Monitoring Forest Health

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Students will conduct a forest health checkup of a local forest area, will take forestry measurements, and will evaluate the ecological services provided by trees and forests.

Subjects
Biology, Environmental Science, Geography, Mathematics

Concepts
1.1 Biodiversity results from the interaction of living and nonliving environmental components such as air, water, climate, and geologic features.

1.2 Forests, as well as other ecosystems, contain numerous habitats that support diverse populations of organisms.

2.1 Organisms are interdependent, and depend on nonliving components of the Earth.

Skills
Analyzing Data, Comparing and Contrasting, Evaluating, Observing, Researching

Materials
Copies of all student pages; area map showing potential study sites (optional); flag markers; clipboards, tape measures; string; colored chalk; spades or trowels, plus paper cups or small plastic bags; distilled water; eyedroppers; Petri dishes or plastic containers; pH paper (with range of at least 5–10); white paper; compass; overhead transparency sheet

Time Considerations
Part A—one 50-minute period, plus time in the field (which can vary)

Part B—one to two 50-minute periods, or partly as homework

Related Activities in Other PLT Guides
Making the Global Connection (Forests of the World module); Researching Forests Around the World (*Forests of the World* module); Green Space (*Places We Live* module)

Objectives
- Students will conduct a forest health checkup of a local forest area.
- Students will evaluate the ecological services provided by trees and forests.

Assessment
- Have students write personal summaries of what they learned from the forest health checkup, including the following: Is this a healthy forest ecosystem? What evidence supports this conclusion? What influences—both natural and human-caused—are affecting this forest? What is the prognosis for this forest? What can people do to change this prognosis, either for better or worse?
- Ask students to use the information they gathered about ecological services of trees to describe the services and benefits of the local forest area.

Background

A forest is a complex system with many interdependent elements, including plant and animal species, soil and water, and cycles and processes. When it is functioning well, this system supports a diversity of species, helps to store and filter water, improves air quality, stores carbon, and performs other vital ecosystem services. People depend on healthy forests for these ecosystem services, as well as for wood and other products.

Forest health describes the resiliency, ***productivity***, and sustainability of forest ecosystems. The health of the forest is an indication of the relative condition of the forest.[1]

The U.S. Forest Health Monitoring program uses data from ground plots and surveys, aerial surveys, and other sources to develop analytical approaches to addressing forest health issues that affect the sustainability of forest ecosystems.[2] The monitoring program is designed to determine the status, changes, and trends in forest condition on an annual basis.

Foresters measure forest health in a number of different ways. Assessments may include the number of acres of forestland, the rates of growth of trees, the condition and diversity of plants, and the animal species supported by the forest ecosystem. Because measuring the many components of forest ecosystems for every forest would be impractical, forest health monitoring focuses instead on specific indicators of forest health.

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In this activity, students will examine vital sign indicators that provide a checkup on forest health. (See the "Forest Health Indicator" student pages for information about the specific indicators.) Students will also evaluate some of the ecosystem services provided by healthy trees and forests.

Endnotes

1. Northern Arizona University School of Forestry 2011.
2. USDA Forest Service 2011b.

Getting Ready

Part A

Make copies of the "Forest Health Indicators" student pages for each assessment chosen to be conducted, and make copies of the "Forest Health Summary" student page. On a transparency sheet, make a copy of the "100-Circle Grid Transparency" student page.

Find one or more forested areas that would be suitable for the activity. Depending on your location, possible areas may include a plot of trees on school grounds, a nearby urban park or botanical garden, a greenway, a university campus, or a public or privately owned forest. After researching possibilities, consider whether you or the students will make the final site selection. After choosing the site, obtain any permission you might need from the landowner or government agency.

To save time, you may choose to mark the study plots in advance (as described in step 6) instead of having students do it.

Ask a local forester or natural resource specialist to meet with your class before or during the forest checkup. That person may also be interested in receiving a report of your students' findings.

Part B

Make copies of the "Evaluating Tree Benefits" student page.

Choose a site for the activity. The site may be the same as in Part A or may be individual trees on the school grounds. Note: If you are using the same site as in Part A, you may choose to have students measure the trees for Part B while visiting the site for Part A.

Determine what tree species are likely to be at the site, and bring in sample leaves (if possible) and field guides to help familiarize students with those trees.

Doing the Activity

Part A—Forest Health Checkup

1. Ask students the following questions: "What do you think forest health means? Why should we care whether forests are healthy or not? What factors do you think might promote or diminish forest health?"

2. Explain to students that they are going to study a local forest to look for indications of its health. Point out that just as a doctor takes the temperature and measures blood pressure to assess a patient's general health, foresters use specific vital signs to assess forest health.

3. Ask students what sorts of things might indicate that the forest is healthy, and list their ideas on the board. Ask them what things might indicate poor health, and add those ideas to the list. Give students copies of the "Forest Health Indicator" student pages, and discuss the indicators included. How do the indicators compare with the list generated by the class? Is there anything from the class list that should be added as an indicator? How would that indicator be investigated? Are there any indicators that would not make sense for your forest?

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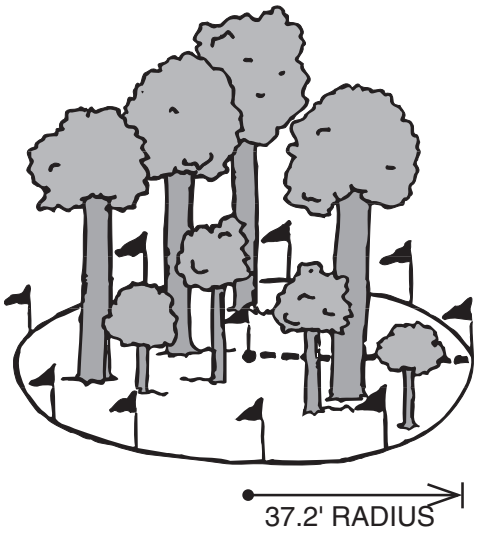
4. Describe the site(s) you have researched (see Getting Ready). You might point out each location on a map. If students will be selecting the forest area to study, have them discuss the pros and cons of each site and then vote for the forest they want to study.

5. Explain that the class will mark off a 0.1-acre study plot (or several plots), within which the class teams will conduct one or more of the investigations. You may choose to let each team have its own plot for doing all the investigations, or you may have one plot to study as a class, with different teams doing different investigations. In either case, have at least two teams do each investigation to increase data validity.

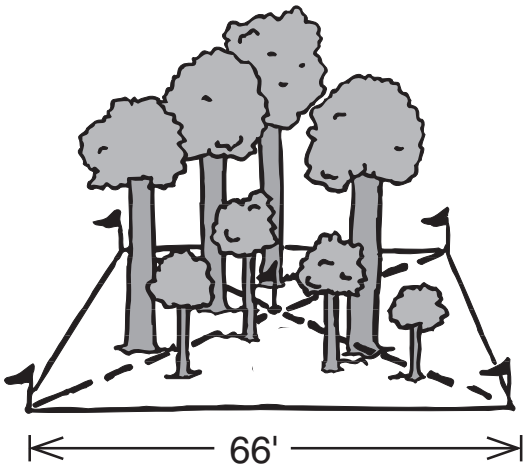
6. At the study site, decide whether the plot(s) should be circular or square, depending on the terrain. Have students mark the boundaries of each 0.1-acre plot (4,356 square feet, or 405 square meters) as follows:
   - For a circular plot, have students place a flag in the ground to denote the center of the plot. Then, have them use a 50-foot tape measure to measure 37.2 feet (11.34 meters) from the center. They should make a circle around the center marker with the outstretched tape and should place flags to mark the circumference of the circle.

Circular Plot



   - For a square plot, have students measure a square with sides 66 feet (20 meters) long. It may help to stretch two strings diagonally from corner to corner (the strings should be 93 feet, or 28.3 meters, long) to establish the plot's boundaries, plot center, and corners. Have students flag the plot boundaries.

Square Plot



7. Divide the class into teams to perform the investigations. You might have groups mark trees with chalk (with a different color for each group) to indicate which trees were sampled.

8. Give each student a copy of the "Forest Health Summary" student page to complete. If all the teams conducted each of the investigations, have the teams tally their results on that page. If different teams conducted different investigations, have the teams share their results. Give teams sufficient time to reach a conclusion about the overall health of the forest plot.

9. Discuss the following questions:
   - What was your assessment of the overall health of the forest plot?
   - Which results were the most important in making your assessment?
   - Do you think the results are representative of the entire forested area? Why or why not? How might a more accurate assessment be obtained?
   - How do human activities either degrade or enhance the health of this forest?
   - What could people do to improve it?

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Part B—Ecosystem Services

1. Point out to students that a healthy forest provides a variety of ***ecosystem services***. Ask students what they think the term ecosystem services means. If necessary, explain that ecosystem services are the services that humans derive from environmental functions such as ***photosynthesis, biodiversity***, oxygen production, watershed protection, and ***carbon sequestration***. Have students work in groups to create a list of ecosystem services that forests provide, and suggest that students start with parameters investigated in Part A. Invite each group to share some of its responses while making a class response list on the board.

2. After looking at the class list, ask students if they can think of any ecosystem services that are missing. (Be sure that the list includes water filtration, biodiversity or ***wildlife*** habitat, improvement of air quality, and carbon sequestration.)

3. Introduce students to the website at http://www.treebenefits.com, and explain that students will use the online calculator to assess the ecosystem services of the forest area from Part A (or from individual trees on the school grounds or other chosen location). Explain, as necessary, the various parameters included on the "Evaluating Tree Benefits" student page.

4. Point out that students will need to determine each tree's species and its ***diameter at breast height*** (or DBH). They will also estimate the tree's height; although not necessary for the online calculator, it is a useful measurement for assessing a tree's value. Explain the steps for measuring tree height and diameter as described on page 53. (Note that the treebenefits website can be used only for trees with a DBH of 45 inches, or 114cm, or less.) With the leaves you brought in, offer students practice in using field guides to identify the tree species that they may find at the site.

5. Take your students to the selected site, and divide them into teams. Assign each team a tree to identify and measure while using the directions on the "Evaluating Tree Benefits" student page. (If desired, the identification and measurement may also be done at the same time as the Part A investigations.) Teams should record their results on the student page.

6. Back in the classroom, allow time for your students to use the treebenefits.com website to determine the ecosystem services of their assigned trees. Have them record their results on the student page.

7. Discuss the following questions:
   - What ecosystem services does your tree provide?
   - What does this activity suggest about future management and care of your tree?
   - How do the services and benefits calculated for your tree compare to those of other trees?
   - What additional ecosystem services and benefits do trees and forests provide?
   - What connection is there between forest health and ecosystem services?

Enrichment

- Revisit the same forest site at another time of year, or visit a different site. Repeat the "Forest Health Indicators" investigations or the analysis from the treebenefits.com website. Compare the results. What factors may explain any differences?

- Working with local foresters, have students develop and implement an action plan to improve forest health. Their plan may include, for example, planting trees or removing invasive species.

- Tree growth over time is another useful indicator of forest health. At the same time each year, have your students measure and record the height and diameter of each tree in their plot, using the methods described on the "Evaluating Tree Benefits" student page. Each subsequent year, students can compare tree growth. If you have access to an increment borer, you might also take core samples to determine tree health: closer rings indicate a stressed tree, while wider rings indicate fast growth as a result of abundant sunlight, water, nutrients, and so forth.

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- Create an ecosystem services guide to your forest including (a) an introduction to the ecosystem services and other benefits the forest provides to the community, (b) a map that shows a route for walking in the forest and that highlights different ecosystem services, and (c) descriptions of tree species or other pertinent features of the forest.

- Conduct a "bioblitz" of your forest that is similar to the one conducted by the National Geographic Society and the National Park Service in a national park every year and in which as many species as possible are tallied in a 24-hour period. You could invite local experts (such as an ornithologist, entomologist, arborist, and so on) to help students identify animal and plant species in your forest.

- Evaluate different management schemes for your forest plot. Use the treebenefits.com calculator to compare the effects of (a) leaving the land as is, (b) thinning it by removing 20 percent of the trees, or (c) clearing the land for a different purpose.

Resources

Arbor Day Foundation and Karina I. Helm. 2009. *What Tree Is That?: A Guide to the More Common Trees Found in North America*. Lincoln, NE.

Brockman, C. Frank, and Rebecca Merrilees. 2001. *Trees of North America: A Guide to Field Identification*. Rev. ed. (Golden Field Guide Series). New York: St. Martin's Press.

Stolte, Kenneth, Barbara Konkling, Sally Campbell, and Andrew Gillespie. 2002. "Forest Health Indicators: Forest Inventory and Analysis Program." USDA Forest Service. October 2002. Document no. FS-746. http://fia.fs.fed.us/library/brochures/docs/Forest_Health_Indicators.pdf .

USDA Forest Service. 2009. *Valuing Ecosystem Services.* http://www.fs.fed.us/ecosystemservices/About_ES/index.shtml

Many states have state-specific tools for online tree identification. Search the Internet by using "tree identification" and your state's name. Here is a sampling of such online tools:

- "Common Trees of the Pacific Northwest" (an online dichotomous key): http://oregonstate.edu/trees/dichotomous_key.html.

- "An Interactive Key of Common Iowa Trees" (an online guide): http://www.extension.iastate.edu/Pages/tree/site/key.html.

- "What Tree Is It?" (an online guide to identifying Ohio trees): http://www.oplin.org/tree/.

- "Key to Leaves of Virginia Trees" (an online guide to identifying Virginia trees): http://www.fw.vt.edu/dendro/forsite/key/intro.htm.

Media Connections

Community Trees: A Living Investment. USDA Forest Service. This 20-minute video (available at http://www.na.fs.fed.us/urban/community_trees/index.shtm) and 6-minute clip (available at http://www.youtube.com/watch?v=KzEFl2wrVW8) describe how trees improve the air we breathe, purify our water, cool our cities, increase revenues in shopping districts, slow down traffic, and even help children concentrate.

Earth & Sky—Curtis Woodcock: Earth's Forests from Space. Scientist Curtis Woodcock talks about how scientists can track forest change with satellites and the importance of forest ecosystem services. Download the 90-second or 8-minute interviews at http://earthsky.org/earth/curtis-woodcock-earths-forests-from-space.

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Forest Health Indicator: Tree and Crown Condition

Name(s):_____
_____
Location:_____
Date:_____

Damage to trees from disease, weather, and activity by animals, insects, and humans can affect overall forest health. Several of these signs are included in the chart below.

Materials

Paper, pencils, chalk

Method

Count all the trees in the plot, marking the trees with colored chalk to help you keep track. Note trees that have one or more signs of disease or damage (see below). To count it as diseased or damaged, 10 percent or more of the tree should be affected. Calculate the percentage of all trees in the plot that have such signs.

Signs of Disease or Damage	
Sign	**What it may indicate**
Tree has ragged leaves with holes	Insects feeding on the leaves
Black or brown leaves	Stem or leaf disease
Spots or bumps on leaves	Insects and mites
Twisted or malformed leaves	Insects and disease, herbicides
Leaves changing color before fall	Trunk or root damage, drought, pollution
Branch decay	Unhealed wounds
Peeling or broken bark, holes in the bark	Trunk wound, canker disease, or damage caused by humans or animals
Dying branches on one side of crown	Root decay, root injury or internal stem disease, insect attack
Canker (a dead section of a trunk or branch)	Fungal infections
Splits	Broken branches
Hollows	Water entering through old wounds and supporting wood decay by fungi
Fungi or mushrooms growing on tree	Internal decomposition of wood by fungi
Green or brown spots on needles	Air pollution

Results

Total number of trees with signs of disease or damage in plot: _____ (Value A)
Total number of trees in plot: _____ (Value B)
Percentage of trees damaged = (Value A ÷ Value B) x 100 = _____ percent

Rating

Tree and Crown Condition		
Rating	**Description**	**Points**
Good	Less than 25 percent of trees have damage	3
Fair	25–50 percent of trees have damage	2
Poor	Greater than 50 percent of trees have damage	1
Overall *Tree and Crown Condition* rating for sample plot:		

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Forest Health Indicator: Forest Diversity

Name(s):_____
_____
Location:_____
Date:_____

A healthy forest includes a variety of different plants and animals. One way to assess this diversity is to determine whether there is a mix of plant species of different sizes and ages, thus creating forest "layers" that provide habitat for many species.

Materials

Pencil, paper, tape measure, chalk, tree identification guide (optional)

Method

Look at the leaves, bark, seed pods, or flowers of the trees in your forest plot to determine whether they are the same or different species. Use the *Tree Species Diversity* chart below to catalog this information. Tree identification guides are helpful with this step, but not necessary. If a tree identification guide is not available, use your observation skills to describe the differences in tree types and include this information in the *Tree Species Diversity* chart below.

Measure (or estimate) the diameter at breast height (DBH) for all trees in the sample plot. Count (or estimate) the number of trees of different size classes using the corresponding DBH size classifications found in the *Size Diversity* chart below and record your findings. To help you, consider using chalk to mark the trees you have already counted.

Assess the presence or absence of different forest layers, using the descriptions found in the *Forest Layer Diversity* chart and record your findings.

Results

Tree Species Diversity		
	Name or Description	**Number found in sample plot**
Species 1		
Species 2		
Species 3		
Species 4		
Species 5		

Note: Please continue listing to account for all species present in sample plot.

Size Diversity		
Tree Size	**DBH**	**Number found in sample plot**
Saplings or Poles	4–9 inches (10–24 cm)	
Small	10–14 inches (25–37 cm)	
Medium	15–19 inches (38–49 cm)	
Large	20–29 inches (50–75 cm)	
Giant	30 inches or greater (> 75 cm)	

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Forest Health Indicator: Forest Diversity (cont.)

Forest Layer Diversity		
Tree Layer	**Description**	**Present in sample plot? (Yes/ No)**
Overstory	Trees whose canopies are fully exposed to the sun	
Understory	Trees growing in the shade of other trees	
Tall shrub	Shrubs (woody plants with several stems arising from the base) greater than 6 feet (1.8 meters) in height	
Short shrub	shrubs less than 6 feet (1.8 meters) in height	
Forb	herbaceous (non-woody) plants such as ferns, wildflowers, and grasses	
Leaf litter	Dead and decaying leaves and other matter on the forest floor	

Rating

Tree Species Diversity		
Rating	**Description**	**Points**
Good	Three or more tree species present	3
Fair	Two tree species present	2
Poor	One tree species present	1
	***Tree Species Diversity* rating for sample plot:**	(Value A)

Size Diversity		
Rating	**Description**	**Points**
Good	Three or more size classes present	3
Fair	Two or size classes present	2
Poor	One size class present	1
	***Size Diversity* rating for sample plot:**	(Value B)

Forest Layer Diversity		
Rating	**Description**	**Points**
Good	Five or six layers present	3
Fair	Three or four layers present	2
Poor	One or two layers present	1
	***Forest Layer Diversity* rating for sample plot:**	(Value C)

Overall Rating

Determine the overall rating by adding up the points shown for the tree species, size, and forest layer diversity ratings; then dividing the total by 3. Round the total to the nearest whole number.

(Value A + Value B + Value C) ÷ 3 = _____ (Average point value)

Overall rating for Forest Diversity:
Good: Average point value of 3 *Fair:* Average point value of 2 *Poor:* Average point value of 1

Overall *Forest Diversity* rating for sample plot: _____

Sources

Greenleaf Forestry and Wood Products Inc. 2010. "Forest Health Checklist." http://www.greenleafforestry.com/greenleafservices_006.htm.

Portland State University. 2010. "Protocol: Measuring Tree Diameter, Class Size, and Average Species Diameter." *Ecoplexity*. http://ecoplexity.org/node/236?page=0,4.

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Forest Health Indicator: Lichen Abundance

Name(s):_____
_____
Location:_____
Date:_____

Lichens often grow on trees and shrubs, absorbing nutrients from the atmosphere. Because lichens are very sensitive to air pollution—particularly to sulfur dioxide, fluoride, and ammonia—their presence or absence is an indicator of forest health. The acidity of a tree's bark can also affect lichen abundance.

A lichen is actually two different organisms—either a fungus and an alga, or a fungus and a cyanobacterium—living in a symbiotic relationship. The fungus provides protection and moisture, while the alga or cyanobacterium provides food through photosynthesis.

Trees help support many other living organisms, including these lichens. Far from harming the tree, lichens indicate pollution-free air. Photo by USDA Forest Service - Northeastern Area Archive, USDA Forest Service.

Materials

String, tape measure, compass, chalk, 100-circle grid transparency

Method

Select 10 trees on your study plot to sample. For each tree, tie a string around the trunk at a standard height (such as diameter at breast height, or DBH). Use a compass to determine north, south, east, and west; then mark the directions with chalk on the tree at the string line.

At each of the 4 directions, place the 100-Circle Grid Transparency against the tree, and count the number of circles in which lichens are showing. That number represents the percentage of lichen coverage. For each tree, find the average lichen coverage by totaling the lichens found within the circles and then dividing the total by 4. Find the total average lichen coverage of the plot.

Results

For each tree and direction, record the number of circles that show lichens. This number represents the percentage of lichen coverage.

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Forest Health Indicator: Lichen Abundance (cont.)

Lichen Abundance						
	North	**East**	**South**	**West**	**Total**	**Tree Average (%)**
Tree 1:						
Tree 2:						
Tree 3:						
Tree 4:						
Tree 5:						
Tree 6:						
Tree 7:						
Tree 8:						
Tree 9:						
Tree 10:						
Totals:						
Average:						

Add up the tree averages, which will be recorded in the final column in the chart above. Divide this total by the number of trees sampled to get the average lichen coverage for the entire sample plot.

Average Lichen Coverage for sample plot: _____ percent

Rating

Lichen Abundance		
Rating	**Description**	**Points**
Good	Greater than 5 percent lichen coverage	3
Fair	3–5 percent lichen coverage	2
Poor	0–2 percent lichen coverage	1
Overall *Lichen Abundance* rating for sample plot:		

Sources

Pathfinder Science. 2006. "Sampling Procedure for Lichen Coverage." http://www.pathfinderscience.net/so2/cproto1.cfm.

Smith, Gregory L., and Thomas R. Baker. 2003. "Lichens as Bioindicators." In *The Middle School Science Classroom*, NSTA ScienceScope, 16–19. http://tbaker.com/tbaker/academics/papers/published/sciscope_lichens/released_byNSTA/Lichens%20as%20Bioindicators.pdf.

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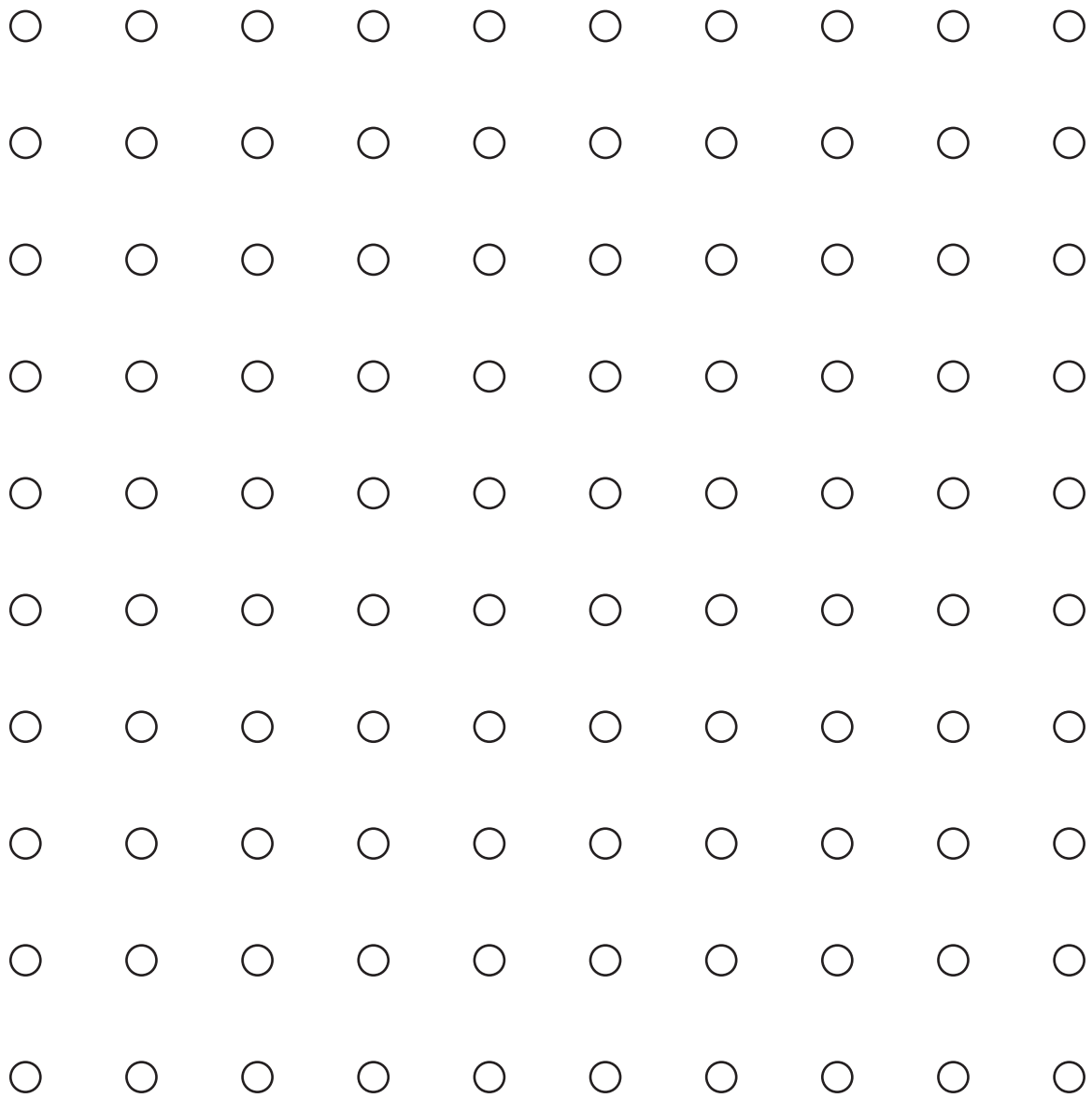
100-Circle Grid Transparency



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Forest Health Indicator: Soil Quality

Name(s):_____
_____
Location:_____
Date:_____

The quality of the soil in a forest is an important indicator of forest health. How well the soil functions directly influences the health of the trees and other forest organisms. An evaluation of soil quality usually involves measuring the soil's physical, chemical, and biological makeup at different depths.

Materials

Spade or trowel, 3 paper cups or plastic bags, distilled water, eyedropper, 3 Petri dishes or plastic containers, pH paper, white paper

Method

Choose a soil sample site that represents the overall forest plot, and measure 1 square foot (0.09 square meters) of ground, marking the corners with sticks or rocks. Within the plot, first remove the leaf litter layer with a spade or trowel. Next, collect soil samples from depths of approximately 3 inches (7.5 cm), 6 inches (15 cm), and 1 foot (30 cm). Use paper cups or plastic bags to store the samples.

Conduct the following assessments for each sample, recording your results in the "Soil Quality Results and Ratings" chart below.

Results

Soil Type

Most soils are a mixture of sand, silt, and clay. The specific content of a given soil influences how well it holds nutrients and water. To find out your soil type, take a small amount of soil (about the size of a marble), and moisten it with a few drops of water. Squeeze it between your thumb and fingers.

Soil Types		
Soil Type	**Squeezed Moist Soil**	**Rating**
Sand	Feels gritty and cannot hold ball shape	**Poor**—Has few nutrients, holds little water, and is prone to drought
Sandy Loam	Can be molded into a ball, but ball breaks up easily	**Good**—Has good balance of nutrients and moisture retention
Silt	Can be molded into a ball that is easily deformed; does not feel gritty and has silkiness like flour	**Fair**—Has more nutrients and holds more water than sand, but washes away (erodes) easily
Loam	Can be molded into a ball that can be handled quite freely without breaking	**Good**—Has good balance of nutrients and moisture retention
Clay Loam	Can be formed into a long thin rod or "ribbon" that will break readily, barely sustaining its own weight	**Good**—Has good balance of nutrients and moisture retention
Clay	Sticky and can easily be formed into long thin rod or "ribbon"	**Fair**—Holds water very well, but does not allow movement of air or water, so doesn't drain well

Record your results in the "Soil Quality Results and Ratings" chart.

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Forest Health Indicator: Soil Quality (cont.)

Soil pH

Soil pH is a measure of how acidic or alkaline the soil is, and it is an indicator of soil quality. Measure 1 tablespoon of soil from each depth, place this amount onto individual Petri dishes or plastic containers, and label the soil samples. Wet each soil sample with 5 drops of distilled water, and allow it to sit for 3 to 5 minutes. Place one piece of pH paper on each soil sample. Determine the approximate pH of your soil.

Soil pH		
Rating	**Description**	**Points**
Good	pH of 5.51–7.2, which is optimum for many plant species	3
Fair	pH of 7.2–8.5 (moderately alkaline) or 4.0–5.5 (moderately acid)	2
Poor	pH of 4.0 and less (acid), or greater than 8.5 (alkaline)	1

Record your results in the "Soil Quality Results and Ratings" chart.

Soil Organisms

The presence of living organisms in the soil is an important indicator of productive soils. Soil organisms aid in nutrient cycling, soil creation, and decomposition of organic matter and dead organisms. Pour the remaining soil sample onto a white piece of paper, and look for the presence of the following organisms. For each type, circle whether it is present or not. (Soil fungi are microscopic cells that grow as long threads or strands in the soil.)

Soil Organisms						
Soil Depth	**Ants/ Termites**	**Centipedes/ Millipedes**	**Earthworms**	**Fungi**	**Other**	**Other**
3 in (7.5 cm)	Present None	Present None	Present None	Present None		
6 in (15 cm)	Present None	Present None	Present None	Present None		
12 in (30 cm)	Present None	Present None	Present None	Present None		

Soil Organisms		
Rating	**Description**	**Points**
Good	3 or more types of soil organisms present in soil sample	3
Fair	1 or 2 types of organisms present in soil sample	2
Poor	no soil organisms present in soil sample	1

Record your results in the "Soil Quality Results and Ratings" chart.

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Forest Health Indicator: Soil Quality (cont.)

Rating

Circle the ratings that apply for each depth and each assessment. Determine the average score for each depth by adding up the points shown for each rating and dividing the total by 3. Find the average of the three "Average Soil Quality at Each Depth" ratings to get the overall soil quality.

Soil Quality Results and Ratings			
	3 in (7.5 cm) deep	**6 in (15 cm) deep**	**12 in (30 cm) deep**
Soil Type	Type:_____ *Good:* 3 points *Fair:* 2 points *Poor:* 1 point	Type:_____ *Good:* 3 points *Fair:* 2 points *Poor:* 1 point	Type:_____ *Good:* 3 points *Fair:* 2 points *Poor:* 1 point
Soil pH	Type:_____ *Good:* 3 points *Fair:* 2 points *Poor:* 1 point	Type:_____ *Good:* 3 points *Fair:* 2 points *Poor:* 1 point	Type:_____ *Good:* 3 points *Fair:* 2 points *Poor:* 1 point
Soil Organisms	Type:_____ *Good:* 3 points *Fair:* 2 points *Poor:* 1 point	Type:_____ *Good:* 3 points *Fair:* 2 points *Poor:* 1 point	Type:_____ *Good:* 3 points *Fair:* 2 points *Poor:* 1 point
Total Points			
Average Soil Quality at Each Depth (rounded to nearest whole number)			
Overall Soil Quality (rounded to nearest whole number)			

Good: Average point value of 3
Fair: Average point value of 2
Poor: Average point value of 1

Overall *Soil Quality* rating for sample plot: _____

Source

USDA Forest Service. 2007. "Soil Vital Signs: Soil Quality Index (SQI) for Assessing Forest Soil Health." http://www.fs.fed.us/rm/pubs/rmrs_rp065.pdf.

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Forest Health Indicator: Regeneration

Name(s):_____
_____
Location:_____
Date:_____

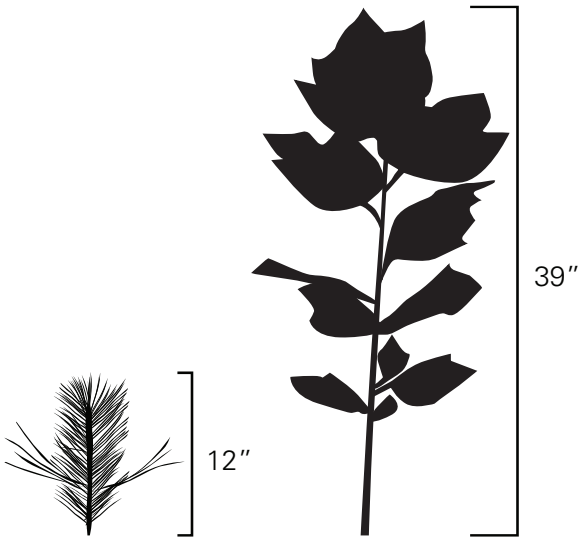
Forest regeneration is a good measure of the health of the forest habitat. When a forest can produce enough young trees to replace the canopy trees when they are cut, blown down, or die, such production is an indication that the forest is vibrant and sustainable. An overabundance of regeneration, however, can result in competition for limited resources among adjacent trees. Regeneration is measured by the number of tree seedlings present.

Materials

Tape measure, string or other marker

Method

Using a tape measure and string or other marker, divide the study plot into 9 equal segments (8 equal segments, if it is a circle plot). Survey each segment and determine whether there is a healthy seedling that is at least 12 inches (30 cm) tall if it is a conifer, and at least 39 inches (1 meter) tall if it is a deciduous tree. To be considered healthy, the seedling must not have any apparent damage to its leaves or stems.



Coniferous seedling Deciduous seedling

Results

Number of forest plot segments with at least one healthy seedling: _____ (Value A)
Number of total forest plot segments: _____ (Value B)

Percentage of plots with at least one healthy seedling
(Value A ÷ Value B) x 100 = _____ percent

Rating

Plot Segments		
Rating	**Description**	**Points**
Good	More than 66 percent of plot segments have at least one healthy seedling.	3
Fair	33 to 66 percent of plot segments have at least one healthy seedling.	2
Poor	Less than 33 percent of plot segments have at least one healthy seedling.	1
Overall *Regeneration* rating for sample plot:		

Source

Forestry Branch, Province of Manitoba. 2010. "Silviculture Surveys: Regeneration Surveys." http://www.gov.mb.ca/conservation/forestry/renewal/surveys.html.

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Forest Health Indicator: Snags and Coarse Woody Debris

Name(s):_____
_____
Location:_____
Date:_____

In natural forest ecosystems, snags (standing dead trees) and coarse woody debris (dead logs and large branches on the ground) are important indicators of forest health. Their presence indicates a forest of diverse ages, and the snags and debris provide animal habitat, energy and nutrient cycling, and stable soils.

Note: In parks or near structures, forest managers may remove snags or coarse woody debris to prevent fire and other safety hazards. If your forest plot is in such an area, the presence of snags or debris may not be a relevant forest health indicator.

Materials

Tape measure

Method

Count the number of snags and the number of live trees in your forest plot, and calculate the percentage of standing trees that are snags. Then, count the number of dead logs and downed large branches in your plot that are more than 4 inches (10 cm) in diameter and more than 39 inches (1 m) in length, and calculate their abundance.

Results

Snags

Number of snags in plot: _____ (Value A)
Number of live trees in plot: _____ (Value B)

Total number of standing trees in plot:
Value A + Value B = _____ (Value C)

Percentage of snags:
(Value A ÷ Value C) x 100 = _____ percent (Value D)

Coarse Woody Debris

Number of logs and downed branches greater than 4 inches (10 cm) in diameter and 39 inches (1 m) in length: _____ (Value E)

Abundance of course woody debris:
(Value E ÷ Value B) x 100 = _____ percent (Value F)

(**Note:** For some forest plots, abundance may be more than 100 percent.)

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Forest Health Indicator: Snags and Coarse Woody Debris (cont.)

Rating

Snags		
Rating	**Description**	**Points**
Good	From 10 to 15 percent of standing trees are snags.	3
Fair	From 5 to 10 percent of standing trees are snags.	2
Poor	Fewer than 5 percent of standing trees are snags.	1
	***Snags* rating for sample plot**	points (Value G)

Coarse Woody Debris		
Rating	**Description**	**Points**
Good	More than 15 percent abundance of coarse woody debris.	3
Fair	From 5 to 15 percent abundance of coarse woody debris.	2
Poor	Fewer than 5 percent abundance of coarse woody debris.	1
	***Coarse Woody Debris* rating for sample plot**	points (Value H)

Overall Rating

Determine the overall rating by adding up the points shown for the snag and coarse woody debris ratings, and then divide the total by 2. Round to the nearest whole number.

(Value G + Value H) ÷ 2 = _____

Good: Average point value of 3
Fair: Average point value of 2
Poor: Average point value of 1

Overall *Snags and Coarse Woody Debris* rating for sample plot: _____

Source

National Park Service. 2009. "Forest Health: Course Woody Debris and Snags." Resource Brief, Northeast Temperate Network. http://science.nature.nps.gov/im/units/NETN/Education/Resource%20Briefs/NETN_RB_CWDSnags_FINAL.pdf

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Forest Health Indicator: Wildlife

Name(s):_____
_____
Location:_____
Date:_____

The presence of a variety of wildlife is an indicator that a forest is vibrant and healthy. Actually seeing the animals may be difficult, but tracks, droppings, burrows, dens, nests, chewed leaves, and other evidence or "signs" reveal their existence. You are more likely to see or hear the animals if you are quiet, respectful, and patient.

Materials

Pencil, paper, binoculars or magnifying glass (optional)

Method

In your forest plot, look on the ground, under shrubs, and in trees for mammals, birds, reptiles, amphibians, spiders, or insects, or for signs of those animals. Record your observations.

Results

Animal Signs and Sightings		
Animal Class	**Signs**	**Sightings**
Mammals		
Birds		
Reptiles		
Amphibians		
Spiders		
Insects		
Other		

Rating

Wildlife		
Rating	**Description**	**Points**
Good	Signs or sightings of 4 or more different classes of animals	3
Fair	Signs or sightings of 2–3 different classes of animals	2
Poor	Signs or sightings of 0–1 different classes of animals	1
	Overall *Wildlife* rating for sample plot:	

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Forest Health Summary

Name(s):_____
_____
Location:_____
Date:_____

Use this page to tally the Forest Health Indicator investigations that you have conducted for your forest plot, while noting any key observations. Use the indicators to make an assessment of the forest's overall health.

Forest Health Summary			
Forest Health Indicator	**Overall Point Value (3, 2, or 1)**	**Overall Rating (Good, Fair, or Poor)**	**Key Observations**
Tree and Crown Condition			
Forest Diversity			
Lichen Abundance			
Soil Condition			
Regeneration			
Snags and Coarse Woody Debris			
Wildlife			
Averages / Conclusions			

What is the Overall Health Assessment for your study plot?

_____

_____

Explain your reasoning.

_____

_____

_____

_____

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Evaluating Tree Benefits

Name(s):_____
_____
Location:_____
Date:_____

1. Select a tree to study. Use a field guide or other source to determine the tree's species.
   Tree Species: _____

2. Determine the tree's diameter at breast height (DBH), and then measure the tree's height. Methods for collecting these measurements are described at the end of this student page.

   DBH: _____ inches (or _____ cm)
   Height: _____ feet (or _____ m)

3. Visit the Tree Benefits website (http://www.treebenefits.com) to determine the ecological services that your selected tree provides by entering the species name and DBH (in inches).

   Record your findings below.

   Overall Benefits
   At current size: $_____ a year
   If it continues to grow: $_____ a year

   Stormwater
   _____ gallons of storm water intercepted a year

   Property Value
   $_____

   Energy
   Electricity conserved (for cooling): _____ kilowatt/hours
   Oil/Natural gas conserved (for heating): _____ therms

   Air Quality
   Ozone (O_3), deposited: _____
   Volatile Organic Chemicals (VOC), avoided: _____
   Nitrogen Dioxide (NO_2), deposited: _____
   Nitrogen Dioxide (NO_2), avoided: _____
   Sulfur Dioxide (SO_2), deposited: _____
   Sulfur Dioxide (SO_2) avoided: _____
   Particulates less than 10 microns (PM_{10}), deposited: _____
   Particulates less than 10 microns (PM_{10}), avoided: _____

   Carbon Dioxide (CO_2)
   Total pounds of atmospheric carbon reduced: _____

4. Describe any other ecosystem services or benefits provided by this tree.

   _____
   _____
   _____

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Evaluating Tree Benefits (cont.)

How to Measure Diameter at Breast Height

Because some trees may be much wider at the base than others, foresters measure tree diameter using a standard called Diameter at Breast Height—or DBH. The DBH is the diameter of the tree at 4.5 feet (1.4 meters) above the ground.

First, use a tape measure to determine the circumference of the tree at 4.5 feet (1.4 meters) above the ground. This measurement is the Circumference at Breast Height (CBH). To obtain the diameter at breast height (DBH), divide the CBH by 3.14 (or π). The Tree Benefits website requires this measurement to be in inches.

$$CBH \div 3.14 = DBH$$

Foresters often use tools, such as a diameter tape or a biltmore stick, to measure diameter directly.

How to Measure Tree Height

One of the simplest methods for measuring a tree's height is setting up a proportion.

- Have a friend stand at the base of the tree while you walk a distance away from it.
- Hold a ruler at arm's length. Walk backward or forward until both the top and bottom of the ruler line up with the top and bottom of the tree.
- Note how tall your friend appears on the ruler (for example, 5 cm).
- Divide the length of the ruler by the apparent height of your friend. (For example, if the ruler is 30 cm, you would divide that number by the 5 cm from above, to get 6.)
- Multiply this number by the actual height of your friend. The result is the height of the tree. (For example, if your friend is 140 cm tall, you would multiply by 6, from above, to get 840 cm, or 8.4 m.)

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