Brannian Creek extensively, one of the 22 small watersheds that drains into Lake Whatcom, and have determined from the abundance of macroinvertebrates in the stream that it is healthy. But you are concerned that the health of this stream, and the others, would be put in jeopardy by phosphorous runoff from increased logging and development.

You came to the meeting today to present facts on phosphorous levels in the lake and to ask the county council to consider regulations for loggers, developers and watershed residents to prevent runoff.

Things to think about during discussion

- How much more phosphorous will be added to the watershed from the land that is zoned for development?
- What causes will contribute the most increase of phosphorous to the watershed?
- How will your plan affect other stakeholders?

Your thoughts for other stakeholders

- County Council could require low-impact development (such as driveways that allow water to soak into the ground).
- County Council could require developers to build fewer homes per acre (down-zone).
- County Council could raise money to purchase lands from the state to prevent development (this would require a tax increase for city residents).

What is your sustainable management plan? How will your proposal affect other stakeholders?

City Water Technician

Your job is to monitor the actual quality of water leaving the water treatment plant and reaching homes in Bellingham, and to ensure it meets federal standards. In fact, it routinely exceeds these standards. That is not to say, however, that it is perfectly “pure.”

Large amounts of algae in the lake can clog the water filters at the water treatment plant. Also, removing organic matter, like algae requires chlorine treatment. When you use large amounts of chlorine to treat the water, some of those chemicals are still in the water by the time it reaches Bellingham city residents, and those chemicals have been known to cause cancer.

However, you are confident that the water is still of high quality and exceeds federal standards under the Drinking Water Act and other rules.

You would like to see the government come up with regulations that would limit the amount of phosphorous that enters Lake Whatcom. That way the phosphorous won't cause algae growth, and you won't have to use chlorine to treat the water. You think preventative measures are the best way to sustainably manage the watershed.

You came to the meeting today to present the facts of the water quality that you have gathered over the past few years and encourage stakeholders to realize what is going on in the watershed. You would like to see a proposal that helps maintain a high quality of drinking water for Bellingham residents.

Thinks to think about during discussion

- How increased chlorine usage affects city residents who drink the water.
- What would you like other stakeholders to do so you won't have to put as much chlorine in the water?

Your thoughts for other stakeholders

- Loggers could limit the amount of phosphorous runoff by building better roads and drainage ditches, and leaving behind some fallen trees and ground cover (leaves) so the soil is not exposed.
- Developers could build neighborhoods that have more porous surfaces to allow rain to filter through the ground before it enters Lake Whatcom.
- Watershed residents could also make sure their land has lots of trees and natural vegetation, which will help filter the rainwater, instead of things like long driveways and basketball courts.

What is your sustainable management plan? How will your proposal affect other stakeholders?

Wildlife Biologist

You have studied the plants and animals in the habitats around Lake Whatcom and have discovered several species that are affected by the logging and development in the watershed.

Winter wrens like living in the older forests with more downed trees and better protection from predators. When loggers clear-cut an area they are taking away habitat from the winter wrens. The loggers remove all the downed trees, and they also replant the area with only one species of tree. You have observed that the winter wrens are not adapted to live in this new habitat, so you are concerned that more logging will further reduce their habitat. This could cause the species to die.

You also want to prevent loggers from cutting down trees in the Lake Whatcom watershed because the trees play an important role in the global carbon cycle by pulling carbon from the atmosphere and storing it in their trunks and leaves. You have heard there are ways for loggers to do their jobs in a more sustainable way.

You came to the meeting today to encourage sustainable management of the Lake Whatcom watershed by standing up for the plants and animals as non-human stakeholders. You want to encourage biodiversity in the watershed because it is a sign of the watershed's health. You would like to see government regulations that prohibit the destruction of winter wren habitat, as well as the habitat of all the other plants and animals that thrive around Lake Whatcom.

Things to think about during discussion

- What other plants and animals depend on the forests and streams around Lake Whatcom?
- Is it possible that some of the other stakeholders won't take you as seriously because you are taking the side of the plants and animals, not humans?
- Why is biodiversity important in a habitat?
- Are you a less important stakeholder because you are only advocating for the plants and animals?

Your thoughts for other stakeholders

- Loggers could still do their jobs while preserving habitats by cutting down the trees throughout a longer 100-year cycle instead of all at once.
- Developers can still build homes while protecting habitat by grouping the homes closely together in neighborhoods instead of spreading them out (or else they would need to build more roads so residents could reach their houses, destroying habitat).

What is your sustainable management plan? How will your proposal affect other stakeholders?

Loggers

Loggers are often criticized as the stakeholder that contributes most to phosphorous runoff in the Lake Whatcom watershed. But you also play an important role in society, providing humans with the materials they need to build homes to keep them warm and help them survive as a species. While most other stakeholders would like to see logging eliminated in the Lake Whatcom watershed, you recognize the importance of your industry and want to brainstorm ways you can help with the sustainable management of the watershed.

There are already government regulations in place that require loggers to leave some trees behind when they clear-cut an area; the trees will produce seeds so more trees will grow. You are also required to replant the area with trees, although you don't always plant the same kind of trees that were there to begin with. But you know the new trees will grow and create a different habitat for different plants and animals to move into.

You came to the meeting today to stand up for your rights as a stakeholder to help manage the resources in the Lake Whatcom watershed. You want to about more sustainable practices for cutting down trees in the watershed, without too many restrictions that might make it too expensive for you to do your job. You also want to remind the other stakeholders, experts and County Council members that they rely on your industry, and that if they prevent logging in the watershed it only means you will have to get the logs from somewhere else.

Things to think about during discussion

- Why are there so many criticisms of your industry? Are they true? How can you help change them?
- Think back to the conversation between old loggers and new loggers. How did their logging practices differ? Which are more sustainable?
- How could your industry reduce soil disturbance, erosion and phosphorous while still making money?
- You probably cannot give into ALL the stakeholders' demands because it would be too expensive for you to run your business.

Your thoughts for other stakeholders

- Wildlife biologists could help your industry identify which areas in the watershed would be the best places to log while preserving plant and animal habitats.
- Watershed scientists could help your industry choose better locations for roads and ditches to help prevent phosphorous runoff.

What is your sustainable management plan? How will your proposal affect other stakeholders?

Developers

You are a land developer. You make a living building homes for others. Your industry provides many jobs in the area. Like loggers, your industry is also criticized as one of the stakeholders that contributes most to phosphorous runoff and the destruction of plant and animal habitat in the watershed.

Property in the Lake Whatcom watershed is very valuable because many people feel water views are an important part of their relation to nature. When restrictions are imposed on development, it makes houses more expensive and slows down the building process. You believe it is not feasible or desirable to stop or slow growth.

Your idea for a way to encourage sustainable management of the Lake Whatcom watershed is to prevent houses from being built far apart. You think you should be able to build neighborhoods with houses close together as long as you keep the natural habitats nearby. That way you have to build fewer roads to the homes, which means you can leave more forest & soil alone.

You came to the meeting today to represent one group often blamed for problems in the watershed. You would like to see a proposal that allows development to continue but are willing to make some compromises, such as reducing the impacts of your development, while ultimately keeping your building costs down. Any new regulations imposed on you will make it more expensive for the people who buy the houses you build.

Things to think about during discussion

You have many examples of practices that reduce development impacts:

- Fencing of sediments during digging
- Saving or creating wetlands
- Decreasing impervious surfaces (like pavement)
- Don't clear land during the rainiest season
- Successful stormwater catchment system

Thoughts for other stakeholders

- Could the Lake Whatcom watershed be sustainably managed while still allowing some logging and development?
- Watershed residents will have to pay more for their houses if you are required to reduce phosphorous runoff.
- If you build homes, you WILL have to cut down some trees and destroy some animals' habitats.

What is your sustainable management plan? How will your proposal affect other stakeholders?

Bellingham City Residents

You live in the city of Bellingham and your drinking water comes from Lake Whatcom. You do not live in the watershed, but you visit the lake in the summer with your family to explore the woods and swim in the water.

You have read in the Bellingham Herald about the degrading quality of the Lake Whatcom watershed. This concerns you because you have young children and wonder if the water is safe for them to drink. You have considered switching to bottled water for drinking, but as an environmentally conscious citizen you hesitate to do this.

You also are concerned about the plants and animals that live around Lake Whatcom. You enjoy hiking there in the summer and love listening to the winter wrens and other birds in the trees. You don't want to see their habitat destroyed by loggers and developers, but you understand that those industries are necessary to provide goods and services to society.

You came to the meeting today to find out how safe the water is to drink and to promote strict policies to keep the drinking water clean. You also want to advocate protecting the habitats around the lake so you and your children can enjoy exploring there for many years to come.

Things to think about during discussion

- What is causing the water quality to be poor?
- Could areas around the lake be protected from logging or development in a way that would benefit the public?
- Even if you do not live directly in the watershed, do you still impact it?
- What responsibilities do you have as a stakeholder since you drink the water from Lake Whatcom and also recreate in and around the lake?

Thoughts for other stakeholders

- County Council could raise money to purchase lands from the state to prevent development (this would require a tax increase for city residents).
- County Council could strengthen the regulations regarding development in the watershed, and how that affects your expenses as a resident.

What is your sustainable management plan? How will your proposal affect other stakeholders?

Watershed Residents

You live in the Lake Whatcom Watershed. You probably paid a higher price for your property compared to similar property outside the watershed, especially if you are close to the water.

Living around the lake, you regularly interact with it, and probably impact it. You have heard a lot about this in the news, and in information sent to you by the City or the County. You gather that there is some concern about the quality of the water. There are already rules and regulating the fertilizer you can use on lawns in the watershed, and that it cannot contain ANY phosphorus. You want to know what else is going on, and how you can help without being drastically affected.

You came to the meeting today to find out what the situation really is. You also want to be included in the discussion if any big changes that directly impact you are being planned.

Things to think about during discussion

- Does your house have more pavement than yard? (Do you have a long driveway or a basketball court?)
- How do you maintain the land on your property? How much soil is disturbed, exposing nutrients that might erode into streams?
- How do you manage your pet or livestock waste?
- Are you willing to pay higher prices for housing and taxes to fund improvements in stormwater systems?

Thoughts for other stakeholders

- How are my actions affecting Bellingham residents who drink the water?
- If you disagree with development in the watershed, are you being hypocritical?
- What responsibilities do you have as a user of this resource?

What is your sustainable management plan? How will your proposal affect other stakeholders?

Plant Concentration

Adapted by Anna and Kaylani from a Coyote's guide

Facilitators: Anna on day 1, Kaylani on day 2

Subject: Trees and other Plants

Duration: 45 mins

Group Size: 15

Objectives

Get students to notice the difference in the trees and plants around them.

Materials

Three bandanas

Optional: Plant Field Guides

Preparations

Collect samples of the leaves/plants/branches you will be having the students look at and

place them on a bandana and cover them with another bandana

Procedure

0:00 Gather Students around the bandanas and explain what it underneath them. Tell them that they are going to have to look really hard in order to recreate the pattern they see on another bandana

0:03 Reveal the leaves and let them look carefully for 30 seconds

0:04 Cover the leaves back up and send students off to look for those leaves, setting parameters for picking and distances

0:06 Give students 10 mins (or however long they need and you have time for) to look and come back and place the leaves in order

0:20 Reveal when then get it right then talk about each leave and ask where the student got it. Depending on how much time you have you could have the group go and look at the tree the leaf may have come from

Extensions

Use this as an opportunity for moving along trails and teaching about the differences they see in the forest

Assessment

Students will be able to notice the leaves on the plants and identify them throughout the day through their observations

Risk Management

Students will always be in sight of a Spring Blocker or other chaperone

HOLY ERRATICS

Adapted from Rachel Bishop

Facilitator: KayLani Siplin

Location: Gordon Carter Outdoor School

Duration: 15 minutes

Students: 15 sixth grade students

Goals:

To illustrate the geologic history of Bellingham and the Puget Sound area.

Objectives:

The students will be able to:

- Identify rocks that are foreign and explain how they arrived at their current location

Materials:

-Piece of sandstone rock

- Piece of phyllite rock
- Large glacial erratic
- Map of coastal British Columbia
- modeling clay
- sand
- ice cubes

Procedures:

(0:00-0:05) Hike to erratic.

(0:05-0:25) Explain what a glacier is and how it travels. Discuss the formation of Lake Whatcom. Explain the erratic, what it is, and where it comes from.

All over Washington there are large rocks such as this one. These seem to not belong here; they are foreign, because they are so different from the sandstone that makes up this part of the state. Show sandstone rock and ask students to state some differences between the granite and the sandstone. In actuality these rocks originate from the coast of Northern British Columbia. Have a map showing the whole coast of British Columbia from southern Alaska to Washington State. Point out on the map (Map #2) where the rocks started and they are now. The rocks travelled hundreds of miles. How could they have gotten there? Pose this question to the students. 10,000 years ago, when mammoths roamed over the Pacific Northwest, there was 5,500 feet of ice lying on top the Puget Sound area, called Fraser Glacier. As ice formed and moved south toward Washington State from British Columbia these granite rocks were carried with it. Ask the students if they remember when I said the glacier was here. Exactly 10,000 years ago and when that ice began to melt it left these granite rocks here for us to ponder and explore.

Lake Whatcom is a result of the advancement and retreatment of the glacier 10,000 years ago. The scouring of the ice carved away the land past sea level. Unlike much of the land around the area, the predominate rock is phyllite instead of sandstone. Ask students why this might be? Have them look over the sandstone rock and take into account its strength. It is possible that the sandstone that had been laid down was eroded away by the glacier, leaving only the phyllite behind.

(0:25-0:40) Glacier simulation option

Abrasion Project with Clay

Materials needed are: modeling clay, an ice cube and sand. Record your observations after each step. Take an ice cube and press it against the flattened modeling clay; move it back and forth several times. Now place a small pile of sand on the clay and then place the ice cube on top of the sand. Leave it for one minute. Pick up the ice cube and observe the part of the ice cube that was touching the sand. Place the same side of the ice cube on the sandy part of the clay; move it back and forth several times. Wipe the sand off the clay.

Assessment:

By asking the students how many years ago the ice was still the Bellingham area assesses whether or not they were paying attention to the beginning of the lesson. Although this is the only erratic in the area, students should be able to tell which rocks in other places in the same area are foreign.

Background Information:

Glacial erratics on Sucia Island are granite rocks originating from northern, coastal British Columbia. These granite rocks are igneous and made up of mica, feldspar, and quartz. These differ from the Chuckanut Sandstone and Nanaimo rocks that make up Sucia Island. 30,000 to 10,000 years ago the Fraser Glacier reached from Alaska down into what's now known as the Puget Sound. 5,500 feet of ice lay on top of Sucia Island. The heavy weight of the ice carved the land as we see it today and the depths of the sound. As this glacier moved south toward Washington State it carried with it large granite rocks from the north. As the ice melted, ending this ice-age period, the granite rocks were left behind.

The definition of erratic is not even or regular in pattern, or unpredictable. Erratics originated from the Latin word *errare*, meaning to make mistakes, wonder, or roam.

The Natural History of Puget Sound Country By: Arthur Kruckeberg

- The geologic history of the Pacific Northwest is shaped by glaciers, thousands of years ago
- During the last Ice Age, glacial ice covered western Whatcom County to depths greater than 5,500 feet. This tremendous volume of ice scoured the underlying rock.
- The current lake bathymetry, or underwater topography, was created as the glacier advanced and retreated multiple times. It scoured the less resistant rock, while leaving the two sills of resistant material that now divide the lake into its three distinct basins.
- The tremendous weight of the ice also depressed the land beneath it, much like a finger pushed into a balloon. As the ice retreated approximately 10,000 years ago, the weight was relieved and the land began to rebound.

Geologic History**Rocks and Soils Found in the Watershed**

Beneath the surface of the watershed lie the sedimentary rocks of the Chuckanut Formation with a metamorphic rock called phyllite and glacially derived sand and gravel being exposed at the far south end of the lake. The Chuckanut Formation, often referred to as Chuckanut Sandstone, extends from the Cascade Range to Lummi Island and is actually a group of rocks that includes layers of sandstone, conglomerate, shale, and coal.

Formation of the Lake and Surrounding Hills

The same tectonic forces that shaped the Cascade Range also tightly folded the layers of the Chuckanut Formation to create the Chuckanut Mountains including the hills around present day Lake Whatcom. More resistant layers, typically sandstone, tend to form ridges or high points while weaker rocks, such as shale, will form low points.

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Lake Whatcom's Marine Connection

After the ice was gone and as sea levels rose with water released from the melting glaciers, but before the land had fully rebounded, it is likely that Lake Whatcom formed a fjord that was directly connected to marine waters. There are a couple of things about the watershed that indicate this possible past connection with marine waters — fossils and fish.

- Marine fossils have been found in deposits near the northern portion of the lake.
- Kokanee, the land-locked form of sockeye salmon, are found in Lake Whatcom. These fish probably became isolated from their ocean-going counterparts as the land rebounded. As the land rebounded, the lake became higher than Bellingham Bay and natural barriers formed between the marine and lake system, such as the multiple waterfalls in Whatcom Falls Park.

Geology and Land Use Issues

The soils that are derived from the Chuckanut Formation and the steep topography of some portions of the watershed leave the area naturally prone to landslides. Land uses such as timber harvest, forest road building and usage, residential development, and utility installation and maintenance can all increase the natural rates and timing of sediment delivery, with associated effects on stream and lake water quality, fish and fish habitat, and ultimately human health and safety.

Geology References

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How Many Bears Can Live in This Forest

Adapted from *Project Wild* by Justin Hull

Grade Level: 5-8

Duration: 45 minutes-1 hour

Group Size: 15

Big ideas: Limiting Population Factors; population; habitat; carrying capacity

Objectives

Enduring understandings:

Students will understand that....

- 1) Affects to the population and overall health of all living species are dependent on specific and

unique amounts of habitat, food, water, sunlight/shade, nutrients, and many other factors.

2) It matters not whether the species is an animal or plant, such as a black bear or a western red cedar, but that all living species require certain needs to sustain their health and population.

3) The concept of phosphorous as a limiting factor to Lake Whatcom is similar to the factors affecting population and health of other species.

Learning Standards: EALR 4: Life Science

Big Idea: Ecosystems (LS2) LS2A, LS2B, LS2D

Core Content: *Flow of Energy Through Ecosystems*

In prior grades students learned how ecosystems change and how these changes affect the capacity of an ecosystem to support populations. In grades 6-8 students learn to apply key concepts about ecosystems to understand the interactions among organisms and the nonliving environment. Essential concepts include the process of photosynthesis used by plants to transform the energy of sunlight into food energy, which is used by other organisms, and possible causes of environmental change. Students also learn to investigate environmental issues and to use science to evaluate different solutions to problems. Knowledge of how energy flows through ecosystems is a critical aspect of students' understanding of how energy sustains life on the planet, including human life.

Essential questions

1) What affects the population and health of a living species?

2) How are the factors supporting the population of animals similar to that of plant species? How are they different?

3) What happens to a species if one of the factors affecting their population increases? What happens if that factor were to decrease drastically?

4) Other than food, water, and habitat what other factors, natural or human-related, might also limit the growth of species population?

Methods

Students become black bears and western red cedars to look for one or more components of habitat during this physically involved activity.

Materials

Five colors of construction paper (a couple of sheets of red, blue, yellow, and orange) or an equal amount of some other colored objects; one sharpie marker; blindfolds; whiteboard and marker

Preparation

Make a set of 2"x2" cards from the colored construction paper. Arrange the cards into two orange cards labeled N-20, eight orange cards labeled N-10, two purple cards labeled B-20, eight purple cards labeled B-10, two yellow cards labeled I-12, eight yellow cards labeled I-6, two red cards labeled M-8, eight red cards labeled M-4, two green cards labeled P-20, eight green cards labeled P-10, and 19 blue cards. The color of the cards represents the type of habitat component or factor

the bears need to survive. Orange represents nuts, blue represents water, purple represents berries, yellow represents insects, red represents meat, and green represents plants.

The number on each card represents the number of pounds of that food or component. In order for bears in this activity to live healthy and full a bear needs at least 80 pounds of food- 60 pounds from nuts, berries, and plants; 12 pounds from insects; and 8 pounds of meat. There should be less than 80 pounds of food per student available in total, so there is actually not enough food in the area for all the bears to survive.

Procedure

(00:00-00:05)

Discuss with the students the habitat needs, range, and diet of the black bear.

In a large forest area scatter the colored pieces of paper. Do not tell the students what the colors, initials, and numbers on the pieces of paper represent. Tell them only that the pieces of paper represent various kinds of bear food. Since bears are omnivores-they like a wide assortment of food- and the students should gather different colored squares to represent different needs the bears must have in order to survive.

(00:05-00:08)

Have the students mark a spot with their journals and any sticks or rocks to mark their "den site", these sites should all be at a starting line in front of the forest area. Each student will need to have their own den.

(00:08-00:12)

Have the students line up on the starting line in front of their dens. Give them the following instructions: "You are now black bears. All bears are not alike, just as you and I are not exactly alike. Among you is a young male bear who has not yet found his territory. Last week he met up with a larger male bear in the big bear's territory and before he could get away, he was hurt. He has a broken leg (assign one student to be this bear- they must hop on one leg to collect their food). There are also two mother bears each with two small cubs waiting back in their den. These two mothers must gather twice as much food as the other bears in order to feed their young (assign two students to be mother black bears).

(00:12-00:15)

Instruct the students that at the start of the game the students must enter the forest area and once they find a colored paper they should pick it up and return it to their den before picking up another colored square (explain to the students bears usually would eat their food as they find it but for the sake of the game these bears are going to eat back in their dens). During the game some competitive activity is acceptable as long as it is under control. Bears are territorial and when they fight, which they seldom do, they can become injured and unable to meet their survival needs.

(00:15-00:20)

Once the students have picked up all of the squares of paper in the area, have them return to their

dens and take a seat. Explain what the colors and numbers represent. Ask the students to add up the total number of pounds of food they gathered- whether it is nuts, meat, berries, or plants. Have the students record the total weight in their journals.

(00:20-00:30)

Using a whiteboard create a chart with 15 columns representing each bear symbolized using the first initial in the students' name. Ask the injured bear and the two mothers how much food they acquired and record it in the chart. Then ask all the other students the number of pounds they gathered and record it on the whiteboard. Tell the students each bear needed 80 pounds of food to survive. Which bears survived? What about the mother bears? Will they be able to feed their cubs? Will she feed her cubs first or herself? Usually mother bears eat first and the cubs get whatever, if any is left. The mother must survive; she is the hope for a continued bear population. She can have more cubs in her life. Also each bear should have picked up one water (blue) square in order to survive. Water can be a limiting factor.

(00:30-00:35)

Ask the students to arrive at a class total for all the pounds of food they gathered as bears. Divide the total by the 80 pounds needed by an individual bear in order to survive in a 10-day period. How many bears could this habitat support? What affected what bears survived and what bears did not? Ask the students to determine the amount of food cards that must be added to support all of the bears in the activity. Other than food, what factors, natural or human-related, might also limit the growth of the bear population?

(00:30-00:35)

Drawing off of their discussion, have the students suggest examples the factors, cultural and natural, that would be likely to influence the survival and population of other animals and their populations.

Extensions

(00:35-00:45)

Tell the students that just like bears and animals, plant species have many factors affecting their population and health. Pick ten students to go out among the forest area acting as young cedar trees. Have five other students act as birds, rain, or wind. Give them the orange, blue, and yellow cards. Tell them to randomly set the cards at the bottom of each western red cedar. Tell them that the orange cards represent nutrients the cedars need to grow such as nitrogen, the blue represents water, and the yellow represents the sun. Tell them that young western red cedars prefer to grow in shade so they may randomly choose a cedar or two to give an abundance of yellow cards.

(00:45-00:50)

Once all of the cards are given out, have the cedar trees collect the cards they received and come back to the starting line. Tell them the orange represents nutrients such as nitrogen, the blue

represents water, and the yellow represents sunlight. Tell the students much like the bear scenario they each needed at least two water cards, and two orange cards to survive. However, because western red cedars prefer to grow in the shade when they are young if they received more than two yellow cards their needles unfortunately will continue to respire water, and as the soil moisture drops the force required to remove water from the surface tension with soil particles becomes very great, and the tree is water stress.

Evaluation

1. Describe some of the factors that may limit the survival of an animal or plant. What might be the consequences to the individual animal or plant and to its population if one of these limiting factors were no longer limiting?
2. Have the students compare the western red cedar scenario compared with the Black bear scenario game. What was the same? What was different? What would happen to the cedars if there was an overabundance of nutrients such as nitrogen? Would the cedar trees take over?
3. Discuss with the students the role phosphorous plays as a limiting factor towards the Lake Whatcom ecosystem. Have the students compare phosphorous and its affect on Lake Whatcom with population factors such as abundance of food or water.

Background

This activity demonstrates the consequences for a population of bears if one or more habitat components are relatively scarce. When any element, nutrient, or factor in a habitat is inappropriate or exceeds the upper or lower tolerance range for an animal or plant population, it directly affects the well-being of the plant or animal and may result in death or population reduction. These factors can limit the animal or plant population or livelihood relative to other factors which are in more plentiful supply. These factors are defined in population ecology as density dependent and density independent mechanisms. Density dependent factors include competition for habitat components such as food, water, shelter, nutrients, disease, and predation. Density independent factors affecting population and the well being of species includes climate, humidity, sunlight/shade, and other abiotic disturbances.

Black Bear habitat limits black bear populations, especially through the influences of shelter, food supply, and the social tolerances or territoriality of the animal. Shelter or cover is a prime factor. Black Bears need a wide range of habitat- for feeding, hiding, bedding, traveling, raising cubs, and denning. Male black bears can cover habitats of up to 8-60 square miles, while females cover ranges of between 1-15 square miles. With limited ranges for habitat, adult bears will kill young bears or run them out of the area. These bears must keep moving around either until they die or until they find an area vacated by the death of another adult bear.

When food supplies are reduced by factors such as climatic fluctuations this affects the feeding territory of the bears, thus possibly increasing competition. Some adult bears might temporarily move to seldom-used areas of their home range, sometimes many miles away. They must live on what food is available in the area. These individuals may become thin and in poor condition for winter hibernation or, in the case of young bears, be forced from the area by more aggressive

adults.

Not all possible conditions are covered by the design of the activity. However, by this simple illustration it is possible for students to grasp quickly the essential nature concept of “limiting factors”-habitat components that affect the survival of an animal or plant and can restrict the population, health, and range of the animal or plant species.

Find Your Fern Friend

Adapted from: Taking a Likin' to Lichen

Teacher Name: Lindsey

Location: Gordon Carter Outdoor School

Duration: 45 min- 1 hr.

Students: 15 6th graders

Enduring Understanding:

Students will understand that...

- 1) Ferns are ancient plants different from the trees and flowers growing around them
- 2) Ferns are only found in moist areas but those areas stretch from Canada to the equator

Essential Questions:

- 1) What are some identifying characteristics of ferns?
- 2) What are the differences between evergreen and deciduous ferns?

Background:

Ferns can be found from temperate to tropical regions of the world. When reproducing, a fern releases spores, those spores if they land in a favorable place grow into a plantlet called a gametophyte. The gametophyte only contains half of the genetic material but both male and female organs. The sperm is released from the gametophyte which swims through the water on the ground to the female organs of either the same gametophyte or a neighboring one. If fertilization takes place then a proper fern can grow.

There are over ten species of fern in Washington State. Seven can be seen in Gordon Carter.

Learning Standards:**6-8 EALR 2: Inquiry****6-8 INQA**

Question Scientific *inquiry* involves asking and answering *questions* and comparing the answer with what scientists already know about the world.

6-8 INQC

Investigate Collecting, analyzing, and displaying data are essential aspects of all *investigations*

Materials:

- journal with a blank page or two
- pen or pencil
- plant identification guides

Procedure:

:00- :10

Introduce ferns. They are a plant more ancient than the flowers and trees they are surrounded by. Can anyone name a few of the fern species we have around here? Are there others you don't know? Today we are going to take some time to learn a little more about the ferns we see around us every day and how to tell them apart.

Explain to the students that they are going to draw two ferns that they find. Have them draw the patterns of the leaflets and note how the leaves sprout from the ground. A distinguishing characteristic of ferns is the texture of their leaves (evergreen v deciduous) and how they grow (singular v whorl).

:10-:30

While the students are drawing, Spring Blockers will be making the rounds to see how kids are doing. Ask them questions about what they see. If they think they have the main details of a plant figured out then draw a second one to compare with. Then identify them in the guides.

:30-:45

Bring the students back together. What did they discover about their ferns? How many species do they think are here? How are they all different?

Possible management problems:

- boundaries
- possible hazardous plants (thorns or stings)

Management strategies:

Set boundaries before letting them go to explore and find their fern friend. Warn them of possible hazard plants.

Extensions:

Playing any of the games we have in the curriculum.

Lesson Name: Plant observation

Teacher Name: Chrissy (original lesson)

Location: Gordon Carter Outdoor School

Duration: 45 min- 1 hr.

Students: 15 6th graders

Enduring Understanding:

Students will understand that...

- a. observable differences are part of how people distinguish between groups of genetically related organisms
- b. Features that at first don't appear notable or important to people may be related to a plant's survival or reproduction.
- c. practice at detailed observation of key parts of plants helps us learn to quickly see what kind of plant community we are in.

Learning Standards:

6-8 EALR 2: Inquiry

6-8 INQA

Question Scientific *inquiry* involves asking and answering *questions* and comparing the answer with what scientists already know about the world.

6-8 INQC

Investigate Collecting, analyzing, and displaying data are essential aspects of all *investigations*

6-8 INQE

Model

Models are used to represent objects, events, *systems*, and processes. *Models* can be used to test *hypotheses* and better understand *phenomena*, but they have limitations.

Materials:

- whiteboard and dry erase markers
- worksheets that guide the students through focus points of plant observation
- harvested specimen samples of 5 different plants to talk about with the students
- three bandanas
- a time keeper (watch, phone, person counting)
- additional pieces of the five discussed plants to make the plant mosaic on one of the bandanas

Preparation:

- make a worksheet that includes spaces for three different plants to be drawn and described and a space for additional notes on their three chosen plants and for the five we will talk about as a group. Include written instructions and perhaps an example of how it should be done in each section.
- copy and staple 15 copies of worksheet so each student has one.
- select the 5 different plants I want to talk about

- harvest samples of those five different plants that will be good for demonstrating key characteristics and for passing around as well as smaller pieces that will be used for the mosaic
- let helpers know before the lesson begins that I will need them to mark the exploration boundaries
- lay one bandana flat on the trail a little farther down from where the rest of the activities are taking place
- lay another bandana on the trail right next to the first. On this bandana create a plant mosaic that the students will have to replicate on the other bandana.
- On the bandana that has the plant mosaic, lay another bandana over the top of it, so that the plant mosaic is covered and hidden until you are ready to show it.

Procedure:

-(0:00- 0:02) *Note: This lesson will be led by the person "from the future" who has traveled back to our present time to learn how things were in the past.* Sometimes, when I first started spending time in the forest, I would get bored because all of the things I looked at seemed to blur together. All plants were just plants and all trees were just trees and yeah, they were cool but not very *interesting*. That is until I started looking at the individuality of the plants and trees. That's when I started to notice each and every plant that makes up a forest system is unique. Sort of like us humans. We have eye color, and hair color, big noses or small noses that set us apart from everyone else. It is sort of the same with plants but instead plants have different leaf shapes and number of leaves, flowers, leaf patterns, heights and so on. Once I started noticing these things I started to learn that the forest is a very diverse and fascinating place. How many of you know some of the plants around here? Well, I want to help you discover more and observe more deeply the wide array of plants and trees growing here in Gordon Carter.

-(0:02- 0:05) Tell the students that in a minute I will let them explore. Explain that while they are exploring they need to find three different plant species to look at closely. They need to focus on the plant's leaf shape by drawing it as well as describing the shape in a couple of words. They need to look at how the leaves are arranged and draw that as well. *Explain at this point, using the white board, that the leaves have different shape outlines. Give examples such as lance shaped, oval, elliptical, etc. and that the leaf arrangement pattern on the branch of the plant can be straight across from each other, alternating, or following some other pattern.* Tell them that by doing this that they will begin to develop a powerful vision that helps you pick out special species of plants right away in this blur of green and brown forest. In the future this has been a very important skill to use because not only can you show off to all your friends but also start to understand the uses of different plants and where to go to find them so you can use them. But before we work on all that we must hone our identifying skills! So once you are done with leaf shape and pattern observe other details about your chosen plants, such as what it looks like, smells like, or where it's located. *This will all be made into a paper packet handout that they can work in* Tell them they will know to come back when I start ribbiting like a frog. When they hear me or their classmates ribbit they should join in and come back to the group.

Let chaperones and student teachers know beforehand that they will be spread out to form the boundaries of where the students are allowed to explore
Set them free for exploration time.

-(0:05- 0:20) Exploration time

-(0:20- 0:21) Collect students

-(0:21- 0:31) Indicate some of the harvested species of plants that I have laid out on the path. Ask the students to determine whether or not any of the three plants they observed match with the specimens on the path. Go one plant specimen at a time, each time asking if any of the students think they observed a plant that matches. Have two randomly chosen students who think they have a match share their drawing and have them describe their drawing to the group as well as read any other notes they made about the plant.

-(0:31- 0:38) Let the students know the names of each plant, both the common name and the latin name. Write them on the white board in a chart format. Underneath each species in the chart on the white board, list the appropriate term to describe leaf shape and pattern, and perhaps any coinciding vocabulary that relates to its other characteristics or habitat. Explain to the students that in order to be able to identify plants and later understand their uses means to have a common language among people that are interested in these sorts of things so that knowledge isn't confused or lost through the translation of many people making similar discoveries to the ones we just underwent.

-(0:38- 0:43/45) Open up the discussion to more general/miscellaneous questions about the plants we've been looking at. This would be a good time to talk about some habitat characteristics, plant communities, and human uses if it seems to fit in naturally. Walk a little ways down the trail slowly and quiz students on plant names and leaf structures to assess whether or not they are able to more quickly identify different plants and plant characteristics.

-(0:45- 0:47) Stop walking down the trail when you get to the two bandanas laid out on the path. Show the students the bandanas. Explain to them that the first one is actually two stacked on top of one another. In between the two is a mosaic of the plants we just learned about. In a moment I am going to lift the top bandana and your job is to concentrate on the pattern of the plants laid out on the bandana and the plants that make up that pattern. But the trick is that you will only have 30 seconds to look. After that I will lay the top bandana back down so you cannot see the pattern anymore. Your goal is to memorize as much as you can so that working with your classmates you can recreate the pattern on the second bandana by collecting the plants you saw and laying them down in the same pattern as you saw on the first one. Any questions?
(0:47- 0:48) Gather students around so that they all can see the first bandana. Lift bandana to uncover the plant mosaic. Time out 30 seconds. Lay top bandana back down so that the pattern is covered once again.

(0:48- 0:51) Let students go collect plant pieces that will help them recreate the plant mosaic on the second bandana. Tell them that they only have three minutes to collect their pieces and make the pattern.

(0:51- 0:55) Lift bandana one again to see how closely the students' pattern matches the first one. If it is close enough, congratulate them. If the students' pattern needs a bit more work, allow the students to look for 10 more seconds at the first pattern, hide the first pattern again, and then have them make any rearrangements they need. Ask them if they think they would have been able to complete this activity at the beginning of the lesson. Ask why or why not? Lead them towards thinking about the process it took them to become better at plant identification and observation through the course of the lesson.

Assessment:

- Did the students find three different plants' leaves and leaf pattern? Did the students use words and drawings to convey what they discovered?
- Were some of the students able to match the plants they observed to the harvested specimens?
- Were the students engaged and participating in the discussion by asking questions and volunteering to share their discoveries?

- Were the students able to recreate the plant mosaic on the first bandana on the second bandana?

Background Information:

- include the plants chosen; at this point will probably be Salal, Oregon Grape, Salmon Berry, False Lily of the Valley, and Red Huckleberry
- Template of worksheet
- Chart format I want to use to help with defining the different vocabulary
- Vocab for leaf shape and structure

Expanding Our Senses: Animal Sense

Adapted from Coyote's Guide to Connecting with Nature

Facilitator: Justin Hull

Location: Pioneer cabin

Duration: 15 Minutes

Students: 25 high school age

Coyote's Guide Principles:

Core Routines: Expanding Our Senses, Animal Forms, Mind's Eye Imagining, Exploring Field Guides

Child's Passions: Running, Jumping, Catching, Sneaking, Imitating, Pretending, Being Animals, Making up Characters, Playing House

Book of Nature: Birds and Mammals

Natural Cycle: Northeast: Open and Listen, South: Focus

Indicators of Awareness: Quiet Mind, Aliveness and Agility

How-To

After inspiring people with a personal story about using all your senses, such as the one above, have everyone stand in a circle outdoors. Then invite the group to expand their senses by imitating the following set of animals. You can adapt these however you see fit. If you have an attentive group, you can do them all together. Or, you might break them up over a series of days, practicing a new sense each day. When the group is ready, read the following aloud.

Owl Eyes. This is a way of using peripheral vision. Pick a single point somewhere straight ahead of you, glue your eyes on it, and imagine that your eyeballs can't move, just like an owl's eyes. Owl's big eyes are literally stuck in place, so they turn their heads all around when they want to focus. They spend most of their hunting time open eyed and gazing widely, waiting to notice the tiniest movement in the field that would be their food. Imagine and become an owl perched on a tree; feel the wind ruffle your feathers, feel your sharp talons and the strength in your wings.

Still anchored on that single point, let your eyes go soft into peripheral vision and notice that without moving your eyes, you can actually see in all directions for 180 degrees. You naturally use this type of vision when you look at the night sky hoping to catch a shooting star, or when you want to catch the hidiers in hide and seek.

Now stretch your peripheral vision: hold your hands straight out in front of you and wiggle your fingers. Notice that you can see the wiggling movement. Now move your arms slowly out towards your sides while your eyes still look absolutely straight ahead; stretch the edges of your vision sideways as far as you can to still notice the wiggling. Bring your wiggling hands back in front of you, then stretch one up and one down. Widen your vision again, this time vertically.

Relax your arms and now notice with your Owl Eyes if you can see tiny movements of leaves when the breeze lifts them. Notice all the different colors you can see, the different shapes, the shades of light and dark—all without moving your eyes even once.

Deer Ears. Let your ears become the huge ears of a deer. Deer ears have huge bulging muscles that can turn about like satellite dishes to focus on different sounds. To put on deer ears, cup your hands behind your ears and turn your head to focus on certain sounds. Do you notice that the sounds become louder? Now cup your hands and put them in front of your ears, so you can hear behind you without turning around? Does it make a difference? Wow, you can hear twice as much as your eyes can see because your hearing picks up a full 360 degree sphere of sound.

While also keeping your vision wide, pay attention to all the sounds around you. What do you hear in front of you? From your sides? Behind you? Are there constant sounds, like wind or running water, birds, or maybe your own breath? Listen for soft sudden sounds like little birds or buzzes. Where are they coming from? What is the closest sound? What is the farthest sound?

Raccoon Touch. Now, use the touch of raccoons. Raccoons practically feel their way through the world. They don't have good vision or great hearing, but they have long and amazingly sensitive fingers. They can use them to break into our garbage cans and then feel for the food they want. So, while keeping your Owl Eyes stretched and your hearing tuned, feel with your skin.

Feel the clothes on your body. Feel your feet touching the ground. Do you feel heavy? Light? Do some parts of your body feel cold and some warm? Feel the sun on your skin. Feel the wind on your skin; which way does the wind blow? Feel your heart beating.

Dog Nose. Think of dogs you have seen walking down the street, with their noses to the ground, or sniffing around every bush, smelling everything as they go. Turn into a dog and pay attention to your sense of smell. Take quick sniffs of the air around you like a dog. What do you smell? Smoke from a fire? The grass or the flowers? Yourself?

Can you smell differently with a long breath than with quick sniffs? Try taking a long slow breath in through your nose. Try sucking in a tiny bit of air through just parted lips. Get down on all fours like a dog, or pick up a leaf or handful of dirt and hold it close to your nose. If it's safe, taste your leaf. What do you smell? Does it smell like it tastes? How would you describe it? What smells hit your nose the strongest? Still keep your Owl Eyes wide and your Deer Ears perked and your Raccoon Touch sensitive.

Synthesis. Now turn on all your senses together. Let your eyes be soft and stretched, listen with your ears to the little sounds around you, feel the wind on your face, smell the air with long breaths. Hold this whole, wide-open awareness for as long as you can stand it. How long can you simply pay attention like a wild animal? Some animals do this all day long, that's why we never see them. By expanding your senses, you too can have the awareness of a wild animal.

Sensory Explorations

By Virginia J. Cleaveland

Gordon Carter Environmental Education Curriculum Spring 2012

Location: At or near site of group's first lesson (for Macroinvertebrates, stay in field near home base or choose spot on the way to Brannian Creek).

Target audience: 6th graders.

Group/Instructor: 10-15 students, 2 instructors, chaperones.

Materials: 3 pages in field journal: 1 page for sound, 1 page for sight, 1 page for touch. Colored

pencils (if available, 2-3 per child so their drawings can have some color), pencils, whistle, pen and white board (to draw an example of a sound map).

Content Standards:

EALR 2 Inquiry: The student knows and applies the skills, processes, and nature of scientific inquiry.

GLE 2.2.5 Evolution of Scientific Ideas: Understand that increased comprehension of systems leads to new inquiry.

Objectives:

Big ideas: Scientific inquiry through sensory explanation, data collection and communication of findings, connection to nature through observation.

Essential questions: How can tuning in to each of my senses individually while outdoors help me connect with a location? Why is it important for me to develop a connection with the places I visit outdoors?

Enduring understandings: I can use each of my senses individually when observing in nature to help me arrive at a more complex understanding of the habitat and the animals that live there. I can share my connection to nature with others, to encourage stewardship and advocate for sustainable management of a habitat's plants and animals.

Procedure

00:00-00:03: Our first lesson today is all about getting to explore at the Gordon Carter site. I know a lot of you have fun memories from when you visited Gordon Carter as third graders, and now is your chance to return to the site and put your scientific observation skills to use to discover something new about the plants and animals around you. We are going to focus on each sense individually, so it may feel funny at first to close your eyes and simply focus on what you hear, or to get close to a tree and touch it to feel what the texture is like. But right now it's totally cool to do weird stuff as you explore.

Sensory exploration is one of my favorite things to do when I'm outdoors. It's a chance to stop worrying about whatever responsibilities I have at school or home, and really just tune in to nature and try to focus on all the amazing things I can discover around me. I hope today's sensory exploration will give you the same experience, and next time you go hiking or you are playing in the park, maybe you can try these activities again and see what you discover.

We're going to do three short sensory explorations – touch, sight, and sound – and write and draw our observations in the corresponding journal pages (**O**). Hopefully at the end of the lesson, we'll be able to answer the question: "Why is it important for me to develop a connection with the places I visit outdoors?" (**W**) Just remember that at Gordon Carter, we are guests in other plants' and animals' neighborhoods, so explore respectfully, watch where you are stepping so you don't destroy someone's home, and always leave things how you found them.

TOUCH

00:03-00:05: The first sense we're going to explore is TOUCH. Now who's ready to get their hands dirty? What are some of the things we could observe by touching them at Gordon Carter? How

would they feel? (Solicit responses.) **(H)**

Turn to Page X in your field journal. For the next five minutes, you're going to be a wildlife biologist studying the plants at Gordon Carter. Your challenge is to find two VERY different specimens and use your sense of touch to observe and explain how they are different. (If any kids look squeamish, say: You don't have to pick something dirty, and everything you would touch out here is the good kind of dirty, like soil and leaves, not bad dirty, like trash on a sidewalk in the city. You can also pick up a handful of dirt or touch a plant yourself.) Try looking for two different plants or trees that are growing next to each other, so you can touch them both at the same time. Think about how their leaves feel different, and how their bark feels different. Draw the two specimens in your field journal and write down the different textures, so you can take your observations back to your lab and explain them to other biologists. For example, list rough vs. smooth for bark, or smooth vs. jagged for leaves. Try to come up with two texture comparisons for each specimen. **(E1)** You can do this exploration alone or in pairs, but please fill out the journal pages separately. Share with each other what textures you feel, and see if you come up with similar observations! **(T)**

When I blow the whistle, you're free to explore! Come back to home base for the next challenge when you hear the whistle blow again. You cannot go outside the boundaries of ___ and ___. (Define boundaries by pointing to natural landmarks like trees or rocks or streams.) Raise your hand if you understand! On your mark, get set, go!

00:05-00:10: Sensory exploration: TOUCH. Instructors and chaperones can walk around to different groups or individuals, ask them to explain what they are drawing and remind them to label the drawings. Remind students to practice respectful exploration, if needed.

00:10-00:13: Solicit responses from children about what they observed. **(R)** What was the hardest part of finding words to describe plants using only your sense of touch? **(E2)**

SIGHT

00:13-00:15: Introduce next sense: The second sense we're going to explore is SIGHT. First think about how you see things as a human in the forest. Look above you: How tall are you? How tall are the trees above you? (Solicit responses.) As humans we tend to see things from our point of view, but how do you think the Gordon Carter site looks to other animals? (Solicit responses.) **(H)**

Turn to Page X in your field journal. For the next five minutes, I challenge you to imagine what Gordon Carter would LOOK like to a mouse. Get up close to a plant, tree, downed log or pile of dirt and see it like a mouse would. (Instructor should get on the ground next to a downed log, preferably lying or kneeling.) Who wants to get down here with me? (Invite 1 or 2 students to join, use their names.) What would a mouse see from this viewpoint? (Solicit responses.) **(H)**

For this next exploration, I want you to draw and write down what you see from a mouse's eye view. Try observing these things: Do you see any other plants or bugs that are smaller than you? Bigger than you? What do the trees look like above you? Would you want to make your home in this spot? Would this spot keep you safe from predators? **(E1)** You can do this exploration alone or in pairs, but please fill out the journal pages separately. Share with each other what you see, and see if you come up with similar viewpoints! **(T)**

When I blow the whistle, you're free to explore! Come back to home base when you hear the whistle blow again. Remember, you cannot go outside the boundaries of ___ and ___. Raise your

hand if you understand! On your mark, get set, go!

00:15-00:20: Sensory exploration: SIGHT.

00:20-00:23: Solicit responses from children about what they observed. **(R)** What was the hardest part of seeing the forest from another animal's point of view? **(E2)**

SOUND

00:23-00:25: Introduce final sense. The third sense we're going to explore today is SOUND. Sound is a very important sense to most animals, including humans, because we use it to listen for predators. For this challenge, we're going to pretend to be a deer in the forest, listening for predators and listening to all the natural sounds around us. Deer have a great sense of hearing, and they can turn their large ears in the direction of an unusual sound, like a snapping twig or the crunch of leaves, because it could mean a predator is coming. Remember to observe only with your ears, and you need to be very still and quiet do you don't drown out the natural noises at Gordon Carter. **(H)**

Turn to page X in your field journal. For the next five minutes, I challenge you to draw as many sounds as you can hear on a sensory map. Here's an example (get out white board): Place an X in the middle of the page for where you are sitting. (Remember: deer can turn their ears in every direction.) Close your eyes and start tuning your ears into the sounds of nature around you. Do you hear water rushing? Do you hear birds chirping? Open your eyes and label the sounds in the direction they come from on your map. Use your imagination to draw the SOUNDS, not a picture of the thing you hear. I like to draw Vs for birds (draw on map) and squiggly lines for the sound of running water or wind in the trees. How else could you draw running water or wind in the trees? (Solicit responses.) **(H)** Be quiet, but get creative, and remember that since you are not sitting in the same spots, no two sensory maps have to look the same! **(E1)** I know we worked in pairs for the last two explorations, but please find your own place to sit for this one. **(T)**

When I blow the whistle, quickly find a spot to sit down. Come back to home base when you hear the whistle blow again. Remember, you cannot go outside the boundaries of ___ and ___. Raise your hand if you understand! On your mark, get set, go!

00:25-00:30: Sensory exploration: SOUND.

00:30-00:33: Solicit responses from children about what they observed. **(R)** What was the hardest part of creating a sensory map using only your sense of sound? **(E2)**

CONCLUSION

00:33-00:35: I hope you had fun using your senses to observe new things about the plants and animals at Gordon Carter. What are some of the interesting things you discovered? (Solicit responses.) Why is it important for each and every one of us to develop a sense of connection to the places we explore outdoors? (Solicit responses.) **(E2)**

SENSORY EXTENSIONS

- Smell and compare cedar, true fir and spruce needles
- Taste licorice root
- Listen for sound of creek before it comes into sight
- See owl snag tree along path
- See sporangia on underside of ferns

- Listen for winter wrens
- See deer in the forest
- Touch moss growing on downed tree

Instructors: Feel free to add whatever sensory details you discover throughout your time at Gordon Carter. Encourage children to practice sensory exploration as they are traveling in between lessons (while keeping them on track and on time).

Shrinking Habitat

Adapted by Freya and Demi from Project Wild
(see attached)

Woodpecker Checker

Original Lesson by Megan Braun

Facilitator: Megan Braun

Subject: Woodpeckers

Group Size: 15 to 20 students

Grade of Students: 6th

Duration: 45 minutes

Location: On the trail in view of the largest snag with woodpecker holes, and this is by the phosphorus site.

Goal: Familiarize students with identifying local woodpecker species through direct experience observing them and signs of them, their adaptations, their roles in the ecosystem, and habitat needs.

Objectives:

Students will be able to:

- Predict the effects of deforestation practices on woodpecker populations
- Identify at least 3 species of local woodpeckers and point out visible signs of them
- Discuss connections in the forest involving the woodpecker

Method:

Students portray different types of woodpeckers' behavior and adaptations in order to teach other students about them.

Materials:

- Woodpecker species flashcards (provided in lesson plan)
- Red bandanas to show coloration
- A blank page in their printed journals for notes
- Ball of twine
- Role cards
- Paper towel rolls to be used as spotting scopes

Procedure:

(00:00-00:10)

Woodpecker hunt to our site using toilet paper rollers, walking quietly, and listening for woodpecker sounds.

(00:10-00:17)

Instructor discusses four species of woodpeckers with large pictures to share with the group. This is all very broad information about the woodpecker in general. Students are then counted off by fours so that you end up with 3 or 4 students in each group. The groups are each given cards with one of the four local species of woodpeckers on them. The cards include information that is species specific including the main differences and interesting facts about that species in particular.

(00:07-00:25)

The students are given time to come up with a creative way to present the information to the class and try to embody that specific species and its differences from the others. They have the option to perform a short skit, or do an interpretive dance, or choose another way to present. Instructor

needs to be sure that each group finds a tree or example woodpecker hole nearby that serves as an appropriate background for their skit or presentation. This tree should be one that the groups' species would favor. Instructor and helper are floating around keeping students on task.

(00:25-00:35)

Each woodpecker species group presents their creation to everyone else. As an assessment instructor asks each group if the Gordon Carter site seems like a healthy place for their specific woodpecker given the habitat and holes observed.

(00:35-00:55)

Weaving the Web activity: Each student is given a card with a role on it, either a woodpecker, other animal, tree, insect, or the logging company. Then we all stand in a circle where string is given to a student. the student must identify another whom their role is connected to. The ball of string is tossed and connections are made visible. The roles continue on until every role has at least one connection made. Instructor presents different scenarios for the web to react and feel pressure from. Our circle represents the local Gordon Carter forest ecosystem. Instructor asks students what they notice about the shifts that occur.

Example scenarios:

- The logging company cuts down the biggest oldest trees in the forest. (Logging co. tugs harder on the string because it is taking from the forest, putting pressure on the pileated woodpeckers, thus the small rodents who make homes in their holes feel the tug, and so do smaller trees that are sometimes killed by pileated woodpeckers)
- The ant population increases dramatically one summer (ants walk into circle making less stress on woodpeckers)
- There is an increase in competing starlings that decide to move to the forest (smaller woodpeckers are forced to compete for their homes, and possibly migrate)

(00:55-01:00)

Conclusion: Instructor then discusses with group the importance of keeping nature natural for balance in our ecosystems such as locally around Lake Whatcom. Instructor asks what we can do to keep the forest healthy for woodpeckers and all the connecte parts of the system.

I challenge you to listen and look for woodpeckers as we continue on throughout the day, and whenever you see a sign of a woodpecker, like holes in a snag, point it out to the group.

Background Information:

on Woodpecker species (there is more to come):

Hairy Woodpecker *Picoides villosus*

How to Identify it: A black and white woodpecker, similar to the Downy with a much larger bill. Like the Downy, this woodpecker will forage in deciduous woods but also works the darker conifer forests as well. It tends to forage more on the trunks and larger branches, while the smaller billed Downy works the smaller branches. It nests in conifer forests but picks out a dead deciduous tree

for its nest site. Pairs form in the winter, nest building begins in mid-April, eggs are laid in early May and young of the year can be seen in mid to late-June.

Pileated Woodpecker *Dryocopus pileatus*

How to Identify it: Crow-sized woodpecker with prominent and distinctive red crest.

This is the largest woodpecker in North America and it makes large oval excavations in dead trees in search of wood boring insect larvae and Carpenter ant larvae. A mated pair maintains a permanent territory and during spring they make their distinctive laughing calls to stay in contact. The pair will do a head swinging courtship display in March and then excavate a nesting hole in a large tree. The young of the year can be seen as early as late-May but June is more common. The young of the year are fed by parents until the end of June and then go their own way. The large cavities which this bird excavates for nesting are made fresh each year and abandoned nests are prime homes for squirrels.

Northern Flicker *Colaptes auratus*

How to Identify it: Robin-sized woodpecker with heavy spots on the belly, a black chevron mark on its upper chest, the underside of wings flashes yellow or red in flight. Males have a red or black moustache.

This woodpecker prefers to forage on the ground rather than in trees, although it does spend time on deciduous tree trunks. It makes a loud, Keeleer call to announce its presence. In March the mated pair will dance around a tree, wagging their heads and giving a wika wika call, they will excavate a nest in a well decayed Alder or other deciduous tree and young can be seen following after adults begging for food in mid-June.

Red breasted Sapsucker

How to Identify it: Black and white woodpecker with a red head.

Sapsuckers drill a series of holes in trees, then return to harvest the sap and the insects which get caught in the sap. They may remove large pieces of bark on smaller trees such as willow and you can often find their machine gun-like holes in cedar trees. The bird will return again and again to freshen the hole and harvest the sap. Rufous Hummingbirds utilize the sap wells and often a good tree will become a defended part of a hummingbirds territory. Sapsuckers build a nest in a well decayed deciduous tree and the young of the year can be seen by the end of June.

Hooks and Ladders Game

see attached

Solo Hike/Sit Spot

Adapted by Haley Rutherford

Subject: Solo Reflection Time

Duration: 45-60 minutes

Location: EOTO trail

Group Size: 13 Students

Objective:

Through this lesson students will be able to spend some one-on-one time enjoying and observing the natural world. The students will use this time to reflect on their experience during Outdoor School. The goal is to set up an unstructured time for the students to explore.

Materials:

- Notecards with thought-provoking phrase

Preparations:

Facilitator will need to write up the note cards.

Procedure:

(00:00-00:05) Explain to the students that they will be doing a solo/silent hike and sit spot. The facilitator will put cards down on the trail that the students will need to think about, do, or write about in their journal. Tell them that they will only be about a minute apart from each other, so if they become too close to the person ahead of them they need to slow down. Remind them that this is a SILENT reflection time so they need to respect the other people in the group. If some show hesitation, let them silently walk with the last instructor or chaperone.

(00:05-00:07) Have the students find a spot in line or within 10 feet to sit silently with their journal. The facilitator at this time will start hiking down the trail with the prompts. The second instructor will send one student out every 1 ½ -2 minutes.

(00:07-00:23) As the hikers arrive at their location they will be assigned a sit spot with their journals.

Conclusion:

(00:25-00:35) Have students reflect together on their experience.

Reflection questions will include.

- How was enjoying nature separately different from doing it as a group?
- Did you find that you liked it better or worse? Why?
- What did you think of the prompts that were given to you?
- Did you make any drawings or writings that you would like to share with the group?

Evaluation:

The evaluation will be based on the student's answers and participation in the group discussion at the end.

Risk Management Plan:

On account of the students getting separated during different parts of the this activity, a head count will have to occur before, during, and at the end of each section in order to assure that no one is

missing. There will also need to be a facilitator in the area in case of any emergencies. There will be a first aid kit to ensure immediate response to any injury that may occur.

Weird Webs

Adapted from Gene Myers and Global Environment and Outdoor Education Council

Subject: Food webs

Location: Open area

Duration: 10-15 minutes

Group Size: 13-17 students

Methods:

Students use a ball of twine to create a classroom food web that shows the interactions between the members of the ecosystem. Students will appreciate interconnections and interdependence within the natural community and will identify food chain relationships and energy flows within the “web of life”.

Materials:

- Ball of twine/string/yarn
- Signs with pictures of animals and what they eat with tape or string for student to wear, enough for one card for each student

Preparation:

Make cards with ecosystem components (animals, plants, sun, etc.)

Procedure:

(00:00-00:05) Have students stand in a circle, still showing the tags they received. You should also be part of the circle. Have every student describe their card, i.e. ‘who they are.’

(00:05-00:08) Tell students that they can pass the ball to another ecosystem element in the circle “only if it needs you in order to survive, or if you need it in order to survive”.

For example, the squirrel could pass the ball to the tree (which it needs to survive) or to the owl (which needs it to survive). Make sure that each exchange is justified by each student as they pass the ball to another. Make sure that the whole group understands and agrees with the rationale that is given. Challenge students to establish connections with everyone in the circle, so that no organisms are left out. (Note: you might find it useful to have students rehearse this by having them point to ecosystem elements they need to survive - or that need them to survive - before the ball of string is passed)

(00:08-00:20) Tell students that one of the facilitators will be playing the role of the sun, the ultimate source of life for all things (as befits your role as teacher!). Pass the ball to the tree, and say “I am

passing the ball to the tree, because it needs me to survive. I give energy to the tree.” Continue until everyone has a hold on the string.

(00:20-00:25) When you have every organism connected, ask students to pull gently to take in the slack so the string becomes taut. Ask students to examine the pattern they have created. Tell them that this pattern represents the very complex pattern of interconnections between organisms that

occurs in a natural ecosystem. For this reason, interrelationships within an ecosystem are sometimes referred to as the ‘web of life’. Ask students if the web they created is more simple or more complex than the web of life that actually exists in their schoolyard or in a park; students should realize that things in nature are far more complex than the simple web they have created.

(00:25-00:30) Next, tell students that something has just happened to change this ecosystem: a timber company has just received the right to log this forest ecosystem. Keeping the string taut, ask the “tree” student(s) to suddenly release the string when you count to three. After the string is released, immediately ask if anyone felt the tension in the string change when the tree dropped out (several, including the squirrel, should say yes.) Ask those affected by the loss of the tree to say how they are affected. Count to three again, and ask these “affected” students to in turn drop the string. Keep going until everyone has dropped the string. Students should come to realize that any change to an ecosystem - whether slight or profound - is felt throughout the system.

Extension:

Ask students to repeat this activity using the following changes to the ecosystem:

- the municipality sprays to remove pesky mosquitoes from the area
- hunters come in to harvest moose, elk, and white-tailed deer from the area
- decreasing ozone levels allow more ultraviolet radiation, which kills cells and slows the growth of the trees
- the forest is in a park - but the park is too small to preserve large carnivores, so they are extirpated from the area (Note: tell students that recent studies are showing that carnivores are far more important than previously thought - that their presence or absence will actually dictate how healthy the entire ecosystem is.)

Oh, Deer!

Adapted by Haley Rutherford from Project Wild and RiverVenture

Subject: Biology/Ecology

Grades: 6-12

Standards: See end of lesson plan

Time: 20 minutes (can last longer depending on how many rounds you play)

Lesson objective:

Students will understand and graph population change over time according to habitat availability.

Content:

This game looks at the numbers of an organism over time. Many factors affect the ability of wildlife to survive over time. Weather conditions, disease, predators, pollution and habitat destruction are some examples. Habitat is the key to wildlife survival and population size. For the purposes of this exercise, habitat is defined as food, cover and water. If any one of them is lacking or restricted in availability then wildlife numbers are reduced. In the accompanying exercise, participants learn that organism numbers will be governed by the availability of habitat elements.

Procedure:

(00:00-00:02) Divide the class into two smaller groups; one of deer and one of habitat components. (Groups may be equal in size or with only one or two deer. Having only one or two deer tends to show population growth better.)

(00:02-00:05) Explain that we are using three elements to define habitat for the purpose of this exercise - food, water, and cover. Demonstrate how to make the symbols for each habitat component. For food, place both hands over the stomach. For water, hold the fingers to the lips. For cover, touch the hands together over the head.

(00:05-00:07) Establish two horizontal lines approximately 18 meters apart in an open area. Put the deer behind one line and the habitat components behind the other.

(00:07-00:08) Have the deer and the habitat components turn around on the line so that they cannot see one another. Everyone will decide on a habitat component. The deer are deciding what component they need or want; the components are deciding what they are. Each person makes the symbol for his or her chosen component. Once they are ready, count slowly to three, and then allow both lines to turn around.

(00:08-00:11) Everyone mills about throughout the space between the two lines (or- can be a tag game). The deer are looking for their habitat component; once the deer have found the component they want, they link hands with that component and walk back behind the "deer" line. Since this deer has found the component it needed, it will "use" the component and be able to survive and reproduce, so the person who was the component will now become a deer. Note: Neither the deer nor the habitat can change symbols once they have decided on one during each bout of selection. Any deer that fails to find the habitat element they needed "dies" and will become a habitat symbol. (Once the deer dies, its nutrients will nourish the grass, which would be eaten by the deer; therefore, a dead deer is kind of a part of the habitat.) The habitat person can only satisfy one deer, so if two or more deer try to get the same one, only the first one to reach the habitat person survives.

(00:11-00:20) Repeat the process as many times as you'd like with the new assignments. The leader should record the number of deer at the beginning and end of each bout or round. Running about 10-15 rounds of selection is usually adequate to let participants see how population and habitat quality interact.

Conclusion

At the end of the game, plot the deer numbers against "years" (bouts). Note the change in behavior of the deer as well. As the habitat becomes more limiting, the deer will run or compete to get the needed habitat first. The leader could also record the numbers of habitats

Lead a discussion with the participants on what they observed and did during the game. They should be able to discuss what animals need to survive and how these elements work as limiting factors that affect the animal's survival. They should recognize that the habitat and the population are both dynamic. Finally, they should be able to recognize the increasing competition by the deer and the stress that places on them.

Answer the following questions about the activity.

- a. What three habitat requirements were in the activity?
- b. How did the organisms act when their habitat requirements became limited?
- c. Describe how populations of organisms change over time with respect to habitat availability?

Extension

If desired, run a few bouts with "trucks" or "hunters" as mortality factors, where any deer taken becomes habitat. Discuss how that changes the dynamics of the process and the relative pros and cons of each type of population reduction. A volunteer with arms extended moving across the flow of traffic makes a good "truck." Limits to hunting could be applied if desired. Leader could also make natural disasters occur and determine who/what is still there.

Animal Races

Adapted by Aaron Ettel from Gene Myers

Facilitator: Aaron Ettel

Subject: Animal gaits

Duration: 45 min- 1 hour

Location: Gordon Carter Site

Group Size: 14-17

Method:

Outdoor physical activity; students will show how different animals walk and move around

Objectives:

For students to reduce stress and have fun while also learning some basic movements of specific animals.

Materials:

- 2 sticks to mark a start and finish line
- 4 small sticks if you want to do a relay race

Preparation: You will need a fairly large open field area for the students to be able to run without falling and getting hurt. You also want the area to be pretty big so the race isn't too short. Before you begin explaining the game you want to set up a start and a finish line as well.

Rules:

- 1) Each student must start behind the starting line.
- 2) Each student can only begin racing after the facilitator says go.
- 3) Each student can only race as the animal that they are told to race as.
- 4) There will be multiple animal types that the students have to race as (frogs, bears, worms, crabs, etc.)

Procedure:

Bring all the students together in a circle so they can all see you talking.

(00:00-00:03) Explain above rules to all the students.

(00:03-00:05) Tell students that they will be racing as a frog (they can only hop on all fours when they race), a worm (they have to army crawl when they race), a bear (they can only run on all fours), a crab (they can only crab walk), and cougar (they have to stalk through the forest as quietly as possible and hide behind objects).

Have a fellow facilitator placed in the middle and finish line of the race so they can make sure no one is cheating.

(00:05-00:20) Cycle through all the different animals types until they have all been done.

Extensions: Most likely it won't take a full hour to run through all the animal types so a good extension would be to break the students up into 3 or 4 groups and do a relay race with all the different types of animals all in one big race.

Risk Management: There will most likely be some branches and bushes that students could trip over so tell them to watch out for that. Another thing to tell them is to spread out a little bit when

they race so they don't run into each other on accident. There will be first aid kit close by so if anyone does get hurt we will be able to patch any wounds.

Camouflage/Eagle Eye

Adapted from *Coyote Guide*, *Islandwood*, and *Sharing Nature with Children*

Facilitator: All

Subject: How animals camouflage themselves to hide from predators (FILLER ACTIVITY)

Duration: 10-20 minutes, depending

Location: Area on trail or clearing with many trees and bushes to hide behind

Group Size: 10-15

Objectives:

Students will be able to identify how animals hide themselves from predators

Procedure:

Option one: One person in the middle, doesn't move. Closes eyes and counts to 25 while everyone hides. Names people they can spot from where they are. Counts to 20 while everyone high fives the person and hides in a new spot. Repeat, counting 5 seconds less every time.

Option two: (will add once I have a **Coyote Guide** handy!) must get closer every time?

Option three: Person in middle counts to 20 or 25 with eyes closed. When open, makes an animal motion and the hiders have to make a call for that animal (must be able to see the predator). Count down from there.

Five Fingers

Adapted from YMCA

Facilitator: All

Subject: Get-to-know-you game

Procedure:

Go around the circle so everyone can share their hand:

Thumb= Something you like/are proud of

Index finger: The direction you are going (what you're looking forward to at GC)

Middle finger: Something you don't like (are worried about? need help with?)

Ring finger: Something you are committed to

Pinky: Something funny/odd about you

Meet a Tree

Adapted from *Coyote Guide*, *Islandwood*, *The Living Forest*, *Sharing Nature with Children*

Subject: Silent (FILLER ACTIVITY) to get to know a tree

Duration: 15-30 minutes

Location: Area where there are a lot of trees with little to no underbrush

Objectives:

Students will use all their senses (except taste) to become familiar with a tree

Materials:

- Enough blindfolds for half the group

Procedure:

(00:00-00:07) Have the children group into pairs and pass one blindfold out to each pair. Explain that one person will be blindfolded while the other person leads them carefully through the woods to a tree. Make sure they understand that they must be careful; walking slowly and being mindful of rocks, fallen logs, etc. The non-blindfolded person should not give any clues as to where they are taking the other.

(00:07-00:12) Once they reach a tree, the blindfolded person will use touch, smell, and hearing to learn as much as they can about the tree. Encourage them by asking if the tree has moss on it, how big the base is, how far their arms can go around it, how does it feel against their cheek, what does it smell like, etc.

(00:12-00:15) When their done, their sighted leaders should bring them back to the starting point, perhaps by a different route to make it more challenging. Once back, the children remove their blindfolds and begin looking for their tree.

(00:15-00:25) Have children swap roles with each other.

Tree Tag

Adapted from *Coyote's Guide*

Subject: Natural history, identification skills, active game (FILLER ACTIVITY)

Duration: 15-20 minutes

Location: On trail with many different trees around

Primer: Who would like to play a game of tag? Alright, are you sure? Okay... I'm warning you, for this game you better know a little bit about the trees and plants around here. But don't worry... if you don't, you'll learn quickly. Ready?

Procedure:

- Gather up and choose a volunteer to be the starting Chaser. The caller (a teacher) begins the game by shouting, "You're safe if you're touching a (insert tree/plant name of identification clue... such as "an evergreen tree" or "an oak-tree" or "a tree that makes fruit you can eat"). These tree types become to "base" where people must touch to be safe. Once a runner finds the right tree, and tags it, they can't leave it until the next round begins. If a runner has tagged the wrong tree, they're fair game for the Chaser. The Caller can give out additional clues during the round if needed.
- Anyone who gets tagged becomes a Chaser for the next round. Chasers must re-form near the center of the playing field after each round. For each new round, call out a new "base," a different type of tree or plant. The game ends when everyone has been caught and turned into a Chaser, or when the set time has ended.