NATURE LAB Educator Resources

SEEING THE WOOD FOR THE TREES:
Introduction to Sustainable Forestry

Subject Area: Science, Environmental Science

Grades: 6th-8th

Time: This lesson can be completed in two 45-minute sessions.

Essential Question:

- What methods can be used to characterize different kinds of forestry?

Soft wood trees in Mexico that have been selectively harvested to use in toothpick production.
© Erich Schlegel/TNC

Overview:
Students use Google Earth to compare forests that have been logged selectively with those that have not. For an outdoor activity, students create a comprehensive list of all the tree species in their study area.

Themes:

Healthy forests filter water.

Forests provide numerous benefits, including net production of oxygen.

Wood and paper products come from forests.

Introduction:
In this lesson, students explore sustainable forestry and the pros and cons of selective harvesting. The indoor component of the activity uses satellite imagery to identify areas where sustainable forestry is practiced and to recognize some basic harvest methods. Students are challenged to use a scaling factor to measure specific areas covered by the satellite image.

An outdoor activity encourages students to appreciate the variety of different trees in their own neighborhoods or local parks. The students are introduced to important aspects of sampling. Students collect leaves and work as individuals, then as teams, to identify the trees in their sampling area. The class data is pooled to allow simple calculations of rarity indices for the various tree species.

Objectives:

The student will…

- Contrast different forestry methods.
- Critique sampling methods and recommend alternative approaches.
- Propose methods for evaluating satellite images.
- Devise sampling methods for satellite images and field studies.
- Analyze a satellite image.
- Organize field sample data.
- Distinguish between different forestry methods.
- Combine data from field investigations.
- Interpret key features of a satellite image.
- Determine types of forestry methods used in an area based on satellite imagery.
- Estimate land area based on an appropriate scaling factor of a satellite image or map.
- Know that satellite imagery can be used to quantify impacts of forestry methods.
- Know that selective logging offers a sustainable method of harvesting of lumber.
- Know that some methods of logging may not be sustainable.
- Identify common tree species from their leaves.

Standards:

Next Generation Science Standards – Middle School

Disciplinary Core Ideas

- PS1.A Structure and Properties of Matter
- LS2.A Interdependent Relationships in Ecosystems
- LS2.B Cycle of Matter and Energy Transfer in Ecosystems
- LS2.C Ecosystem Dynamics, Functioning, and Resilience
- ETS1.B Developing Possible Solutions
- ETS1.A Defining and Delimiting Engineering Problems
- ESS3.A Natural Resources
- ESS3.C Human impacts on Earth systems

Crosscutting Concepts

- Causation
- Patterns
- Stability and Change
- Systems
- Energy and Matter

Science and Engineering Practices

- Analyzing and interpreting data
- Constructing Explanations and designing solutions
- Engaging in argument from evidence
- Communicating information

Performance Expectations: Middle School

- PS1-3: Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.
- LS1-4: Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.
- LS1-6: Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.
- LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
- LS2-2: Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.
- LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
- LS2-5: Evaluate competing design solutions for maintaining biodiversity and ecosystem services.
- ES3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
- ES3-4: Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.
- ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Common Core English and Language Arts Standards for Speaking and Listening

For Grade 6 (see grade 7 and 8 online)

- CCSS.ELA-LITERACY.SL.6.1: Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly.
- CCSS.ELA-LITERACY.SL.6.2: Interpret information presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how it contributes to a topic, text, or issue under study.
- CCSS.ELA-LITERACY.SL.6.4: Present claims and findings, sequencing ideas logically and using pertinent descriptions, facts, and details to accentuate main ideas or themes; use appropriate eye contact, adequate volume, and clear pronunciation.

Vocabulary:

Clearcutting: A forestry method that harvests all trees in a given area at one time.

Forestry: The theory and practice of sustainably growing and harvesting trees for human use.

Monoculture: A field or forest that consists of only one plant species.

Scale: The proportionate sizes of a series of measurements.

Selective harvesting: A forestry method that harvests only selected trees of a certain age, species or location.

Sustainability: An environmentally healthy practice that can continue indefinitely.

Materials:

Nature Lab videos that support this lesson plan:

- ***Forests – The Stuff of Life*** introductory video http://vimeo.com/77811131
- ***Meet the Scientist: Bill Patterson*** http://vimeo.com/77229003
- Scientist Interview Questions
    - ***Forests #1: Importance*** - "How are forests important?" http://vimeo.com/79497480
    - ***Forests #2: Benefits*** - "What are the benefits of forests?" https://vimeo.com/79497482
    - ***Forests #3: Selective Harvesting*** - "What are the benefits of selective harvesting of lumber?" http://vimeo.com/79497479
    - ***Forests #4: Sustainable Forestry*** - "What kind of science is important to maintaining a sustainable forestry?" https://vimeo.com/79497478
    - ***Forests #5: Water*** - "How can sustainable forestry help keep water plentiful and safe to drink?" https://vimeo.com/79497485

Activity 1

For each individual or group of students:

- Computer with Internet access
- 8x11 clear acetate sheet with a 1 cm x 1 cm grid
- Fine point marker to draw the grid
- Ruler

Alternative option

- Print-outs of satellite image of forested area

Activity 2

For each individual or group of students:

- Copies of the Tree Frequency and Tree Rarity Handout
- Large plastic bag that can close
- Marker, pen
- Notebook
- Digital camera (optional)

For each group of students, at least one of the following:

- Computer with Internet access
- Cell phone or tablet with tree identification app
- *Tree Guide (see* https://www.thoughtco.com/top-tree-identification-guides-reviewed-1342643 for a list of guides)

Classroom Activities:

Activity 1: Where's the Wood?

Part 1: Engage

Have students look around the classroom. How many products are made from wood? They might just list tables and chairs. But they might be surprised at the number of items that use wood. Other objects might include pencils, measuring rulers, bookshelves and so on. Of course, most paper is made from wood, too.

1. Have students use the index cards to label all items in the classroom made of wood. Ask students to imagine what the classroom would look like if there were no items made of wood.

2. Have students consider where these products come from. Wood comes from forests. Ask students to make a list of how they think forests are important.

3. Show students the ***Forests – The Stuff of Life*** (http://vimeo.com/77811131) introductory video. Review students' lists as a class and note any additional items not on their lists.

4. Explain that most wood comes from managed forests. Before managed forests, wood came from wild or "virgin" forest. Before industrialization such forest was widespread.

5. Show students the maps of virgin forest cover in the United States from 1620 to the present day (http://www.slideshare.net/WorldResources/virgin-forests-southern-usa).

6. Have students count the number of dots representing 25,000 acres in your state for virgin forest today.

7. Evidently, there is almost no virgin forest left in the United States. Have students make a list of reasons why all the virgin forest has disappeared.

8. Ask students to review the class list of why forests are important and consider the impact on wildlife and other aspects of forests, such as watershed protection. As a reminder, you can show the video ***Forests #2: Benefits*** (https://vimeo.com/79497482).

9. Show students the NASA Earth Observatory map of current woody biomass in the United States (http://eoimages.gsfc.nasa.gov/images/imagerecords/76000/76697/whrc_carbon_us_lrg.jpg). There is still forest cover in many parts of the country. The challenge for forestry is to manage forest resources so that forests can continue to provide benefits to humans. Have students use the whiteboard to list differences between **conservation** (maintenance of resources for future use) and **preservation** (setting aside resources so that they will never be removed or destroyed).

10. Explain to students that they will learn to use satellite imagery to distinguish between two different ways of managing forest resources.

Part 2: Explore

1. Ask students what they think ***selective harvesting*** means. Provide the definition: A forestry method that harvests only selected trees of a certain age, species or location. Then ask what they think *clearcutting* means. Provide the definition: A forestry method that harvests all trees in a given area at one time.

2. Have students brainstorm and record the advantages and disadvantages of each method, clearcutting and selective harvesting, and share their thoughts after about 10 minutes. Supplement student responses based on these advantages and disadvantages:

Advantages	**Disadvantages**
Clearcutting is less costly per unit harvested and technically easier.	If not carefully planned and balanced with areas of mature forest, clearcutting can deprive animals of forest habitat and eliminates the benefits of ecosystem services such as watershed protection.
Clearcutting can produce the same amount of wood from a smaller harvest area, lowering the impact on mature forest animal habitat.	Clearcut areas may need to be planted to recover if not properly implemented but can provide important young forest habitat that some species require (example, the snowshoe hare and Canada lynx from Maine).
Selective logging has a smaller environmental footprint.	Selective logging is more expensive.
Selective logging can be highly *sustainable* for the environment, workers, and forest products.	Selective logging may require specialized techniques. (You may want to show the video of specialist machinery to have students observe this point.)

3. In the hands-on activity, students use satellite imagery to identify an area that is subject to selective logging. They contrast this with areas that have been clear-cut.

4. Have students access the Google Map image of the St. John River Forest by putting the following coordinates into the Google Map search field: 46.285556, -69.835833 or go to https://goo.gl/maps/RGYvGHrKsRM2.

5. Students will need to select an appropriate *scale* to perform their analysis. The scale is indicated in the bar on the right side of the image. Have students select a zone for analysis and print out their selected zone.

6. If necessary use an overhead or whiteboard to demonstrate the following procedure to scale satellite images and to estimate the areas.

7. Have students use markers to draw a grid of 1 cm x 1 cm squares on the acetate sheets.

8. Have students place the grid on their printout of the St. John's Wood, and calculate the appropriate scaling factor. Ensure the resolution of the image can detect differences in usage. The scaling factor is determined by the resolution. For example, 1 cm to 250 m will show enough detail to detect differences in land usage.

9. Have students use the grid to estimate the areas of forest cover with different land usage in areas of the St. John's Wood conservation area.

10. Have students quantify the forest cover in three types of forest management regimes:
    - Clearcutting
    - Selective harvest
    - Mature forest
    - Categorize non-forest areas as "Other land use"

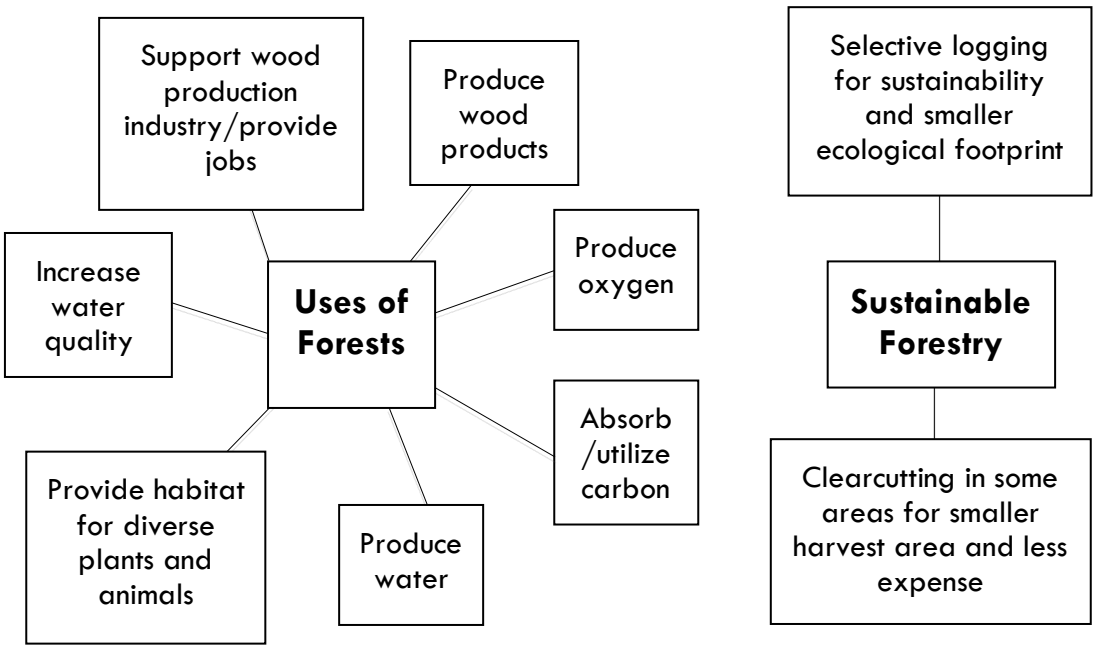
11. Have students quantify the three regimes in terms of percent forest cover.

Part 3: Explain

1. Have students create a concept map of the uses of forests by humans and wildlife.

2. Have students incorporate features of sustainable forestry into a second concept map.

   Sample Concept Maps:



3. Review the concept maps as a class. Ensure students understand that there are different approaches to forestry and that although forests are a renewable resource, the harvest of wood has to be balanced with the rate at which wood can grow.

4. Students should articulate the numerous benefits of forests, and that other animals depend on forests. Therefore, sustainable forestry is a sound management practice. Have students explain how satellite and aerial photo data are invaluable for evaluating change in forests over time. Scientists are also using satellite technology to monitor forestry practices and to ensure protected areas are not illegally logged.

Part 4: Extend

1. Show the scientist video ***Forests #5: Water*** (https://vimeo.com/79497485), that answers the question, "How can sustainable forestry help keep water plentiful and safe to drink?"

2. For additional information, students can search and explore the following online:

    - Variations in selective logging practices
    - Conservation of biological diversity
    - Maintenance of productive capacity of forest ecosystems
    - Maintenance of forest ecosystem health and vitality
    - Conservation and maintenance of soil and water resources
    - Maintenance of forest contribution to global carbon cycles
    - Maintenance and enhancement of long-term multiple socio-economic benefits to meet the needs of societies

Part 5: Evaluate

Students will be evaluated on their understanding of the benefits of trees, of the complexity of foresting issues, and of the importance of sustainable forestry. Give students the following task to complete.

Imagine you are a forest manager, asked to evaluate a new tract of forest for logging potential. What are some key questions you need to consider? Write a paragraph on the importance of forests and sustainable forestry and a list of questions to consider.

Answer Key for Evaluation

Students should articulate the numerous benefits of forests and note that sustainable forestry is a management practice that ensures the ongoing health of forests. They should include at least 3 of the considerations.

Benefits of forests:

- Produce oxygen, absorb/utilize carbon dioxide
- Produce water, ensure quality by filtering water
- Provide habitat for diverse plants and animals
- Produce wood products for human use
- Support wood production industry/jobs
- Provide opportunities for recreation

Considerations:

- What are the needs of the wildlife that inhabits the forest?
- How do people utilize the forest (for recreation, logging, etc.)?
- What waterways are in the forest?
- What kinds of trees grow in the forest?
- What is the budget for management of the forests?

Activity 2: Tree Diversity and Sampling

Part 1: Engage

1. Have students compare and contrast a field of wheat to a meadow. A wheat field is a ***monoculture***. The meadow has many different kinds of plants. Forests are similar. Tree plantations, such as a plantation of Sitka Spruce, are monocultures. Natural forests have diverse kinds of trees. The woods of different kinds of trees have various properties, enabling them to be used for different products. The diversity also allows a forest (and a meadow) to withstand an attack (e.g., disease, insect) on any one species.

2. Tree diversity is also important because a wider variety of trees support a greater range of wildlife. Ask students to brainstorm why this might be. Lead them to the idea that more species and a more varied habitat provide animals with more ways to find food and shelter.

3. Have students revisit the labels they made earlier for different products made from trees. Then have them look at the Idaho Forests site (http://www.idahoforests.org/wood_you.htm) that lists different kinds of products made from wood.

Part 2: Explore

1. In this outdoor activity students will collect as many different leaves as they can in order to gauge the tree diversity of their area. Have students collect leaves from the ground to ensure no harm to living trees. Students can do this activity anywhere trees or woody plants are growing.

2. If necessary, obtain permission from the landowner to conduct the activity.

3. Have students work individually to collect as many *different* leaves as they can from the natural area, placing them carefully in a plastic bag. Emphasize that each student should only collect one leaf for each different type they find. Limit the collection time to 30 minutes.

4. As an option, students can use their notebook to record other characteristics of each tree type, such as features of the trunk, seeds, or fruit. Ideally students take a digital picture of the tree to match the leaves they collect.

5. Back in the classroom, students can use an identification key from the Arbor Foundation (https://www.arborday.org/trees/whattree/) to name each species they find. A booklet is also available on the site for a fee or students can download a tree identification app on a smartphone.

6. Students can work in groups to help each other with identification, but they should keep their leaf samples separate.

7. Have students make a list of all the trees they identified.

8. Pool the lists of trees to get a comprehensive list of all the tree species in their study area.

9. Ask students what they noticed about the different kinds of trees. Were some trees more common than others? Were some trees represented only by one or two individuals? Compiling the class data will quantify the samples collected by the students and indicate how rare or common different kinds of trees are.

10. In the list of all trees, record how many students found a particular tree:

Type of tree	Number of students who found that tree

11. Have students create a bar graph of the tree frequency data. The rarest trees are those with the fewest students who found that tree.

12. Have students consider the shortcomings of this sampling method. Trees might be over or under-represented in the area students were working. What approaches might be taken to overcome these shortcomings? Answers might include that students could be assigned sections over a larger area of forest and that they might do preliminary online research to see if there is baseline information about trees in the area.

Part 3: Explain

1. Ensure students can articulate a basic understanding of sampling and why it's used: Samples are limited representations of a complete group or system. Sampling allows scientists to quantify items or phenomena they can't simply count (because of time, energy, budget). For example, we can't count or identify every individual tree in a forest.

2. Ask students how they might improve the sampling program. Students should explain that a systematic approach is needed, such as using a transect (all individuals along the line are sampled) or a quadrat (all individuals in a square area are sampled).

Part 4: Extend

1. Have students devise an index to characterize the rarity of particular tree species. One way to do this is to use percentages. For example, assume five species of trees were collected in all, with the following frequencies (number of students who found that tree). The total number of samples is 53. (This may be more than the number of students since each tree may be found by more than one student.) The rarity index is a percentage of this number for each tree species:

Type of tree	Number of students who found that tree	Rarity index (%)
A	14	26
B	3	6
C	8	15
D	12	23
E	16	30
Totals	**53**	**100**

   In this sample, species B is the rarest and E is the most common.

2. Have students consider how this rarity index might be useful in comparing different areas of forest, or two different forests. For example, imagine another forest in which they also found five species, of which 53 samples also are found. This time, they calculate the rarity index as follows:

Type of tree	Number of students who found that tree	Rarity index
V	29	55
W	6	11
X	2	4
Y	9	17
Z	7	13

   In this case, the number of species and samples is the same but the rarity indices are different. There is a greater range. Species V dominates this forest, whereas in the first forest no species clearly dominates.

3. If time is available, have students research the history of the area of woodland they sampled. Have them hypothesize based on the historical data on the type of forestry practiced in that area.

Part 5: Evaluate
Have students self-evaluate on their notes and observations. Consider how well they worked in teams to identify their samples compared with their diligence collecting specimens in the field.

Specific questions:

1. Consider the accuracy of the data on the tree species collected. How could the data be improved? What factors would extend the sample?

2. Five students have collected the following leaf samples:

Type of tree	Tammy	Kanesha	Josh	Melinda	Ernesto
Maple	✗	✓	✗	✓	✓
Holly	✓	✓	✗	✓	✗
White oak	✓	✗	✗	✗	✗
Sweet gum	✗	✓	✗	✗	✓
Elm	✓	✓	✓	✓	✓

   i. Which of the trees is the most common, according to this sample?
   ii. Which of the trees is the rarest?
   iii. Calculate the rarity index for sweet gum.
   iv. Offer three hypotheses as to why Josh may have collected fewer species of trees than the other students.

Answer Key for Evaluation

1. Data assumes that all tree leaves have the same probability of being found. Trees with fewer leaves may appear to be rare even though they might be more common than trees that produce more leaves. This is a more significant problem because the activity was conducted using fallen leaves. The data could be improved by identifying and counting the actual trees rather than using only the leaves.

2. Answers as follows:
   i. Elm is the most common tree.
   ii. White oak is the rarest.
   iii. The rarity index for sweet gum is 14.
   iv. Answers may vary. Four reasons why Josh may have collected fewer species of trees include (1) the area of forest where he was working had fewer species of trees, (2) he spent less time looking for different kinds of trees, (3) he covered a smaller area during his time looking for different kinds of trees, and (4) he could not identify the other species of trees. Note that hypotheses 2 and 3 can be combined as Josh making less effort to look for different kinds of trees.

Additional Resources and Further Reading:

Websites

- Terra-I: A Cool Tool for Detecting Deforestation (The Nature Conservancy) https://www.nature.org/science-in-action/leading-with-science/terra-i-a-cool-tool-for-detecting-deforesation.xml

- Forest Conservation: Responsible Trade (The Nature Conservancy) http://www.nature.org/ourinitiatives/habitats/forests/howwework/responsible-forest-trade-forest-certification.xml

- Selective Logging Fails to Sustain Rainforest (Scientific American) https://www.scientificamerican.com/article/selective-logging-fails-t/

- Forest Cover in the US (Wikipedia) http://en.wikipedia.org/wiki/Forest_cover_by_state_in_the_United_States

- The concentration of biomass—a measure of the amount of organic carbon—stored in the trunks, limbs, and leaves of trees (NASA) http://earthobservatory.nasa.gov/IOTD/view.php?id=76697

Journal Article

Trani, Margaret K. 2002b. "Terrestrial Ecosystems." In Wear, David N., and John G. Greis, eds. Southern Forest Resource Assessment. Gen. Tech. Rep. SRS-53. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station.

SEEING THE WOOD FOR THE TREES

Student Handout: Activity 2, Parts 2 and 4

Directions: Combine the class tree identification data by recording the type of trees identified and the number of students who found those trees in the table below. Then create a bar graph of the tree frequency data.

TREE FREQUENCY (Part 2)	
Type of tree	**Number of students who found that tree**

Directions: Using the class data, now calculate the rarity index (%) for each species. Enter the data from page one and then total the number of students who found all of the trees and enter it at the bottom of the middle column. Then calculate the rarity index by dividing the number of students who found a tree species for each row by the total number of students who found the trees and multiply by 100 and enter it on the table.

TREE RARITY INDEX (Part 4)		
Type of tree	**Number of students who found that tree**	**Rarity index (%)**
Totals	*(Add all the numbers in this column and enter here)*	**100**