•

Optimal Regeneration Conditions for Selected Tree Species*

This chart lists the conditions under which the seeds of certain tree species will most readily germinate and grow.

Tree species	Light Level	Soil Moisture Level
White pine	Partial Shade	Dry to moist
Red pine	Partial shade to full light	Dry to moist
Pitch pine	Full light	Dry to wet
Hemlock	Partial to full shade	Moist to wet
Balsam fir	Partial shade	Moist
Red spruce	Partial shade	Moist
White spruce	Partial shade	Moist
Atlantic white cedar	Partial shade	Moist
Northern white cedar	Partial to full shade	Moist to wet
Eastern red cedar	Full light to light shade	Dry to moist
Larch	Full light	Moist to wet
Red maple	Not critical	Dry to wet
Sugar maple	Partial shade	Moist
Silver maple	Full light	Moist to wet
Paper birch	Full light	Moist
Black birch	Partial shade	Moist
Yellow brch	Partial shade	Moist
Beech	Partial to full shade	Moist
Ash	Full light to light shade	Moist to moderately wet
Basswood	Partial shade	Moist
Black cherry	Partial shade	Moist
Butternut	Full light to light shade	Moist
Red oak	Partial shade to full light	Moist
Black oak	Partial shade to full light	Dry to moist
Scarlet oak	Partial shade to full light	Dry to moist
Chestnut oak	Partial shade to full light	Dry to moist
White oak	Partial shade to full light	Dry to moist
Shagbark hickory	Partial shade	Moderately moist
Other hickories	Full light	Dry to moist
Yellow poplar	Light shade	Moist
Aspen; poplars	Full light	Moist
Elm	Partial shade	Moist

*Adapted from Table 14, “Optimal Conditions for Regeneration of Major Tree Species.” *Working With Your Woodland*, by Mollie Beattie, Charles Thompson, and Lynn Levine. University Press of New England: 1983. pp. 142-3.

Mimicking Nature:
Resource Management Practices

1. What kind of management practice was used at this site?

2. What kind of natural process does it mimic?

3. Look up at the tree canopy. How much sky can you see through the leaves? Draw a sketch of what you see, filling in the leafy canopy and leaving the sky white.

Canopy Cover

4. In this managed area, is the forest floor shaded or sunlit for most of the day? How do you think the area's soil moisture and temperature compare with the surrounding forest? What kinds of trees would you expect to sprout under these conditions?

5. Sketch the forest layers present in this management area. Be sure to note snags (standing dead trees) and downed logs if you see them.

Overstory (canopy)

Mid-story

Understory

Shrubs

Ferns & grasses

Humus (leaf litter) & Soil

6. How might wildlife benefit from the changes created by the management practice? Which wildlife species might benefit?

How much wood? Calculating Tree Volume

Working in groups of two or three, select a tree to measure.

Calculating tree diameter.
To measure the tree's diameter, first measure 4.5 feet up from the base of the tree. This is the height at which all resource managers measure tree diameter (why wouldn't it be a good idea to measure lower down?). At this height, wrap your measuring tape around the tree trunk and record the circumference in inches, below.

Circumference = _________inches

Now that you have the circumference, how can you determine the tree's diameter? *(Circumference = Π x diameter, so diameter = circumference ÷ Π)* Go ahead and calculate the diameter, using a calculator. If calculators are not available, you can roughly estimate diameter by dividing the circumference by 3.

Diameter = _________inches

Next, you need to determine the height of the merchantable (sellable) part of the tree's trunk. Though resource managers use either a special measuring stick called a Biltmore stick, or a tool called a hypsometer to measure tree height, you can also calculate height with just a ruler.

Have your partner stand at the base of your tree. Holding the ruler at arm's length, move away from the tree until the bottom of the ruler lines up with the bottom of the tree and the top of the ruler lines up with the top of the trunk, before it branches out into the canopy. Note the height of your partner's head on the ruler.

Height of your partner's head on ruler: ________inches.

Next, measure your partner's actual height, in inches: ___________inches.

Now you can create a simple ratio to figure out the tree's height.

$$\frac{\textbf{Length of ruler}}{\textbf{Length of partner on ruler}} = \frac{\textbf{Height of tree}}{\textbf{Height of partner}} \qquad \frac{12''}{\square} = \frac{X}{\square}$$

Example: *Let's say that the top of your partner's head aligned with the 1 ¾" mark, and that your partner is 60 inches tall.*

$$\frac{12''}{1.75''} = \frac{x}{60''}$$

x = 411" or 34' of usable timber

Lastly, you can determine the number of board feet of lumber available in your tree. *(A board foot refers to a piece of wood one foot long, one foot wide, and one inch thick)* The table on the back of this sheet gives you all the information you need. In our example, the tree has two 16-foot logs in it. Let's say that the tree's diameter was 20 inches. The tree thus contains 300 board feet. *(An average, 2000-square-foot house requires 15,000 board feet of lumber*

Number of board feet in your tree ___________

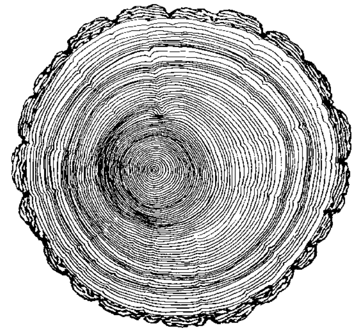
Bonus question: If a 20" diameter tree has one 16-foot log, its volume is 170 board feet. So, if it has two 16-foot logs, the volume should be 340 board feet, right? But if you look at the tree scale chart on the back of this worksheet, you'll see that, for any given tree diameter, the volume of two 16-foot logs is always less than double that of a single 16-foot log. Why?

TREE SCALE (International ¼ inch)

DBH (in.)	Number of 16-foot logs							
	½	1	1½	2	2½	3	3½	4
	Contents in Board Feet							
12	30	60	80	100	120			
14	40	80	110	140	160	180		
16	60	100	150	180	210	250	280	310
18	70	140	190	240	280	320	360	400
20	90	170	240	300	350	400	450	500
22	110	210	290	360	430	490	560	610
24	130	250	350	430	510	590	660	740
26	160	300	410	510	600	700	790	880
28	190	350	480	600	700	810	920	1020
30	220	410	550	690	810	930	1060	1180
32	260	470	640	790	940	1080	1220	1360
34	290	530	730	900	1060	1220	1380	1540
36	330	600	820	1010	1200	1380	1560	1740
38	370	670	910	1130	1340	1540	1740	1940
40	420	740	1010	1250	1480	1700	1920	2160
42	460	820	1100	1360	1610	1870	2120	2360

Written Down in Wood:

The Story of Tree Rings



Tools needed: ruler

1. Working in groups of two or three, choose a tree stump at least 12 inches in diameter to examine. Starting at the center of the stump, count the number of annual growth rings. How old is your tree?

2. On average, how many growth rings does your stump have per inch (To get the average, count growth rings/inch at three different places on the stump. Add the three results together and divide by three).

3. So how many years does it take for your tree to increase one inch in diameter?

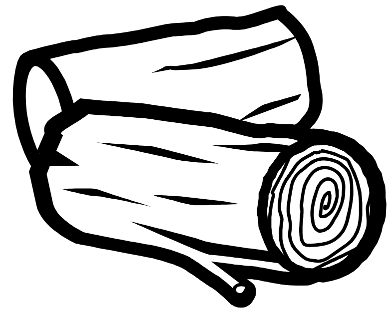
4. Look carefully at your stump's growth rings. Note where rings are tightly spaced and where they spread further apart. Are they closer together on one side of the stump than on the other? Why might that be? (For example: tight spacing of tree rings toward the center of the stump might indicate crowding or shading by taller trees early in the tree's life. A sudden increase in ring width could mean the tree was released by competition, either by a harvest or by a blowdown or death of nearby trees…). Write a brief biography of your tree, as determined by the tree rings. When would your tree's biography end? When the tree is harvested, milled into boards or used in other products, sold to a retail consumer, consumed, recycled? When does a tree's life "end"?

5. When the first phase of a shelterwood harvest is complete, the remaining trees have much more room, light, and access to water and nutrients. If you were to examine their growth rings in the years following the shelterwood cut, what would you be likely to see?

6. Let's say that a 12-inch sugar maple was left on a shelterwood harvest site after the first cutting phase. The maple then grew vigorously, at a rate of 5 growth rings per inch, until it was harvested 15 years later during the second phase of the shelterwood harvest. What was its diameter at the time it was cut?

Calculating Cords of Firewood per Acre

Key Developer



Brendan Murphy
 - Carrabec High School
P.O. Box 438
Bingham, ME 04920
brendan_murphy@carrabec.sad74.k12.me.us

Snapshot

This unit of study is primarily a data collection, data conversion / manipulation, decision making project. Students survey/sample a representative section of forestry land (this usually can be done within walking distance of many schools), and extrapolate this data to quantify cords of firewood per acre of "typical" localized forestry lands. Students survey a 37-foot radius of forestry land, recording and measuring each tree with a diameter greater than five inches. Students estimate the height of each surveyed tree using various techniques and record this data as well. When the plot of land has been accurately surveyed and "measured" (usually one - two class periods), they return to the classroom to "quantify" their data.

Students convert their data to usable volume of cubic feet and ultimately to cords of firewood. Depending on the age group and skill levels of the students, the math component can be modified to range from somewhat complex to reasonably easy. Students see firsthand how they can translate their math knowledge to real world situations to make intelligent decisions based upon a relatively small data sample. Once again, depending on the age group of the students, this project (which can be team-taught with the science department) can transition into numerous tangents including topics such as:

1. Pro's and con's of different harvest techniques

2. Hardwood vs. softwood comparison

3. Selective harvesting

This project is easy and inexpensive to do and students enjoy the fact that they can go "out into the field" to do their math.

Profile

Unit Information

Primary Content Area:
Guiding Principle 1: A self-directed and life-long learner.
Guiding Principle 2: A creative and practical problem-solver.
Grades Used: 9-12
Grades Suitable: 5-12
Target Audience:

Maine Learning Results Alignment

Click here to edit or add.

Content Area 1

Grade Level:	Secondary Grades
Content Area:	Mathematics
Content Standard:	B. COMPUTATION

Students will understand and demonstrate computation skills.

1. Use various techniques to approximate solutions, determine the reasonableness of answers, and justify the results.

Content Area 2

Grade Level:	Secondary Grades
Content Area:	Mathematics
Content Standard:	F. MEASUREMENT
	Students will understand and demonstrate measurement skills.
	1. Use measurement tools and units appropriately and recognize limitations in the precision of the measurement tools.

Content Area 3

Grade Level:	Secondary Grades
Content Area:	Mathematics
Content Standard:	C. DATA ANALYSIS AND STATISTICS
	Students will understand and apply concepts of data analysis.
	4. Demonstrate an understanding of the idea of random sampling and recognition of its role in statistical claims and designs for data collection.

Overall

The beauty of this unit of study is its ease of completion while reinforcing many important math concepts. Students, many times without even realizing it, are using a tremendous amount of math and problem solving skills to arrive at a logical, intelligent, real-world decision. These data analyses and decision making skills are truly what we should be teaching our students. Math can and should be more than "memorizing formulas" and punching numbers.

Because this unit is so easy and inexpensive to complete, it is open to all schools and all age groups. The individual teacher can decide what level this project should be completed on, based upon the skill level and ages of their respective students. Students see firsthand how and why this knowledge will help them in their lives as they graduate high school and transition into the working world.

The originators have had tremendous success with this unit in the past with my students; any chance to get students out of the classroom is typically met with excitement and anticipation. As the unit progress, students ask very insightful and intelligent questions, leading off into many equally important and interesting tangents. Although this is primarily a math project, a science department is are currently working on a semester long team-taught unit of study.

Procedure

By doing a random sampling of local forestry land, students quantify their accumulated data into usable cords of firewood that can be generated per acre of forest. By measuring only a relatively small percentage (10%) of an acre, students are required to extrapolate their data into a "typical acre" of forestry land and ultimately into cords of firewood.

Unit of Study

Before actually beginning this unit of study, provide the students with an overview of the project as well as teacher expectations. Try to keep this discussion somewhat general in scope; many of their questions are left unanswered at this point. Typically they answer their own questions as they get "into" the project as they research/explore their own questions to satisfy their curiosity. Discuss the project overview a couple of days before actually going out into the field to accumulate the data so the students are appropriately dressed for fieldwork. They are required to produce a data recording form before heading out into the forest; depending on the age group of the students, this form can range from very basic to all encompassing.

Project Grouping

Depending upon class size, students are divided into groups of two-four. Given the logistics of physically accumulating the data, at least two students are required to survey the plot of land; the optimal group size is three-four students. Teachers may choose to select the groups, which are designed to promote teamwork and a spirit of cooperation, and to avoid the formation of classroom cliques. It is clearly explained to all students that their equal participation is expected and required; at the end of the project each student receives an individual grade as well as a "group" grade.

Project Time-Frame

Allow two-three days (two or three 75 minute blocks) in the field to accumulate data and another two-three days back in the classroom for data manipulation and conversions. Make sure that once students leave the field/forest that they have all the necessary information, as students are not allowed back into the field once they have the information required to complete the project.

Back in the classroom, students use graphing calculators (typically the TI-83, but other graphing calculators are sufficient) to translate the data. Students are also encouraged to produce graphs/charts and tables of their data either on their calculator or the classroom computer. For project completion, each group of students is required to make a presentation to the rest of the class explaining how it arrived at the final quantity of firewood. Given block scheduling, this usually takes just one day for all groups to complete their presentations.

Detailed Procedure

On day one of the fieldwork, walk the school grounds to select a "typical" forest plot that is representative of the local terrain. In rural Maine this can usually be done either on or adjacent to school property; in more urban settings the teacher may want to pre-select a representative plot to survey. Students are instructed to survey/measure a 37-foot radius of forestry land and to record/measure any tree in this plot with a diameter of five inches or more. Students inevitably ask why a 37 foot radius and why only trees with a diameter greater than five inches, which I tactfully try not to answer, encouraging them to figure out on their own why we have selected these dimensions. (The 37-foot radius translates into approximately one tenth (1/10) of an acre and trees with a diameter less than five inches are usually considered immature and usable as firewood.) The logistics of measuring out a radius in a forest should not be underestimated, teachers are encouraged to act as just facilitators, allowing the students solve this problem on their own.

Students record tree diameter (four-feet above ground level) as well as the approximate height of each tree. Depending on the math background of the students, tree height can be approximated by using trigonometry, using a pre-measured 10-foot 2x4, or rod, or simply estimating. If a teacher team teaches this unit of study with the science department, record tree species as well (this is not required if the project is purely a math exercise). When trees "fall" on the perimeter edge of a plot, record only every other tree that fits in this category. Students are encouraged to estimate tree height using various techniques. This is the one dimension that is the hardest to quantify.

Depending on the number of students in the class and/or proximity to decent forestry land, teachers may have groups measure different plots or have each group survey the same plot. In either case, when their final data are quantified, compare and discuss any similarities and/or differences in cords of firewood and discuss how this information should be used before extrapolating into cords per acre. As an interesting side note, if this project is repeated every year with different students, students can survey the same plot of land and compare their quantities to see if annual tree growth impacts results.

Back in the classroom, students are required to convert their data into volume of firewood using geometric formulas and their graphing calculators. Once again, as students ask insightful questions, I usually try and talk them through an appropriate answer/assumption. For example, the question that is usually asked is about the assumption that each tree takes on a cylindrical shape, when in reality most trees are not cylindrical. We discuss the reasonableness of assumptions and how much the volumes might be skewed by these assumptions. When final tree volumes are calculated, students translate this information into cords of firewood. Students are required to find/figure out what the volume of a cord of firewood is, this volume is usually accepted to be 4' high x 4' wide x 8' long or 128 feet cubed.

Modifications for Special Learners and Different Age Groups

Although this unit of study was originally designed for high school students, it can be easily modified for special learners and/or different age groups. If teachers help students with the math conversions to accommodate their abilities, the data collection and final decision making processes should remain basically intact. Younger students (grades 5-8) really enjoy the measurement component of this project and should be able to understand the majority of the math conversions. Special learners can be accommodated by concentrating their efforts on the "measurement" component of the project.

Project Materials

The following list of materials will be needed to complete this unit of study:

1. Measuring devices - 25 foot tape measure and a 6 foot flexible tape measure, similar to what a tailor would use

2. Graphing calculators

3. Preprinted recording form (designed by the students)

4. A 10 foot long measuring "stick" (a 2x4 piece of wood works well)

5. A large protractor to measure the height/angle of each tree

Teachers can improvise with these materials to reflect what his/her school has available and/or what is most appropriate for the students.

Project Benefits

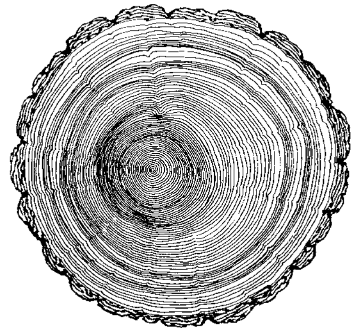
The usefulness of this project extends far beyond the mathematical understanding of the required conversions; students see first hand how they can use their knowledge in the real world to make intelligent, informed decisions. By completing this unit of study, students exhibit numerous proficiencies in the different content areas as required by the Maine Learning Results. Students find this project fun and usually do not even "see" how much data manipulation and mathematics understanding is really required to complete this project. Students quickly realize that math can be so much more than just memorizing formulas and doing homework problems, and is in reality a lifelong learning skill.

Project Assessment

Final project assessment is based upon a 0-4 rubric that students receive before beginning the unit of study. Expectations and requirements are clearly spelled out and, at times, students have "added" their own requirements, which I have rolled into my rubric. Students receive both an individual grade and a "group" grade to help encourage equal participation by all group members.

Time and Cycles Lesson

"Logs of Straw: Dendrochronology" Activity (Allow 45-60 minutes)



In this activity straws will be used to simulate tree-ring core samples. Using the straws, students will work in groups to reconstruct a 50 year climatic history. Students will record this chronology on a 3 meter time line designed to highlight significant social, personal, and scientific events covering the same period.

Dendrochronologists seldom cut down a tree to analyze its rings. Instead, core samples are extracted using a borer that is screwed into the tree and pulled out, bringing with it a straw size sample of wood about 4 millimeters in diameter. The hole in the tree is then sealed to prevent disease.

Materials

For each group of four students:
One set of white straws marked with ring patterns (see illustration below). Markings can be produced with permanent black marker on paper or plastic straws.

- One 3-meter strip of adding machine tape for each group
- Colored pencils for each group
- Colored markers for each group
- A notebook for recording results (optional)
- Reference material such as almanacs that provide students with the dates of social and scientific events over the last 4 decades.

Prior to the activity the teacher should construct sets of straws similar to the set shown in the illustrations. Group students in teams of four. The following information on the straw samples can be recorded on the blackboard or copied and handed out. Review with the students some of the tips on reading tree rings found in the boxed section.

Reading Tree Rings

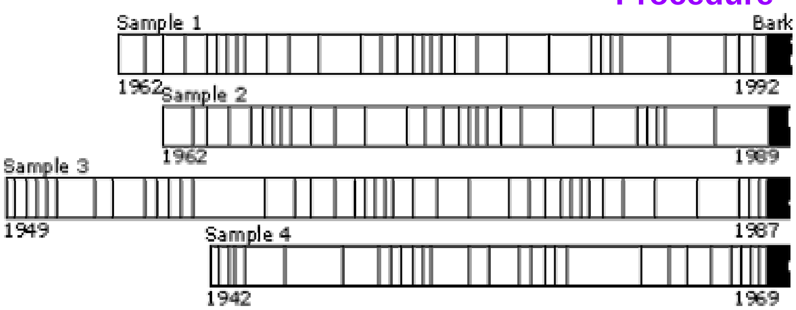
Core sample 1 is to be used as a standard against which to compare the others, because a bore date of 1992 has been established. Notice the varying patterns of ring widths in sample 1; look for similar patterns in other samples.

Core sample patterns are alternating dark and light lines. The darker lines of a core sample represent the end of a growing season The light-toned space between the two darker lines represents one growing season.

Tree rings are formed from the center of the tree outward. The ring closest to the bark is the youngest and final growth ring. The ring closest to the center of the tree is the oldest growth ring. Neither the outer layer of bark nor the central pith layer of a sample is counted when determining the age of a sample.

Similar ring patterns are found between trees growing under the same conditions. The most obvious feature of these patterns is varying widths. Widening of a ring indicates good growing conditions, while narrowing indicates poor ones. Conditions can include climatic factors such as temperature and moisture as well as factors such as erosion, fire, landslides, etc.

Procedure



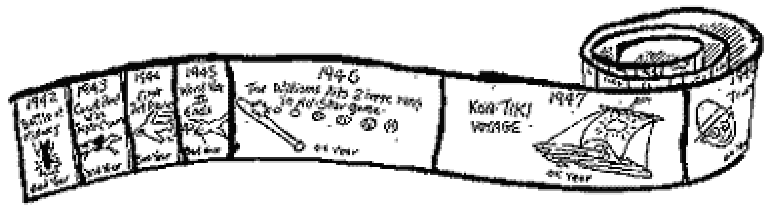
Imagine you have core samples from four trees:

- Sample 1. From a living tree, July 1992, Pinetown Forest.
- Sample 2. From a tree from the Pinetown Christmas Tree Farm.
- Sample 3. From a log found near the main trail in Pinetown Forest.
- Sample 4. From a barn beam removed from Pinetown Hollow.

1. Determine the age of each tree (how many years it had been growing) by counting the rings. Record your answers in your notebook or in the first column on the chart below:

	Age of tree	Year tree was cut	Year growth began
Sample 1			
Sample 2			
Sample 3			
Sample 4			

2. Look for patterns in the rings. Patterns in this exercise match well, but actual ring patterns will vary among different species of trees. Once a ring pattern has been discovered, line up all the samples. Because you know that Sample 1 was cut in 1992, you can match the patterns of all the other samples and determine when all the other trees were cut or cored and also when they began to grow. Record this information in your notebook or fill in the chart above.
3. Make a time line. Spread out the adding machine tape. Beginning at the left end of the tape, record each year from the earliest year identified on the tree-ring samples through 1992. After the years are recorded on the strip, identify years that were good growing years for the trees in Pinetown, and years that were poor. Think of other events that might have happened during this time period such as your birthday, Presidential elections, important scientific discoveries, or record-setting sports achievements. Fill them in on the time line. You can color the time line and illustrate it with drawings, photographs, or newspaper clippings.



Questions

- Which ring on each tree represents your birth year?
- What kind of growing season existed that year in Pinetown?
- In which years did droughts occur in Pinetown?
- Is there a pattern to the droughts?
- What buildings in your areas were built during the lifetime of these trees?

Extensions

Find and map the locations of some of the oldest known trees in your neighborhood. Sketch what you think a core from one of these trees might look like.

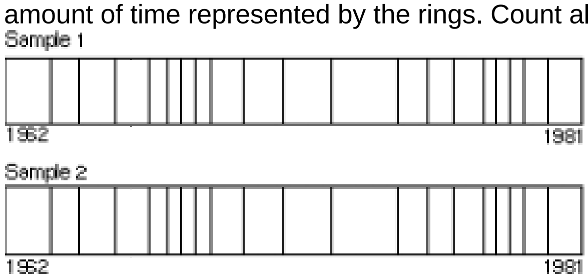
Contact your local forestry service or science museum and obtain some actual cross sections of trees that have been cut in your area. Use the techniques applied during this activity to "read the tree." If a tree has been cut in your neighborhood recently, look at the tree rings on the stump or ask if you can keep a small piece of the trunk.

Create some simulated core straws of your own for another group to analyze and report about.

For the Teacher

Aligning the Samples in the Lesson

The following illustration shows how samples 1 and 2 can be aligned. Have the students align all four samples so that the patterns match, and determine the years when each tree was cut and when it began to grow. Have them count all the rings from the oldest samples as they are aligned with the younger samples to determine the total amount of time represented by the rings. Count aligned rings that appear on several samples only once.



Charts

The charts should be completed as follows:

	Age of tree	Year tree was cut	Year growth began
Sample 1	31	1992	1962
Sample 2	28	1989	1962
Sample 3	39	1987	1949
Sample 4	28	1969	1942

The total time covered by the tree rings is 50 years, from 1942 to 1992.

Answers to Questions
The answers to some of the questions in the activities will depend on the individual class-for example, when they were born or when buildings in their area were built. In looking at the climate record as revealed in the tree rings, notice that there is a significant period of poor growing conditions in each of the four decades covered by the tree samples. This pattern, which can be graphed, is the type of pattern scientists might look for when studying climate change.

Classroom Resources

Angier, Natalie, Warming?-Tree rings say not yet: New York Times, Tuesday, December 1, 1992, p. C-1, C-4.
U.S. Geological Survey, 1991, Tree rings-timekeepers of the past: Reston, Virginia, USGS, 15 p.

http://interactive2.usgs.gov/learningweb/teachers/globalchange_time_lesson.htm

Maps and Mapping

What Else is Here?

Maps are made for many reasons, and as a result, maps are of many kinds. Some made for general purposes may show roads, towns and cities, rivers and lakes, parks, and State and local boundaries. One example of such a versatile map, or ***base map***, is the 1938 topographic map of Oswald Dome, Tennessee. Other maps are much more specific, conveying information primarily on a single topic. The 1989 earthquake map of the United States is a good example of a special-purpose map, or ***thematic map***. Every map is made for a purpose and serves that purpose best.

The history of civilization has been illustrated by maps- battle maps by soldiers, exploration maps by empire builders, thematic maps by scientists. By modern convention, and for no scientific reason, modern maps are usually oriented with north at the top. But Al Idrisi's 1154 world map shows the Arabian Peninsula in the top center of the map, with south at the top. Contrast this map with the 1452 Leardo world map. Different societies in different places literally have different perspectives, which may result from differences in physical geography, language, religion, cultural values and traditions, and history.

Even within a culture, a time, and a geographic realm, maps can vary widely. This is because a map shows the cartographer's bias as well as the purpose. Maps are the result of conscious design decisions. Cartographers decide how to generalize and symbolize what they are trying to show. They select features (or themes) to show and omit other features. They often generalize the data, simplifying the information so that the map is easier to read.

In choosing the scale, mapmakers determine how large an area they can map and how much detail they can show. The selection of symbols (which can include lines, patterns, and colors) also affects the legibility, aesthetics, and utility of the map.

Cartography blends science and art. A beautiful map may become popular, even though it may be less accurate than a plainer version. Details of cartographic style affect how a map is perceived, and perception varies with perspective. In short, people understand the world differently, have different modes of expressing this understanding in maps, and gain different understanding from maps.

Geographic features can be shown at different sizes and levels of detail by using ***scale***. Maps include selected basic geographic information to provide ***context***. Every map has a purpose or theme. The ***map design***, which includes artistic aspects such as composition and balance, affects the success of the map‹that is, its ability to communicate.

Scale is the relationship between the size of a feature on the map and its actual size on the ground. Scale can be indicated three ways. The ***bar scale*** is a line or bar that has tick marks for units of distance. The bar scale is especially important because it remains accurate when a map is enlarged or reduced. A ***verbal scale*** explains scale in words: "one inch represents 2,000 feet." The ***representative fraction*** is a ratio such as 1:24,000, in which the numerator(l) represents units on the map and the denominator (24,000) represents units on the ground; in the example of 1:24,000 scale, one unit (any unit‹feet, millimeters, miles, etc.) on the map represents 24,000 of the same units on the ground.

Scale controls the amount of detail and the extent of area that can be shown. Scales can be described in relative terms as ***large scale***, intermediate scale, and ***small scale***. A large scale map (for example, the 1886 Sanborn map, originally at 1:600 scale) shows detail of a small area; a small scale map (for example, the 1877 geologic map of north-central Colorado, originally at 1:253,440 scale) shows less detail, but a larger area. (A comparison of representative fractions shows that 1/600 is larger than 1/253,440.)

The humorous l893 quotation from Lewis Carroll illustrates this point by taking scale to the extreme. Some small scale maps are regional ***compilations*** of more detailed maps, bringing information together for the first time at a common scale.

Context is information that serves to orient the map reader to the mapped place. As you look at the maps on the poster, you may look for familiar features (such as the "boot" of Italy) to Identify the area shown. Geographic information that provides context can include coastlines, boundaries, roads, rivers and lakes, cities and towns, topographic features, place names, and latitude and longitude.

Distortion is another important aspect of context; every flat map of a curved surface is distorted. The choice of map projection determines how, where, and how much a map is distorted. It is important to understand the kind and amount of distortion on the map sheet. The typical mapping project now plots information on a base map, which shows where the place is and establishes the scale, orientation, context, and spatial distortion of the information to be mapped. The type and scale of the mapping project affect the choice of base map. Digital, or computerized, mapping frees the cartographer from some constraints imposed by a base map, because features can be readily selected or deleted, and the projection and scale can be changed easily.

A map's purpose is usually clear from its title and explanation, but other information (author, date, publisher, source of funding, etc.) hints at why and for whom the map was made. A knowledgeable map reader, recognizing that a map is both a simplification and a distortion of reality, will look for clues to the cartographer's purposes and biases.

The information collected for a mapping project is called ***spatial data***. Any object or characteristic that can be assigned a geographic location can be considered spatial data. Spatial data always include location, but many also include values to be represented.

These two kinds of information are ***qualitative data*** (for example, schools, roads, rivers, States) and ***quantitative data*** (for example, altitudes, amount of precipitation, per capita income, population density). Qualitative data, while not numeric values, may be ranked, as in categories of roads or schools.

Quantitative data can be treated in many ways. The cartographer may first decide to ***generalize*** data. Several closely spaced points may be generalized to one symbol; features may be eliminated as map scale is reduced; questionable data may be eliminated where other data are sufficient.

Likewise, ***grouping*** of data can be done in different ways. Large ranges of numbers may be grouped with breaks at round numbers (for example, 10, 20, 30) or at statistical mean and standard deviation values; in this case, the individual points may be mapped in various colors or sizes to correspond with group values. Another way to group data is within geographic areas, using colors or symbols for areas, rather than symbols at each data location. Generalization and grouping dramatically affect the message the map presents by simplifying the data.

The success of a thematic map depends on ***map design***. Scientific maps like Edmund Halley's 1701 map of compass variations usually show only enough geographic data to orient the user, while emphasizing the content. Halley, for whom the comet is named, pioneered several cartographic techniques. The 1701 map introduced ***isolines***, lines of equal value, a technique now used on topographic and other kinds of maps. The 1886 Sanborn fire insurance map includes as much as its business purpose requires, but nothing more. Triangulation maps, such as the 1744 map of France, show the network of points and lines, in this case colorfully framed within national boundaries. The 1989 earthquake map of the United States indicates the relative hazard by a contoured and colored surface, which also shows State boundaries.

Recommended Reading

Monmonier, Mark. *How to Lie with Maps.* Chicago: University of Chicago Press, 1991.
Wood, Denis. *The Power of Maps.* London: The Guilford Press, 1992.

Mapping the Third Dimension

Make a stereoscope. Great advances in mapping in the 20th century were based on the three-dimensional image visible in the stereoscope. In this activity, students work in pairs to construct a simple stereoscope. A pair of stereo photographs is included to use to view a three-dimensional image.

Time

One 50-minute period for step 1.
30 minutes for remainder of the activity.

Materials for each pair of students

- One cardboard box (an empty copier box works nicely)
- Knife for cutting the box
- Two locker mirrors (durable, light weight, about 4 by 5 inches)
- Ruler
- Transparent Tape
- Overlapping (stereo) aerial photos (enclosed)

Procedures

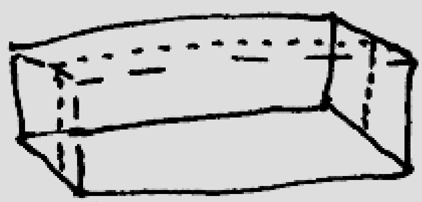


Illustration A

1. Make the stereoscope as follows.
    - o Remove the top of the box, leaving the box at least six inches deep.
    - o Cut the box in half along the longer dimension (see illustration A) and set one half aside.
    - o Place the half of the box (let's call this the "frame") in front of you so that you are looking into it. Along the back and front edges of the bottom panel, measure half the distance between the left (L) and right (R) end panels. Mark these points C1 and C2 and connect them with a line (see illustration B.) Measure the height of the back panel of the frame (H). Set the frame aside temporarily.

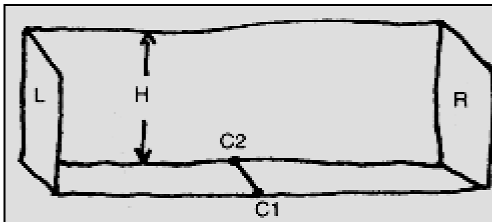


Illustration B

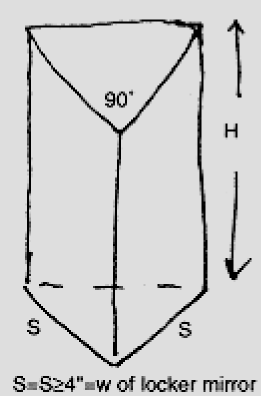


Illustration C

- Using another piece of the original box, cut a prism-shaped piece that has a 90-degree angle (see illustration C). The two sides (S) of the prism that meet at the 90-degree angle must be the same size, one inch wider than the locker mirrors. The long dimension of the prism need not be longer than the value H.
- Attach the prism to the frame (see illustration D). Orient the prism so that the edge with the 90-degree angle is on the center line (C1-C2) and is pointed at the open side of the frame. The sides of the prism should be against the back panel of the frame, and the distance (D) between the sides of the prism and the end panels should be equal.

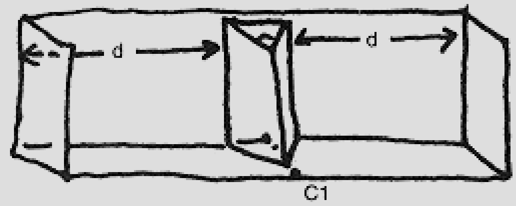


Illustration D

- Tape the mirrors to the prism, resting them on the bottom panel of the frame, as shown in illustration E. Mirrors should meet at the 90-degree angle. This completes the stereoscope.

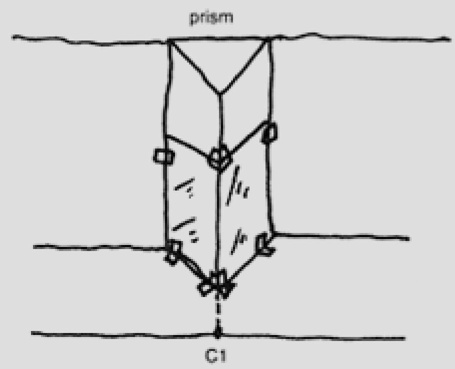


Illustration E

2. Using paper clips, attach the enclosed stereo photographs to the ends of the box, being careful to position them so that the right eye sees the area of overlap in the right mirror and the left eye sees it in the left mirror.

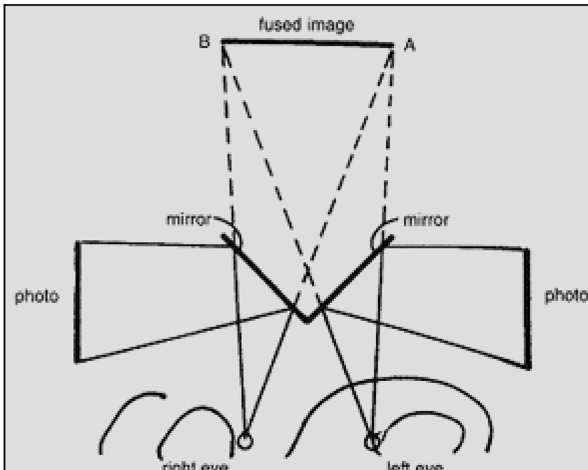
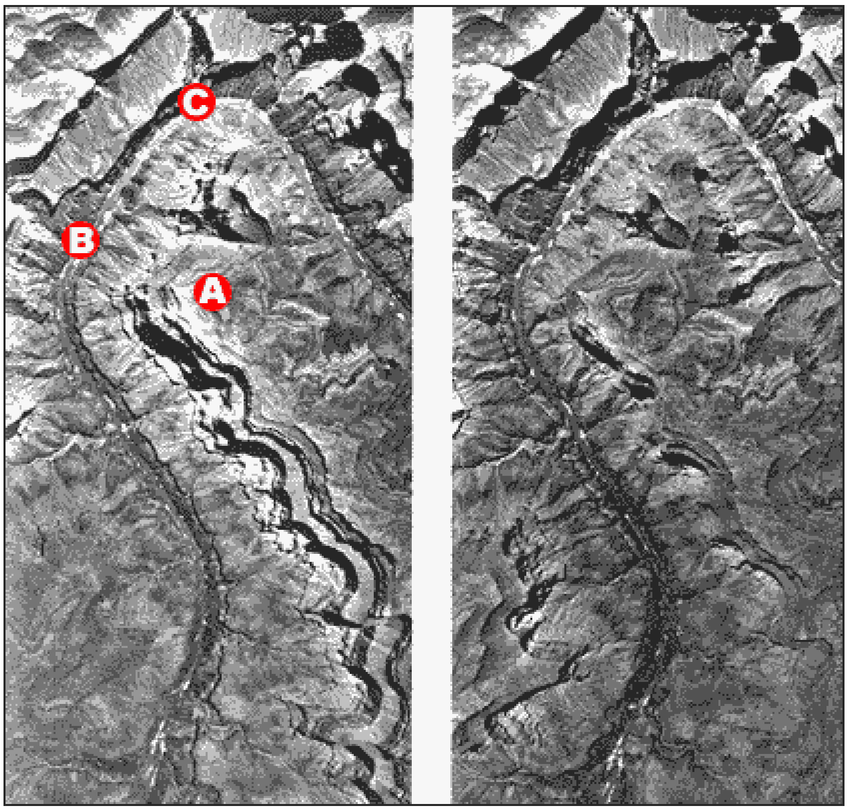


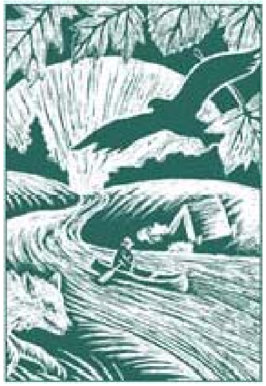
Illustration F

3. Position the stereoscope so that both photographs are illuminated equally.
4. Look straight at the near edge of the mirrors from about a foot away (see illustration F). Tips for seeing the three-dimensional image: As you look for the stereoimage, try closing first one eye and then the other. Choose a distinctive feature and find it on both photographs. As you look, keep one image fixed and move the other image slightly to make the images of a distinctive feature on the two photographs come together. The three-dimensional image of the whole scene may suddenly appear (and perhaps, disappear). Once you see the stereoimage, it is generally easier to see it again.
5. As a class, discuss how your brain constructs a three-dimensional from the two, two-dimensional air photos. Photographs are taken sequentially along a flightline so that adjacent photographs overlap by about 60 percent. The left photo shows the perspective from the left camera station, and the right photo shows the perspective from the right camera station. Thus, your left eye sees the image from a different perspective from the right eye. The brain fuses the two images so that you see the entire area of overlap in three dimensions.
6. In this exercise, the three-dimensional image in your brain exaggerates the vertical relief; the slopes look steeper and buildings look taller on the stereo image than they are. This vertical exaggeration is a function of the geometry of the camera and the altitude of the camera when the photographs were taken. Vertical exaggeration, which can be useful in topographic mapping, can be quantified (or even eliminated) by photogrammetric mapping instruments. Judging by the vertical relief in the stereo image you see, sketch a topographic map of the area of overlap; select a contour interval and make the map at the same size as the stereo image.



Social Trade-Off's

http://www.sciencenetlinks.com/lessons.cfm?BenchmarkID=7&DocID=71



Purpose

To make and evaluate decisions by weighing the benefits and drawbacks of each alternative.

Context

In this lesson, students practice the skill of decision-making through role-playing. Students are presented with a scenario in which they, along with their brothers and sisters, have just inherited a section of forestland. They must attempt to balance their interests with those of their siblings in order to reach a fair settlement on the use and management of the land. Students will work as a class to evaluate the benefits, drawbacks, and potential risks associated with each alternative before making a final decision.

It is recommended that students be given many additional opportunities to practice their decision-making skills across disciplines, and within the context of everyday life. (*Benchmarks for Science Literacy*, p.164)

Planning Ahead

Preview the Web articles central to the lesson and print them out ahead of time, if necessary.

Motivation

Grandma Peterson has left a parcel of forestland to her grandchildren: Alex, Kim, Marty, and Sam. Each one has a very different viewpoint and opinion of what should be done with the land. You must try to resolve this issue as a class.

You will be divided into teams, with each group representing one of the children. (Depending on size of class and teams, there may be two groups representing each child.) You will begin by learning more about the natural cycles of the forest, how forests are managed, and the ways in which humans can impact the forest in positive and negative ways. You will work with your group to develop a plan for how Grandma Peterson's land should be used and managed.

The four Petersen grandchildren have just inherited 200 acres of forest land from their grandmother. Grandma Petersen's will specifies that they cannot sell the land and they must agree on how to manage it. Each grandchild has a different perspective on managing the land. How can they work together to decide on a management plan?

Meet the Grandchildren:

1. **Alex Petersen** is a smart student who is very aware of the value of things, like how much money should be paid as a weekly allowance. Alex is always looking for a good investment and is definitely interested in the money that Grandma's land might generate. Alex is primarily concerned with producing income from Grandma's land.
2. **Kelly Petersen** is a science buff who spends time at the library researching rare plants and animals. Kelly can tell you all about the habitat needs of many types of animals. Kelly is concerned that Grandma's land is already showing signs of being overrun by too many people. Kelly is also concerned about the needs of the unique plant and animal habitats on Grandma's land.
3. **Chris Petersen** is really excited about spending lots of time hiking and biking on Grandma's land. Chris can't wait to see what kinds of trails are available. Chris is primarily interested in the recreational activities Grandma's land can offer.
4. **Sam Petersen** is an avid conservationist who uses everything carefully. Lately, Sam has been doing lots of reading on the lack of clean water in the world. In the latest issue of one magazine, Sam read that clean water and fertile soil may become the scarcest commodities of the 21st century. Sam's big concern is protecting soil and water on Grandma's land.

You will present this plan to your classmates, who will evaluate it and decide whether or not to support it.

Development

Tell students:" *In order to make an informed decision on how to use the land, you will need to learn more about the forest ecosystem. Forests are constantly changing, either quickly or slowly, with or without human interference. We will begin by reading about two forests: one that goes through a natural cycle of change, and one that is changed as a result of humans."*

Have students read the Westside Time Machine to learn about the natural succession that occurs over a 1000-year time period. After teams read the article, either online or on printouts, have them answer the following questions:

- How does the forest change over time?
- Why do the shade-tolerant trees take over?
- What role does fire have in the natural cycle of a forest?

Have students view the Eastside Time Machine.
Ask students:

- How was the cycle of this forest different from the previous one?
- What was the role of humans in the cycle of change for this forest?
- How have humans' decisions impacted the forest?

Tell students:" *There are many different ways to use and manage forests.* (You may wish to share some of the other forest management strategies on the Westside Puzzle page.) *Your group must keep in mind that humans' decisions can have both a positive and negative impact on the natural world. Therefore, you need to research the best way to use and manage the land and look at all of the possible risks and drawbacks.*

Have groups view Nurse Log, the first of the five pictures showing the different parts of Grandma Peterson's land.
Have each group answer the following questions, keeping in mind the viewpoint that they represent:

- How do you view this part of the forest?
- Is it of value to you? Why or why not?
- How would you use this land?
- What would your interest in protecting it be, if any?

Have each group share its viewpoint, then return to Nurse Log to read each sibling's opinion, as written on the site.
Have groups look at the remaining four pictures independently, jotting down answers to the above questions:

- Road
- Standing Snag
- Stand of Trees
- A Forest Stream

Allow time for groups to share their ideas, then read the viewpoints presented on the site.

Students should work in groups to complete the following research according to the role that they have been assigned:

Alex / Investor
Promote Tree Growth
Forest Products
Kim / Science Buff
Home is Where the Habitat Is
Vole's Eye View
Marty / Outdoorsman
Forest Fun
Time Treasures (Explores the value of the artifacts left behind by people who have enjoyed and used the land.)

Sam / Conservationist
Water Ways
Sheltering Soil

If time permits, encourage students to read the research assigned to other groups, as it might be helpful in formulating their arguments.
Have students write 2-3 sentences to explain what they learned from each article. They will refer back to these notes when the team works on a resource management plan. Allow time for students to research and discuss ideas in small groups.

Distribute a map to each group. (Print out the pdf file of Page 17 for a blank map that students can color.)
Students should divide and label the land to show how much they will set aside for the following: logging, recreation, conservation land, and/or animal preserve.
Each group can also create a poster and/or written management plan to address the following:

- How will you use the land? (see map)
- How did you make this decision?
- How will this affect others, either negatively or positively?
- Are there any risks involved in this plan?
- How will this benefit humans? Are there any drawbacks for humans?
- How will this benefit animals? Are there any drawbacks for animals?
- How will this benefit the natural cycle of the forest? Will it interfere?
- How much human intervention will you use to manage the forest? What method will you use? (Forest fires, weeding out, logging, etc.)

Allow each group to present its plan. The rest of the class will evaluate the merits of each plan according to a student-generated set of criteria and/or the following:

- Who will be affected by this plan? How?
- Do the benefits of this plan outweigh the drawbacks?
- What trade-offs are being made?
- Are the risks involved in this plan worth taking?

Have students vote for the plan that they consider the most realistic. They should not feel obligated to vote for their own group's plan, but rather the plan that balances the benefits and drawbacks most effectively. Tell students that they will be asked to justify their decision in writing. Tally votes and allow students to share some of the reasons they are for the plan and/or against it. Allow time for students to ask additional questions of the group and raise any concerns that were not addressed.

Assessment

Have students complete a journal entry using words and/or pictures to answer the following questions:

- Which plan did you vote for? Why?
- Do you think that this was a fair way to handle the decision-making? Why or why not?
- Did you have to compromise in order to accept this plan? In what way?
- Do you think that it was a fair compromise? Why or why not?
- What steps does one need to go through when making a decision?

Extensions

Go to the Tech Museum of Innovation's exhibit on robots entitled Get a Grip. This online exhibit explores the increasing role of technology in our society. Use Case #1 Robots in the Workplace to explore the issue of replacing humans with robots in the workplace. What are the benefits? Drawbacks? Risks? Are the risks worth it?

Consider relating the issues presented in the case study to the school setting. What would happen if robots replaced humans in the cafeteria, computer lab, gym, or library? What would be the benefits and drawbacks? What would be the potential risks? Is it worth it to take those risks? Allow students to conduct a classroom debate related to this issue.

Air Quality Terms and Definitions

Purpose and Objective: To improve students' vocabulary and knowledge of air pollution.

Grade Level: 7th through 12 grades

Background: Air pollution is a problem in many areas of the United States. It can damage trees, lakes, and make people and animals sick. It can also damage buildings and other structures. Air pollution also can cause haze, reducing visibility in national parks and sometimes interfering with aviation. The federal government regulates air pollution in order to protect human health and the environment. There are several words that are used when discussing the subject of air pollution.

Procedure: Print out the words and let the students use it to increase their vocabulary of air pollution and air quality terms. Students may want to make flash cards for the study of these terms.

Terms and Definitions

air pollution
the soiling of the atmosphere by contaminants to the point that may injure health, property, plant or animal life, or prevent the use and enjoyment of the outdoors.

ambient air
outdoor air

atmosphere
the whole mass of air surrounding the earth

benzene
a colorless, hazardous hydrocarbon emitted during gasoline storage and transfer and from refining processes

carbon dioxide
a colorless, odorless gas formed during breathing, combustion, and decaying that adds to the greenhouse effect

carbon monoxide
a colorless, odorless, poisonous gas produced when carbon-containing substances such as coal, oil, gasoline, wood, or natural gas do not burn completely

catalytic converter
an air pollution control device that uses a chemical reaction to reduce emissions from motor vehicles

chlorofluorocarbons (CFCs)
chemicals used as coolants in refrigerators and air conditioners that can harm the ozone layer in the upper atmosphere and add to the greenhouse effect

combustion
burning or the production of heat and light energy through a chemical process

contaminant
an element or pollutant that soils the air

dispersion
the process of breaking up high concentrations of air pollutants

emission
a discharge or release of pollutants into the air, such as from a smokestack or automobile engine

environment
the combination of all external conditions and influences relating to the life, development, and survival of all living things

fossil fuels
coal, oil, and natural gas formed from the remains of ancient plant and animal life

hydrocarbons
compounds found in fossil fuels, glues, paints, and solvents that can react with other pollutants to cause smog

hazardous air pollutant
a contaminant that may cause an increase in rates of death or serious illness

meteorology
a science that deals with the atmosphere, weather, and weather forecasting

nitrogen oxides
gases that form when nitrogen and oxygen in the atmosphere are burned with fossil fuels at high temperatures

ozone
a colorless gas that is formed when pollutants react with sunlight and that is a major part of smog

particulate matter
specks of solid or liquid matter, including dust, smoke, fumes, spray and mist

photochemical process
the chemical changes resulting in smog brought about by the energy of the sun acting on air pollutants

plume
the visible emission from a smokestack or chimney

pollution
impurities in air, water and land that create an unclean environment

respiratory
anything having to do with breathing and taking in oxygen and releasing carbon dioxide

smog
the ground level haze resulting from the sun's effect on air pollutants

smoke
the gaseous products and small carbon particles resulting from incomplete combustion

stomata
tiny openings on the underside of leaves through which a plant takes in carbon dioxide

stratosphere
the layer of air that extends from about 10 to 30 miles above the earth's surface

toxic
something that can be poisonous or deadly if it is eaten, touched, or inhaled in large enough amounts

volatile organic compounds
contaminants that can help form ozone near the ground and can be harmful to health

Spencer Kagan: Cooperative Learning, 1992.
Lea Land, Stephen F. Austin Universtiy Nacogdoches TES Course, 1994

Lesson provided by the Texas Natural Resources Conservation Commission
http://www.tnrcc.state.tx.us/air/monops/lessons/lesson_plans.html

Air Pollution Word Search

There are 25 words that are often used in connection with air pollution listed in the word search below. Can you find them?

W	O	D	Q	F	B	I	O	O	V	N	I	Q	B	R	O	J	O	C	P	X	J	I	V	K
P	P	Y	M	O	Z	Y	N	R	N	B	O	G	P	S	E	N	J	O	N	F	A	X	K	D
Q	E	Q	W	O	O	P	Y	D	X	R	L	I	I	T	O	D	P	X	C	K	A	S	R	U
U	H	K	G	C	O	R	I	T	U	V	T	R	S	R	J	U	H	S	W	F	O	G	X	J
D	X	A	O	N	R	S	C	E	X	S	N	W	K	R	L	O	R	A	D	U	S	W	B	T
Y	I	Q	G	M	J	F	M	B	D	F	T	N	A	A	E	E	K	N	H	N	A	C	J	S
L	J	F	W	V	S	K	Y	Q	Y	I	I	R	T	W	T	V	Y	I	O	C	V	B	X	U
Z	X	P	Z	M	E	T	H	J	Z	G	X	I	Y	L	I	R	N	B	S	C	F	U	V	A
X	F	O	W	K	P	Z	B	X	Y	Q	O	O	I	E	I	L	R	I	D	R	O	J	T	H
M	D	L	E	R	Q	M	J	L	K	N	S	F	I	O	W	A	N	E	G	Y	X	O	T	X
B	X	L	C	D	S	E	P	H	L	X	A	Y	U	D	C	R	M	U	U	Q	N	N	S	E
A	X	U	A	R	V	A	S	F	B	O	O	E	Z	O	N	Z	H	R	X	Z	E	N	K	J
H	A	T	R	G	W	A	J	D	U	J	L	D	R	H	G	O	E	Z	B	M	H	F	J	L
K	L	I	P	X	T	C	N	D	Y	D	B	D	T	O	B	P	B	I	N	U	E	Q	Z	W
S	D	O	O	X	O	M	I	M	J	T	Y	J	M	S	H	B	U	R	I	A	A	I	S	V
U	W	N	O	F	Z	H	J	O	I	H	N	S	N	P	B	S	E	B	A	U	C	L	D	Q
C	X	Q	L	L	C	Q	Q	W	E	C	F	H	Q	W	C	V	U	R	T	C	C	G	P	A
U	E	D	O	X	O	N	O	M	N	O	B	R	A	C	O	Y	L	O	J	X	C	R	E	E
M	W	F	Y	T	B	E	K	E	R	V	S	S	L	G	D	I	M	C	F	L	C	H	S	H
E	R	E	H	P	S	O	M	T	A	G	E	N	V	I	R	O	N	M	E	N	T	A	O	R
N	T	I	A	Y	C	U	U	S	N	Q	L	M	R	S	B	T	Y	A	Z	A	E	K	L	M
S	V	S	J	I	U	A	D	U	H	Q	H	B	K	I	Q	K	N	Z	E	S	N	M	T	X
R	I	H	A	T	K	P	L	I	S	V	D	J	L	G	D	A	B	R	I	P	V	E	M	V
A	Z	L	V	W	I	J	I	H	Y	D	D	E	S	W	I	P	B	D	I	X	E	M	Q	L
N	Z	P	W	Y	C	U	F	C	L	A	W	P	Q	R	K	I	Z	P	Y	J	N	T	G	H

Here are the words to look for:

Ash	Atmosphere	Automobile	Breathe
Carbon Dioxide	Carbon Monoxide	Carpool	Clean Air
Disease	Dust	Environment	Exhaust
Filters	Government	Hydrocarbons	Industry
Inversion	Lungs	Mucus	Oxygen
Pollution	Population	Smog	Smoke
Waste			