A Sense of Place in Environmental Education: A Forest Ecology Curriculum Unit

by

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Project Summary

Growing up in rural Minnesota gave me a multitude of opportunities to utilize my local forest ecosystems as a place of learning. As an environmental educator, I've witnessed students of all ages enjoy the chance to be outdoors while learning about the environment. Experiential learning outside of the classroom has greater benefits than just visualizing the concepts students learn about in science class, it also presents the opportunity for students to bond with their local landscapes and develop a sense of place. Fostering a sense of place in environmental education opens the door for student agency in learning and makes the material relevant in student's lives as they explore the outdoor spaces that are closest to them both physically and emotionally. I've seen how a sense of place is intrinsically linked to environmental stewardship. How can we teach about the environment in a way that also connects learning to environmental responsibility? How can we teach on environmental issues in a way that is relevant and empowering to students? How can students bond with local ecosystems while also meeting the learning needs of standardized education? Overall, I aimed to answer the question: *How does a sense of place help environmental education create stewards for the environment?*

My goal was to create a science curriculum that aligns with the most recent Minnesota Academic Science Standards (2019) and allows 7th graders in the state to bond with local ecosystems while solving issues that impact them. There are 14 lesson plans for a 50 minute science class. I suggest it be performed in the spring for a variety of reasons.First, many of the lesson require taking students outdoors and late spring weather in Minnesota has a more mild weather season. Second, there are lessons involving the identifying of trees, shrubs, and flowers and a lesson on forest phenology which could be

easily observed during this time of year. Thirdly, the lessons require a prior understanding of concepts like cells, photosynthesis, and populations, lessons that could be taught prior to engaging in this outdoor curriculum. I included both qualitative and quantitative assessments for this unit to support the student's exploration of their sense of place while also giving teachers the ability to provide a grade that assesses student's comprehension of the scientific concepts within forest ecosystems.

I dedicated myself to researching the definitions of a sense of place and environmental stewardship. It was through this diligent research that I saw how correlated these two concepts in environmental education truly were. Developing a sense of place means that a person is making a personal connection and investment in space (Cresswell, 2014). It also involves determining the importance of places to one's self and their community. The goals of environmental education are to create citizens who have environmental awareness, knowledge, and skills to protect and restore the social-ecological world that surrounds them (Potter, 2009); also known as environmental stewardship (Bennet et al, 2018).

Pedagogies that foster a sense of place in learning utilize place-based educational frameworks. Because of the localized nature of place-based education, it looks different depending on the community's capabilities and environments. Rural schools may be able to utilize vast outdoor landscapes for experiential learning, while urban schools may utilize ecojustice education. However, place-based education is unified under six major design principles: (a) Community as a classroom, (b) Learner-centered, (c) Inquiry-based, (d) Local to global, (e) Design Thinking, and (f) Interdisciplinary (Vander Ark et al., 2020). I utilized these design principles in the construction of this curriculum unit.

The local environmental issue being discussed in this unit involves invasive species. Invasive species impact many ecosystems in Minnesota, with invasive earthworms being a major contributing factor to declining forest health (MNDNR). Students visualize this issue by creating a model of the forest floor and collect data using the scientific method to describe how invasive earthworms overconsume the duff layer of the forest floor that provides the growing habitat for forest seedlings and makes the forest resilient to erosion, nutrient leaching, and provides biodiversity. This experiment teaches the students about decomposition and the cycling of matter and has them use empirical data to explain how invasive species impact native ecosystems.

Furthermore, developing a sense of place requires students to observe, inquire, and communicate how they feel and what they notice in local outdoor landscapes. To accomplish this within the curriculum, nature journaling can be a useful tool for educators. I incorporated this into the curriculum as a supplementary qualitative assessment tool that can be done as a reflection after the activities in each lesson plan. There are journaling prompts that require students to go outside of the classroom and explore a forest ecosystem.

The last section of the unit is a final presentation of comprehension. Students choose an invasive species other than earthworms to study. Their presentation can be in any format they choose by must answer the following questions:

- Who: What is the invasive species? Who is impacted by it? (people, animals, plants?)
- What: In what way does this invasive species impact the ecosystem it is invading?
- When: When was this species introduced to Minnesota? How did it get here?

- Where: Where is the species from? What limits that species from becoming invasive in its natural habitat?
- Why: Why is this an issue the student cares about? Why should others care?
- How: How would you control this species? Is it a species that can be controlled?

Written for a 50-minute science class, this curriculum unit has a 3-week calendar. However, the observable changes in the experiment may require a longer timeframe for the earthworms to decompose the material and shift the measurable layers in the model. While the journaling within this lesson can be done in class, time and spatial constraints may require the prompts to be answered as homework. Teachers may also choose to have students answer some of the prompts in class and some outside of class, for example, students could make the biodiversity index during a class where the teacher takes them outdoors and assign the species richness bar graph as homework since this is a prompt that could be done at home.

In developing this curriculum unit, my hope is that teachers and students can bond with their local environments and communities to enhance their sense of place. The curriculum is made to help students to create important connections to develop a sense of place while furthering their learning of science and environmental concepts. I outlined the methods I took to do so in this project to give educators an example of how this can be done so that they may be able to mimic these methods to create programs and curricula that teach about environmental issues in their locality. I hope that by doing so, students can develop an awareness for their local ecosystems that leads to a desire to learn more about them and gives them the skills and knowledge to combat environmental issues through an empowering and relevant learning process.

Forest Ecology Curricular Unit Plans (for 50-60 minute blocks)

Introduction:

- Lesson Plan Details
- Lesson Plan Template

Lesson Plans:

- Lesson Plan One: Introduction to observing the forest/outdoors
- Lesson Plan Two:Invasive Earthworm Experiment Part One
- Lesson Plan Three: The Forest Floor
- Lesson Plan Four: Invasive Earthworm Experiment Part Two
    - Worm Collection Activity
- Lesson Plan Five: Tree ID
- Lesson Plan Six: Tree Nutrient Label
- Lesson Plan Seven: Food Webs in the Understory
- Lesson Plan Eight: Forest Canopy and the Umbrella Effect
- Lesson Plan Nine: Biodiversity
- Lesson Plan Ten: Species Richness and Evenness
- Lesson Plan Eleven: Phenology
- Lesson Plan Twelve: Ecosystem Services of the Forest
- Lesson Plan Thirteen: Ojibwe Forest History
- Lesson Plan Fourteen: Invasive Species Presentation

Grading Rubrics

- Invasive Earthworm Experiment Grading Rubric
- Presentation Grading Rubric

References

Links To Resources

Lesson Plan Details:

Skills Utilized:	Learning Goals/Outcomes:
● Scientific Method ● Data Collection ● Observation ● Critical thinking on problem-based solutions ● Communication of results and scientific concepts	● Student identifies how nutrient cycling contributes to forest health ● Student identifies the importance of biodiversity for ecosystems as resilience ● Students see the impacts of invasive species on biodiversity and identify the human connections to the spread of invasive species. ● Students identify a bond to the forest ecosystem through expressions of memories, experiences, and relationships. ● Student expresses a desire to mitigate the effects of invasive species by presenting ideas for solving the issue ● Student identifies the importance of community engagement as a way to relay information that is important for people to understand to protect their environment

Previous lessons needed:
-Cellular biology
-Resource Availability/Niches
-Population Analysis
-Some knowledge of the scientific method/variable interpretation

Education Standards: Minnesota State Science Standards 2019:

Strand 3 Developing possible explanations of phenomena or designing solutions to engineering problems

Substrand 3.1 Developing and using models Standard 3.1.1 Students will be able to develop, revise, and use models to represent the students' understanding of phenomena or systems as they develop questions, predictions and/or explanations, and communicate ideas to others.
Code 7L.3.1.1.3 Develop and use a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. (P: 2, CC: 5, CI: LS2)
Substrand 3.2.1 Students will be able to apply scientific principles and empirical evidence (primary or secondary) to construct causal explanations of phenomena or identify weaknesses in explanations developed by themselves or others.

Code 7L.3.2.1.1 Construct an explanation based on evidence for how environmental and genetic factors influence the growth of organisms and/or populations. (P: 6, CC: 2, CI: LS1, ETS2)
Strand 4 Communicating reasons, arguments and ideas to others Substrand 4.1 Engaging in argument from evidence
Substrand 4.1.2 Students will be able to argue from evidence to justify the best solution to a problem or to compare and evaluate competing designs, ideas, or methods.* *Code 7L.4.1.2.1 Construct an argument supported by empirical evidence that changes in physical or biological components of an ecosystem affect populations.* (P: 7, CC: 7, CI: LS2)* *Code 7L.4.1.2.2 Evaluate competing design solutions for maintaining biodiversity or ecosystem services.* (P: 7, CC: 2, CI: LS2, ETS2)* **Substrand 4.2 Obtaining, evaluating and communicating information** *Code 7L.4.2.2.1 Gather multiple sources of information and communicate how Minnesota American Indian Tribes and communities and other cultures use knowledge to predict or interpret patterns of interactions among organisms across multiple ecosystems*

Lesson Plan Template:

Lesson Plan Number and Title
Objectives: Learning objectives for each lesson
Preparation/background: Teacher background information on the subjects in each lesson and preparations to be done before class starts.
Materials: Needed materials and links to webpages used in the lesson plan
Procedure: Steps on how to lead the in-class activities
Journal Prompt: Journal prompt for students to complete at the end of class or as homework

Lesson Plan One: Introduction to observing the forest/outdoors

Objectives: Students will (1) identify a forest (2) describe their initial observations and inquiries about forests in Minnesota

Preparation/background: Forests are a major ecosystem in Minnesota, covering about one-third of the state. Minnesota has 59 state forests! They are a valuable ecosystem to the state providing clean air and they are crucial to conserving and filtering water in our lakes, rivers, and streams. Forests are also habitats for many plants and animals. Forests also provide a great habitat for natural play that has students assess risk, be imaginative, and explore natural phenomena. The major purpose of this lesson is to have students bond with a forest and feel the benefits of natural exploration themselves. Before beginning the lesson, walk around the school to find an outdoor spot with multiple trees to perform the class.

Procedure:

1. Take the group to an outdoor place with trees. Group Discussion: Share a memory to your neighbor about a time you spent in a forest or if you haven't been to one, talk about a forest you have previously learned about.
2. Have the students write their name, the date, the time, and the weather at the top of their first journal page.
3. Tell the students to find a spot in the outdoor space and go to it to journal. First allow them to decorate the cover of the journal as they please. After a few minutes of decorating, have them describe how to get to their spot then answer the journal prompt: *"Within this setting finish the following phrases: I notice…(observations about the forest) I wonder…(questions I have about this place) It reminds me of…(connections to memories or other experiences)"*
4. Divide the students into groups and have each student share their spot with the groups
5. Have the students complete survey bellow:

PRE-SURVEY

Thinking about the place you identified as a forest, please fill in the boxes to show how much you agree or disagree with the following statements:

	Strongly Disagree	Somewhat Disagree	No Opinion	Somewhat Agree	Strongly Agree
This place has unique value that I cannot find in other places	○	○	○	○	○
I am happier in this place than any other place like it	○	○	○	○	○

The things I can do in this place are hobbies of mine	○	○	○	○	○
I identify with the landscape of that place	○	○	○	○	○
That place means a lot to me	○	○	○	○	○
I don't care more about this place compared to others	○	○	○	○	○
I have memories tied to this place	○	○	○	○	○
I try to protect this place from being harmed	○	○	○	○	○
Why did you choose this place?					
What is important to you about this place, if anything?					

Lesson Plan Two:Invasive Earthworm Experiment Part One

Objective: Students will (1) begin the earthworm experiment by collecting materials and making the models (2) identify the independent and dependent variables and write a hypothesis statement for the earthworm experiment

Background/Preparation: Outlining the design and methods of experimentation facilitates an organized process in experimentation. On this day, the students will begin their earthworm experiment by researching the issue and then outlining the steps for the experiment. To prepare for this, read all of the parts of the earthworm experiment to familiarize yourself with the steps. One the board, draw a diagram of the two liter bottles the students will be making as an example for what they will diagram in their journals. The journal prompt in this lesson is a preparation step for a later lesson one phenology.

Materials: Devices with access to the internet

Procedure:

1. Have students research the issue of worms as an invasive species in Minnesota utilizing the MNDNR's website on this subject: https://www.dnr.state.mn.us/invasives/terrestrialanimals/earthworms/index.html#:~:text=During%20the%20late%201800's%20and,remote%20areas%20of%20the%20state.
    a. Students should develop research questions based on their data collection and take outline notes about the subjects they learned about while researching. Research questions should be something they can answer by observing the behavior of the worms in their container. Examples include: *Do different types of worms break down the same material faster? Will the worms behave differently if the layers of soil are different? Do worms break down different types of leaves faster?*
    b. This is when they should also research the human influences that led to invasive earthworms in Minnesota and the impacts people will feel if this issue is not addressed, if they will feel anything at all. Examples of impact statements could include: *Forest clean the air we breathe. Forests are important water reservoirs. Forest help prevent floods. Forests are habitats. People use the forest for lumber. People use the forest for recreational activities.*
2. Give the students time to describe the experiment in their journals. Have students model the design in their journals by making a diagram of both the class container and their individual container, as an added math teaching moment, have students calculate how much of each material they will need to collect to create the specified layers.
    - Equations
        - Volume of a cylinder: $cm^3 = pi\ x\ radius\ x\ height$
        - Cubic centimeters of soil in Grams: $grams\ of\ soil = cm^3\ X\ 2.66$
    - Given measurements:
        - Average 2 Liter Bottle has a radius of 5.7 centimeters
        - Heights: 5 cm of sand, 15 cm of soil, 1.5 cm of litter
        - Average particle density of soil is 2.66 grams/cm^3 sand is 0.65grams/cm^3 Organic matter (Litter) is 0.8 grams/cm^3
    - Volumes in cm³
        - Sand: $pi\ X\ 5.7\ X\ 5\ = 521\ cm^3$

- Soil: $pi\ X\ 5.7\ X\ 15\ =\ 1563\ cm^3$
- Litter $pi\ X\ 5.7\ X\ 1.5\ =\ 131\ cm^3$

- Cm³ to grams
  - Sand: *521 cm³ x 0.65 grams = 900 grams*
  - Soil: *1563 cm³ X 2.66 grams = 4157 grams*
  - Litter: *131 cm³ X 0.8 grams = 104 grams*

3. Utilize the scientific method to hypothesize what they think will happen in each bottle based on the research they performed, then outline the methods they will use to create the experiment, and the way in which they will collect the data.
4. Decide on what variables to change for the treatment bottle which is up to their dissertation to decide how to use. Examples could be utilizing only one type of worm, utilizing only one type of leaf litter, or adding a substance such as plastic to observe the differences in the breaking down of natural and man-made materials, or changing the size of the layers in the bottle. The permitters should be that whatever variables they chose to change in the treatment bottle have to be different from the worm-only bottle.

Journal Prompt: "*Choose something in nature that changes over time (examples include budding plants, caterpillar chrysalis, flowers, a section of a deciduous tree branch, colors of leaves in autumn, frog eggs, or a potted plant). Begin by making a drawing on one half of a journal page and focus on parts of the object that you think will change the most. Write the location of your object as you will be coming back to this changing object."*

Lesson Plan Three: The Forest Floor

Objective: Student identifies how decomposition contributes to forest health in the forest floor.

Background/Preparations: In this lesson, the students will dissect the forest floor and record their findings. This is to introduce them to the part of the ecosystem they will be isolating in their earthworm experiment. Identify an outdoor location to perform the activity in. It could be where they first went outdoors or they could be traveling to a forest. A place with a lot of leaf litter is preferred.

Materials: String, journals, optional: magnifying glass

Procedure:

1. Group discussion questions: What happens each fall to the trees in a forest or their front yard? Why isn't there a huge pile of leaves and other forest material under the trees?
2. Have the students go to their spot and make a circle with the string. Record all of the items that they see inside the circle both living and non-lining.
3. Remove the leaves and sticks without digging into the soil. Lay the items outside the circle. Record organisms they see and tally how many of each they see. They also need to list at least three adjectives about each of the organisms they find.
4. Dig 3-4 inches into the soil recording any organisms they find.
5. Once all three observations are completed, return the soil, organisms and leaves to the area. Ask why it is important to return the circle to its natural state.
6. Share their observations with a partner.

Journal Prompt: "*The forest floor is an important ecosystem to the forest. Species will look different if they are meant to be on the forest floor. Describe the forest floor using numbers, words, and pictures. Note the types of species and their similarities and differences."*

Lesson Plan Four: Invasive Earthworm Experiment Part Two

Objective: Students create their "mini-forest" floors and collect worms for the experiment

Background/Preparation: In this second part of the invasive earthworm experiment, the students will collect the materials for the experiment and create their "mini-forest floors". Prepare the materials for the experiment, identify a place outdoors to perform the worm collection activity

Materials:
Container: Teacher's experiment container should be a larger installation that the class keeps track of as a group, so it is recommended that this container be a 5-gallon glass tank. One side of the container should be clear as students will be observing the different layers of soil that will be going in the container. Student experiments can be done individually in 2-liter soda bottles. Students need one bottle for control experiment, one bottle representing worm invasion, and one bottle for testing possible treatments.
Measuring tools: Rulers will be used to measure the changes in soils layers. There is also an additional math lesson incorporated in determining the volume of each soil layer, so a gram scale will be needed.
Divider: A durable material such as glass, plastic, or sturdy installation is needed to divide the container in half to visualize differences between the side that is infested with worms and the other that is not
Soil: Layering the soil is important for reproducing forest soils which contain layers of different soil types. To replicate this in the container you will need to layer two inches of sand at the bottom and four to six inches of a light-colored soil (worm casts contain organic material that makes them a dark color, so a light or red color of soil is recommended for contrast).
Forest floor material: To obtain materials such as dried leaves and tree bark have students either bring in materials from a forest near their home or take class to a forest nearby to collect materials. Students can collect forest floor materials in plastic sandwich bags, they will need enough to create about ½ inch of litter in their bottles.
Worms: The collecting of worms is another great opportunity for students to engage in an outdoor activity. Students should research responsible ways to collect them such as making sure that if they are transporting the worms from a farther location they need to be placed in a sealed container such as a Tupperware and only released into the containers meant for the experiment. This is also a good opportunity for teaching students to identify different local worms. The experiment steps guide contains an activity if teachers should decide to collect the worms as a part of the experiment.
Marking materials: Students and teachers will use different colored tape, permanent marker, or paint to label and date the layers over time to observe changes in soil layer levels.

Procedure:
1. Collect the materials:
2. Make the containers without the worms and have students mark the layers present on that date.
3. Perform the worm collection activity: *Teachers may also decide to source worms from bait shops.*
4. Have students add the worms to the worm-only bottle and worm-treatment bottle. Leaving one bottle without worms creates a control variable that would mark what would have happened to the soil layers if there were no worms present.

WORM COLLECTION ACTIVITY

Materials: Mustard Powder, Water, Container, Measuring Tape, Worm ID guide, GPS
Location: Outdoor area - Earthworms could possibly be found in any soil plot, this could include a grass area in the schoolyard, school gardens, or nearby forested area.

Steps:

1. Mix ⅓ cup of mustard powder in 4 liters of water
2. Measure a 1 foot by 1 foot square in the ground.
3. Pour half of mustard water over the area, mustard irritates worms and forces them up out of the soil. This is a recommended collection for earthworms from scientists with the Great Lakes Worm Watch.
4. Wait for the worms to pop up and collect them in container
5. After the worms stop popping up, pour the remaining water over the area for the next wave of worms that burrow deeper in the soil.
6. Students can identify the types of worms they find. These reports can be sent to the Great Lakes Worm Watch as a "Documentation of an Occurrence Study." The required data needed to report an occurrence is the GPS coordinate of the site and documented occurrence of earthworms. The website link provided below gives detailed instructions for sending in data to the Great Lakes Worm Watch: https://wormwatch.d.umn.edu/join-team/conduct-your-own-study/document-occurrence

Journal Prompt: *Forests are identified by their trees. The type of trees that are dominant in the forest identify the different types of forest. Identify 3 different types of trees in your local area and what is unique about each type of tree. Note the differences in bark, leaves, seeds, and branching patterns. Use words, numbers and pictures.*

Lesson Plan Five: Tree ID

Objective: Students (1) illustrate the makeup of a tree and (2) utilize a Tree ID tool to identify different tree species present around their school.

Preparation/Background: Trees are complex organisms that students might not even notice as they pass them. In this activity, the class becomes a tree! Before class, you may choose to make printouts of each part of the tree that the students will be mimicking for them to hold while they perform the activity. Make print outs of the Minnesota Tree ID Tool for students to take with them as they identify the trees.

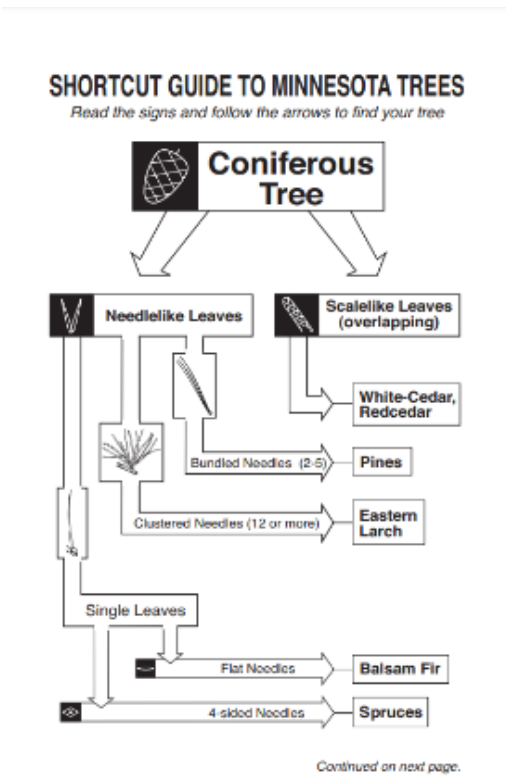
Procedure:

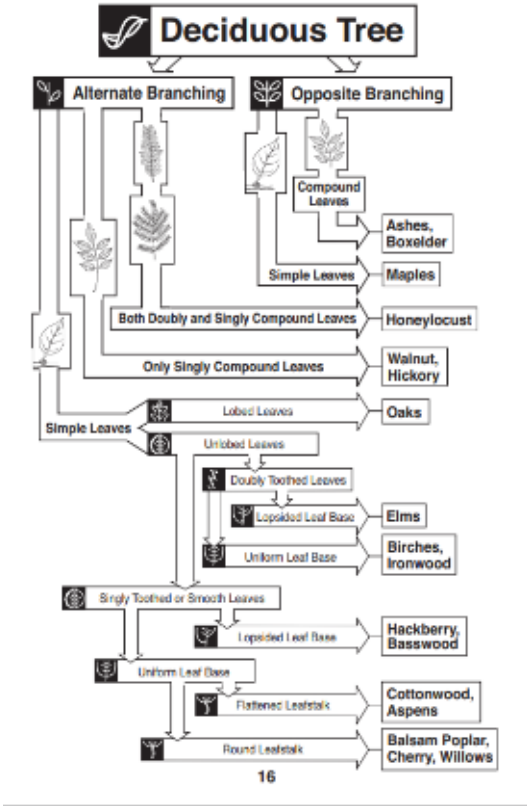
1. Make the first observations and measure the changes in layers that have happened in the earthworm experiment.
2. Assess your students' prior knowledge and awareness of trees by asking how many different types of trees each student sees when coming to school. Ask students how to list parts of the tree that they know of.
3. Tell the students they will be making their class into a tree. First have the students make a circle then make the layers. Give each student a part of the tree to be and a phrase to say every time you add a layer:
    a. Heartwood Layer: One student stands in the center. The heartwood is the inner core of the tree and is responsible for holding the trunk and branches upright. It's the oldest part of the tree, so old that it is dead! It used to be alive and had tubes that brought water up and down the tree, but as the tree got old, the tubes clogged up with resin. Have them say, "I am tall!"
    b. Taproot: One student comes and sits at the feet of the heartwood. They are the taproot that digs down about 30 feet into the ground. They are responsible for keeping the tree sturdy and sucking up water and nutrients from the soil. Have them say "I support!"
    c. Lateral Roots: Have three students lie on the ground around the taproot. They are the lateral roots. There are hundreds of them on a tree and they are helpful for proving more support and they grow towards water and nutrient sources in the ground. Have them wiggle their fingers and say "Slurp! Slurp!"
    d. Sapwoods: Have four students surround the "tree" and tell them they are the sapwoods. Sapwood is also called xylem and they draw water from the roots and bring them to the top of the tree for the leaves in the canopy. Have them squat up and down and say "Pump! Pump!"
    e. Cambiums: Have 4-6 students form another layer around the tree and identify them as the cambium. Every year, they make the trunk and branches thicker by making new cells. Have them say "Bigger! Bigger!
    f. Phloem: Have 6-8 students make another layer around the cambiums. They are the phloem, responsible for moving nutrients in the form of sap from the soil to the canopy. Have them squat up and down and say "Sap! Sap!"
    g. Bark: Have the remaining students make one final layer around all of the tree. They are the bark. They protect the tree like a big bodyguard. Ask the students for examples of what a tree might need to be protected from. The bark students say "Protect! Protect!"
4. After completing the activity, hand out the worksheet from the University of Minnesota that identifies Minnesota trees. Take the students outside to identify trees around the school and

label them in their journals.

a. Tell the students that they can identify trees based on branching patterns
   i. Whirl patterns: pine, fir, and spruce
   ii. Opposite pattern: maple, ash, and dogwood
   iii. Alternate pattern: oak and cottonwood
b. Tell the students that leaves are also a good identifier of trees. To identify a tree, find the leaves below the tree or on a tree branch and identify them with the ID worksheet. If there is a tree that they cannot identify around the school have them draw a section of the tree branch with it's leaves and fruit in their journals and use online resources to identify it

Minnesota Tree ID Tool:
https://conservancy.umn.edu/bitstream/handle/11299/49816/6593.pdf?sequence=1&isAllo





Journal Prompt: *The individuals of the forest interact together to create communities within the forest. Just like people in your community are different, so are the tree species in the forest. Make a Venn-diagram of two types of trees. Ask questions as to why they are similar and why they are different. Make notes of which species you see more of in the forest (identify the dominant species of the forest).*

Lesson Plan Six: Tree Nutrient Label

Objective: Students (1) construct a nutrition label for a tree

Background/Preparation: Trees are composed of different kinds of chemical units (organized in thousands of different molecules): the three elements Carbon (C), Hydrogen (H) and Oxygen (O) represent more than 90 % of plants. The rest are Nitrogen (N), Potassium (K), Magnesium (Mg), Calcium (Ca), Phosphorus (P), Sulfur (S); uptaken either in gaseous form from the atmosphere (Carbon, Hydrogen, and Oxygen) or ions dissolved into water in the soil. The nutrients contained in the soil come from primary mineral weathering (Ca, Mg, K) and organic matter decomposition (N, P). Write the three primary elements on the board and the other vital chemical units under a secondary category.

Materials: Nutrition labels from food packages for each student, permanent markers, white colored pencils or metallic permanent marker, painters tape, 12-inch rulers

Procedure:

1. Explain the background information to the students. that a
2. Pass out nutrient labels from food packages and have the students read what nutrients are in the food label. Use a permanent marker to cross out nine of the listen nutrient lines in the label, the number after serving size. Use a white colored pencil to write in the nine nutrients a tree needs. Also write “Tree Height” in the crossed out serving size.
3. Bring the students outside and have them pick a partner and a tree. Have students measure the height of the tree using the following method:
    a. On a 12" ruler, mark the 1" and 10" lines with tape.
    b. Have a partner stand at the tree’s base. Hold the ruler in front of your eyes at arm's length and walk back until you see the whole tree from top to bottom between the 0" and the 10" marks on the ruler.
    c. Move your body forward and backward until the base of the tree is exactly at 0 inches and the top of the tree is exactly at 10". Sight out from the 1" mark to a point on the trunk above the base.Have your partner mark with tape that spot on the trunk.
    d. Measure the distance from the base of the tree to the tape mark. Multiply by 10 to get an approximate height of the tree.Replace “serving size with the height of the tree on the nutrition label.
4. Next, have students make a guess as to how much of each nutrient the tree is made of. Group discussion questions: where do you think trees store their nutrients? Where do the nutrients in the leaves go when they fall off the tree?

Journal Prompt: “*Nutrients are nonliving parts of a forest that are very important for the growth of plant species. Draw a diagram showing where the nutrients in the forest are.”*

Lesson Plan Seven: Food Webs in the Understory

Objective: Students create and analyze a food web in the forest understory

Background/Preparations: The forest understory is home to the most consumers in the forest. It is in this layer that ecological food webs form. In this lesson students will be categorizing species found in the forest into their various consumer levels and then illustrate a food web by connecting index cards of the species with string.Teachers may choose to make the index cards before class to save time.

Materials: Index cards and string

Procedure:
Have students collect their first set of data from the invasive earthworm experiment by measuring and marking the labels and taking notes in their journal. Make sure they date the markings on their experiment and have them look at the teacher's large scale forest floor.

1. Explain that the forest understory is the habitat for many species in the forest including squirrels, deer, raccoons, and insects like butterflies and mosquitoes. Within this layer of the forest there are all types of consumers.
2. Make index cards with different species that live in the understory. Identify what type of consumer it is and what it consumes for food:

Primary Consumers - Herbivores
Mouse: grass, plants, mushrooms, berries, tree buds
Deer: grass, plants, mushrooms, berries, crops, trees
Grasshopper: grass, plants, berries, crops, trees
Rabbit: grass, plants, mushrooms, berries, tree buds
Chipmunk: grass, plants, mushrooms, berries, nuts and cones
Squirrel: grass, plants, mushrooms, berries, nuts and cones
Secondary Consumers - Omnivores
Bullfrog: grasshopper, earthworms, small fish
Snake: mouse, grasshopper
Raccoon: mushrooms, crops, mouse, bird eggs, berries, nuts and cones
Tertiary Consumers – Carnivores
Weasel: mouse, grasshopper, rabbit, chipmunk. Squirrel
Bear: mushrooms, fish, berries, nuts, mouse, grasshopper, rabbit, chipmunk, squirrel
Fox: bird eggs, berries, nuts, mouse, grasshopper, rabbit, chipmunk, squirrel
Eagle: mouse, rabbit, chipmunk, squirrel, snake, small raccoon, baby weasel
Hawk: mouse, rabbit, chipmunk, squirrel, snake, small raccoon, baby weasel
owl:mice, grasshopper, rabbit
mountain lion: mouse, rabbit, chipmunk, squirrel, snake, raccoon, weasel
Coyote: mouse, rabbit, chipmunk, squirrel, snake, small raccoon, baby weasel
Bobcat: mouse, rabbit, chipmunk, squirrel, snake, raccoon, weasel

3. Have students lay out these cards and use string to connect them to what each consumes.
4. Have students remove one or more species from the web and adjust their string accordingly. Write down in their journals how the web changed and what species were impacted by removing one or more species from the food web.
5. Connect this experiment they are performing by having them list what materials are in the duff layer they made. What species in the web consume grass, leaves, plants, berries, nuts, or cones? Explain that all these things need the duff layer to grow.

Journal Prompt: "*The forest understory is between the space between the forest floor and the canopy. Dominated by saplings, vines, moss, and shrubs the understory provides food and shelter for many animal species. Describe the forest understory using numbers, words, and pictures"*

Lesson Plan Eight: Forest Canopy and the Umbrella Effect

Objective: Students (1) identify the osprey as a species that lives in the canopy and (2) visualize how the canopy percolates water to the other layers of the forest

Background/Preparation: The osprey is a large raptor, often known as the "fish hawk." Both male and female ospreys work together to create the nest. Once eggs are laid (typically 1-3), the osprey takes turns incubating the eggs. The family diet is 99% fish, supplemented with other reptiles and crustaceans. When the chicks are 10 days old, they are already mobile and eat between one and three pounds of food per day. The University of Minnesota Raptor Center manages a live camera feed of an osprey nest that can be interesting for students to watch to see a canopy species of Minnesota forests. Before the class, project the osprey live camera on the board and prepare the material.

Materials: Projector that connects to the internet, access, large tupperware tub, water pitcher or cups, pennies. Osprey Live Camera Link : https://arb.umn.edu/content/osprey-cam

Procedure:

1. Begin with a group discussion questions: *Have you ever seen a bird flying way above the trees? Why do you think bird species put their nests high in trees?* Explain the background of osprey and let the students know they are a native bird species that lives in the canopy of the forest and have the students watch the live osprey camera for a few minutes
2. Divide students into groups and give each group a tub, pitcher of water, and a handful of pennies. You may also choose to line the bottom of each tub with paper towels to show where the water hits the bottom of the tub.
3. Have them make a pile of pennies in the tub. Pour the water from the pitcher into the tub from standing height onto the pile of pennies. Write down how the pennies moved when the water was poured directly on them.
4. Have them reset their tub of water and pile of pennies. Now, one student in the group holds their open hand below the falling water. Write down how the pile of pennies moved. Try this again with multiple hands at different levels and write how the pennies moved.
5. Explain to the students that they are observing the umbrella effect of the forest canopy. Connect this experiment to forest canopies by discussing how tree canopies percolate water to the forest floor to prevent soil from washing away when it rains. Why is this important? Where does the water in the forest go? Where would all the soil, organic matter, or litter go in the forest if there was no canopy?
6. Connect this experiment to the invasive earthworm experiment with the following questions: What if there was a cover over the pennies in the umbrella effect experiment? How is this mimicked in your forest floor model?

Journal Prompt: "*The canopy is the top of the forest, consisting of the tallest trees in the forest. It is the home to many bird species in the forest. It also causes rainwater to trickle into the forest system. Describe the forest canopy using numbers, words, and pictures."*

Lesson Plan Nine: Biodiversity

Objective: Students recognize the importance of biodiversity in the forest and formulate a biodiversity index

Background/Preparation: Biodiversity provided the forest with resilience. Having a biodiverse ecosystem means that the forest can recover from disturbances like forest fires, insects, and disease. The students will be making a biodiversity index in this lesson. Locate an outdoor space with multiple species present. You may choose to scout out a second place for students to make an index for if there is time.

Materials: Projector connected to the internet, coloring materials, optional: cameras to take pictures of the species for future reference, plant ID book for Minnesota plants
Link to Biodiversity Video: https://ed.ted.com/lessons/why-is-biodiversity-so-important-kim-preshoff

Procedure:

1. Explain to the students how forests are biodiverse, meaning they have many individual species within them. Play the biodiversity TED Ed video.
2. Tell students that they will explore the area looking for different kinds of trees and shrubs, cataloging each one in their journals.
3. Tell students that they will use drawing and writing to briefly capture key details (leaf shape, fruits or flowers, form of growth) of each plant, but that they do not need to make a detailed, pretty picture of each one. Have them also make tally marks to count how many of each species they see during their survey.
4. Set up the boundaries of the survey area
5. Tell students to begin by working alone, to focus on a few important details of each plant before moving on, and to compare notes with classmates once they think they have found all the species in the area.
6. Have a group discussion on the index they collected. How many species did you find? Describe a place with very little biodiversity.

Journal Prompt: *Biodiversity is in the forest, but your community is also diverse! Make a biodiversity index of your classroom, community, or family. How does each person you list in the index help their "ecosystem"?*

Lesson Plan Ten: Species Richness and Evenness

Objective: Students illustrate species richness and evenness using graphs

Background/Preparation: Species richness and evenness graphs help scientists to visualize these factors of biodiversity. High species richness means there are a lot of different types of species in that location. High species evenness means that there is an even amount of each species in the location. Before class, draw example graphs on the board. One graph should show a short line and a long line to show the difference in species richness. One graph should show a more horizontal line and a more curved line to show the difference in species evenness.

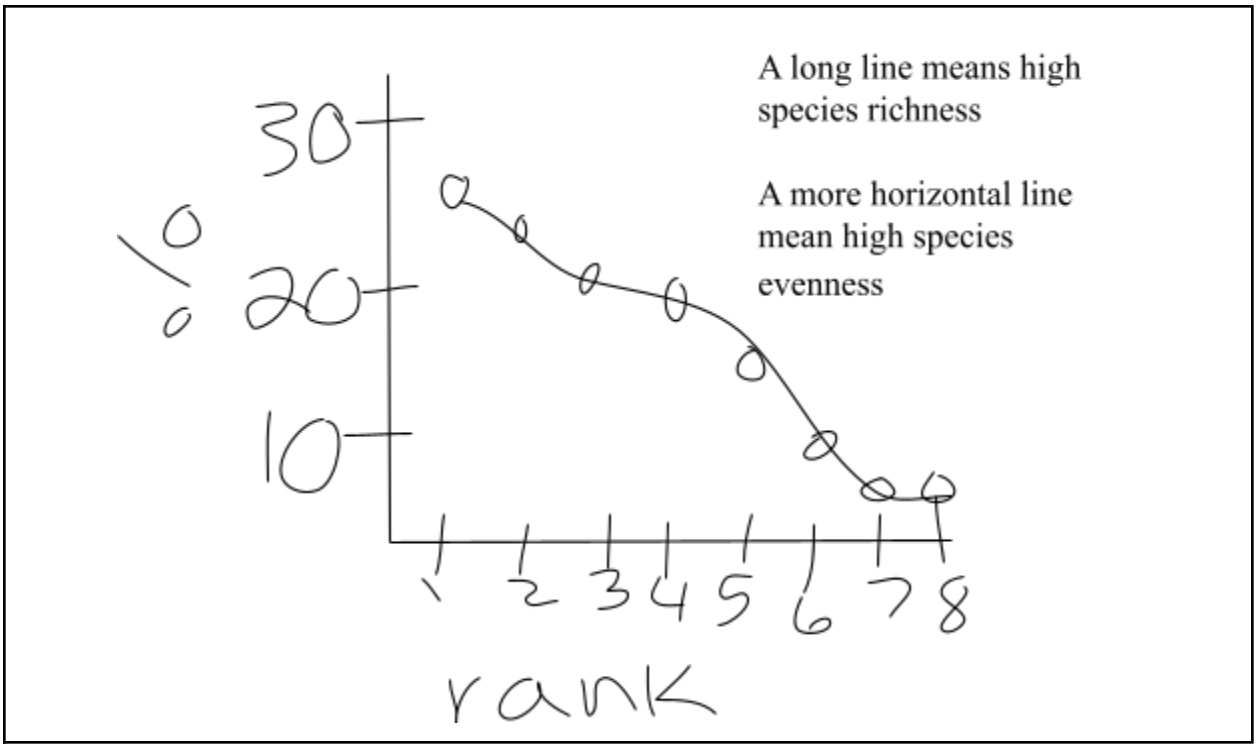
Materials: Coloring utensils

Procedure:

1. Explain to the students that with their biodiversity index they can calculate species richness which refers to the number of species you find in an area.
2. Give each species in their notes a letter code, starting with A for the species with the highest count, then B for the next highest, and so on
3. Use your diversity data to make a bar graph. On the horizontal (x) axis, list all the species you found by their letter code. On the vertical (y) axis, make a scale that goes as high as the species that was the most abundant. Draw bars to show the number of individuals identified.
4. Next students will make a ranked abundance curve. To begin, have them create a table. In the first, left-most column, list all the species you found. You do not need to know the names of the species; you can use letters or your own descriptive names. In the second column, write the number of individuals you counted in the sample. Add up the numbers in this column to get the total number of individuals you counted. Write this total at the bottom of the column. In the third column, calculate the proportional abundance of species by dividing the number of individuals by the total number of individuals in all the species combined.
5. Assign a rank to each species starting with 1 for the most abundant species. If two species have the same number of individuals, choose one to be a higher rank, the other to be the next highest. Graph the results with the rank on the horizontal axis and the percent of the sample on the vertical axis. To convert proportional abundance (number in sample divided by total) to percent, move the decimal point two places to the right.

Journal Prompt: *Species richness and evenness are important factors to biodiversity and forest resilience. Describe a place that has low species richness and evenness and a place that has high species richness and evenness using words, pictures, and numbers. What do you think would happen to a place with low richness and evenness if there was a disturbance in that place?*

Example Chart:


A long line means high species richness
A more horizontal line mean high species evenness
30
20
10
1 2 3 4 5 6 7 8
rank

Lesson Plan Eleven: Phenology

Objective: Students (1) define phenology and phenophases and (2) order Minnesota species into Chionophile Chioneuphore, Chionophobe categories.

Background/Preparation: Every species moves through a series of life cycle stages that are related to environmental cues. The study of these life cycle stages is called phenology and the observable stages are called phenophases. Write on the board: Chionophile Chioneuphore, Chionophobe. Then write "Chiono - snow" "Phile - dear, beloved" "phore - An agent, bearer, or producer of a specified thing" "Phobe - fear"

Materials: Devices with access to the internet, link to MNDNR website on mammals: https://www.dnr.state.mn.us/mammals/index.html Optional link for Minnesota birds: https://www.dnr.state.mn.us/birds/index.html

Procedure:
Have students collect their second set of data from the invasive earthworm experiment by measuring and marking the labels and taking notes in their journal. Make sure they date the markings on their experiment and have them look at the teacher's large scale forest floor. Make notes of qualitative changes to their bottles.

1. Explain to the students that studying nature often includes studying how landscapes change over time, particularly through the seasons. Explain the background on phenology and phonophases,
2. Explain that one example of phenophases are migration, hibernation, and adaptation. Animal species in the forest choose one of these phenophases to survive in the cold winters of Minnesota. Chionophiles fare so well in winter they have actually developed special characteristics to help them in snow and cold. Chioneuphore Chioneuphores generally get through winter pretty well, even though they have no special adaptations so they burrow or hibernate. Chionophobes know better than to stick around in winter so they migrate
3. Have students use the MNDNR website on mammals (linked bellow) in Minnesota to identify an animal, read about its seasonal habits, and identify it as a Chionophile Chioneuphore, Chionophobe. You can choose to have them do this individually, with a partner, or in small groups but have every student make a list identifying each animal in their journals. If there is extra time have them try doing the same thing for birds in Minnesota (link also listed bellow)
4. Come together as a group and have students share an animal from their list, but not whether it is a Chionophile Chioneuphore, Chionophobe. As a group, figure out its category and list it on the board under the correct one.

Journal Prompt: *Returning to your changing object. Sketch the object and use words and numbers to describe how it has changed since you last saw it. Describe the phenophases for this changing object in words or pictures.*

Lesson Plan Twelve: Ecosystem Services of the Forest

Objectives: Students formulate ecosystem services from the forest.

Materials: Big umbrella, medium umbrella, smaller umbrella, index cards, devices with access to the internet. Link to Timeline webpage from the Minnesota Forest History Center: https://www.mnhs.org/foresthistory/learn/timeline

Procedure:

1. Open a large umbrella to represent a healthy forest. Ask the students to brainstorm ideas of what forests are used for. Put each idea on a card and lay it on top of the umbrella.
2. When the umbrella is covered, slowly start to collapse it, letting some of the cards slide off. Tell them that as a stand of trees die, many other things are affected. When the umbrella completely collapses, its value to the things on the cards is gone.
3. Habitat change can be shown by having smaller, various umbrellas pop up, some supporting very little. Discuss the interdependence of living things with students.
4. The broken umbrella is not able to hold any, or few, cards. Bring in the idea of human intervention and management of a forest. Tell how tree planting and a forest plan can regenerate the same type of habitat, ensuring the healthy forest for longer.
5. Next ask the students "Why should people care about the forest environments?" and "why do we need healthy forest ecosystems?" then have students partner up and brainstorm ten ways in which you depend on healthy ecosystems, and their components, for your lifestyle.
6. Explain that the Minnesotans have depended on the forest since people first came here. Have students read the Timeline webpage from the Minnesota Forest History Center and make a timeline by listing the timeframes and quick notes from the webpage.

Journal Prompt: *Go around your home or school and find objects that come from trees. List or draw them in your journal.*

Lesson Plan Thirteen: Ojibwe Forest History

Objectives: Students (1) process information about the Native American history of Minnesota forests and (2) examine career opportunities in forestry

Background/Preparation: Indigenous people in Minnesota work in and use the state's forests in many of the same ways as do other Minnesotans. This includes jobs such as foresters, loggers, wildlife biologists, interpretive naturalists, educators, and wildland firefighters. Indigenous people also use the forest to create various forms of art and enjoy leisure and life activities such as camping, hiking, hunting, and fishing. Students of all backgrounds can benefit from learning about careers in the forest that they can aspire to have one day as well as respect the cultural history of Native Americans in the state and their contributions for forestry. One way to also teach this lesson is to have a representative of one of these careers come to the class and have the students ask them questions about their jobs. Contact local forestry workers to see if they would like to come to the class on this day. Before class, you may choose to print out the MNDNR's sheet on jobs involved in forestry: https://files.dnr.state.mn.us/mcvmagazine/young_naturalists/young-naturalists-article/tree_guardians/tree_guardians.pdf

Materials: Projector with access to internet, link to Ojibwe Treaty Rights video: https://www.youtube.com/watch?v=hxWXwdVpvj4

Procedure:

1. Have a group discussion and ask: What importance does our culture place on the natural environment? What importance did/do Native American cultures place on the environment? How and why are the answers to these questions different?
2. Watch the video, Ojibwe Treaty Rights: Connections to Land and Water
3. Explain to the students how people and the forest both benefit each other.
4. Go outside and have the students read the following sheet from the MNDNR on jobs involved in forestry.

Journal Prompt: *You have read about people who have jobs in the forest. Write about one job you read about that you might like to do someday.*

Lesson Plan Fourteen: Invasive Species Presentation

Objectives: Students (1) identify an invasive species they want to learn more about, (2) communicate with their teacher their chosen method of communicating their research, and (3) research an invasive species

Background/Preparation: The final day of this curriculum is centered around a presentation. Students will begin by finalizing their data from their invasive earthworm experiments, dispose of experiments, create visual representations of the data, and communicate their results to peers. After this, they will research their chosen invasive species to study, it can be any species and their demonstration can be in any format. Teachers set a deadline for the presentation to be completed and set a day in the future to have a class presentation day. *Note: make sure to give them time in future classes to work on their presentations.*

Materials: Devices with internet access

Procedure:

1. Have students make their final data collection of the earthworm experiment
2. After the experiment is over, have students summarize their results in their journal. Have the students choose a visual to utilize to show the differences in qualitative data (create a chart, table, or diagram). Then have them report the qualitative data (write about 1 paragraph utilizing adjectives).
3. Group discussion: How did the "mini-forest floors" change over time? Is there more or less leaf litter in the worm only bottle compared to the other two bottles? Share your results with a partner.
4. Have students turn in their journals at this time to allow the teacher to grade their experiments using the Invasive Earthworm Experiment Grading Rubric.
5. Begin the presentation phase by having the students make a presentation describing an invasive species in Minnesota. Students choose which species and how they want to present their data. Their presentations should answer a who, what, when, where, why, and how format:
    a. Who: What is the invasive species? Who is impacted by it? (people, animals, plants?)
    b. What: In what way does this invasive species impact the ecosystem it is invading?
    c. When: When was this species introduced to Minnesota? How did it get here?
    d. Where: Where is the species from? What limits that species from becoming invasive in its natural habitat?
    e. Why: Why is this an issue the student cares about? Why should others care?
    f. How: How is it controlled in Minnesota? Is it a species that can be controlled?
6. Set a deadline for the presentation to be shown in class where they show off their chosen project (it is important that they be given time during class to work on their presentation so they have their teachers guidance, do not only have projects rely on students creating them as homework). Use the Presentation Grading Rubric to grade presentations.

Journal Prompt: *Complete the survey from the first day again and compare how you answered on the first day and how you answered after learning more about forest ecosystems*.

POST SURVEY

Thinking about the place you identified as a forest, please fill in the boxes to show how much you agree or disagree with the following statements:

	Strongly Disagree	Somewhat Disagree	No Opinion	Somewhat Agree	Strongly Agree
This place has unique value that I cannot find in other places	○	○	○	○	○
I am happier in this place than any other place like it	○	○	○	○	○
The things I can do in this place are hobbies of mine	○	○	○	○	○
I identify with the landscape of that place	○	○	○	○	○
That place means a lot to me	○	○	○	○	○
I don't care more about this place compared to others	○	○	○	○	○
I have memories tied to this place	○	○	○	○	○
I try to protect this place from being harmed	○	○	○	○	○

How has your opinion of the forest changed since you last completed this survey?

What are some new things you have learned about the forest?

Grading Rubrics:

Presentation Grading Rubric			
	Does not meet expectations 0	Partially meets expectations 1	Meets expectations 2
Aesthetics	Student did not create a presentation	Student created a presentation, but it is not organized or legible	Student created a presentation that looks organized and readable
Articulation	Student cannot explain any part of their design	Student can explain the parts of their design but does not connect their collected data to their explanation	Student can explain each part of their presentation including the process of making it and how it connects to the data they collected
Who, what, when, where, why, and how	Student presentation does not answer any of the questions	Student presentation answers some of the questions	Student presentation answers all the questions
Showing it off	Student made no effort to present their presentation to anyone else	Student made and effort identify how they could show off their presentation but did not engage in trying to do so	Students identified a way in which they could show off their presentation and engaged in presenting it or otherwise had a reasonable excuse as to why they could not.

Experiment Grading Rubric			
	Does not meet expectation 0	Partially Meets expectations 1	Meets Expectations 2
Material Collection	Student did not collect any materials	Student only collected a few of the materials	Students collected all necessary materials and showed a thoughtful analysis of the reasoning behind why certain materials were chosen.

Research	Student has no notes in their journal on invasive earthworms	Student took some notes on invasive earthworms	Student has one page or more of notes on earthworms organized in an outline format
Research Question	Student has no research question listed in their journal	Student has a research question listed but it does not pertain to the subject.	Student has a research question that pertains to the subject.
Human history of the issue	Student has not identified how the issue of invasive earthworms came to Minnesota or identified how people are impacted by invasive earthworms	Student has identified the way in which earthworms got to Minnesota, but did not relate the impacts to humans	Student has identified the way in which invasive earthworms got to Minnesota and expressed how people are impacted by them
Model	Diagram modeling the experiment is not present	The diagram modeling the experiment is not legible or labeled	Diagram modeling the experiment is present and labeled
Hypothesis	No hypothesis is presented	An informal hypothesis is presented	A formal hypothesis that identifies the control, independent, and dependent variables is presented.
Data Collection	Student did not collect any data in their journal	Student collected only quantitative or only qualitative data	Student collected both qualitative and quantitative data
Data Summary	Student did not summarize their findings	Student summarized only their qualitative or only their quantitative data	Student summarized qualitative data using a table, graph, or chart and summarized qualitative data at least one paragraph

References:

Bennett, N. J., Whitty, T. S., Finkbeiner, E., Pittman, J., Bassett, H., Gelcich, S., & Allison, Edward H. (2018). Environmental Stewardship: A Conceptual Review and Analytical Framework. *Environmental Management*, *61*, 597–614. https://doi.org/10.1007/s00267-017-0993-2

Cresswell, T. (2014). *Place : a Short Introduction.* John Wiley & Sons, Incorporated. https://ebookcentral.proquest.com/lib/hamline/detail.action?docID=1780033&pq-origsite=primo

Holdsworth, A., Hale, C., & Frelich, L. (2017, April). *Earthworms | Minnesota DNR*. https://www.dnr.state.mn.us/invasives/terrestrialanimals/earthworms/index.html

Potter, G. (2009). Environmental Education for the 21st Century: Where Do We Go Now? *The Journal of Environmental Education*, *41*(1), 22–33. https://doi.org/10.1080/00958960903209975

Vander Ark, T., Liebtag, E., & McClennen, N. (2020). *The power of place : authentic learning through place-based education*. Association for Supervision & Curriculum Development.

Links to Resources (as they appear in the curriculum):

Minnesota Department of Natural Resources (MNDNR) on Invasive Earthworms:
https://www.dnr.state.mn.us/invasives/terrestrialanimals/earthworms/index.html#:~:text=During%20the%20late%201800's%20and,remote%20areas%20of%20the%20state.
Great Lakes Worm Watch Document an Occurrence:
https://wormwatch.d.umn.edu/join-team/conduct-your-own-study/document-occurrence
A Beginner's Guide to Minnesota Trees:
https://conservancy.umn.edu/bitstream/handle/11299/49816/6593.pdf?sequence=1&isAllo
Osprey Live Camera:
https://arb.umn.edu/content/osprey-cam
Biodiversity Video:
https://ed.ted.com/lessons/why-is-biodiversity-so-important-kim-preshoff
MNDNR Minnesota Mammals
https://www.dnr.state.mn.us/mammals/index.html
MNDNR Minnesota Birds
https://www.dnr.state.mn.us/birds/index.html
Timeline from Minnesota Forest History Center:
https://www.mnhs.org/foresthistory/learn/timeline
Ojibwe Treaty Rights video:
https://www.youtube.com/watch?v=hxWXwdVpvj4